PARTNERS IN AMPHIBIAN AND REPTILE CONSERVATION

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

Technical Publication HMG-1 2nd Edition

PARTNERS IN AMPHIBIAN AND REPTILE CONSERVATION

This publication was made possible by the support of the following agencies and organizations.

The authors are pleased to acknowledge the generous support of the USDA Forest Service (Easter Region), the USDA Natural Resources Conservation Service, and the USDI National Park Service. Their contributions were vital to the development of this and other PARC regional habitat management guides. We also thank the USDI Fish and Wildlife Service (Northeast Region), State Wildlife Agencies, and all other contributors, both for their generous support to PARC, and for their commitment to amphibian and reptile conservation.

Front cover image is a composite constructed by Mark Raithel and Cliff White, Missouri Department of Conservation, using photographs taken by Jeff Briggler , Missouri Department of Conservation, depicting the Eastern Hellbender in its native stream habitat.

Back cover image of a Copper-bellied Watersnake provided by Omar Attum. Stream image provided by Scott Gibson.

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

Technical Publication HMG-1, 2nd Edition

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, 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 Partners in Amphibian and Reptile Conservation (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. Applying the general management principles in these Guidelines across the landscape will promote conservation of these animals by helping to:

- Keep common species common,
- Stem the decline of imperiled species,
- Guide the restoration of amphibian and reptile habitats while benefiting many other wildlife species, and
- Reduce the likelihood that additional species will be added to endangered species lists.

Scott Gibson

Common Gartersnakes are one of the more ubiquitous species of the Midwest and can be found in most habitat types. They are harmless and amphibians comprise a large portion of their diet. In many regions, the absence of gartersnakes is a sign of severe habitat deterioration.

Mike Graziano

As their name implies, Mud Salamanders live in muddy environments, such as the edges of floodplain forests, small streams and springs, bogs, and swamps. Despite their bright coloration, they are rarely observed as they spend much of their time buried in mud. Within the Midwest, Mud Salamanders are found only in southern Ohio.

ISBN 0-9667402-8-9

Suggested citation: Kingsbury, B.A. and J. Gibson. (editors). 2012. Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States. Partners in Amphibian and Reptile Conservation Technical Publication HMG-1, 2nd Edition. 155 pp.

Additional copies of these Guidelines may be obtained through PARC. Visit ***www.parcplace.org*** for more information about placing orders. Donations to PARC help defray the costs of development, printing and publication, postage, and handling, and can be made by check, credit card, or money order.

Jeff Briggler

Jeff Briggler

Zack Walker

North Dakota Fish and Game

Natural seasonal wetlands are embedded within larger habitats, such as forests (top) and grasslands (bottom). The combination of seasonal wetlands used as breeding sites and surrounding upland habitat is needed for the persistence of Ringed (top inset) and Eastern Tiger Salamanders (lower inset).

TABLE OF CONTENTS

Scott Gibson

A healthy hardwood forest scene. Hardwood forests once covered much of the eastern portion of the Midwestern landscape. However, clearing for agriculture and development has greatly reduced the acreage of hardwood forest remaining. The Hoosier National Forest and surrounding undeveloped lands, including the Charles C. Deam Wilderness Area shown above, represent the largest continuous tract of forest in Indiana. Such areas represent important strongholds for species that require larger tracts of continuous forested habitat, such as the Timber Rattlesnake.

PREFACE

A PARC objective is to increase communication and cooperation among many diverse groups that have a common interest in amphibians, reptiles, and their habitats. The diversity of partners makes PARC the most comprehensive conservation effort ever undertaken for these two groups of wildlife. Through documents such as this, PARC provides individuals, agencies, industries, and organizations ideas for conserving and managing amphibian and reptile habitats. 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 book is part of a five-volume series covering the United States, including Alaska, and parts of Canada. Each volume covers a regional, geographic area and is largely based on ecoregions. The Midwest volume was written with the expectations that many readers will not read the book in its entirety. Consequently, some redundancy among sections was required to ensure that key points were captured for their benefit to those who may not read the document in its entirety.

Development of the PARC Habitat Management Guidelines series 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 (HMGs) 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. Following that meeting, the Habitat Management Guidelines for Amphibians and Reptiles of the Midwest was the first HMG to be completed, appearing in print in 2002. The Southeast HMG, then the Northeast HMG, followed in 2006. In 2008, the Northwest HMG went to press, and the HMG you have in hand is a revision of the original Midwest HMG, expanded in scope and content, and made consistent in form to the HMG series. Soon to come will be the last of the originally conceived

Jeff Briggler

Box turtle populations across much of the Midwestern United States are threatened by habitat loss and fragmentation, road mortality, collection, and in some areas high nest predation. Two species and one sub-species of box turtle are found in the Midwest. The Eastern Box Turtle, and the Three-toed Box Turtle (a sub-species; shown above) primarily inhabit areas of deciduous forest in the eastern and central regions of the Midwest. The Ornate Box Turtle is found in the grassland ecoregions extending into the western areas of the Midwest.

series, the Southwest HMG. Some of the introductory sections of this revised document were extracted or developed from more recently published Guidelines with the express permission of the lead authors.

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. Please see the Acknowledgements section at the back of this book for greater details about those who have helped with text, photos, and production of these guidelines. Lead writers, organizers and editors for this book were Bruce A. Kingsbury and Joanna Gibson. Kingsbury is Professor of Biology at Indiana-Purdue University Fort Wayne and Director of the Center for Reptile and Amphibian Conservation and Management. Gibson is a member of the technical staff of the Center for Reptile and Amphibian Conservation and Management.

Copying and distribution of this document is encouraged, but please provide credit to the original sources of information. Contributors retain copyright ownership of their photographs.

To learn more about PARC, please visit our web site at: ***http://www.parcplace.org.***

Kristin Stanford

Scott Gibson

The principal authors/editors Bruce Kingsbury and Joanna Gibson.

Zack Walker

Bird-voiced Treefrogs have a limited distribution in the PARC Midwest region, occurring only in southern Illinois in the Interior Low Plateau and Upper East Gulf Coastal Plain ecoregions. The species is aptly named in reference to their breeding call which has been described as a repetitive bird-like whistle.

Zack Walker

Hellbenders are one of only four entirely aquatic species of salamander found within the Midwest. They occur in the Ozarks, Interior Low Plateau, North Central Tillplain, and Western Allegheny Plateau ecoregions. Once thought to have inhabited most large streams within their range, hellbenders have experienced considerable population declines and are now one of the most threatened herpetofaunal species within the Midwest. Water pollution, sedimentation, and the impoundment of water courses have contributed to these declines.

Zack Walker

The shell of the Spiny Softshell is covered by soft and leathery skin, instead of the hard carapace typical of other turtles. These highly aquatic turtles are primarily residents of rivers, but also occupy other larger permanent aquatic habitats such as lakes and reservoirs. They do best in clean water where natural sandbars provide basking and nesting areas. Spiny Softshells and other species of riverine turtle will benefit from the protection of nesting sites.

INTRODUCTION

Amphibian and reptile populations are declining in North America, and will continue to do so as human populations and associated development expand. We need to do what we can to halt, or even reverse, these declines, and that will require habitat conservation, proper maintenance and restoration. To complicate things, despite their diversity and perceived abundance, amphibians and reptiles have only recently received consideration in many wildlife management programs. Their ecological importance has become better 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.

This HMG provides guidance to property owners and land managers of the Midwest as they strive to address amphibian and reptile population declines and management needs. The Midwest region of PARC is defined as Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. As amphibians and reptiles do not recognize administrative boundaries, and population distributions align more naturally to ecoregions, land managers in southern Canada and states surrounding the Midwest may also find these guidelines applicable to their needs.

The habitat management guidelines included in this document are collaboratively derived and scientifically based, using published information on amphibians and reptiles of the Midwestern United States, as well as the extensive experiences of concerned biologists/scientists. These guidelines are not regulations, nor

Bill Flanagan

Kent Bekker

Instilling a love of nature at an early age can help children grow to be excellent ambassadors for the environment.

are they in any way an attempt to limit landowner rights. They are simply recommendations from the PARC community for landowners and managers as they consider the needs of amphibians and reptiles in the course of their land management activities.

PARC's goal was to use the best science available to produce habitat management and conservation guidelines that are easily understood and practical for landowners and managers to integrate with other management objectives on the landscape. The 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 ways that have general positive benefits for the associated amphibians and reptiles, as well as a variety of other wildlife.

Habitat conservation is preventative maintenance. If enough landowners and land managers implement even some of the guidelines outlined in this document, the collective effort will not only benefit amphibians and reptiles via habitat protection, but may also diminish the likelihood of additional species being added to endangered species lists. Landowners and land managers may thus benefit by avoiding potential impacts from regulation.

HOW TO USE THESE GUIDELINES

We recognize that landowners and land managers have multiple goals and objectives for managing their land, and not every land manager or landowner can be expected to implement all of the guidelines. 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 Midwestern landscape will be significant and positive.

Given multiple goals and objectives, 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.

Using the information in this handbook, you will be able to:

1. Identify the habitats at your site upon which you wish to focus.
2. Gain an understanding of which species are likely to occur and live in those habitats.

USGS

USGS

Aerial photographs are excellent tools for visualizing the spatial arrangement of habitats and can be used to identify where specific actions can be implemented to benefit amphibians and reptiles, as well as other wildlife. For example, the top image shows wetlands that have been isolated from nearby forest patches and other wetlands. By restoring buffers of natural habitat around these isolated wetlands and corridors that connect them to nearby forest (outlined in black on lower image), the value of these areas to herps and other species will be greatly enhanced. Aerial photographs may be available from local USDA, NRCS offices, local County offices, or on the Internet (e.g., Google Earth, etc.).

Omar Attum

Nathan Engbrecht

Herpetologists can help to identify the species of amphibians and reptiles present on a property. Visual surveys (left) can determine the presence of many larger species, and specialized sampling equipment, such as minnow traps (shown at right), can be used to reveal the presence of more cryptic species that use aquatic habitats for breeding, such as the Mole Salamanders shown here.

3. Establish your management goals 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.

c. Investigate available conservation programs that may help you implement your goals, often through cost-sharing.

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 assessments could range 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 them to determine where the problem is located. Consider getting a herpetologist involved. Successful land management is a mix of land-use history, art, and science, and a willingness to adjust when things aren't working.

DEVELOPING A MANAGEMENT PLAN

An important first step in managing habitats for amphibians and reptiles, regardless of the designated land use, is the development of a management plan. For a private landowner, a management plan may include a few simple steps. First steps would include identifying the different habitats on their property and formulating a list of species of interest that might occur in each habitat. Next would be detailing the land-use activities associated with each habitat, and identifying which land-use activities may be compatible or incompatible with amphibian and reptile habitat requirements. Ultimately and perhaps most importantly, the plan should include a description and schedule of specific actions that will be implemented to reduce the impacts of those activities that may be less suitable for conserving amphibians and reptiles. Of course, public land managers or large landowners will wish to develop a more comprehensive management plan (see Appendix A).

AMPHIBIANS AND REPTILES OF THE MIDWEST

The Midwest region of the United States supports at least 163 native species of amphibians and reptiles including 33 frog species, 38 salamanders, 20 turtles, 16 lizards, and 56 snakes. A complete list of Midwestern species, detailed by scientific and common name, and information on state occurrence, primary habitats, and rarity status, is presented in Appendix B. As common names for amphibians and reptiles vary regionally, users may wish to consult regional and state guides for other names applied to species.

The amphibians and reptiles native to the Midwest illustrate an impressive 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 Midwest are included in the list of resources at the end of this guide.

Carl R. Brune

The high-pitched "peeping" call of the Spring Peeper heralds the arrival of spring across many areas of the Midwest. These small frogs breed in seasonal and permanent wetlands. Outside of the breeding season they occupy wooded areas and grasslands, but they are rarely encountered. Protection of small, temporary wetlands and surrounding upland habitat is important for the continued survival of this species.

Omar Attum

Aquatic turtles, such as these Painted Turtles, use emergent logs to bask and warm themselves. Early morning and during cool days are the best times to observe such activity. As log "real estate" may be limited, it is not uncommon to see individual turtles vying for a position on one these "sun decks." Sometimes land managers can benefit these species by adding basking structures (e.g., logs or large rocks) to ponds where they are in short supply.

NATURAL HISTORY OF AMPHIBIANS AND REPTILES

Amphibians and reptiles are frequently called "herps," an abbreviation of the word "herpetofauna," which refers collectively to both amphibians and reptiles. The branch of science that relates to the study of amphibians and reptiles, or herps, is called "herpetology" and a person who studies herps is called a "herpetologist."

Amphibians and reptiles are commonly referred to as "cold-blooded," but this characterization is misleading. When active, they are not cold. In fact, some reptiles even prefer to be warmer than humans. Most biologists now focus instead on the fact that herps need to acquire heat from their environment, and thus refer to them as ectotherms. "Ecto" refers to coming from the outside, and "thermy" refers to heat. In contrast, mammals and birds are endotherms. They get their heat from within ("endo") via metabolic processes. Herps maintain their desired temperature via "behavioral" thermoregulation, selecting warm microhabitats, such as by basking in the sun if they are too cold, or seeking shade or going underground when too hot. This is especially evident with reptiles. It is not uncommon to see a turtle basking on a log, or a snake resting in a sunny spot. Their dependence upon the environment means that these needs must be locally met. If they cannot thermoregulate effectively in a particular area, they may leave or perish. Conservation efforts therefore need to provide for a diversity of temperature conditions, including safe access to sunshine for basking, and refuges from extreme temperatures.

Jeff Briggler

By flattening their bodies while sunning, lizards such as this Eastern Collared Lizard increase the surface area receiving heat conducted from the rock below and from sunlight, enabling them to "warm up" faster. Open rocky areas that are often embedded within more extensive habitats such as forests and grasslands, provide critical habitat for this species. Eastern Collared Lizards occur in the Ozarks, Crosstimbers and Southern Tallgrass Prairie, Osage Plains/Flint Hills Prairie, Central Mixed-Grass Prairie, and Central Shortgrass Prairie ecoregions of the Midwest.

Although amphibians often function at cooler temperatures than reptiles, an important consideration for a majority of them is ready access to moisture. Even if they don't live in wetlands year-round, most amphibians breed in such habitats and require them within their home ranges (the area where they live). Amphibians also need access to water or moist soil to avoid drying out. For some species this means they need to be within a few hops of open water to soak. For many others, they at least need damp soil or moist leaf litter to burrow into to rehydrate. As habitat dries, many amphibians will seek a moist shelter to wait for wetter weather. This may result in extended periods of inactivity, referred to as aestivation. However, many salamanders may continue to be active underground in burrows, out of sight.

Reptiles lay eggs with a calcified shell, much like a chicken egg, though softer, or produce offspring via unshelled eggs ("live birth"). Snakes and lizards typically lay their eggs in burrows constructed by other

Jeff Briggler

Greg Lipps

Salamanders need access to moist conditions to survive. Salamanders in the family Plethodontidae lack lungs and instead rely on cutaneous respiration, i.e., they "breathe" through their skin. To facilitate gas exchange their skin must remain moist (the inside of human lungs are also moist for the same reason). If you think about it, the skin of a plethodontid salamander, like the slimy salamander (at left), functions like an inside-out lung! This reliance on access to moist conditions is why salamanders often seek refuge in moist soil or bury in moist leaf litter. Timber harvesting activities can negatively affect salamanders by removing access to moist conditions. For example with the loss of the tree canopy, low growing ground plants, and leaf litter following timber harvesting (at right) the once moist, humid forest floor becomes dry due to exposure to solar radiation and wind, creating an inhospitable environment for salamanders.

Bob Hay

Nearly all reptiles, including this Milksnake, lay shelled eggs. Milksnakes typically lay their eggs under logs or other material where they develop for about two months before hatching.

animals, in rotting logs, or under rocks or other objects on the ground. Turtles lay their eggs in shallow nests they dig themselves in sandy, open, sunny locations. Suitable nesting areas with the requisite open canopy and loose soils may be some distance from areas used for other activities, but they must be available via a safe corridor across the landscape. Turtles live a long time and thus have many years to successfully produce offspring. However, predation rates upon turtle nests and hatchlings are generally very high, so recruitment into the adult population may be very low most of the time. This means that adults are a "precious commodity," and loss of adults from turtle populations due to human causes is very detrimental.

Reptiles have dry scales covering their bodies that serve as a protective barrier to moisture loss. As a result, they are able to exist in drier habitats that exclude many amphibians. However, few reptiles can

Jim Harding

Jim Harding

Open canopy areas with relatively loose soils provide ideal nesting conditions for turtles. Females use their back legs to dig and then cover their nest. As the eggs are incubated by the warmth of the soil surrounding them, incubation time can vary, but in general hatching will occur after about two to three months.

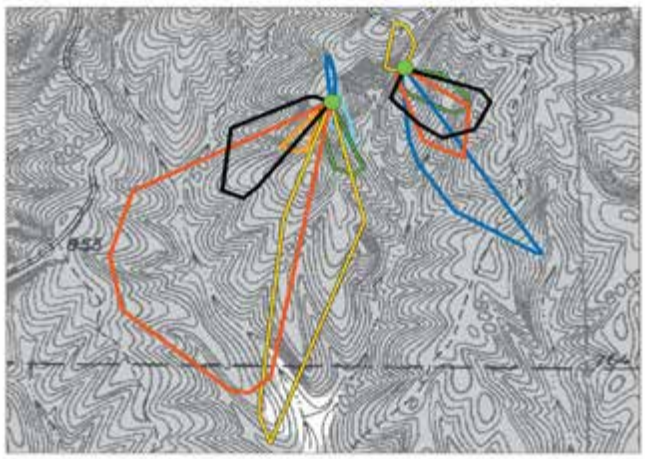
withstand long periods without water. Indeed, most are active when conditions are moist (e.g., during or just after rainfall or high humidity) and stay concealed during periods of dry weather.

Many species of amphibians and reptiles use a variety of habitats during the year. Salamanders may live in the forest most of the time, but travel to adjacent wetlands to breed every spring. Turtles may live in wetlands, but they must move onto land to lay their eggs. In many cases, individuals return to the same places year after year for particular activities. For some species, such as Timber Rattlesnakes, hibernation sites may be few and far between and require extensive movements through other habitats to be reached. Some animals may travel miles each year to reach all of the habitats they need!

Habitat fragmentation due to human alterations can negatively affect such species by preventing them from reaching all of their habitats. Removing the forest around a wetland, for example, may prevent the forest salamander from reaching the pond to breed. A road constructed between a wetland and a turtle nesting area may cause road mortality of female turtles.

Roads are a particularly serious problem. They may block the way or present risks from cars or from predators that can see the herps out in the open. Millions of herps are killed on roads annually. Because of such impacts, strategies for promoting herpetofaunal diversity must incorporate means to provide a diverse variety of habitats in close proximity, and safe corridors between these areas to reduce the risks for migrating individuals.

Most Midwestern reptiles and amphibians hibernate or become inactive during the winter. A classic example of a "hibernaculum" would be a rocky outcropping in the Southwest to which numerous snakes migrate each fall to communally share a spot to overwinter. However, in the Midwest, many species such as garter and watersnakes spend the winter underground in crayfish burrows. Oddly enough, they are hibernating underwater in such locations. The saturated soil actually resists freezing and thus protects the snakes while keeping them moist. Other species find refuge in mammal burrows, under tree stumps, in barns, or other protected areas. Many species of turtles and frogs overwinter in shallow wetlands where the water is just deep enough that the muddy bottom does not freeze. They burrow into the mud and wait for spring. Other herps use locations like those described for snakes, while amphibians such as the Wood Frog, Cope's Gray Treefrog, Gray Treefrog, Spring Peeper, and chorus frogs simply burrow into moist leaf litter



Scott Gibson

Timber Rattlesnakes can use specific overwintering sites, often called "dens," that may be poorly represented in the landscape, and individuals usually use the same overwintering site for their entire life. In spring they emerge from the den and typically disperse to forage, mate, and bear their young, before returning in fall. For example, the map above shows two dens (green dots) used by Timber Rattlesnakes, and each colored polygon shows the extent of movements for one individual (over a period of one year) that overwintered in one of these two dens. As shown, multiple individuals often hibernate communally in the den. Because of their fidelity to specific dens, destruction of a den could prove catastrophic for all individuals who hibernated there. Likewise construction of a road between a den and areas used for foraging and bearing young could also be detrimental through road mortality.

and soil on the forest floor for the winter. They produce a glucose-based "antifreeze" that allows them to survive freezing if conditions don't get too extreme!

Amphibians and reptiles do not require much energy each day. A lizard uses perhaps only 15% of the energy of a similar-sized bird during a normal day. With nights, cold weather, and all seasons considered, over the year the lizard might only use 1% of the energy needed by the bird! Thus, herps can go a long time between meals. This is especially true for some snakes, which can eat large prey and then go weeks or even months between meals if necessary. A snake may only require a few mice a year to get by!

Of all the herps in the Midwest, snakes undoubtedly arouse the greatest fear and fascination. For many people, the first thing that comes to mind when they encounter a snake is whether or not it is venomous. However, few of the snakes of the Midwest are of any danger to humans. In fact, there are only six venomous snake species in the Midwest, and their distributions are generally rather limited. All of these species belong to the "pit viper" group, distinguished by sensory pits (openings) located between the eye and the nostril on each side of their head. These pits detect heat and help the snake locate warm-blooded prey, even in the dark. All of our rattlesnakes will have stubby tails and rattles. Even the smallest ones have a little button rattle on the tip of their blunt tail. Finally, contrary to a common misconception, virtually all aquatic (water) snakes in the Midwest are not venom-

Mike Redmer

Jeff Briggler

Roads pose a serious serious threat to many species of amphibians and reptiles, and thousands are killed on roads each year in the United States. Female turtles often travel considerable distances to nesting sites and many are now forced to cross roads in order to reach these areas. Roads may also separate habitats used by amphibians during different times of the year, such as wetlands used for breeding and forests used for overwintering.

ous, nor otherwise dangerous. The Cottonmouth, the one species of aquatic snake that is venomous and thus poses a real risk to human health, only occurs in a few areas in the southernmost part of our region (in very southern southwest Indiana, southern Illinois, and southern Missouri, in the Ozarks, Mississippi River Alluvial Plain, Upper East Gulf Coast Coastal Plain, and the Interior Low Plateau ecoregions), and in most cases, is so rare that few people actually ever see them.

Tadpoles, or "pollywogs" as they are often called, are the aquatic larval form of frogs and toads, much like caterpillars are the larvae of butterflies. Many species of amphibian go from egg to larvae to the adult-looking form in just a few months. That is why they can reproduce in wetlands that are dry by summer. Other tadpoles, such as those of the Green Frog and American Bullfrog, must survive in wetlands until the following year, as they do not take on the adult form until their second or third summer. Either way, if fish are introduced to the ponds where these amphibians live, they usually eat too many of the eggs and larvae for many species to persist.

Amphibians are considered sensitive environmental indicators. They reproduce via unshelled eggs that must be in water or otherwise stay moist, and 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 appropriate the habitat otherwise appears to be. The prey they eat to grow and reproduce may also be a source of harmful chemicals that can be passed on to offspring or up the food chain to other predators.

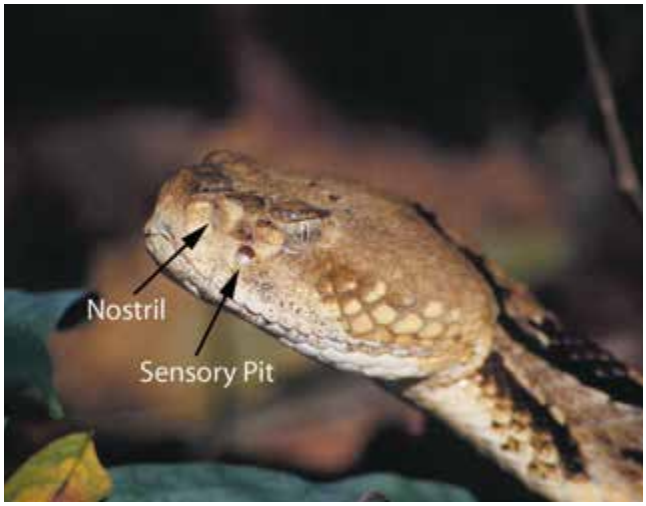
Longevity and survival are other key biological characteristics to consider if management is to have the desired beneficial effect for amphibians and reptiles. Most turtles and many salamanders take many years to reach sexual maturity, living much longer than most game species. Long life and high adult survival are needed by many herp populations to balance the

Joe Sage

Massasaugas commonly overwinter in crayfish burrows or hollows formed by decaying root systems. Researchers monitoring massasaugas have found that they actually spend much of the winter under water, affording the snakes protection from desiccation and, perhaps counterintuitively, freezing. Other snake species (e.g., gartersnakes and ribbonsnakes), amphibians, and even invertebrates have been observed to share these overwintering locations with massasaugas. Lowering local water table depths during hibernation may kill all such animals by removing the protection from freezing.

Kenneth B. Storey

Five species of frog, including the Wood Frog shown above, are freeze-tolerant: they produce a glucose-based "antifreeze" that enables them to survive sub-freezing winter temperatures. When temperatures dip, the liver produces excess glucose that prevents ice from forming in body cells. The heart also stops beating! When temperatures begin to warm their hearts start to beat again and the antifreeze is circulated out of the body.



Scott Gibson

Over the entire Midwest, all venomous snakes belong to the "pit viper" group, and can be identified by the presence of sensory pits (openings) located between the eye and nostril, on each side of the head, as shown on the Timber Rattlesnake above.

poor survival of juveniles. This is essentially the case for many snake species as well, even though they do not live as long as turtles. Collection of individuals from populations of many species is thus often not sustainable, whether it be for commercial harvest, or simply children taking herps home for pets.

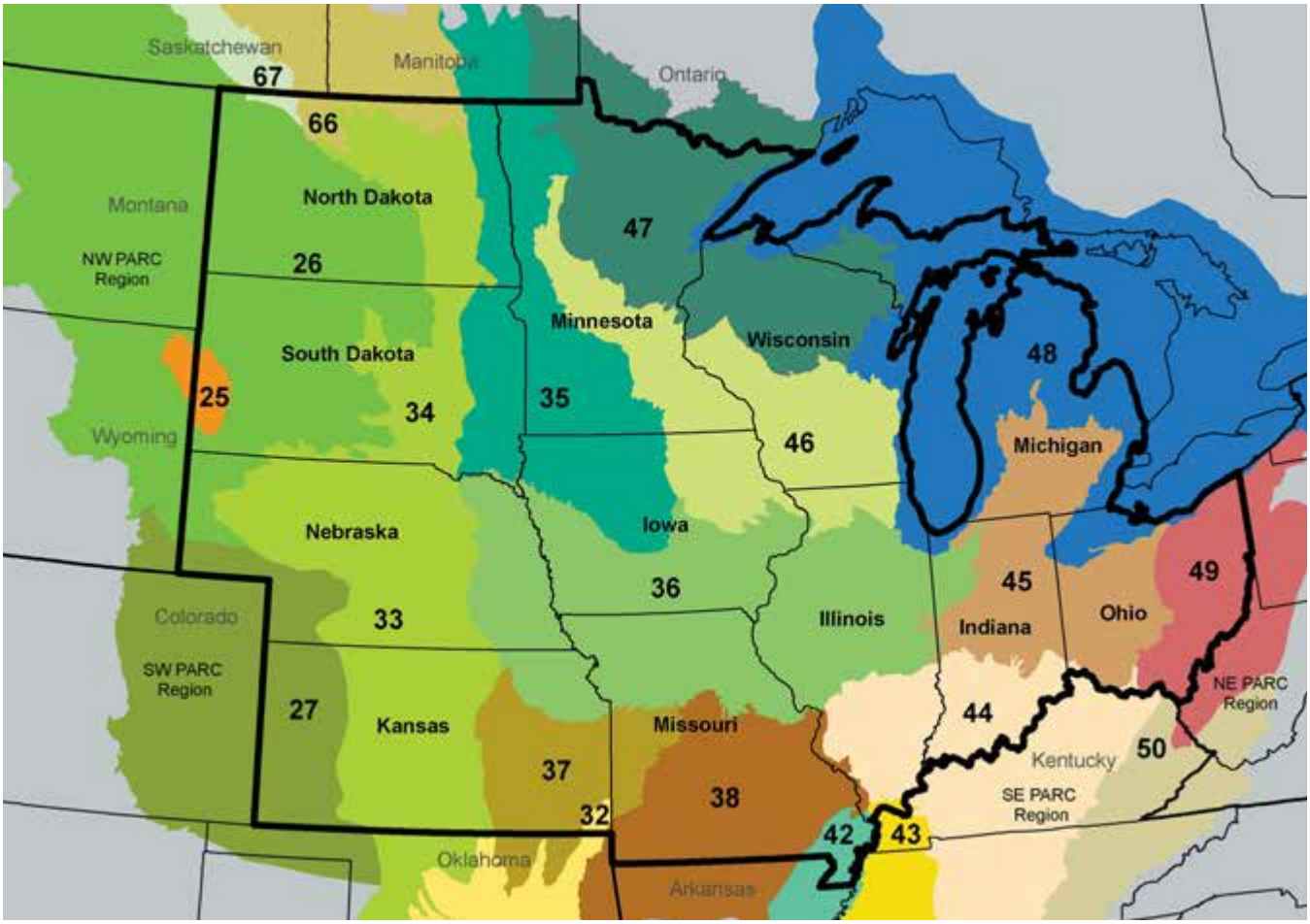
Reptiles and amphibians play an important role in the "balance" of nature and often benefit humans by eating insects, rodents, and other pest species. As prey themselves, they are major links in the flow of energy from aquatic to terrestrial systems. We hope you agree that these fascinating creatures are worth protecting by proper habitat management. We also hope that with this guide we provide what you need to help you protect these spectacular animals.

Zack Walker

Bob Hay

Bob Hay

Most amphibians need aquatic sites for breeding. Eggs are laid in masses (top image), in long strings, or singularly. Once the eggs hatch most amphibian larvae, such as the toad tadpoles (bottom image), or Eastern Tiger Salamander larvae (middle image), remain in water until they metamorphose and move onto land. The eggs and larvae are extremely sensitive to chemical changes in the breeding pond -runoff of sediment or chemical pollution into these areas can kill eggs and larvae, and in turn negatively impact population persistence.



Ecoregions of the Midwest

25 Black Hills
26 Northern Great Plains Steppe
27 Central Shortgrass Prairie
32 Crosstimbers and Southern Tallgrass Prairie
33 Central Mixed-Grass Prairie
34 Dakota Mixed-Grass Prairie
35 Northern Tallgrass Prairie
36 Central Tallgrass Prairie
37 Osage Plains/Flint Hills Prairie
38 Ozarks
42 Mississippi River alluvial Plain
43 Upper East Gulf Coastal Plain
44 Interior Low Plateau
45 North Central Tillplain
46 Prairie-Forest Border
47 Superior Mixed Forest
48 Great Lakes
49 Western Allegheny Plateau
50 Cumberlands and Southern Ridge and Valley
66 Aspen Parkland
67 Fescue-Mixed Grass Prairie

Jennifer Anderson-Cruz

The Mississippi River runs the length of the Midwest region, from Minnesota to Missouri. It provides habitat for amphibians and reptiles along its entire length, and is the life blood for many surrounding habitats.

ECOREGIONS OF THE MIDWEST

Despite a lack of dramatic topography, the Midwest is ecologically diverse. The rain shadowing influence of the Rocky Mountains to the west, climatic extremes due to its interior continental position, and influxes of tropical air from the south, all contribute to this diversity. The twelve Midwestern states span some 21 ecoregions. An ecoregion, as defined by The Nature Conservancy, is a portion of the country 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). Delineating ecoregions helps us identify where various habitats are regionally dominant, and knowing that enables us to help the species reliant on those types of landscapes. The natural historical distribution of vegetation and soil types that define ecoregions also helps us understand the distributions and habitat needs and preferences of amphibians and reptiles, and can thus provide excellent information for habitat management and restoration efforts. Much of the central to western portion of the Midwest region covered by these Guidelines are dominated by grassland habitats, while forests dominate the landscape further east. On the other hand, forests of one kind or another occur in virtually every ecoregion, as do seasonal wetlands.

HABITATS IMPORTANT TO AMPHIBIANS AND REPTILES

The Midwest Working Group identified five aquatic and eight terrestrial habitats in the Midwest that are recognizable and distinct, and that can be associated with certain assemblages of amphibians and reptiles. Few amphibians or reptiles occur exclusively in any one habitat type, however. Quite often species occupy several habitat types. Some of these habitats are relatively small (e.g., seasonal wetlands, caves) and are often embedded within larger habitats (e.g., forests). Each of the Midwestern habitats is described in detail in the Management Guidelines by Habitat Type section.

Aquatic Habitat Types Include:

1. Seasonal Isolated Wetlands
2. Permanent Wetlands
3. Wet Meadows, Bogs, and Fens
4. Small Streams, Springs, and Seeps
5. Rivers and Large Streams

Terrestrial Habitat Types Include:

1. Hardwood Forests
2. Coniferous Forests
3. Woodlands and Savanna
4. Grasslands and Prairies
5. Caves and Karst
6. Rock Outcrops, Glades, and Talus
7. Agricultural Lands
8. Urban and Residential Areas

Nathan Engbrecht

Cope's Gray Treefrogs occur in most states in the Midwest. Because of their ability to change background coloration depending on environmental conditions and activity, their appearance can be quite variable. They are found in forests and more open habitats (as long as there are trees/shrubs close by), but they require wetlands for breeding.

Jeff Briggler

Common Gartersnakes do well in moist grassy areas and in forest and field interfaces and are thus often found in farming landscapes, and sometimes in suburban areas. These beneficial predators are excellent garden guests as they readily eat pests such as slugs and insects.

John White

The Common Five-lined Skink can tolerate shady or moist conditions, but they may also inhabit drier areas such as open or sparse-canopy habitats. Natural ground debris, such as logs and rocks, provides refuge for this species.

Jeff Briggler

Eastern Tiger Salamanders are large and stocky, and occur in every state in the Midwest. They use a wide range of habitats across their range, from forests to open prairies, but access to suitable breeding sites (fish-free permanent and semi-permanent wetlands) limits their distribution.

Paul Frese

Slender and beautifully patterned, Milksnakes reside in a wide range of habitats from grasslands and forests to farmyards and suburban parks and sometimes, backyards. They spend much of their time hidden under cover objects such as logs, boards, and rocks. Rodents comprise the bulk of their diet, and as such these harmless snakes can benefit farmers and other landowners.

Nathan Engbrecht

Found in every state in the Midwest, Painted Turtles occur in permanent aquatic habitats such as creeks, lakes, marshes, and ponds. They often do well in farm ponds, especially when there is a ready supply of basking structures (e.g., logs, rocks).

USGS

Across many areas of the Midwest, natural habitats have been fragmented and remnants isolated, existing now as "islands" in a sea of altered landscape. Habitat fragmentation can be a difficult concept to visualize, but is perhaps best appreciated using aerial photography. This aerial photograph shows patches of forest and wetlands surrounded not only by agriculture, but also further fragmented by intersecting roads and residences. Amphibians and reptiles living in these isolated patches of natural habitat face considerable challenges for survival, especially when migrating from one "island" to another.

CONSERVATION CHALLENGES

NASA

This satellite view of the United States taken at night highlights widespread development. As urban sprawl continues to expand, habitat available for amphibians and reptiles is reduced.

The Midwestern United States is a resource-rich region within which 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. Roads, commercial and residential development, agriculture, and other challenges are facts of life in the Midwest. Consequently, most species have experienced population extirpations (local extinctions) and declines since European colonization.

However, by recognizing the impacts of these uses of the landscape on amphibians and reptiles, we hope to give land managers realistic options that can minimize adverse effects and maximize conservation potential. With this in mind, this mini-review provides a backdrop for land owners and managers to understand why biologists, naturalists, and herpetologists are concerned about these animals.

In developing guidelines for the 13 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 Loss, Alteration, and Fragmentation
- Impacts of Roads and Trails
- Exploitation
- Fire Suppression
- Use of Herbicides, Insecticides, and Fertilizers
- Use of Mechanical Techniques for Vegetation Control
- Invasive Exotic Species
- Subsidized Predators

HABITAT LOSS, ALTERATION AND FRAGMENTATION

Naturalists, scientists, and land managers agree that local habitat alteration is a major cause of amphibian and reptile declines in the Midwest. Many land-use management activities including agriculture, industrial complexes, urbanization, some forms of recreation (e.g., golf course construction, marina development), 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 areas ("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. Such populations are also more vulnerable to catastrophic events such as extreme weather or disease outbreaks. Simply finding one another for mating and reproduction is a challenge without adding the dangers of dispersal and migration through expanses of inhospitable habitats. Small, isolated habitat patches seldom support viable populations in the long-term.

Habitat alteration changes the suitability of an area for herpetofauna. Individual amphibian and reptile species often respond differently to the same habitat alterations (i.e., abundance of some species may increase while others may decline). Species associated with habitats that take long periods of time to develop, such as fens, 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 over the year to complete their life cycle (e.g., moving from overwintering habitat to breeding habitat). Immigration, necessary for genetic diversity, may also be impeded.

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

Wisconsin DNR

Roads and urban development often result in considerable amphibian and reptile population declines as they "break-up" or fragment once continuous areas of natural habitat. This aerial photograph highlights how wetland and forested habitats have been fragmented by houses and roads. Amphibians and reptiles living in this environment face considerable risk from continued loss of habitat, road mortality, and isolation of populations.

Nick Bieser

Clear-cut logging operations are a stark example of habitat alteration. Along with loss of vegetative cover, temperature and moisture conditions are drastically altered, the ground cover layer is often considerably disturbed, and the soil is compacted.

Carl R. Brune

Railroads fragment habitat and can create a barrier to the movement of some species of amphibians and reptiles. This image shows an Eastern Box Turtle trapped between the rails. Due to the exposed conditions of railroads, herps trapped between the rails eventually overheat and die.

USFWS

USFWS

Seasonal wetlands, such as prairie pothole wetlands, are one of the most important and threatened habitats for amphibians and reptiles in the Midwest. Seasonal wetlands once interspersed much of the Midwestern landscape, but due to extensive ditching, draining, and tiling for agriculture and development, widespread degradation or outright loss of much of these aquatic habitats has taken place.

Mike Graziano

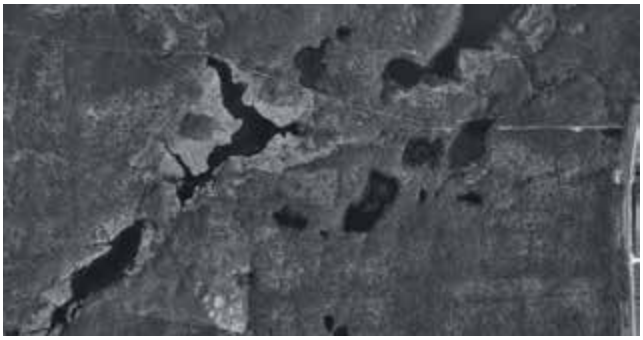
North Dakota Fish and Game

Many species of amphibians and reptiles need access to multiple habitats to meet their life history needs. For example, Western Chorus Frogs breed in seasonal and permanent wetlands, such as prairie pothole wetlands (shown above), but spend the remainder of the year in surrounding grassland and prairie habitats. Outside of the breeding season they are rarely encountered as they seek moist refuge under ground surface cover. It is important that landowners and land managers integrate the concept of multiple habitat use into management plans to help ensure the conservation of the many species of amphibians and reptiles that rely on more than one habitat type.

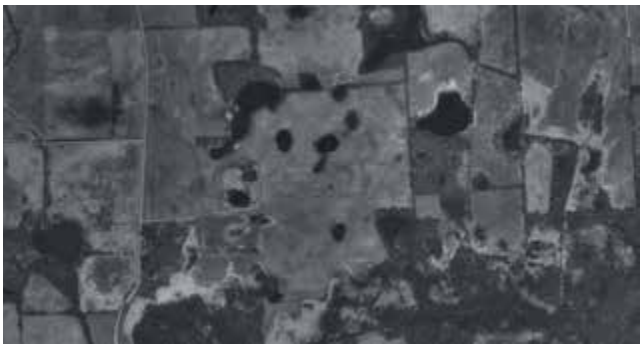
LANDSCAPE SCALE AND CONNECTIVITY

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. Many species use upland and wetland habitats 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 grassy or forested strips may contribute to maintaining water quality but may not meet the needs of those species of amphibians and reptiles that are reliant on large blocks of floodplain forest adjacent to the river.

Though their secretive nature at some times may mask it, most amphibians and reptiles need two or more habitats during their lifetimes if not each year. Habitat requirements change seasonally due to repro-



USGS



USGS

Christine Barlow

By providing access to all of their needs, areas of continuous natural habitat have the most value to amphibians and reptiles, and other wildlife (top image). Fragmented and disjunct islands of natural habitat (middle image) are harsh environments for amphibians and reptiles, because safe corridors are lacking between habitat patches they need to visit to meet all of their needs. The value of all habitat patches can be maximized by retaining existing corridors and restoring lost ones (lower image).

ductive and foraging behavior, and may change annually as individuals shift areas that they use over time. It is important to integrate the concepts of multiple habitat use, the distances between and relative positions of habitats with respect to one another, and the types of corridors between them into your vision of how to manage your land. Think about what amphibians and reptiles face on your land. Envision their world.

Think about the habitat "matrix" on a "landscape scale," and consider all possible habitats when creating management plans. 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.

The **Landscape** is the geographic scale of the management area in question, and includes all the interactive aspects of the habitats in that area. This can be an entire watershed defined by natural boundaries or a specific area under management. **Landscape matrix** refers to the complex of different habitat types, including the altered or unsuitable land, between intact habitat fragments. When viewed from the animal's perspective, the matrix includes all of the relatively inhospitable habitat they must traverse in order to move along essential habitats.

Think connectivity. Safe corridors between required habitats will enhance survival during migration and are essential for the conservation of many species. Consider what kinds of terrain amphibians and reptiles will have to move through when migrating from one area to another. Corridors of safe landscape through which herps may pass are very 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 factors to consider …

- Roads can have a substantial impact on the viability of many populations of amphibians and reptiles.
- Oil, de-icing chemicals, and other contaminants from road traffic contribute pollutants to adjacent streams and wetlands.
- Roads may provide corridors for invasive plant species and travel corridors for predators such as raccoons, coyotes, cats, and dogs.
- 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 http://www.fs.fed.us. Using the concepts illustrated in the handbook may 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. If roads must be constructed, consider multiple uses. For example, perhaps roads may double as fire breaks.
- Road placement should take into account the locations of sensitive habitats and migration routes. Avoid these sensitive areas by rerouting road corridors.
- Consider using wood chips to construct walking/nature trails and compacted gravel for bike trails in open grassy habitats. Use of permeable materials helps to reduce erosion and runoff.
- Planting native grasses, mulching, liming and fertilizing closed trails and dirt roads can minimize soil erosion. State conservation practice standards include "Forest Trails and Landings" and are available through the USDA Field Office Technical Guide (http://www.nrcs.usda.gov/technical/efotg/). Restricting access by gating or permanently closing nonessential roads can be very effective and is easily accomplished on some public and private lands.
- Consider seasonal road closures using gates to protect migrating animals. This simple measure helps protect species and habitats. Gates may be opened selectively to permit 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 underpasses can be used in some cases to funnel

Jeff Briggler

Increases in road width, traffic volume, and traffic speed represent formidable odds for the safe passage of any species of amphibian or reptile.

Jeff Briggler

Female turtles often cross roads to reach nesting areas and unfortunately many are thus killed on roads each year. Studies on aquatic turtle populations situated near roads have found that a majority of such populations are comprised of males, because females are disproportionately killed on roads.

Mike Graziano

Adult Eastern Tiger Salamanders migrate to fish-free permanent and semi-permanent ponds and pools in spring to breed. After breeding, they disperse into surrounding upland habitats for the remainder of the year. Roads placed between breeding sites and terrestrial uplands can negatively impact populations through road mortality.

Greg Lipps

The open canopy conditions of roadsides often lure nesting turtles. Unfortunately, the females, and eventually their offspring (if the nest survives), face considerable risk from vehicular mortality and nest predators. Raccoons, in particular, can exert a heavy toll on nests laid along roadsides because they often forage along habitat edges.

wildlife safely from one side of a roadway to the other. Information on designing wildlife road crossings, including amphibian and reptile tunnels, can be found in the "Handbook for Design and Evaluation of Wildlife Crossing Structures in North America" by A.P. Clevenger and M.P. Huijser. Available online at: http://www.westerntransportationinstitute.org/documents/reports/425259_Final_Report.pdf

- The number and width of roads that amphibians and reptiles must cross in the landscape under management should be minimized.
- Mowing and other treatments along roadsides should be limited. Such practices effectively increase the width of the barrier caused by the road in the first place.
- Consider installation of barriers and safer 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.
- Avoid silt fencing and meshes with sizes and designs which will ensnare snakes.

ROADS, ROADS, AND MORE ROADS

In 2002, the Federal Highway Administration calculated that there were approximately 3.95 million miles of public roads in the conterminous United States and that these roads were used by roughly 228 million vehicles. To understand the magnitude of this number, roads exceed the length of all rivers and streams in the United States! Far from being an "innocuous" feature of the landscape, roads are everywhere, and there is no indication that road construction or the number of vehicles using the road system is on the decline.

Millions of animals die on roads annually, but the impact of roads extends far beyond their immediate boundaries. Studies have found that roads decrease species richness and abundance, alter population demographics, and can also influence species distribution and affect population genetic structure. For more information on roads and wildlife, see the Federal Highway Administration's "Critter Crossings: Linking Habitats and Reducing Roadkill" at ***http://www.fhwa.dot/environment/wildlifecrossings/index.htm***.

Yu Man Lee, MNFI

Yu Man Lee, MNFI

The MDOT fence along US-31 has helped to reduce road mortality of Michigan species of special concern, such as this Eastern Box Turtle

TURTLE FENCE, US-31 MUSKEGON RIVER FLOODPLAIN, MUSKEGON COUNTY, MICHIGAN

U.S. Highway 31 bisects a portion of Muskegon River floodplain habitat that is part of the Muskegon State Game Area, managed by the Michigan Department of Natural Resources (MDNR), in southern Michigan. Each year hundreds of turtles attempt to cross this section of road, trying to reach habitat on the opposite side of the road, but unfortunately many are killed by vehicles. Due to concerns about turtle roadway mortality the Michigan Department of Transportation (MDOT) installed a vinyl clad chain-link fence along the outside shoulders of both travel lanes in an effort to protect migrating turtles, particularly those listed as species of special concern within the state (i.e., Eastern Box Turtle, Blanding's Turtle, and Wood Turtle). The fence has dramatically reduced overall vertebrate mortality along the fenced-in area that spans about a mile of roadway in both directions. In 2009 turtle species of special concern were completely excluded from the roadway. Efforts to facilitate the safe movement of turtles across the highway will continue to be explored in coming years.

-Richard A. Wolinski,
Michigan Department of Transportation

CAUTIONS ON THE USE OF PLASTIC EROSION CONTROL MESH

Plastic erosion control mesh or mats are frequently used for controlling erosion on highway, restoration, and landscaping projects. Because of the size of the openings in the mesh and the strength and durability of the fibers, many animals can become entwined, are unable to escape, and eventually die. This is especially a problem for snakes: mortality after entrapment has been observed for at least 13 different species, including species of conservation concern. Turtles, lizards, frogs, and salamanders have also been ensnared, as have mammals and fish.

More wildlife-friendly erosion control measures are available. Loose-weave mesh which is not fused at the intersections of the weave, such as jute, or coconut (coir) fiber, and wood (excelsior) fiber matting, or other products without welded weaves, are viable alternatives. Non-welded weaves allow animals to push through the weave which expands when spread. Compost, which can be installed without any mesh, is a preferred low cost erosion control alternative. Surface application of compost can effectively reduce sediment loss and result in vigorous growth of vegetation (Storey et al. 1996, EPA 2009, Tyler et al. 2009), and water quality concerns such as leachate from organic composts appear to be manageable except in some environmentally sensitive areas (Kirchhoff et al. 2002, Storey et al. 2006). The EPA's GreenScapes program recommends the use of biobased products that are composed of organic materials, as these products are often less harmful to the environment (EPA 2006).

Agencies, companies, and private parties in the erosion control community and those who design or implement erosion control Best Management Practices (BMPs) are encouraged to use compost-based BMPs in their erosion control plans, or at minimum use alternative loose weave erosion mats or mesh anywhere that animal entrapment may occur. This is especially important near wetlands or other habitats occupied by species of conservation concern.

The Indiana Natural Resources Conservation Service (NRCS) now recommends the use of Erosion Control Blankets (ECB) that either have openings of 2-inch minimum width, or those constructed of a woven (leno weave) netting that allows openings to adjust to wide widths for any NRCS projects in areas where species of conservation concern are found. The use of any other types of ECB must be approved by the Indiana NRCS State Biologist.

-Gary S. Casper, University of Wisconsin-Milwaukee Field Station

EPA. 2006. GreenScapes: What Makes It a GreenScape? July 16, 2006. Published online at: http://www.epa.gov/epaoswer/non hw/green/what. htm#large Accessed Dec 2009.

EPA. Using Compost to Improve Stormwater Management and Erosion Control On Roadsides. http://www.epa.gov/reg5rcra/wptdiv/solidwaste/recycle/compost/roundtable.htm Accessed Dec 2009.

Kirchhoff, C., J.F. Malina, and M.E. Barrett. 2002. A Review and Evaluation of Literature Pertaining to Compost Characteristics and to the Application of Compost Alone and Mixed with Different Soils. Report 4403 1, Center for Transportation Research, University of Texas, Austin, Texas.

Storey, B.J., J.A. McFalls, and S.H. Godfrey. 1996. Shredded Brush on Rights of Way for Erosion

Control: Final Report. Report 1352 2F, Texas Transportation Institute, College Station, Texas.

Storey, B.J., A.B. Raut Desai, M. Li, H.C. Landphair, and T. Kramer. 2006. Water Quality Characteristics and Performance of Compost Filter Berms. Report 4572 1, Texas Transportation Institute, College Station, Texas.

Tyler, R., and N. Goldstein. The Living Systems Approach: Compost Based BMPs to Revitalize Disturbed Soils. http://www.landandwater.com/features/vol52no2/vol52no2_2.html Accessed Dec 2009.

Gary S. Casper

Jerry Roach, USDA NRCS

Plastic mesh used for erosion control can have a considerable negative impact on local wildlife. Snakes in particular, such as the Eastern Gartersnake (top) and Northern Watersnakes (bottom), often become entangled in the mesh and die as a result of their injuries.

Jennifer Anderson-Cruz

Kent Bekker

Installation of road caution signs and speed humps can help reduce mortality rates. Signs can be strategically placed at points of known mortality.

Scott Gibson

Bryan Eads

The steep sides and height of traditional street curbing (at left) can pose a formidable barrier to the movement of herps. Salamanders and turtles in particular may be unable to crawl up and over this curbing, and can become stuck on the side of the road. Gently sloping Cape Cod curbing (at right) is easily navigated by amphibians and reptiles. The use of such curbing instead of more traditional types along known migration routes and movement corridors may reduce the number of amphibians and reptiles that become trapped and killed on roadsides.

EXPLOITATION

Exploitation is the removal of individual amphibians and reptiles from their native habitats for commercial, recreational, or aesthetic benefit to humans. Commercial trade in live amphibians and reptiles and their skins is a multimillion-dollar business. Although most states in the Midwest have laws regulating commercial take of these animals, many are still illegally removed from their natural populations. Laws protecting amphibians and reptiles vary from state to state and enforcement is often lax even where adequate laws exist. Eastern Box Turtles, Wood Turtles, some snakes, and some frogs and salamanders are still being extensively 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 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.

AMPHIBIAN AND REPTILE COLLECTION

Both legal and illegal collection of amphibians and reptiles can have a negative impact on native populations. For some species, such as turtles, even low levels of collection can result in population declines. Many states have passed comprehensive amphibian and reptile laws that restrict the collection and sale of native herpetofauna. However, despite these laws, illegal collection and trade does still occur. Laws and regulations on the collection of amphibians and reptiles differ between states. State specific information on these laws and regulations are usually available through state conservation entities, such as your state's Department of Natural Resources, or equivalent. As a landowner or manager it is important to be familiar with current laws and regulations, particularly as you may be approached by citizens for permission to collect or conduct research on your property. Casual, very small-scale collection by children can have educational value, and use of animals for research can provide important information that may otherwise be lacking. However, in both instances it is important that state laws are abided by, and relevant permits attained, where required. Illegal and commercial collection has proved detrimental to many amphibian and reptile populations, and help from state officials (such as local natural resources police, or game wardens) may be necessary if such activities are identified on your property. The presence of boards or tin placed flat on the ground in forested habitat, or turtle or minnow traps in terrestrial or aquatic areas may indicate illegal collection.

Herps and the laws of the state of Indiana provide an example to consider. Prior to 1995, commercial trade of Indiana's herps was rampant. They were being sold at reptile shows all over the United States and several importer/exporters in Florida were purchasing them as well. A comprehensive amphibian and reptile law was passed in 1995, and since then the commercial trade in amphibians and reptiles has changed immensely. Before the law, over 30 Indiana amphibian and reptile species would commonly be for sale by Indiana amphibian and reptile dealers. It is now very rare to see herps native to Indiana for sale by Indiana dealers.

The current Indiana law allows no native amphibians to be sold except for American Bullfrog *(Lithobates catesbeianus)* tadpoles or Green Frog *(L. clamitans)* tadpoles. They can only be sold by people possessing a fish hauler and supplier permit or an aquaculture permit; and then only if the tadpole was produced as a byproduct of aquaculture. The law also allows the sale of nine captive-bred snakes native to Indiana, by the holder of a reptile captive breeding permit. Those snakes are ratsnakes *(Pantherophis)*, hog-nosed snakes *(Heterodon)*, kingsnakes *(Lampropeltis)* and bullsnakes *(Pituophis)*. Also allowed is the sale of captive-bred albinistic, leucistic or xanthic color forms of snakes native to Indiana.

While the commercial collecting of Indiana's herps is now nearly non-existent, the state is still not devoid of herp violators. Several times a year officers make arrests for illegal sale of native herps, mostly turtles. Judging by arrests the illegal trade in venomous snakes does not seem to have diminished very much since the 1995 law was enacted. However, it is rare that the venomous snake is native to Indiana – instead the majority of them have been non-native rattlesnakes or exotics, including puff adders, rhinoceros vipers and cobras!

-Anthony Wilson, Indiana DNR

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 because of a failure to adequately recruit new adults into the population. Many if not most populations of amphibians and reptiles cannot withstand ongoing harvest the same way that deer or turkey can. Typical game species mature in 1-2 years and reproduce whereas turtles often require as much as 15-20 years to mature and even tiny salamanders such as newts may remain in the juvenile stage for 6-7 years.

Laws

- Laws protecting amphibians and reptiles vary from state to state. Check with your local state and federal wildlife conservation agencies.
- 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 Landowners and Managers Do?

- Investigate the validity of any individuals claiming to have permission to collect – ask to see any permits claimed to be in possession.
- 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.

Allen Salzberg

Large numbers of box turtles, including Ornate Box Turtles shown above, were once collected from the wild and exported as pets. Due to threat of extinction, box turtle trade is now regulated by the United States government.

Jim Harding

Amphibians and reptiles are often killed by humans out of fear, and unfortunately sometimes purely for sport. This Wood Turtle died after being shot several times. Hopefully, public education and regulations should help curb such tragic losses.

FIRE SUPPRESSION AND "PRESCRIBED" BURNING

Fire was a natural part of some Midwestern terrestrial ecosystems long before European settlement and fire suppression policies. Depending on regional drought cycles, lightning-sparked fires would burn for weeks or months. Native Americans set fires to clear undergrowth and stimulate herbaceous growth. As a result, many reptiles and amphibians, their habitats, and their prey are tolerant of or even dependent upon the effects of fire on habitats. In the Midwest, such habitats include prairies and woodlands, and many types of wetlands. Fire suppression in recent times has been implicated as contributing to the declines, rarity, and extirpation of many species, such as the Massasauga and the Ornate Box Turtle. On the other hand, fires, including those that have been purposefully conducted ("prescribed" fire) have also been implicated with causing declines in populations of some species such as Spotted Salamander, Massasauga, and Eastern Box Turtle, especially when fires occur during the species' active season, are very intense, or burn all of the available habitat in a single event.

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 wetland or forest stand structure, remove undesirable or introduced vegetation, inhibit succession, stimulate natural growth of the native understory plants, and to maintain a natural ecosystem.

Greg Lipps

Angela Biggs

Use of prescribed burning as a habitat management tool has increased in popularity across much of the Midwest. Fire can be an invaluable tool for the restoration of many habitat types, including oak savanna (top image) and prairie grasslands (lower image). However, because fire can cause mortality to wildlife, land managers should consult with experts to determine risks associated with burn timing.

Many land managers use 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.

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. Anthropogenic factors may also argue against "natural" fire regimes. Landscapes that were once far more continuous provided refugia even during large scale fires, and included fire breaks such as rivers and wetlands. Today, source populations for recolonization of burned areas may not exist. Burns must thus be planned in the context of the landscape that exists presently, as well as the area's history. Ultimately then, natural fire regimes may not be the best option, especially in small, sensitive, or isolated habitat fragments.

The tradeoffs between gains in natural habitat and mortality from fires are still under investigation. While prescribed fire may lead to increases in suitable habitat and suppression of exotic invasives, it may also be lethal to the animals in the same area. Reptiles and amphibians are vulnerable to fire, as they are relatively non-mobile. Burn plans must thus consider not only safety concerns, community politics, and habitat improvement potential, but also the timing of emergence and activity of herps and other animals on site. Other factors may also come into consideration, such as summer burns to stimulate flowering in some areas.

When possible, burns should be conducted when most species are hibernating, or when they are known to have left an area for that part of the active season. Such planning will require the input of experts to be most accurate, but across the Midwest, burning prior to onset of spring emergences (late March-early April) is a starting point for planning. Different species emerge at different times, however, with some amphibians coming out quite early, and so it is important to know who lives on-site when making a plan. Early burns may also challenge one's ability to meet other management goals from the fire, so some balancing of costs and benefits will need to occur.

What Can Landowners and 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.
- Explore the landscape context of the property as it relates to human concerns, anthropogenic constraints on species movements, and opportunities for recolonization of local populations impacted by fire.
- Work with forest and wildlife biologists and qualified fire ecologists to determine how to minimize mortalities and injuries from fire on local wildlife, including amphibians and reptiles.
- Brush piles become wildlife refuges as they age. During prescribed fire efforts, they should either be burned immediately upon construction, or if they are allowed to age, protected from fire.
- Make note of animals injured or killed by fire, and changes of abundance, positive or negative, and use this information to adjust the timing, frequency and location of future fires.

CAUTION! Excessive or poorly planned fires 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, or help fund it, as through a NRCS or USFWS or other cost-share program (See Appendix C).

USE OF HERBICIDES, INSECTICIDES AND FERTILIZERS

Although prescribed fire and prescribed grazing may be the preferred vegetation management tool where amphibians and reptiles are concerned, burning may not be permitted or even feasible under some circumstances. Use of herbicides may thus be warranted in some cases.

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 shrubby encroachment in fens and other open canopy wetlands. Herbicides can be especially effective for meeting some objectives (e.g., diminishing shrub encroachment) when combined with prescribed fire.

However, misuse of pesticides and fertilizers can be hazardous, and the impacts of some individual and combined pesticides and their residues are not fully understood. The same is true for associated carriers, surfactants and adjuvants. We therefore recommend careful consideration of alternatives to chemical applications. Where their use is deemed to be required:

- 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. If pesticides are going to be used in areas that contain aquatic habitat for amphibians, make sure that you use the appropriate formulation for that habitat. For example, herbicides that are widely used in fields are not approved for use in wetlands or even over open water. However, there are other herbicides that have been approved for use to control wetland plants.
- Stay current on the availability of new products. Improved formulations may be more environmentally compatible, or target specific plants, thus having fewer impacts on non-target species and the environment in general.
- When used improperly, pesticides may be toxic to amphibians and reptiles (aquatic species in particular), and may alter habitats and food supplies in unintended ways. If pesticides are going to be used, try to apply at times of the year

Greg Lipps

Pesticides and other chemical applications should be used cautiously and only according to label directions. Where possible, minimize use near wetlands where amphibians breed.

when amphibians are less likely to be active in your region.

- 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 such 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 herbicides. Seek ways to implement bio-control measures and use non-chemical methods to manage undesirable growth after management activities.
- In summary, be careful with pesticides.

Jim Harding

Lynn Betts, USDA NRCS

Runoff from suburban landscaping and agricultural areas can lead to high nutrient levels in nearby water bodies used by breeding amphibians. Increased nutrient levels can lead to algal blooms (top image) which can negatively affect amphibian egg and tadpole development by altering the amount of dissolved oxygen and carbon dioxide in the water. Buffering aquatic areas with zones of natural vegetation can help to reduce runoff from reaching these areas (lower image).

Mike Redmer

Michael Lannoo

X-rayed frog image from *Malformed Frogs: The Collapse of Aquatic Ecosystems.* (c) 2008 by the Regents of the University of California. Published by the University of California Press.

In the Midwest in the mid-1990s, malformed frogs in Minnesota caught national interest. Causes of such malformations remain disputed among scientists, but parasites, recovery from damage caused by predators, and pesticides have been suggested. Erring on the side of caution, we recommend that pesticide use be avoided in favor of alternative management techniques where possible, and that when pesticides must be used, that products selected are approved for the habitat involved and label instructions are always followed.

USE OF MECHANICAL TECHNIQUES FOR VEGETATION CONTROL

Mechanical techniques such as mowing, disking, and brush-hogging are frequently used as vegetation control tools, often as complements to prescribed fire and herbicides. They must be used with care, however, as there now is abundant evidence that use of heavy machinery for such operations may cause injury or death to amphibians and reptiles.

What Can Landowners and Managers Do?

Mowing

- Mow during the inactive season (generally late fall, winter, and very early spring).
- When mowing during the inactive season will not accomplish the desired vegetative response, mow during the warmest part of the day on sunny hot days (>88º F) and no more than 25% of the contiguous available open-canopy habitat at one time. This may involve spot mowing to cut exotic species seed heads before they mature. Mow rotationally, allowing canopy heights of mowed areas to re-grow before mowing the next 25%, or;
- Mow up to 50% of the contiguous available habitat at any one time during the warmest part of the day on sunny hot days (>88º F) AND keep blade heights at least 8 or more inches off the ground.
- Using mowers (such as the sickle-bar mowers) which do not create suction or otherwise impact the area below the cut zone (as would flail or rotary blade mowers) will minimize mortalities of herps such as box turtles and large snakes.
- Tires may also crush herps during mowing. Certain tractor tire configurations lead to most of the surface being contacted as tractors pass over. Explore how to minimize the area run over.
- Start mowing in the center of a field and use a back-and-forth approach to avoid concentrating animals where they may be killed or stranded.

Catherine A. Saumure

Wood Turtles often venture into open canopy habitats in spring and summer to forage. Unfortunately use of machinery for vegetation control, such as mowing and disking, during this period can result in Wood Turtle injury and mortality. This individual was mutilated by a disc mower, and died shortly after sustaining these, and other internal injuries. Postponing the use of heavy machinery for the removal of undesirable vegetation in open canopy habitats until fall or winter would help reduce Wood Turtle injury and mortality rates.

Brush and Tree Cutting

- When driven machinery is used to cut, move or store cut material, conduct only during late fall and winter. If soils are likely to be rutted by machinery, restrict activities to only when the ground is frozen.

Disking and Plowing

- Tillage operations such as disking are particularly detrimental to amphibians and reptiles and can have negative impacts such as direct mortality and soil compaction at all times of the year. Consider alternative techniques where practical, and when necessary disk while herps are inactive to minimize any direct impacts.

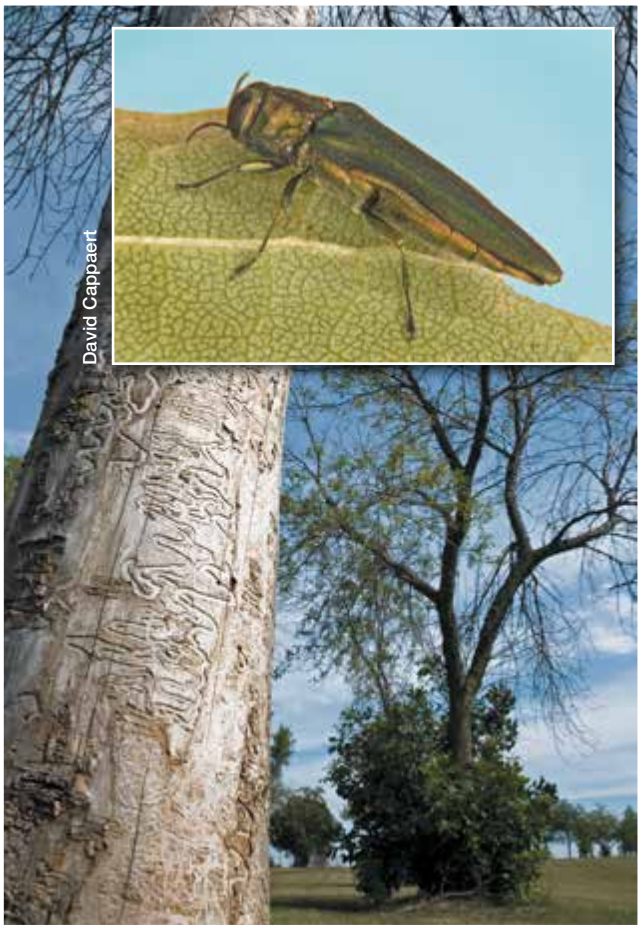
INVASIVE EXOTIC SPECIES

Once exotic (non-native) species become established, they typically have no predators or other organisms that limit their numbers. Consequently, they may reach high densities which may make habitat unsuitable. In the case of exotic animals, they may compete with native herps or their prey for resources, or even prey on the herps themselves. 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.

In the Midwest, the Eurasian subspecies of the Common Reed, *Phragmites australis*, has become invasive, choking wetlands and reducing suitable habitat for reptiles and amphibians. Reed Canary Grass *(Phalaris arundinacea)* has also invaded wetlands across much of the Midwestern United States. Reed Canary Grass is native to North America, but an ecotype has been introduced from Eurasia and the two are extremely difficult to tell apart. Because of its hardiness and aggressive, rapid growth, it poses a considerable threat to wetlands by outcompeting native wetland plants, reducing native plant diversity, and eventually forming dense monocultures. Making matters worse, Reed Canary Grass is extremely difficult to control. The pervasive spread of Garlic Mustard *(Alliaria petiolata)* in forests is dramatically influencing the composition of the herbaceous understory. Beneath the Garlic Mustard, a parallel wave of introduced earthworms spreads as well, denuding the forest of leaf litter, and potentially easing the spread of the Garlic Mustard! The Emerald Ash Borer (a beetle) now threatens all species of ash across the Midwest. An introduced exotic, its expansion is being acceler-

Greg Lipps

Purple loosestrife (foreground) and Phragmites (background) are non-native plants that invade wetlands. These species grow vigorously and if uncontrolled they will eventually take over and choke out native wetland plants. Due to changes in wetland plant structure as a result of the invasion of these non-natives, the wetland habitat may be no longer suitable for many species of wildlife, including amphibians and reptiles.



David Cappaert

David Cappaert

The Emerald Ash Borer is a beetle native to parts of Asia that made its way to the US in packing material made from wood. The larvae are responsible for killing ash trees: they feed on the inner bark (leaving a distinctive squiggle pattern, as shown on the tree in the foreground) and starve the tree by severely limiting the tree's ability to transport moisture and nutrients. Infested trees initially exhibit dieback of branches in the canopy (see tree in background); ragged holes made by woodpecker attacks on larvae are often the clearest symptom. Heavily infested trees will produce a profusion of shoots at the base of the tree (see tree in background), and D-shaped larvae exit holes will appear on the trunk. Management of the Emerald Ash Borer is very difficult and millions of ash tress have been killed. Within the Midwest the Emerald Ash Borer has spread to Illinois, Indiana, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. To help minimize the spread of this species, and other non-native insects that threaten forests, firewood should not be transported. More information on the Emerald Ash Borer can be found at: http://www.emeraldashborer.info/

ated by the movement of firewood and even pallets from area to area.

Invaders do not need to be particularly "exotic." Domestic free-ranging and feral cats, first introduced in the 1600s, kill many thousands if not millions of amphibians and reptiles annually. Feral hogs have degraded or destroyed many coastal and wetland habitats. Even turkeys, improperly introduced, can cause problems.

DON'T TURN IT LOOSE!

For PARC 's policy on the release of captive herps (often from unknown places of origin), including those used as pets and 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 Landowners and Managers Do?

- Use native forage and browse for wildlife food plots.
- Use native plants (grasses, flowers, vines, shrubs, trees, etc.) for commercial and residential landscaping and erosion control.
- Do not release non-native animals into an area, including herps (!) such as the Red-eared Slider *(Trachemys scripta)*.
- Find alternatives to the introduction of non-native wildlife species on game ranches.
- Avoid establishment of plant species beyond their native range, especially those known to be invasive. Learn to identify the most common and aggressive introduced plants in your area.
- Spay or neuter cats and dogs, and consider keeping them indoors or otherwise under control. *Uncontrolled pets kill amphibians, reptiles, songbirds and other wildlife.*
- 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. Funding may also be available from such agencies to help (see Appendix C).
- Do not transport firewood. Using firewood from local sources will help reduce the risk of transporting non-native insects that may threaten the survival of native trees and entire forests.

SUBSIDIZED PREDATORS

"Subsidized" predators include cats, dogs, raccoons, opossums, foxes, crows, ravens, skunks, and now coyotes. Such animals are subsidized by humans, either on purpose, as with house cats, or inadvertently, as by the boon provided crows and ravens at garbage dumps. 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 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. The increase in wild turkey populations is generally viewed as a conservation success story. However, concerns are growing that turkey predation on herps is yet another strain on fragile populations in some areas. Populations of subsidized predators are usually uncontrolled in urban areas and may even flourish in parks. In many parts of the Midwest, furbearing predators such as opossum, raccoon, and fox are at higher numbers due to the decline of trapping in recent decades.

What Can Landowners and Managers Do?

- Reduce the availability of refuges and food sources associated with humans.
- Consider removing subsidized predators 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.

Greg Lipps

This Snapping Turtle nest was destroyed by a raccoon. In some areas of the Midwest raccoons have been documented to destroy up to 100% of all turtle nests. With predation even near such rates, turtle populations decline and disappear because too few juveniles will reach adulthood.

Dan Fogell

Raccoons, along with several other species of wildlife, now associate human development with easily acquired food – essentially they are subsidized by our waste. Within the Midwest, loss of raccoon predators and the decline of the fur trade have resulted in a raccoon population explosion. Raccoons exert an especially high toll on turtle nests.

Jim Harding

Joanna Gibson

Finding turtles with missing limbs is not uncommon in some areas. Subsidized predators such as raccoons are typically to blame. Female turtles often sustain more injuries than males, as raccoons target females during nesting. The top image shows a Wood Turtle with a missing front foot, and the lower, an Eastern Box Turtle with a missing back foot.

CLIMATE CHANGE

Climate change is another emerging conservation challenge for herps. Many areas of the Midwest will experience the global warming most commonly associated with climate change, which in turn will result in shorter, and warmer, winters. Weather patterns are also expected to be more extreme. Ultimately, it remains to be seen how climate change will influence the fate of many species of amphibians and reptiles, but it seems likely that subtle changes in climatic conditions combined with habitat loss and alteration may be enough to push some species to extirpation. Researchers have linked climate change to amphibian declines and disease issues in areas such as Central America, and in some areas of North America, there is evidence that amphibians are breeding earlier because of warmer winter temperatures and earlier spring conditions. We can also expect the ranges of many species to be pushed northward. Such changes may put herps out of sync with prey, or make them more vulnerable to predators or changes in weather. Individuals "following" available habitat north may encounter barriers such as highways.

What Can Landowners and Managers Do?

As a land owner or land manager, responding to climate change may seem above one's pay grade, and in a very real sense it does require a global response. Thus, we do not provide specific recommendations as we can elsewhere in this section of the Guidelines. However, given that climate change will likely impact the availability of limited resources such as moisture, cover, and water, efforts to assure provision of such fundamental needs, including any critical habitats, will help. Providing means for species to "follow" habitat north will also help reduce local extirpations.


Greg Lipps

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, Ranches, Recreation Lands, and other Integrated Land uses
When benefiting amphibians and reptiles is secondary to other management objectives:

- **Fence livestock to control access to 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. Trampling can disturb and compact soil, increasing erosion and sediment. Excessive concentrations of nutrients (as in manure) in aquatic systems may cause unnatural algal blooms, altering dissolved oxygen and CO2 levels, possibly harming aquatic amphibians, reptiles, fish, and invertebrates. Careful control of time and duration of use along with managing livestock numbers is critical to reaching this objective. State conservation practice standards include guidance on "fence" and "Use Exclusion" at: http://www.nrcs.usda.gov/technical/efotg/.*
- **Restore natural fire frequency, intensity, and seasonality to the extent possible. Where possible, favor fire over herbicides as a vegetation management tool, especially in drier upland ecosystems.** *The vegetation in which many reptiles 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. State conservation practice standards include guidance on "Prescribed Burning" at: http://www.nrcs.usda.gov/technical/efotg/.*
- **Plan prescribed fires with herps in mind.** *Burn at times which will minimize direct mortality while deriving long term benefits to the habitat. Know, and then avoid, times and places where herp activity is concentrated.*
- **Where herbicides, pesticides, or fertilizers are used:**
  - *Use the minimum amount required to achieve management objectives.*
  - *Follow label instructions carefully and precisely.*
  - *Use only products approved for the habitats to be treated.*
  - *Make sure that sensitive habitats, especially aquatic systems, are adequately buffered to*

Alisa Gallant, USGS

Jeff Vanuga, USDA NRCS

Unrestricted livestock access to aquatic habitats can result in trampling of shoreline vegetation, erosion and sedimentation, and ultimately poor water quality. Providing alternate water sources away from aquatic habitats and installing fencing to restrict livestock access will help to protect these sensitive habitats and species that rely on them.

minimize impacts of chemicals beyond the targeted area.

- *Give preference to individual stem treatment or spot application. Banded herbicide application, or weed sweeps 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, springs, caves, and rock outcroppings. Leave buffers of appropriate habitat such as forest or grassland around amphibian breeding sites.** *Such habitats are often critical to sensitive species, particularly salamanders. Many species require embedded habitats for part of their life history and seasonal migration patterns. Both the embedded habitat and the surrounding habitat 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 those 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 Streamside Management Zones (SMZs).** *Where appropriate, consider establishing wide SMZs when they are not in place. 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 http://www.forestrybmp.net .*

- **Incorporate missing habitat features back into the landscape.** *Loafing, basking, or escape structures may be absent. Consider strategically placing broken pieces of concrete pipe, plywood, downed trees, or rock, to provide more diverse habitat.*

- **Allow dead trees and other coarse woody materials to decompose naturally. After timber harvests, leave residue such as stumps, blowovers, logs, and dead standing snags.** *Many amphibians and reptiles nest, forage, or seek shelter inside or underneath rotten logs. Standing dead snags, windblown trees, and stump holes are critical refugia for many amphibians and reptiles.*

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

- **Formulate forest regeneration plans before harvesting activities start.** *Diverse vegetation means diverse wildlife. Consult your state forestry agency or a forest ecologist to determine the*

Zack Walker

Mike Graziano

Rock outcrops are often embedded within larger habitats such as forests and grasslands. They provide important microhabitats for many species of amphibians and reptiles, such as Green Salamanders, that inhabit shaded and moist rock outcrops in forested habitats. Because rock outcrops are generally poorly represented in the landscape, Green Salamander populations are highly susceptible to activities that destroy or degrade these areas. Identifying and protecting these sensitive habitats will help to ensure the continued survival of species that depend on them.

Carl R. Brune

Abandoned underground and surface mines are scattered throughout the Appalachians, including southeastern Ohio. Water draining from abandoned mines is very acidic (giving the water a yellow appearance), and as it drains down nearby streambanks and into streams it pollutes and can kill virtually all living organisms. It is important that landowners and land managers identify any abandoned mines on their properties and seek assistance in cleaning up these sites. State DNR officials should be able to help provide information to assist with these efforts.

Kent Bekker

Trash piles that contain chemicals and old appliances can negatively impact surrounding aquatic habitats, and may also contaminate ground water. Illegal dumping of waste should be reported to authorities.

Kenneth Rouston

Timber harvesting equipment can disturb and compact soil, and may negatively affect species of amphibians and reptiles that are closely linked to the forest floor environment. Using heavy machinery in winter, when the ground is frozen will help to minimize soil disturbances.

most appropriate composition of next-generation stands and how to best manage for regeneration.

- **Restore with native plant species from as local a source as possible.** *Promote maintenance of local genetic structure and adaptation.*
- **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 substantive 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.** *The movement of amphibians and reptiles between the habitat fragments may be limited when they are separated from other ones by unfavorable habitat. 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*

Iowa USDA NRCS

Iowa USDA NRCS

The addition of overwintering and basking structures at restoration sites may make these areas more attractive for re-colonization by amphibians and reptiles. The NRCS installed the rock hibernaculum (top) and rock basking structure (above) on land enrolled in the Wetlands Reserve Program (WRP) in Iowa.

Brian MacGowan

Leaving dead trees and timber harvesting residue on site after harvesting operations will provide refuge for amphibians and reptiles.

Greg Lipps

Use of ATVs and other off-road vehicles in sensitive habitats such as rivers, streams, and wetlands can negatively affect wildlife. ATVs destroy streamside vegetation, causing erosion and sedimentation. Use of these recreational vehicles should be restricted from within and around all sensitive habitats.

Brian MacGowan

Brian MacGowan

Consider single-tree harvest or smaller-sized cuts (at left) as opposed to larger clear-cut harvesting (at right). Smaller operations retain cover, thus providing some refuge for herps, especially amphibians in need of moist microhabitats.

Scott Ballard

Scott Ballard

Seasonal road closures will help prevent vehicular fatalities during sensitive times such as salamander breeding and turtle nesting seasons.

shade-dependent species or mature forest obligates are a concern, consider leaving patches of larger trees. These remnants can serve as refugia for forest-dwelling animals, and over time these animals might then 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.

- **Minimize construction of new roads and ATV trails where possible. Gate off 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.*
- **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).*
- **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 aquatic connectivity by assuring that culverts under roads are properly designed.** *Culverts should be as large as possible and*

Bruce Kingsbury

Culverts are more likely to be used if they are large in diameter and short in length, have a substrate that is not raised above the surrounding landscape, and are immediately adjacent to natural habitat and cover on both ends.

David Surovec

Public education programs can help promote the conservation of amphibian and reptiles.

placed such that herps can enter and exit easily. Having natural habitat close to culvert openings will encourage use.

- **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.*
- **Mow in ways which reduce direct mortality.** *Mow roadsides with all tractor tires on the road if possible, with mowing decks at 8" or higher, and during hot times of the day when herps avoid the most exposed habitats. Mow fields from the inside out to avoid trapping herps.*

Jonathan Mays

Installation of road caution signs can help reduce road mortality rates. Signs can be installed only on a seasonal basis (to coincide with amphibian and reptile breeding and nesting seasons), so that motorists do not become conditioned to them.

Elizabeth Rodgers

Plastic erosion control mesh can be deadly for snakes and other species of wildlife. The small size of the openings and sheer strength of the mesh often precludes individuals from escaping once they become ensnared. Replacing plastic mesh with non-welded, loose-weave, expandable mesh, such as jute or coconut fiber matting will help reduce mortality. The openings in these products can expand, thus enabling wildlife to successfully push through openings.

- **When stabilizing soil on construction sites use herp-friendly soil erosion measures.** *Traditional mesh can trap and kill snakes, salamanders and other wildlife. Use natural herp-friendly versions that have larger mesh to reduce risk of trapping. Also make sure silt fence is removed once construction is complete as it can be a physical barrier for wildlife.*

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:

Greg Lipps

Fire can be an important management tool for restoring and maintaining natural habitats, such as this wet prairie in Ohio. At the same time, poorly timed or otherwise improperly implemented fire can be quite detrimental to herps.

- **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 habitat remains and maintain native groundcover vegetation.** *Seek out those areas that have been severely disturbed for required 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. Consult your state forestry agency before implementing any burn.*
- **Plan prescribed fires with herps in mind.** *Burn at times which will minimize direct mortality while deriving long term benefits to the habitat. Know, and then avoid, times and places where herp activity is concentrated.*
- **Direct recreational use (for example, foot traffic, trails, boat landings) away from sensitive habitat features such as hibernacula, wetlands, turtle nesting sites, springs, ravines, and caves.** *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).*
- **Maintain or restore natural hydrological cycles of wetlands by filling old drainage ditches and allowing 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.*

Mike Graziano

Water-filled roadside ditches often attract amphibians and reptiles. This one is full of breeding Wood Frogs. Due to close proximity to the road, if traffic is substantial, amphibian and reptile mortality rates could be considerable around such areas. Installation of drift fencing and passageways under roads may help decrease mortalities.

Greg Lipps

Habitat restoration efforts can achieve amazing results - the seasonal wetland shown above was once an agricultural pig pond. The restoration was undertaken by The Nature Conservancy in Ohio, and the seasonal wetland is now home to Blue-spotted Salamanders (a state endangered species in Ohio), Spring Peepers, Western Chorus Frogs, Northern Leopard Frogs, Gray Treefrogs, and American Toads.

- **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.*
- **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. Many species of amphibians will not even breed in ponds containing fish.*
- **Maintain contiguous corridors (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 species require two or more habitats for their life history and annual activity patterns. Note that some habitat may only be needed for brief periods (seasonal wetlands for breeding) or rare events such as droughts when permanent wetlands provide the only moisture in an area. Nevertheless they are critical. 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. Be sure to use habitat-appropriate formulations.*
- **Remove old cars, tires, electrical appliances, and other items that may leak contaminants into wetlands and streams.** *Chemical contamination from such sources may be harmful to aquatic amphibians and reptiles.*
- **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).*

Stephen J. Mullin

Fish can be removed from wetlands using a chemical called Rotenone. Rotenone is best applied during winter when amphibians are least likely to be present. In this image Illinois DNR personnel and students from Eastern Illinois University assist a private landowner with Rotenone application to remove fish from an amphibian breeding pond.

Greg Lipps

Gently sloping banks and unmanicured shorelines are more beneficial to herps and other wildlife than concrete walls and mowing to the waters edge. Natural vegetation surrounding ponds provides cover, and foraging and basking opportunities. This pond in Ohio supports a large population of Northern Cricket Frogs.

Greg Lipps

Planting native vegetation and adding structural complexity, such as logs, to the shore of this gravel-sided pond would increase its suitability for and attractiveness to amphibians and reptiles.

- **Mow in ways which reduce direct mortality.** *If possible, mow roadsides with all tractor tires on the road, with mowing decks at least 8" or higher if possible, and during hot times of the day when herps avoid the most exposed habitats. Mow fields from the inside out to avoid trapping herps.*
- **Do not mow old fields during the active season.** *Animals will be residing in them. Mowing during the inactive season to shorten vegetation will make areas less attractive later.*
- **In areas where raccoon populations are high, consider humanely reducing populations.** *Raccoons can have a substantial negative impact on turtle populations by destroying nests, predating juvenile turtles, and injuring and killing adults.*

Indiana TNC

Lynn Betts, USDA NRCS

Targeted use of herbicide treatments not only reduces the overall amount of chemicals used, but can accomplish many of the management objectives achieved with broadcast treatments, and may reduce the potential for any unintended consequences to amphibians and reptiles.

Clark McCreedy

Clark McCreedy

Decommissioned roads can make excellent wetland creation sites. Land managers permanently closed this rutted road on the Hoosier National Forest in southern Indiana (top image) to vehicular traffic and began habitat restoration efforts by creating vernal pools within the roadbed. The lower image was taken only four months post-construction (notice that the sediment in the pool has not yet settled). Wetland plants are growing around the edge of the vernal pool. Interestingly these were not planted, but sprouted from seeds in the seedbank.

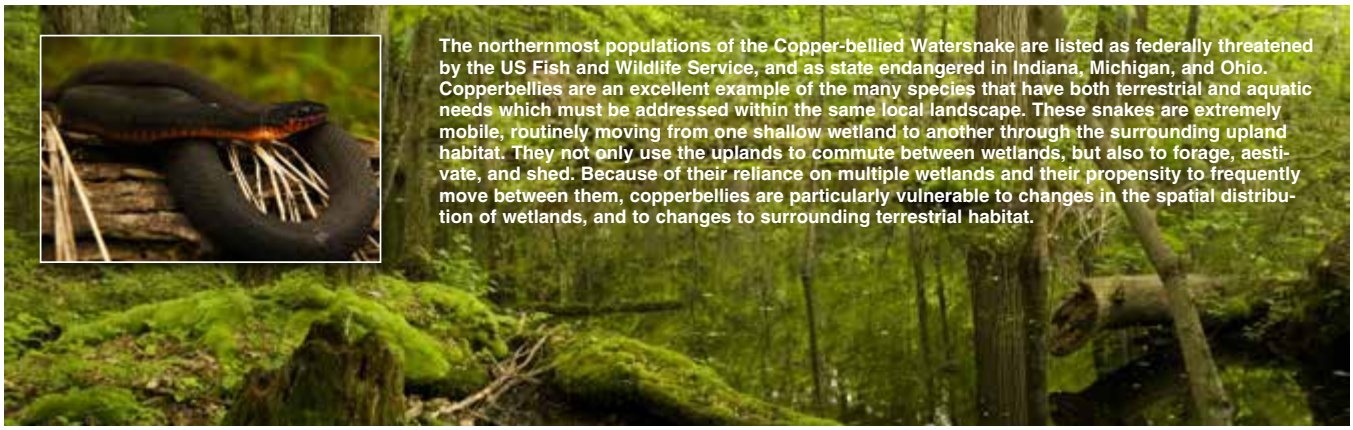
Mike Graziano

MANAGEMENT GUIDELINES FOR SPECIFIC HABITAT TYPES

The following 13 habitat modules contain management recommendations pertinent to their respective habitat. Each of the habitat sections contains two sets of guidelines: *Maximizing Compatibility* and *Ideal*.

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

"Ideal" guidelines are for landowners and land or resource managers who want to make amphibian and reptile conservation a primary objective, such as on nature preserves, wildlife refuges, and private or agency lands where optimizing the diversity and abundance of herpetofauna is desired.



Scott Gibson (habitat), Omar Attum (snake)

The northernmost populations of the Copper-bellied Watersnake are listed as federally threatened by the US Fish and Wildlife Service, and as state endangered in Indiana, Michigan, and Ohio. Copperbellies are an excellent example of the many species that have both terrestrial and aquatic needs which must be addressed within the same local landscape. These snakes are extremely mobile, routinely moving from one shallow wetland to another through the surrounding upland habitat. They not only use the uplands to commute between wetlands, but also to forage, aestivate, and shed. Because of their reliance on multiple wetlands and their propensity to frequently move between them, copperbellies are particularly vulnerable to changes in the spatial distribution of wetlands, and to changes to surrounding terrestrial habitat.

EMBEDDED HABITATS

When considering habitat management options for herpetofauna, keep in mind that some requisite habitat patches are small and isolated from similar habitat, leaving them "embedded" in a matrix of more common habitat. Herps in a particular area may rely on embedded habitats to meet certain needs such as ponds for breeding. If those habitats are not available and accessible, then the dependent species won't be there either. Land use planning should thus consider not only the obvious habitats like forest comprising the matrix, but also the less obvious embedded habitats like seasonal wetlands and seeps. Herp biodiversity will depend on proper management of all habitat types involved.


Scott Gibson

SEASONAL (EPHEMERAL) WETLANDS

Seasonal wetlands, also known as ephemeral wetlands, are one of the most important and threatened habitats for amphibians and reptiles of the Midwest. Seasonal wetlands are often quite small and include vernal pools, floodplain pools, prairie potholes (see the Grasslands and Savanna module), limestone sinks, ditches, and other shallow depressions that fill, and then dry, typically on a seasonal basis. Though these systems may have temporary aquatic connections with other wetlands as a result of occasional flooding, they are often isolated from other bodies of water by terrestrial habitats. They are thus an example of an embedded habitat within a larger matrix. Seasonal wetlands once interspersed much of the Midwestern landscape, but due to extensive ditching, draining, and tiling for agriculture and development, widespread degradation or outright loss of much of these aquatic habitats has taken place. Not surprisingly, animal and plant species associated with these wetlands have also declined in the region.

Midwest seasonal wetlands are typically filled by spring rains and snowmelt, only to nearly or completely dry by late summer or fall. These natural flood-dry cycles have a profound influence on habitat conditions within the wetland. Shoreline slopes are frequently very gradual (10-20:1 - less than 5 degrees), such that extensive shallow areas are pervasive and retained even as wetland water levels change. Fish are usually absent or they occur in very low numbers. Fish are extremely efficient predators on the early life stages (egg, larvae, and juvenile) of amphibians, and thus seasonal wetlands provide a critical fish-free breeding habitat during the life cycle of many amphibians and reptiles. Herps aside, seasonal wetlands also have an entirely different community structure compared to permanent wetlands. For example, they support a variety of aquatic invertebrate species, such as fairy shrimp, and the juvenile aquatic stages of dragonflies and damselflies. Reptiles and amphibians in seasonal wetlands also use the surrounding upland (terrestrial) habitat. In fact, many salamanders and frogs remain in terrestrial burrows and vegetation for most of the year where they forage and hibernate. They often do so several hundred feet from the nearest wetland. Furthermore, some may not return to the wetland for several years until they have grown to maturity (e.g., Spotted, Eastern Tiger, and Marbled Salamanders). Natural and unfragmented upland habitats (e.g., forests and grasslands) are typically required for amphibians and reptiles to safely travel to and from seasonal wetlands. Because of these important associations with terrestrial habitats, we consider nearby upland areas as part of the “core” habitats when making management suggestions.

Many species of reptiles and amphibians are highly dependent on seasonal wetlands and will not occur in areas where such habitats are not available. Eastern Tiger Salamanders, Blue-spotted Salamanders, and Wood Frogs are some amphibian species that rely on seasonal wetlands for breeding sites. Many turtles and snakes, such as the Copper-bellied Watersnake and the Blanding’s Turtle, either inhabit seasonal wetlands or will regularly move into them to forage or seek refuge.

John Roe

Scott Gibson

North Dakota Fish and Game

Seasonal wetlands are embedded within larger habitats such as forests and grasslands. They provide important habitat for many amphibian and reptile species, and their absence in the landscape can limit the distribution of some species of amphibians. For example, Eastern Tiger Salamanders, Blue-spotted Salamanders, and Wood Frogs rely on seasonal wetlands for breeding sites, and will disappear from areas where these wetlands have been lost.

CHARACTERISTIC SPECIES

Four-toed Salamander, Blue-spotted Salamander, Jefferson Salamander, Marbled Salamander, Small-mouthed Salamander, Spotted Salamander, Eastern Tiger Salamander, American Toad, Fowler's Toad, Great Plains Toad, Woodhouse's Toad, Eastern Spadefoot, Northern and Southern Leopard Frogs, Wood Frog, Gray Treefrog, Cope's Gray Treefrog, chorus frogs, Spring Peeper, Spotted Turtle, Blanding's Turtle, Yellow Mud Turtle, Plain-bellied Watersnake, Northern Watersnake, Eastern and Western Ribbonsnakes.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Ranches, Recreation Lands, and other Integrated Land uses

When benefiting amphibians and reptiles is secondary to other management objectives:

- **Develop an awareness of existing seasonal wetlands and the surrounding landscape.** *Identify areas where water pools in the winter and spring. Seasonal wetlands can be difficult to identify when dry, but knowledge of where these habitats are is the first step towards their management.*
- **Consider restoring or creating 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 or restoration sites. These wetlands can also improve habitat for waterfowl and other game species. Promote extensive shallow shorelines and gently sloping banks.*

Scott Gibson

Many different species of snakes, such as this Northern Watersnake, exploit the abundance of food available in seasonal wetlands. This individual arrived in early spring when hundreds of Wood Frogs had gathered to breed.

- **Limit cases of wetland deepening and stabilization.** *Consider letting seasonal wetlands stay seasonal. Transforming seasonal wetlands into farm ponds will eliminate species that require seasonal wetlands. Create deeper farm ponds elsewhere while retaining natural seasonal wetlands.*
- **Avoid ditching and draining seasonal wetlands.** *Seek alternatives to wetland removal.*

- **Enroll low-production wet fields into the USDA Wetlands Reserve Program (WRP).** *The WRP program can have significant financial benefits for the land owner. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **Avoid stocking seasonal wetlands with fish.** *Larger open water wetlands may hold water for several years between drying cycles and are tempting targets for stocking of game fish (e.g., bass, bluegill, and catfish). The presence of fish reduces or eliminates reproductive success for many amphibians.*
- **Maintain native forest or grassland cover surrounding wetlands to provide cool and moist terrestrial habitats.** *Maintaining natural forest or grassland cover around seasonal wetlands provides shoreline structure for breeding, foraging, and refuge, and facilitates movement into and out of the wetland. Amphibians need to be constantly moist. Native vegetation cover in these areas will minimize mortality due to desiccation, and provide the requisite microhabitats (e.g., stump holes, logs, leaf litter) for invertebrate prey resources and refuge sites during hibernation.*
- **Establish core terrestrial and buffer zones of native vegetation in areas around the wetland.** *Amphibians and reptiles use the core terrestrial zone extensively, thus the real buffer is located*

Scott Gibson

The woody materials found in seasonal wetlands provide an important structural base to which many species of amphibians attach their eggs. Once the wetland dries these structures also provide a moist microclimate that serves as amphibian retreat sites for the remainder of the year.

Zack Walker

Jefferson Salamanders can breed as early as December in some areas, when snow still covers the ground. Females lay eggs one to two days after mating, attaching the masses to branches or other structures in the wetland. Outside of the breeding season, adults are rarely encountered because they spend much of the year underground in adjacent forest. Roads placed between breeding sites and terrestrial habitat used throughout the remainder of the year pose a significant risk to Jefferson Salamanders through direct mortality, and from runoff of pollutants into breeding ponds. The eggs are very sensitive to changes in pH, and an increase in acidity can prove lethal to both eggs and larvae.

North Dakota Fish and Game

Prairie potholes are depressional wetlands found in North and South Dakota, Wisconsin, Iowa, and Minnesota. A remnant of glaciation, prairie potholes may hold water year-round, while others are only temporary in nature. They provide important habitat for many species of amphibians and reptiles found in grassland and prairie habitats. Unfortunately prairie potholes are critically threatened by draining and development from agriculture, and more than half of all prairie potholes have been drained or altered (US EPA).

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, 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.*
- **Consider the timing of current and planned land-use practices to minimize conflicts with animals when they are active.** *Land-use activities such as tilling, mowing, and timber harvest conducted during adult and juvenile migrations could result in high mortality rates.*
- **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 number and extent of disturbed areas will reduce the number of negative impacts in the area.*
- **When possible, closely control grazing and watering livestock in and near seasonal wetlands.** *Livestock can trample eggs, and waste products will cause eutrophication, oxygen depletion, and amphibian larval death. Consider fencing livestock out of at least some wetlands or locate watering facilities away from wetlands.*
- **Limit ATV and other recreational impacts on unpaved roads containing pools during amphibian breeding and larval development seasons.** *ATVs and other vehicles degrade water quality and displace eggs and larvae from the pool onto shore where they dry out.*
- **If application of pesticides, herbicides, and fertilizers in or near seasonal wetlands is necessary, carefully follow all label directions.** *Apply to the minimum area needing treatment, and make sure there is an adequate buffer around wetlands. Do not rinse canisters or equipment in wetlands.*

Zack Walker

Access to suitable breeding sites limits the distribution of Eastern Tiger Salamanders. In grassland and prairie habitats Eastern Tiger Salamanders are closely associated with fish-free seasonal wetlands, such as prairie potholes. Outside of the breeding season Eastern Tiger Salamanders are rarely encountered as they spend considerable time underground, and may occupy burrows that they dig themselves. Eastern Tiger Salamander populations have been negatively affected by the loss of prairie pothole wetlands.

Lynn Kulver, USDA NRCS

Lynn Kulver, USDA NRCS

Lynn Kulver, USDA NRCS

These photos follow a prairie pothole wetland restoration on privately owned property enrolled in the USDA NRCS Wetland Reserve Program. The top left aerial photograph was taken prior to restoration efforts while the property was still being cropped. The top right image was taken after tile breakage, ground shaping (including the excavation of shallow water areas and construction of dikes for water retention), and seeding with native grasses and forbs. The lower left photo was taken just one year later. Such restorations provide important breeding habitat for amphibians.

Zack Walker

The presence of spermatophores (the small white blobs shown in the center of this picture) in seasonal wetlands heralds salamander mating activities. Males attach spermatophores, or sperm packets, to leaves or other debris in the wetland and perform a courtship display to try and entice a female to pick up and place one of his sperm packets in her cloaca. The eggs are fertilized internally soon after a sperm packet is picked up.

Scott Gibson

Wood Frogs rely on fish-free seasonal wetlands for breeding and are absent from areas where seasonal wetlands are unavailable, or have been lost. After mating and laying eggs, they return to the surrounding forest where they spend the remainder of the year. This picture shows a pair of Wood Frogs in amplexus – the male embraces the female and sheds sperm over the eggs as they are laid.

Nathan Engbrecht

Female Marbled Salamanders select nesting sites in dried seasonal wetlands, or other temporarily inundated areas. Here they often lay their eggs in cavities they dig themselves under leaf litter or other debris. Females may remain with their eggs until the nest site fills with water before returning to surrounding forest where they spend much of the year underground. Protecting areas of bottomland forest and the seasonal wetlands they contain will help protect this species.

Zack Walker

Once hydrated, the gelatinous egg masses of Spotted Salamanders are quite large. Spotted Salamanders migrate to fish-free seasonal wetlands and lay eggs in late winter/early spring. Eggs typically hatch in late spring/early summer after 1-2 months, and the larvae spend a further 2-4 months in the seasonal wetland before metamorphosing and migrating into the surrounding forest.

- **Locate high-intensity roads, trails, landings, and recreational facilities away from seasonal wetlands and transitional zones into upland habitats.** *In particular, 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, salts, and other pollutants, as well as sediments that can fill seasonal wetlands, decreasing the quality of these important amphibian and reptile habitats.*

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 natural wetland hydrology (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.*
- **Restore all wetlands in the area.** *Most areas have had some or all wetlands removed. Restore them via plugging ditches, tearing out tile, and removing fill, without breaking the underlying layer impermeable to water.*
- **Consider the historical landscape that the embedded seasonal wetland once existed in.** *Use old aerial photographs where possible. Restoring the surrounding habitat to its historical conditions is likely the best choice ecologically for the species that rely on the seasonal wetland.*

- **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.*
- **Maintain natural forested or grassland conditions around portions of seasonal wetlands.** *Many adult amphibians spend the non-breeding season in the surrounding upland habitat, up to 450 feet from the wetland. This is core terrestrial habitat complementary to the wetland, and is necessary for population survival outside the breeding season. Native vegetation also provides organic inputs that fuel aquatic productivity.*
- **Maintain ground cover such as coarse woody materials (logs, etc.) and herbaceous vegetation both on the shoreline and in the terrestrial life zone.** *Amphibians and reptiles require terrestrial cover to avoid exposure to predation and desiccation. Natural ground cover also provides microhabitats critical for the invertebrate prey of adult amphibians.*
- **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.*
- **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.*

IMPORTANCE OF ADJACENT UPLANDS TO WETLAND BIODIVERSITY

A seasonal wetland without appropriate surrounding upland habitat will lose much of its unique amphibian and reptile fauna. Many salamanders and frogs live most of the year hundreds of feet away from the wetlands in which they breed. Species such as Copper-bellied Watersnakes may spend a third of their time away from water, and routinely traverse hundreds of meters to get from one wetland to another. Aquatic turtles, such as Blanding's Turtles, may also travel extensively on land to find appropriate habitat to lay their eggs. Consequently, there is actually a core terrestrial habitat zone for numerous wetland amphibians and reptiles. Any protective "buffer" area around wetlands should thus protect both the core terrestrial habitat and the wetland. Protecting wetland complexes (areas with a variety of wetland types imbedded in suitable upland habitat) is most effective for promoting herpetofaunal population persistence and diversity.

John Roe

Copper-bellied Watersnakes use multiple shallow wetlands and move between them frequently, foraging on the seasonal abundance of amphibians (especially frogs and their tadpoles). Upland habitats that surround these wetlands provide safe travel corridors and suitable overwintering locations.

Brian MacGowan

Blanding's Turtles are one of the more mobile of all North American turtles, making extensive overland movements between multiple wetlands throughout the course of a season to fulfill basic needs such as basking, feeding, aestivation, breeding, and overwintering. Because of their reliance on multiple wetlands that are often spread at some distance apart, their frequent movements between them, and their high degree of site fidelity, changes to the spatial distribution of wetlands and the surrounding upland habitat that provides safe travel corridors may threaten existing populations.

- **Do not stock fish.** *Native and exotic fish of all kinds eat eggs, larvae, tadpoles, and small frogs. Many amphibian species cannot breed successfully in pools containing fish.*
- **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.*
- **Control subsidized predators, especially around turtle nesting areas.** *Predators such as raccoons may reach unnaturally high densities due to resources provided by humans and their developments. Discourage the direct and indirect feeding of subsidized wildlife, and consider removing subsidized predators by humane means.*
- **Facilitate 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.*
- **Construct and maintain tunnels under roads to allow dispersal and reduce mortality.** *Installation of tunnels (ecopassages) with accompanying barriers (where possible) to keep migrants off roads and guide them to the passage has been successful in some places to reduce or prevent highway mortality near breeding sites. Passages should be as large as possible.*
- **Avoid placement of improved or permanent roads within the core 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.*
- **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.*
- **Exclude all vehicle traffic, including ATVs, from wetlands.** *Any vehicular activity will reduce water quality, alter wetland substrates and kill amphibians and reptiles directly. Vehicles may release petroleum products, causing pollution.*
- **Consider a range of management options before using pesticides or other chemical applications in or near seasonal wetlands.** *If they are required, carefully follow label directions and make sure there is an adequate buffer around wetlands. Do not rinse canisters or equipment in wetlands.*
- **Consider constructing artificial wetlands with seasonal wet-dry cycles and gently sloping shorelines where sufficient natural wetlands cannot be restored.** *Guidelines are available to direct proper construction of artificial pools for amphibian breeding. Such wetlands, if properly constructed, 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, encourage plant diversity, and enhance the overall productivity of the wetland.*

Clark McCreedy

Clark McCreedy

Road ruts and pools along infrequently used dirt roads can provide suitable breeding habitat for amphibians. However, off road vehicles can seriously degrade such sites. Land managers at the Hoosier National Forest acquired this previously logged area in southern Indiana, restricted vehicular access, and began restoration by constructing vernal pools in a severely entrenched skid road. Construction involved shaping pools with a narrow blade, low ground-pressure dozer, soil stabilization with the use of an annual such as wheat, over-seeding with natives, and mulching with weed-free straw. Construction of 20 pools in the abandoned roadbed was completed within three days. Both images were taken from the same perspective, with the picture at right taken 14 months post-construction of the vernal pool.

USGS

USGS

Because they detail the spatial arrangement of habitats within the landscape, aerial photographs are excellent tools to assist with habitat restoration efforts. Landowners and land managers can use aerial photographs to help target restoration efforts in areas where amphibians and reptiles, as well as other wildlife, will derive the most benefit. For example, amphibians and reptiles would benefit from establishing corridors and buffers of natural habitat to and around isolated wetlands from nearby forest patches (as shown in black outlines in the lower image).

MAKING AN EPHEMERAL WETLAND: BUILDING IT SO THEY WILL COME

Shallow, seasonal wetlands created in areas where such habitats have been lost or degraded can benefit local amphibian and reptile populations. An excellent resource for land managers or owners considering wetland restoration or creation is Tom Biebighauser's "A Guide to Creating Vernal Pools" (see Appendix D for details). The panel of images shown here (from left to right, top to bottom) follows the creation of a shallow, seasonal wetland. The captions that accompany each image detail the steps used in wetland construction using a bulldozer. The last three images in the panel show wetlands that have been built using these techniques.

Tom Biebighauser

A dozer, previously cleaned of soil to prevent cross-contamination, is used to clear an area at least 60-feet across on a site with less than 6-percent slope containing soils that are high in clay. All trees and shrubs removed are saved for placing back in the completed wetland. Topsoil is removed and placed in piles around the edge of the clearing for later placement in the wetland.

Tom Biebighauser

A core trench is dug approximately 20-feet in from the lower edge of the clearing. The trench cuts through tree roots, layers of gravel, and loose rock. The trench extends around the lower 2/3 of the clearing. The core trench is based on soils that are high in clay, or on bedrock.

Tom Biebighauser

The core trench is filled with clay, and each layer of clay is compacted.

Tom Biebighauser

A low dam with slopes <5% is shaped over the core. Topsoil is then roughly spread in and around the new wetland.

Tom Biebighauser

Trees and shrubs are scattered in and around the wetland. Soils are seeded to wheat and mulched with leaves or straw. Aquatic plants may be planted when the wetland fills.

Lynda Mills

An example of a wetland built using the outlined techniques. This wetland was built in the fall of 2009 on the Mark Twain National Forest in Missouri for only $800.00.

Tom Biebighauser

Another example of a wetland built using these techniques. This wetland was constructed in 2001.

Tom Biebighauser

The same wetland in the fall.

WEST NILE VIRUS

Health concerns regarding West Nile Virus (WNV) have 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. However, not all mosquitoes transmit WNV, not all mosquitoes feed on humans, and not all mosquitoes pervade the same habitat.

Culex pipiens, the northern house mosquito, is a common household mosquito and the primary vector of WNV. Species of Culex will deposit eggs in a variety of water-holding containers such as old tires, birdbaths, buckets, and wading pools. The larvae thrive in pooled water in areas not normally wet, and thus which do not support their predators.

On the other hand, species of Aedes do not carry WNV. They are typically produced in floodwaters and seasonal wetlands in the spring and early summer. Healthy wetlands have balanced predator-prey relationships that provide natural mosquito control which actually reduce the number of mosquitoes reaching maturity.

Mosquitoes are a vital part of wetland food chains, Salamander larvae are major predators of mosquito larvae. Many species of bats target wetlands to forage over them. 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.

- Mark Bailey and Jeff Holmes

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.orgNewsAlerts/westnilevirus.html.***

Zack Walker

Seasonal wetlands provide important foraging and overwintering sites for Spotted Turtles. Individuals typically display high site fidelity, returning to the same wetlands on an annual basis, and often overwintering within the same wetland year after year. Loss of habitat has contributed to Spotted Turtle population declines in the Midwest, where they are listed as either Threatened or Endangered in all the states where they occur.

Jim Harding

This vernal pool in Michigan's Upper Peninsula provides important breeding habitat for several species of frogs and salamanders.

This is the Seasonal Wetlands module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Scott Gibson

PERMANENT WETLANDS: LAKES, PONDS AND MARSHES

The aquatic systems addressed here are characterized by the presence of water during the entire year, although water levels may fluctuate with local rainfall. In extreme drought, some "permanent" wetlands may dry down completely, but water levels usually return to normal within a year. The presence of permanent water allows the establishment of some types of aquatic vegetation not usually found in temporary wetlands. It also means that fish are often a part of the fauna. Permanent wetlands are known by a variety of names; in the Midwest these include marsh, swamp, lake, and pond. While man-made ponds and reservoirs are common throughout the Midwest, naturally occurring permanent wetlands are more abundant in northerly, glaciated portions of the region. Modified wetlands can be a result of human or beaver activities and changes in water levels and their patterns of fluctuation may greatly influence the character of the habitat and its assemblage of amphibians and reptiles.

Although the presence of fish prevents many amphibians from breeding and establishing populations in permanent systems, other species thrive in such systems. Large salamanders such as Mudpuppies and Sirens may occur, as well as a variety of turtles not associated with seasonal wetlands. Furthermore, the shorelines of even large, open water bodies have many of the characteristics of, and thus the residents found in, seasonal wetlands. Consequently, extensive, shallow littoral zones and gradually sloping banks are important features for permanent wetlands where herps are concerned.

Like seasonal wetlands, permanent wetlands in the Midwest suffer a variety of insults. Active management of these wetlands may be necessary in some cases to ensure that they continue to support amphibian and reptile populations. Dams may stabilize water levels. Storm walls, beaches and rip-rap may make the shoreline quite unlike the natural boundary that once existed. Water quality may be impacted by runoff, especially de-icing chemicals in urban and suburban settings and siltation, and pesticides and herbicides in agricultural areas. Invasive plant species such as purple loose-strife, reed canary grass, and phragmites are common in permanent wetlands in the Midwest.

Chris Phillips

Jim Harding

Permanent wetlands include any large bodies of water that hold water year-round and typically do not dry out. The physical properties of permanent wetlands, such as the water depth profile, can greatly influence the species of amphibians and reptiles found in them.

CHARACTERISTIC SPECIES:
American Bullfrog, Green Frog, Northern Leopard Frog, Northern Cricket Frog, Mink Frog, American Toad, Mudpuppy, Blanding's Turtle, Snapping Turtle, Painted Turtle, Spiny Softshell, Eastern Musk Turtle, Pond Slider, Northern Watersnake, Graham's Crayfish Snake.

Nathan Engbrecht

Painted Turtles are a relatively common resident of permanent bodies of water throughout the Midwest. Emergent logs are prime real estate for this species, and it is not uncommon to see multiple individuals piled up basking together. Landowners and land managers may benefit Painted Turtles and other species of turtle, by adding basking structures (e.g., logs, rocks) to permanent wetlands that lack these structures.

Alan Resetar

Beaver activity often results in changed water levels and in some cases the creation of larger, permanent bodies of water. Beavers create new habitats for many amphibian and reptile species to exploit.

THE GREAT LAKES – GRAND DADDY AQUATIC COMPLEX

The Great Lakes are arguably the most prominent landscape feature of the Midwest. While the deep, open waters of the lakes are of limited utility to herps, an astounding array of habitats are available along Great Lake shorelines, islands, inlets, and in the shallower parts of the lakes themselves. Indeed, in one way or another, such areas host a large proportion of herp species found in the region. Given the connectivity of the lakes, associated aquatic linkages, and the continuous shoreline, the Great Lakes no doubt served as a major avenue for the historical colonization of the region by herps. Similarly, in the present the same connectivity facilitates the expansion of invasive plants and animals that may threaten native wildlife.

Bruce Kingsbury

Scott Gibson

MANAGEMENT GUIDELINES

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

- **When possible, do not lower water leves during winter when hibernating amphibians and reptiles would become exposed to freezing tempatures.** *Match timing of managament activities to the biological needs of the animals.*
- **Maintain connectivity among wetlands whenever possible - 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.*
- **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 alter the habitat for many amphibians and reptiles, and thus change the species community composition.*
- **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.*

Carol Hall

Many species of aquatic turtles overwinter underwater in the bottom of permanent wetlands. While surface water freezes solid in more northerly latitudes, deeper water remains unfrozen, providing a safe winter refugia for overwintering turtles. Winter drawdowns of permanent wetlands can have catastrophic consequences for hibernating reptiles and amphibians.

- **Encourage conservation tillage and establish native forest or grassland 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.*
- **If application of pesticides, herbicides, and fertilizers in or near permanent wetlands is necessary, carefully follow all label directions.** *Apply to the minimum area needing treatment, and make sure there is an adequate buffer around wetlands. Do not rinse canisters or equipment in wetlands.*
- **When possible, closely control grazing and watering livestock in and near permanent wetlands.** *Livestock can trample eggs, and waste products will cause eutrophication, oxygen depletion, and amphibian larval death. Consider fencing livestock out of at least some wetlands.*

Zack Walker

Greg Lipps

Northern Cricket Frogs are small frogs that can be abundant around the grassy margins of permanent wetlands, such as this gently sloping lake in Ohio. Unfortunately this species is rapidly declining across many northern locations of the Midwest. The reason(s) for these declines is currently unknown, however habitat alteration, water pollution, and pesticide contamination are thought to be linked to declines.

- **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 or native grassland cover where feasible for adjacent terrestrial habitat.** *Amphibians and reptiles use adjacent terrestrial lands around permanent wetlands extensively. Turtles nest in open, sparsely vegetated areas near wetlands. Canopy cover density can be variable but some cover will ensure that these animals will be able to use both aquatic and terrestrial habitats.*
- **Follow or enhance existing Best Management Practices to control sediment and erosion associated with construction.** *Use native wood chips and hay bales to slow or prevent intrusion into wetlands. Silt in the water column makes the wetland unsuitable for certain sensitive species of amphibian larvae.*
- **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, in this case the healthy 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.*

Jim Harding

Within the Midwest Mink Frogs are found in only the Upper Peninsula of Michigan, northern Wisconsin, and northern Minnesota. They prefer lake and pond edges, especially where there is ample floating and emergent vegetation, such as water lilies. Mink Frogs rarely stray far from water, and they hibernate underwater buried in the mud. Land managers can benefit this species by restoring and protecting shoreline and emergent vegetation around ponds and lakes. The common name of the Mink Frog is derived from the musky, rotting onion odor they emit when handled.

Stephen J. Mullin

This fish-free permanent wetland in central Illinois supports a variety of amphibian species. Researchers have documented ten different species breeding in this wetland.

- **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, marshes, or other seasonal systems.** *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 with permanent stable water levels must be created, seek places to create it rather than modify other wetlands.*

- **Discourage the release of native or exotic pets.** *Native and exotic pets can introduce disease into healthy populations of amphibians and reptiles.*
- **Rock filled crib docks are always preferred over sheet steel covered docks.** *Such structures provide superior habitat for semi-aquatic snake species.*

PROHIBIT UNAUTHORIZED INTRODUCTIONS

Releasing plants and animals into wetlands where they do not naturally occur disrupts the balance of an aquatic system. Introduced non-native game fish and aquarium pets can prey upon and compete with native amphibians and reptiles, and non-native plants can outcompete and overcrowd native vegetation. Released pets can also serve as vectors of disease into a healthy aquatic community. Education materials in the form of posters, sign postings, and brochures that outline these threats may discourage unauthorized introductions and increase awareness of environmental stewardship in visitors to the property.

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 or fill.** *Unnatural fill, intrusion, drainage, damming, or excavation of the wetland basin will change the hydrological regimes or cycles. Amphibians and reptiles in the Midwest are adapted to natural hydrological cycles, and any alteration is likely to reduce survivorship, cause population decline, and otherwise disrupt the natural community.*

Jim Harding

American Bullfrogs are the largest species of frog in North America. They are formidable predators and are known to eat almost any animal they can fit into their mouth. Bullfrogs are habitat generalists and thrive in many types of permanent wetlands.

Nathan Engbrecht

Green Frogs are one of the more common species of frogs found in both permanent and seasonal wetlands in the Midwest. Males have a very distinct courtship call which sounds like the plucking of a loose banjo string. Green Frog tadpoles can have a very long aquatic stage, in some cases overwintering in the wetland and not transforming until the following summer.

Nathan Engbrecht

The Eastern Musk Turtle is a highly aquatic species often observed walking along the bottom of wetlands. Growing to less than 5.5" in total length these small turtles have the ability to secrete a musky smelling substance when threatened that has earned them the alternate common name of "Stinkpot."

- **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.*
- **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.*
- **Consider a range of management options before using pesticides or other chemical applications in or near permanent wetlands.** *If they are required, carefully follow label directions and make sure there is an adequate buffer around wetlands. Do not rinse canisters or equipment in wetlands.*

- **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. In some cases native vegetation may need to be replanted in and around the wetland.*
- **Maintain natural habitat structures such as snags, basking logs, rocks, and overhanging vegetation.** *Management of permanent wetlands with these structures enhances habitat for amphibians and reptiles by providing places to bask and take refuge.*

Greg Lipps

The woody materials in this beaver-created wetland in Ohio provide numerous basking opportunities for aquatic turtles and watersnakes.

- **If possible, avoid using heavy machinery within wetland boundaries or in sensitive riparian areas.** *They can crush amphibians and reptiles present, and their weight and scouring of the land surface alters wetland habitats and invites invasive plants to establish a foothold. If use of such equipment is necessary, follow all applicable Best Management Practices.*
- **Provide natural buffer zones around or adjacent to the 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, and terrestrial vegetation provides organic inputs that drive aquatic productivity and stabilize shorelines.*
- **Maintain or add natural ground cover (e.g., coarse woody materials, herbaceous vegetation) in core habitats, buffer zones, and wetland edges.** *These structures of various sizes are used for hiding from predators and avoiding desiccation. Minimize mowing of these areas.*
- **Minimize barriers (ditches, curbs, retaining walls, fencing) 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 Midwest require open and sunny terrestrial habitats to nest so that nest temperature will be high enough for successful development and hatching. Too much vegetation can also make it difficult for turtles to dig adequately deep nest chambers. Friable soils are also desirable for nesting; clay is not suitable for nesting.*
- **Control subsidized predators, especially around turtle nesting areas.** *Predators such as raccoons may reach unnaturally high densities due to resources provided by humans and their developments. Discourage the direct and indirect feeding of subsidized wildlife, and consider removing subsidized predators by humane means.*
- **Restore basins and hydrological cycles by removing fill, breaking substrate drainage tiles, and filling ditches.** *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 wetlands.** *Vehicular traffic on roads is a prime source of mortality of many amphibians and reptiles. Construction of roads also usually alters the hydrological cycles of adjacent wetlands.*
- **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.*

Joanna Gibson

Unfortunately, roads are often placed in close proximity to permanent wetlands. The open canopy habitat and loose soil provides ideal nesting conditions for many species of aquatic turtles, such as this Spiny Softshell. Females are at risk of being run over by vehicles while nesting, and nests are easily discovered and destroyed by raccoons.

Jerry Roach, USDA NRCS

Adding structural items, such as logs or large rocks to wetlands that lack such structures can benefit amphibians and reptiles by providing basking opportunities and refuge.

Bruce Kingsbury

The natural lake-shore habitat has been altered around many lakes used for recreational and residential purposes. The rip-rap and walls used for bank stabilization often create a barrier to turtle movement.

- **Be aware of damming or draining activities (i.e., beaver or human) that cause changes in wetland water levels.** *Changes in water levels can affect the ecology of the wetland by submerging or exposing aquatic vegetation with possible affects on amphibian and reptile microhabitat availability.*
- **Restrict animal movement into and out of wetlands that serve as retention basins containg contaminants.** *Amphibians and reptiles absorb chemicals, and with their subsequent movements across the landscape can transport those 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.*
- **When restoring wetlands contour so they have gently sloping and irregular shorelines, and variable bottom elevations.** *Such variation in restored or created permanent wetlands helps to maintain diverse, shallow, 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.*
- **Avoid introduction of game fish or other species into areas where they do not naturally occur.** *Restricting vehicular public access may discourage unauthorized stocking. Fish eat amphibian eggs and larvae, and some amphibians will avoid wetlands with fish. Other introduced animals (e.g., aquarium pets) can be vectors for disease into otherwise healthy populations.*

Kurt Buhlmann

Kurt Buhlmann

Open canopy areas with relatively loose soil provide ideal nesting sites for turtles. Female turtles lay their eggs in cavities they dig and fill themselves, and the eggs are incubated by the warmth of the soil that surrounds them. Sites that receive direct sunlight for most of the day provide the best conditions for egg development. Females often return to the same nesting sites (e.g., the same field, or sand dune) year after year and the loss or degradation of these areas can negatively impact populations. Encroachment by trees and shrubs can degrade and eventually eliminate turtle nesting habitat. By maintaining an open canopy, land managers can help restore these important breeding areas. The image at left shows a natural open canopy sand dune used by nesting Blanding's Turtles and the image at right shows a Blanding's Turtle nesting site that is being restored by removing encroaching trees and brush. Restoration activities should be conducted prior to the turtle nesting season, which is generally May through June in the Midwest.

Jerry Roach, USDA NRCS

Jerry Roach, USDA NRCS

Jerry Roach, USDA NRCS

These photos show a wetland restoration project on privately owned property enrolled in the USDA-NRCS Wetland Reserve Program. The top photograph was taken prior to restoration efforts while the property was still being cropped. The middle image was taken less than one year later, following restoration activities, which included ground excavation and shaping (including the creation of a borrow and dike to block drainage). The site was left to re-vegetate naturally. The lower aerial photo was also taken less than one year post restoration activities, and shows the extent of the wetland restoration efforts on this property. Such restorations dramatically improve the value of the area to local herps.

EDUCATING ANGLERS

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.

Zack Walker

Snapping Turtles are found in every state in the Midwest, and inhabit a wide variety of permanent water bodies. These large omnivores eat mostly aquatic vegetation, small aquatic invertebrates, and other animals. Because they are primarily scavengers, and eat dead or dying fish, they play an important role in maintaining the health of wetlands. Contrary to popular belief they are not a major predator of healthy fish.

This is the Permanent Wetlands module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Mike Graziano

WET MEADOWS, BOGS AND FENS

A variety of wetlands are characterized by saturated soils for all or much of the year. They range from small and isolated to relatively extensive areas connected by streams. Wet meadows are generally described as openings in otherwise wooded areas that hold water for a portion of the year, and are dominated by grasses, tussock-forming sedges, and various wildflowers. They occur in poorly drained areas, such as low-lying depressions fed by precipitation, and are often dry in summer.

Bogs are acidic, freshwater wetlands that usually have no inlet or outlet, and contain spongy peat deposits and varying densities of evergreen trees and shrubs. 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. For example, bogs may have abundant sphagnum moss, and dense stands of cranberry or other shrubs. Water sources are rainwater, snow, and occasionally seepages.

Fens are open wetlands that are fed by groundwater and seepages. In the Midwest, they are usually alkaline rather than acidic, and have high nutrient levels that support diverse plant and animal communities. Forested fens are common in parts of the upper Midwest, though most fens are open enough to be dominated by sedge tussocks, rushes, and other emergent plants in the understory. Because wet meadows, bogs, and fens are often isolated from other bodies of water by terrestrial habitats, they are examples of embedded habitats within a larger matrix.

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 parts of the Midwest, grazing by bison (historically), colonization and abandonment by beaver, and, more recently, livestock grazing have helped to maintain or restore the structure of 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 agricultural use, mining, withdrawal of groundwater for human use, and effects of urbanization.

Mike Redmer

Alan Resetar

Wet meadows, bogs and fens may occur as small, isolated habitats embedded within other systems, such as this narrow wet meadow within coniferous forest. However, even the smallest wet meadows may serve to increase species richness locally.

Mike Redmer

The Kirtland's Snake is ranked as the most imperiled herp in the Midwest. This reclusive species spends large periods of time under objects or underground in moist to wet "grassy" habitats such as wet meadows and fens. The loss of shallow-water wetlands through drainage, development, and impoundment, has greatly contributed to population declines.

Mike Graziano

This fen in southwestern Ohio provides habitat for imperiled species such as the Spotted Turtle, Kirtland's Snake and Massasauga.

Nathan Engbrecht

Pickerel Frogs breed in early spring soon after emergence from hibernation. The male breeding call sounds like low-pitched snoring. Breeding takes place in the shallow, cool, clear waters that flow into and through bogs and fens. Because of their reliance on clear water for breeding, water pollution and sedimentation may negatively affect populations.

CHARACTERISTIC SPECIES:
Green Frog, Mink Frog, Pickerel Frog, Northern Leopard Frog, Four-toed Salamander, Spotted Turtle, Eastern Box Turtle, Common Gartersnake, Eastern Ribbonsnake, Kirtland's Snake, Massasauga

MANAGEMENT GUIDELINES

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

- **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.** *Mow during dry periods to minimize soil disturbance and machinery-related mortality of amphibians and reptiles. When mowing fields, 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 inches or more 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. It may also reduce project costs substantially.*
- **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 plants and animals. Open canopy conditions are a requirement of many species associated with bogs, fens, and wet meadows.*
- **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. However, excessive grazing will be harmful as livestock trample vegetation and eliminate important microhabitats.*
- **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 Midwest. Private and public land managers can help minimize this problem by their own enforcement actions.*

Kurt Buhlmann

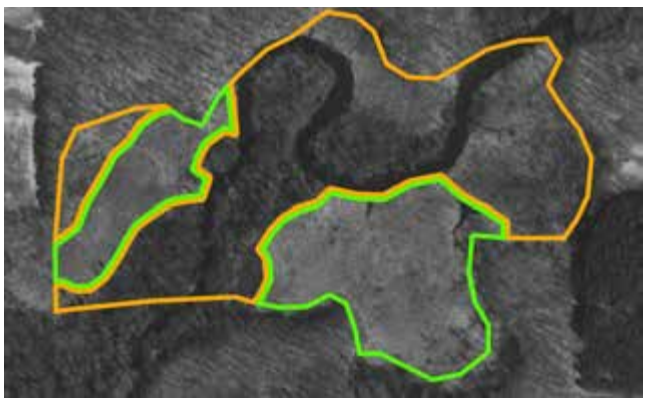
Kurt Buhlmann

Wet meadows dominated by sedges and other native plant species typically have a patchwork of sedges and diverse herbaceous plants, open water areas, and exposed mud (photo at left). For amphibians and reptiles, such as Spotted Turtles and Pickerel Frogs, this patchwork affords basking opportunities atop sedge clumps, cover against predators, and relatively easy movement through the meadow. However, when reed canary grass invades these habitats, its rapid and dense growth soon overcrowds and shades all native plants (photo at right), resulting in the smothering of the native flora and the loss of vegetative structure for many of the amphibians and reptiles that rely on these habitats. Stands of reed canary grass lack elevated basking sites, and the dense growth makes movement by many species difficult. In addition, burrowing into the muck around the base of reed canary grass stands is prohibitive, as the roots form an almost impenetrable mat.

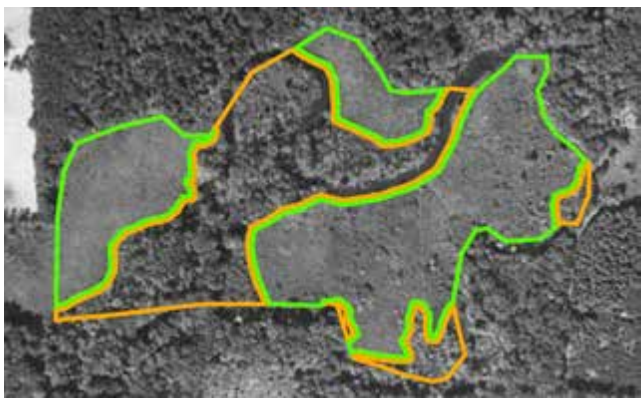
- **Avoid introduction of non-native invasive plants and animals on your property.** *Species like purple loosestrife, Phragmites, buckthorn, and reed canary grass can destroy natural wetlands. They and non-native animals can cause native species to decline.*
- **Where feasible, avoid plowing firebreaks in wet meadows, bogs, and fens.** *A firebreak in a wet meadow, bog, or fen may act as a ditch and cause unwanted drainage. It can also provide an opportunity for invasive plants to infiltrate an area. It is better to let the fire burn through the wetland, as it will recover. When firebreaks are required, cutting and raking by hands is preferred to plowing.*

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:

- **Control encroachment of woody plants and ecological succession.** *Open or moderately open canopy conditions are a requirement of many species associated with meadows, bogs, or fens.*
- **Consider the historical landscape that the embedded wet meadow, bog, or fen once existed in.** *Use old aerial photographs where possible to visualize habitat boundaries. Restoring the surrounding habitat to its historical conditions is likely the best choice ecologically for the species that live in, or rely on, the embedded habitat.*
- **Restore natural surface water and groundwater hydrology.** *Restore via plugging ditches, tearing out tile, removing fill, using water-control devices, or temporary dams if necessary, without breaking the underlying layer impermeable to water. Doing so will help restore the unique vegetation and animal communities in these wetlands.*



USDA Farm Service Agency



USGS

Comparing historic and more recent aerial photography can help determine the extent of woody succession in fen habitats and help land managers target areas requiring more intense management efforts (e.g., shrub or tree removal). Both of the images shown are of the same fen system in northern Indiana. The left image was taken in 1974, and the right in 1998. In 1974 approximately 60% of the delineated site was comprised of open canopy, fen habitat (green outline), but due to shrub and tree encroachment by 1998 (lower image), less than 40% (green outline) of the site remained as open canopy habitat fen habitat.

Lois Behrens, USDA NRCS

By breaking and removing tile, such as the tile clay line shown in this image, the natural hydrology of a site can be restored. Restoring the natural surface water conditions and groundwater hydrology will encourage the recolonization of plants and animals unique to these areas.

- **Restore and maintain herbaceous vegetation using tools such as prescribed burning, cold-season mowing, low-impact mechanical removal of woody vegetation, and low-impact controlled grazing.** *Under ideal conditions, these habitats and their inhabitants respond favorably to occasional disturbances that mimic natural processes.*
- **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.** *The vegetation in such a buffer will take up unwanted chemicals and provide additional cover for amphibians, reptiles, and other animals.*

Zack Walker

Spotted Turtles are found in wet meadows, bogs, fens, and in a variety of other aquatic habitats. Although notoriously difficult to find in summer, on cool spring days they may be found perched basking on sedge tussocks or other clumps of vegetation. Spotted Turtles require these natural wetlands and are less likely to colonize man-made aquatic features such as farm ponds.

- **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. Invasive plants that will negatively impact wet meadows, bogs, and fens include reed canary grass, phragmites, purple loosestrife, and Japanese Stiltgrass.*
- **Assess pros and cons of local beaver activities and manage to attain desired vegetation and open canopy conditions.** *Beavers 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 ultimate value of beaver activity may not be seen for many years.*

Joanna Gibson

The moisture rich environment of fens can be a favorite hangout of Eastern Box Turtles, particularly after emerging from winter dormancy.

Mike Graziano

Sphagnum moss on the margins of bogs is a favored nesting site for Four-toed Salamanders. Females may remain with the eggs through much of the incubation period. Studies have found that attended eggs have a higher survival rate than those that are abandoned.

ADAPTIVE USE OF PRESCRIBED BURNS TO MANAGE MASSASAUGA HABITAT

The Massasauga is very rare and is conferred protection in every state in which it occurs. It is most often found in wet meadows and associated grassy upland habitats because it requires sunny areas to bask and forage. Invasive woody species (trees and shrubs) that can quickly choke out sunlight are most easily managed by periodic prescribed fires. Indeed, disturbance similar to that caused by prescribed fire is crucial to habitats occupied by this species. However, fires lit during the active season of the snake (mid-march through October in the Midwest) can needlessly kill individual massasaugas. Recent studies indicate that massasauga populations recover poorly from the impacts of unnecessary mortality. Thus, in areas where the eastern massasauga occurs, prescribed fire management should be carefully timed to avoid the species' active season.

Mike Graziano

-Mike Redmer

Greg Lipps

Greg Lipps

Prescribed fire can be an important management tool for the control of woody plant encroachment in wet meadows. However, poorly timed burns can have serious negative impacts on a variety of reptiles and amphibians. Shown here is a spring burn (top) and the positive vegetative consequences later in the season (lower).

This is the Wet Meadows, Bogs, and Fens module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Nathan Engbrecht

A milk white belly with black spots and four-toed hind feet are unique characteristics of Four-toed Salamanders. Adults inhabit moist forests within close proximity of seeps, springs, and bogs. Population declines have been documented across much of their distribution and the Four-toed Salamander is listed as a species of conservation concern in most Midwestern states. Conservation and management strategies for this species need to include the protection of breeding habitat and surrounding uplands. Landowners and land managers can benefit this species by maintaining or restoring connectivity between natural habitat patches, such as forest and aquatic breeding sites (e.g., seeps, springs, bogs, and fens).


Scott Gibson

SMALL STREAMS, SPRINGS AND SEEPS

Small streams, springs and seeps are found throughout the Midwest. Small streams include headwater drainages that connect to larger streams. Water to these streams is mainly provided by rain events or associated springs. In general, small streams are seasonal or intermittent, with pockets of shallow water persisting even as the streams dry up. Their substrates are generally rocky or sandy, along with associated debris (leaves, grasses, wood, etc.). Due to the limited flow and shallow depth, small streams typically lack fishes that prey upon many amphibians and reptiles. Because small streams, springs, and seeps are often isolated from other bodies of water by terrestrial habitats, they are an example of an *embedded* habitat with a larger matrix.

Springs and seeps are surface exit points for water that has been traveling underground. A specific set of subsurface features, such as rock formations or geologic faults, must be present in the landscape for a spring or seep to form. Springs provide a continuous flow of cold, mineralized groundwater that serves as a constant water source for streams and rivers. Seep(age)s are characterized by a constant or near-constant supply of groundwater. They are usually shallow, muddy areas with a variety of herbaceous plants.

Small streams, springs, and seeps support a wealth of biological diversity, especially amphibian species. Many salamander species are strongly associated with these aquatic habitats for the majority of their life history, while other amphibian and reptile species use these habitats for some portion of their life history needs, such as breeding, dispersal, foraging, or shelter from drought and cold. The importance of protecting these aquatic habitats cannot be overstated for the continued persistence of many amphibian species.

Jeff Briggler


Scott Gibson

Small streams, springs, and seeps are embedded within other habitat types such as forests, and as such they may be negatively impacted by surrounding land management activities. They provide important habitat for many different species of amphibians, including salamanders such as the Red and Southern Two-lined Salamander.

CHARACTERISTIC SPECIES:
Four-toed Salamander, Long-tailed Salamander, Red Salamander, Eastern and Southern Red-backed Salamander, Spring Salamander, Northern Two-lined Salamander, Northern Dusky Salamander, Green Frog, Pickerel Frog, Northern Watersnake, Queen Snake.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY:
Timberlands, Hunt Clubs, Farmlands, Ranches, 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 seep habitats.** *Livestock will trample microhabitats and waste products will cause eutrophication, oxygen depletion, and death of amphibian larvae.*
- **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.*
- **If application of pesticides, herbicides, and fertilizers near streams or springs is necessary, carefully follow all label directions.** *Apply to the minimum area needing treatment, and make sure there is an adequate buffer around streams and wetlands. Do not rinse canisters or equipment in the habitat.*
- **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.** *Such practices impact populations at areas of collection and also risk introductions where they did not previ-*

Scott Gibson

Many salamander species associated with small streams, springs, and seeps also rely on surrounding upland habitats and live in the interface of stream and forest. Many small streams that are important to salamanders may only hold water for a portion of the year.

Carl R. Brune

Although they may sometimes appear small and insignificant, springs, such as this stone-lined spring at an abandoned homestead, provide important habitat for many species of amphibians and reptiles, especially salamanders. These habitats are very sensitive and should be protected from runoff and sedimentation.

ously occur. Similar concerns relate to crayfish and minnows.

- **Evaluate beaver populations and their effects in the target area and control their numbers if necessary. Protect springs and seeps.** *Although not always a problem, beaver ponding of streams may cause loss of the seep habitats and the stream environment within which a specialized suite of species live. Creation of beaver ponds will alter the species composition. Strive to understand the historical use patterns.*
- **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 seeps.*
- **Remove trash dumped into mouths of seeps and springs.** *Restrict access to minimize/prevent illegal dumping of waste.*

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 (especially salamander) diversity high.*
- **Consider the historical landscape that the embedded small stream, spring, or seep once existed in.** *Use old aerial photographs where possible to visualize how elements of the landscape related to one another prior to human manipulation. Restoring the surrounding habitat to its historical conditions is likely the best choice ecologically for the species that live in, or rely on, the embedded habitat.*

Greg Lipps

Small streams, springs, and seeps provide important breeding and overwintering habitat for Red Salamanders. These large, colorful salamanders are rarely encountered as they spend a majority of time in burrows in springs and seeps, or under logs or other cover in surrounding forest. Like many other salamanders they rely on clean, clear water and populations are negatively affected by water pollution and sedimentation.

Mike Graziano

Long-tailed Salamanders may be found under rocks, logs, and other structures along the margins of small streams, springs, and seeps. During the winter adults overwinter close to the water's edge, in surrounding forest. Activities that result in surface runoff into seeps, springs, and streams can negatively impact Long-tailed Salamander populations. Examples include acid drainage from strip mining, sedimentation from timber harvesting activities, and runoff from roads. Increased stream water temperatures (from loss of canopy cover after timber harvesting) may also negatively impact populations.

Mike Graziano

Southern Two-lined salamanders can be found hidden under rocks, logs, and leaf piles along the margins of small streams and springs. During the breeding season many females will actually attach their eggs to the underside of submerged rocks on stream bottoms. Eggs are laid and attached singly, as shown. Cool, clear water is required for egg and larvae development. Loss of forested habitat surrounding aquatic breeding sites, timber harvesting activities, and runoff into streams have the potential to cause population declines.

Zack Walker

Streamside Salamanders have a very restricted distribution in the Midwest, being found only in southeast Indiana and southwest Ohio, in the Interior Low Plateau and North Central Tillplain ecoregions. They are closely associated with small rocky first- and second-order streams (that often only hold water during the rainy season), in hilly forested habitats, in limestone regions. Outside of the breeding season they are rarely encountered, because they spend considerable time underground, or under surface cover. Timber harvesting and other activities that disturb small streams and the forest that surrounds them will negatively impact this species.

- **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 a diversity of amphibians and reptiles will use these areas extensively.*
- **Provide natural upland buffer habitat around sensitive aquatic features.** *Buffers in ideal management scenarios should be as wide as possible. Intact upland habitat buffers of 100-150 feet can help protect water quality, reduce organic inputs, and ultimately improve the quality of riparian habitat for stream amphibians and reptiles.*
- **Leave snags, other coarse woody material, and rocks in streams to provide microhabitat.** *All these structures provide refugia for amphibians and reptiles. Juvenile and larval amphibians use these structures extensively.*
- **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.*
- **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 seep areas.** *These small habitats are critical to several species of salamanders. Alteration of any kind will cause population decline and potentially lead to extirpation (i.e., local extinction). Provide overflow if springs are boxed.*
- **Remove exotic vegetation.** *Maintenance of appropriate vegatation in stream riparian zones will help support natural water temperatures and higher amphibian diversity.*
- **Avoid the use of fertilizers and pesticides in or around streams, springs, and seeps.** *If chemicals must be used, be sure to adequately buffer these sensitive areas, use the correct formulation and follow label directions.*
- **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 Seeps module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Mike Graziano

Greg Lipps

Female Northern Dusky Salamanders remain with their eggs (top image) for the duration of the incubation period and for a short amount of time after the eggs hatch (the lower image shows recently hatched larvae). During this period females may defend their brood against predators. The larvae are very sensitive to water sedimentation and pollution

Scott Gibson

RIVERS AND LARGE STREAMS

Rivers and large streams are the natural drainages for watersheds in the Midwest. They are responsible for the deposition of large amounts of sediment, giving floodplains some of the richest topsoil in the world. Rivers and streams vary along a gradient related to the "order size" of the waterway. Amphibian and reptile communities vary along this gradient due to microhabitat features and presence of predatory fishes. High-order rivers and streams are characterized by considerable depth, strong currents, extensive floodplains, low gradients, and pass large volume of water, while lower order streams typically have shallow, rocky bottoms, steep gradients and lower flow rates.

In the Midwest, as in much of the United States, flooding from rivers and streams has also caused severe damage to homes, businesses, and agriculture. Because of this, humans have attempted to control them to prevent flooding beyond the main river and stream channels. Further manipulation of rivers and streams has been undertaken to facilitate navigation. These measures have extensively altered these important ecosystems by removing habitat and impacting natural water fluctuations. Other threats to amphibians and reptiles in river and stream systems include changes in water quality, increased erosion and sedimentation, incidental mortality by anglers, and introduced predatory fish.

Rivers and streams provide crucial habitat for many species of reptiles and amphibians. Numerous species have adapted to cope directly with river life. Hellbenders and Mudpuppies, for example, spend their entire lives in these aquatic systems, and many species of turtles leave only to lay eggs. Rivers and streams are also very important for other species of amphibians and reptiles which use these habitats less frequently throughout their lives. Many more depend on the floodplain and its periodic flooding for foraging and breeding. Protection of rivers and streams from degradation not only benefits numerous aquatic species (amphibians, reptiles, fish, crayfish, etc.) but also provides clean drinking water for humans.

Jeff Briggler

Chris Phillips

In addition to providing important habitat for many species of amphibians and reptiles, Midwestern rivers provide water for drinking and irrigating crops. Many large rivers are also used as transportation corridors for the movement of cargo.

FLOODPLAIN: A FORGOTTEN LANDSCAPE?

Scott Gibson

Natural floodplains are an amazing combination of terrestrial and aquatic habitats where herps and other wildlife can flourish. River meanders, old oxbows and beaver ponds imbedded in a rich forest matrix offer amphibians and reptiles a wide array of habitats in close association. Unfortunately, intact floodplain can be hard to find in the Midwest. Floodplains are defined by the periodic inundation caused when rivers and streams breach their banks. Given the potentially devastating effects of such flooding, efforts to contain waterways and deliver their contents downstream quickly have been extensive, and largely successful. With the threat of flooding removed, or at least substantially diminished, most floodplain is now converted for agriculture, taking advantage of the rich soils resulting from historic flooding. To facilitate farming, the land has been leveled and ditched, and drains and tiles installed to quickly remove any standing water. As the last straw, those areas which still flood now face the concentrated brunt of deluges which were once distributed across larger areas.

Where possible, recovery of natural floodplain would be highly beneficial for local herpetofauna. Given its diverse nature, management guidance for floodplains can be found in the modules for Rivers and Large Streams, Permanent Wetlands, Seasonal Wetlands, and Hardwood Forests. The great challenge is restoration of natural flood regimes. For small streams, this may require negotiation with neighbors and local government drainage boards. Along rivers, collaboration with U.S. Army Corps of Engineers and/or regional hydroelectric companies may provide discharge from dams at ecologically appropriate times and amounts. Even modest projects will require an experienced hand that realizes the power of water to manipulate the landscape. The challenges are great, but the benefits for herpetofauna and other wildlife will be extensive. And, as occasional but dramatic flooding events demonstrate, we do not have complete control over nature when it comes to water. Opportunities may arise where floodwater containment may be wedded to creation of herp habitat.

-Bruce Kingsbury

CHARACTERISTIC SPECIES:
Eastern and Ozark Hellbender, Mudpuppy, River Cooter, Alligator Snapping Turtle, Smooth Softshell, Spiny Softshell, Northern Map Turtle, Wood Turtle, Eastern Ribbonsnake, Northern Watersnake, Diamond-backed Watersnake, Queen Snake, Red-bellied Mudsnake

Zack Walker

Hellbenders are the largest salamanders in the Midwest. They are found in southern Ohio, southern Indiana, southern Illinois, and Missouri in the Ozarks, Interior Low Plateau, North Central Tillplain, and Western Allegheny Plateau ecoregions. An entirely aquatic species, hellbenders require clean, clear-flowing water, and structural cover, such as large rocks, under which they can hide. The species is faring poorly within its Midwestern range and is listed as endangered in every state in which it is found. Population declines have been attributed to collecting, pollution and siltation. Unfortunately these harmless salamanders are also often caught by anglers and killed.

Mike Graziano

Mudpuppies are large, entirely aquatic, salamanders. They inhabit large streams and lakes in the Midwest. Relying on their skin and exposed gills for respiration, the species is sensitive to pollutants and changes in water quality. Population declines have been observed in areas of the Great Lakes where chemicals have been used for sea lamprey control.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY: Timberlands, Hunt Clubs, Farmlands, Ranches, 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 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.*
- **If application of pesticides, herbicides, and fertilizers near rivers and streams is necessary, carefully follow all label directions.** *Apply to the minimum area needing treatment, and make sure there is an adequate buffer around streams and wetlands. Do not rinse canisters or equipment on-site.*
- **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, use water gaps, or develop alternative off-site 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 moving back and forth between rivers and the adjacent uplands.*
- **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 such as camping during the nesting season.*
- **Keep snag removal activities to the minimum necessary for boat traffic.** *Components of a*

Jeff Briggler

Jeff Vanuga, USDA NRCS

Unrestricted livestock access to aquatic habitats can result in trampling of streamside vegetation, erosion and sedimentation, and ultimately poor water quality. Where possible, provide livestock with alternate water sources and install fencing to keep them out of these sensitive habitats. The lower image shows water tanks and fencing to keep livestock away from a riparian buffer zone.

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 Midwest as does killing of Hellbenders and Mudpuppies by fishermen who mistakenly fear they are venomous or impact sport fish populations. These practices may be contributing to the decline of some species.*
- **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.*
- **Rock filled crib docks are always preferred over sheet steel covered docks.** *Complex interiors provide habitat for a variety of semi-aquatic snake species and other wildlife.*
- **Avoid filling in wetlands connected to rivers and river floodplains.** *Amphibians and reptiles use such habitats extensively.*
- **Remove trash and police boat launch and recreation areas for persistent offenders.**

A. B. Sheldon

Peter Badra, MNFI

Jeff Briggler

Map turtles (top image) can be relatively common residents of larger river systems within the Midwest. Their diet is rather specialized and consists primarily of freshwater mussels (middle image), snails, and crayfish. Freshwater mussels and map turtles require clean water to survive (bottom image): sedimentation in our rivers kills mussels and results in declines of map turtles.

Zack Walker

Alligator Snapping Turtles are the largest freshwater turtle in North America. Unfortunately, they are also one of the rarest turtle species in the Midwest due in large part to overharvesting. Their technique for capturing food is quite unique – they lie at the bottom of a body of water with their mouth held open while a pink wormlike projection on the floor of their mouth wriggles to attract prey. They do not travel far from a river's edge to nest, thus they rely on vegetation-free sandbars.

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

Jennifer Anderson-Cruz

Downed timber in rivers provides important habitat for basking, as well as structural refuge sites under the water's surface. This section of river in Iowa provides habitat for Wood Turtles.

Chris Phillips

Sand bars provide important nesting and basking areas for several species of aquatic turtles, such as map and softshell turtles. Water level manipulations that raise levels during summer months drown turtle eggs.

- **Exclude point source and non-point source pollution.** *Seek ways to minimize or eliminate such sources of pollution.*
- **Consider a range of management options before using pesticides or other chemical applications near rivers.** *If they are required, carefully follow label directions and make sure there is an adequate buffer around rivers. Do not rinse canisters or equipment 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 the use of these areas and interfere with movements into and out of the water. Rip-rap can trap animals (particularly turtles) and cause inhumane deaths.*

This is the Rivers and Large Streams module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Stephen J. Mullin

Dams create a barrier effect to the movements of riverine fish, amphibians, and reptiles, essentially isolating populations on either side of the dam wall. The effects from the loss of genetic exchange on populations are unknown. In addition, the lake-like conditions created upstream are unsuitable for some species, and have actually contributed to population declines (e.g., hellbenders).

Jim Harding

Wood Turtles do not reach sexual maturity until between 14 - 18 years. Mating activities typically peak in spring and fall, just after and prior to winter dormancy, with mating often occurring underwater. Females nest between May and July in surrounding open, sunny locations, and hatchlings do not emerge until between mid-August and early October.

Chris Phillips

Spiny Softshells inhabit rivers and large streams across much of the Midwest. Water pollution, exploitation, and loss of nesting habitat have contributed to population declines.

Scott Gibson

HARDWOOD FORESTS

The deep shade provided by the continuous overstory of a mature hardwood forest encourages a relatively open understory. Conditions are cooler than nearby open habitats, and the thick leaf litter and extensive root systems help to create a moist, three-dimensional forest floor structure. Downed and decomposing logs, limbs, and leaves provide critical microhabitats for many herps and their prey. The understory and herbaceous groundcover can be species-rich: shrubs, vines and younger trees add vertical structure. In many areas of the Midwest, these forests also have numerous wetlands imbedded in them, greatly enhancing their value for both reptiles and amphibians.

Upland hardwoods generally consist of either oak-hickory or maple-beech-birch forests, while flatwoods and bottomland hardwoods are primarily dominated by red and silver maples, and green ash (at least where the Emerald Ash Borers have not found them!) To the west, the forested landscape ultimately gives way to savanna, principally in Illinois, Iowa, and Minnesota, but as far east as some areas of Indiana, Michigan, and Ohio. Within the forest-woodland-savanna transition, forests consist of primarily deciduous mixed forests of oak, hickory, maple, and basswood.

Deciduous hardwood forests once blanketed much of the Midwest. Today, because of human activity, primarily in the form of conversion to agriculture (clearing, plowing, grazing), as well as industrial and urban development, few extensive tracts of forest remain. In the case of woodland/savanna, less than one percent of the historic forests still exist.

Scott Gibson

Downed trees, coarse woody materials, and a well-developed humus layer and soil structure on the forest floor provide critical microhabitat for many species of salamanders.

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, aspect, latitude, temperature, and moisture all influence 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. Generally, most amphibians rely on cooler, moist habitats to stay hydrated, whereas most reptiles need more sunlight and higher temperatures. Thus, a mosaic of microhabitats in a hardwood forest will support a higher diversity of herps than a forest with uniform environmental conditions.

Amphibians and many reptiles are important players in energy dynamics in forests, as the energy flow through them can be substantial. In one study in a forest of the northeastern United States, the biomass (energy in animal tissues per square meter) of a single red-backed salamander population in New Hampshire was twice that of all birds during peak breeding season and about equal to that of all small mammals in the area.

How humans historically used the land in an area 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. Acid precipitation from human activities far away also impacts herps on the forest floor and in aquatic systems associated with hardwood forests. Fewer salamanders have been found in areas of forests with low pH soils than in areas with more neutral pH.

Jackie Grant

Scott Gibson

Hardwood forests provide a diverse array of microhabitats that help support a wide variety of amphibian and reptile species. Canopy openings facilitate behavioral thermoregulation, allowing reptiles in particular to shuttle between sunny and shady locations to maintain proper body temperatures. Thick accumulations of leaf litter offer a moist refuge for amphibians, and also provide a smorgasbord of invertebrate prey.

CHARACTERISTIC SPECIES:
Eastern Newt, Eastern Red-backed Salamander, Blue-spotted Salamander, Spotted Salamander, Small-mouthed Salamander, Wood Frog, Western Chorus Frog, Spring Peeper, Gray Treefrog, American Toad, Common Five-lined Skink, Red-bellied Snake, Black Ratsnake, Milksnake, Ring-necked Snake, Eastern Hog-nosed Snake, Timber Rattlesnake, Wood Turtle, Eastern Box Turtle.

Carl R. Brune

Box turtles are inhabitants of large forested areas in the Midwest. Females may travel considerable distances (over 1/4 mile is not uncommon) in search of suitable nesting sites to lay their eggs. Unfortunately populations have declined in many areas due to habitat loss, road mortality, and collection for the pet trade. Raccoons also exert a considerable toll on populations; in some areas they are responsible for destroying close to 100% of nests.

MANAGEMENT GUIDELINES

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

- **On logging sites where options exist, favor site preparation techniques that minimize soil disturbance.** *Such efforts will reduce mortalities and loss of suitable microhabitats.*
- **When possible, harvest trees during drier periods or periods with snow cover, and use low-pressure tires.** *Harvesting during periods when the soil is dry or frozen minimizes rutting and disturbance to soil structure.*
- **Leave stumps, some logs, dead standing snags, other coarse woody material, and slash following timber harvests.** *Many amphibians and reptiles require woody materials and stump holes for shelter, nesting, and foraging.*

Mike Graziano

Expanses of continuous forest were once common in the Midwest landscape. Today, many forested areas have been fragmented by roads and development.

- **Leave large cull trees or patches 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 begins to recover.*
- **Meet or exceed existing Best Management Practices for sediment and erosion control.** *Doing so will preserve important microhabitats on the forest floor and protect nearby streams and wetlands.*
- **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.*
- **Limit construction of new logging roads and staging areas - return the natural contours and conditions of such areas when they are no longer needed.** *Minimize the footprint of your operation in the harvested area.*
- **Provide aquatic connectivity by assuring that culverts under roads are properly designed.** *Culverts should be as large as possible and placed such that herps can enter and exit easily.*
- **When using fertilizers and pesticides, be sure to follow label directions and adequately buffer aquatic habitats embedded within forests (e.g. seasonal wetlands, streams, 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.*
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs, fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves.** *Provide connectivity between these habitats and any forested habitat. These microhabitats are important for breeding sites, foraging areas, and hibernacula. Without them many species of amphibians and reptiles will not be present in the forest.*

Mike Graziano

An upper Midwestern species, the Blue-spotted Salamander is an inhabitant of forested areas that contain suitable fish-free wetlands for breeding. As with all amphibian species, the building of roads between their terrestrial environment and wetlands used for breeding threatens populations.

Nathan Engbrecht

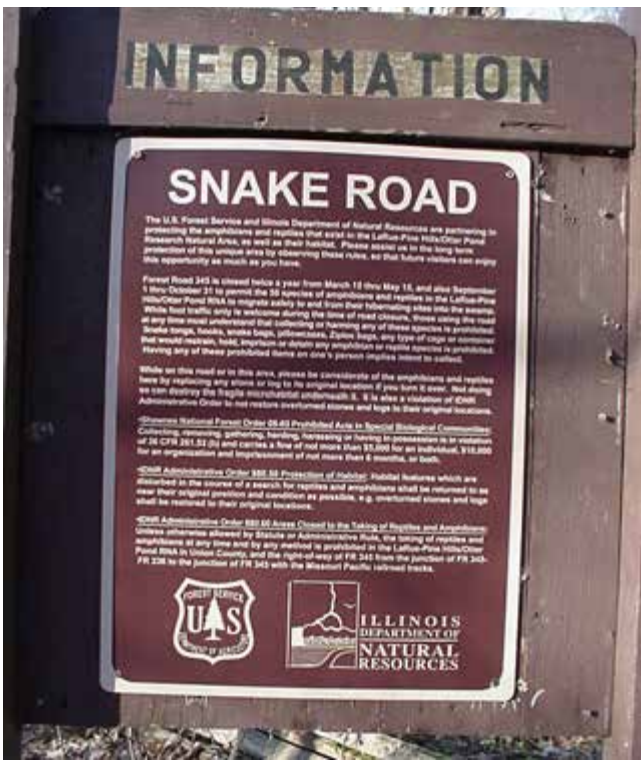
Cope's Gray Treefrogs are primarily residents of deciduous and mixed forests in the Midwest. Their diet consists of insects and other invertebrates. They hibernate on land under leaf litter, logs, and even in old tree hollows. The introduction of fish into ponds used for breeding can negatively affect populations of this species.

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 Midwest, xeric oak and pine-oak ecosystems have significantly declined 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 (red maple, etc.) and increase higher quality oaks.

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.*



Scott Ballard

Seasonal road closures can help protect amphibians and reptiles during sensitive periods, such as during the breeding season. Informative signs can help explain why seasonal road closures are necessary, and can also provide information on laws that protect amphibians and reptiles. This interpretive sign, created collaboratively by the US Forest Service and the Illinois Department of Natural Resources, is placed at each end of Snake Road in the Shawnee National Forest. It provides information on seasonal road closure dates, and interprets laws and protection for migrating amphibians and reptiles.

- **Maintain or restore downed woody materials on the forest floor.** *Allow limbs and snags to stay in place and decompose naturally. Salamanders and their invertebrate prey use such microhabitats extensively.*
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs, fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves.** *Provide connectivity of these habitats to remaining forested habitat. These microhabitats are important for breeding sites, foraging areas, and hibernacula. Without them several species of amphibians and reptiles will not be present.*
- **Avoid fragmenting large blocks of forests with roads, field crops, developments, or other barriers.** *Habitat fragmentation creates small population sizes that are subject to a host of problems, especially if individuals cannot migrate between remaining habitat fragments. Some species will not cross open spaces, and those that try are subject to exposure, desiccation, and predation.*
- **Harvest timber using techniques such as group or single-tree selection, or small clearcuts.**

Scott Ballard

Culverts placed at strategic locations can help reduce amphibian and reptile road mortality. This image shows a dry, slotted top, under-road culvert (with drift fencing) that was installed to help reduce vehicular mortality of migrating timber rattlesnakes from hibernating bluffs to floodplain forest in southern Illinois.

Where shade-dependent species or mature forest obligates are a concern, leave patches of large trees. Forested habitat 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, small clearcuts may help them. Where both late- and early successional species are present, a patchwork of harvest practices may be appropriate.

- **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 materials on site; replace as needed.*
- **Minimize or eliminate barriers to dispersal across the landscape between forest fragments, leave or add windbreaks and hedgerows and make them as broad as possible.** *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.*

Jeff Briggler

Within the Midwest Ringed Salamanders are found only in the Ozark and Ouachita Mountains of Missouri, in the Ozarks ecoregion. They occur in forested habitats in close proximity to suitable aquatic breeding sites (e.g., fish-free ponds and pools). Outside of the breeding season they are rarely encountered because they spend much of their time in subterranean burrows. Because of their restricted and patchy distribution (they are only found near suitable breeding sites) Ringed Salamanders are extremely vulnerable to the loss of aquatic breeding sites and the forest that surrounds them.

Carl R. Brune

The Ring-necked Snakes is a small, secretive species that favors moist conditions found under leaf litter, rocks, logs, and other woody materials. As they are closely tied to the forest floor environment, activities that alter substrate moisture and temperature, such as timber harvesting activities and prescribed burning, may affect populations.

Steve Paes

Older hardwood forests tend to have a more developed humus layer and subsoil structure which provides better habitat for fossorial salamanders (i.e., salamanders that like to dig down, or live in crevices in the soil).

Scott Gibson

Common Five-lined Skinks are named for the appearance of juveniles and young adults, which look completely different from older adults. Younger individuals are patterned with five whitish stripes that run down their back. Juveniles of the species also possess a bright metallic blue tail. As individuals mature they lose their vivid tail coloration and the stripes fade. These lizards are abundant in older hardwood forests where they get inside crevices of old trees in search of prey and safety.

Scott Gibson

The moist conditions of the eastern Midwest support continuous expanses of forest. In contrast, due to the drier conditions in the western regions of the Midwest, hardwood forest is largely confined to riparian corridors.

- **Avoid locating trails through core habitats such as seasonal wetlands, and intact old-growth forests.** *Trampling of the leaf litter, downed woody materials, 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.*

This is the Hardwood Forests module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

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 windthrows, 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.

Joanna Gibson


Scott Gibson

CONIFEROUS FORESTS

Native coniferous forests are found primarily across two areas of the Midwest: the northern regions of Michigan, Wisconsin, and Minnesota (within the Superior Mixed Forest and Great Lakes ecoregions) and the Black Hills ecoregion of South Dakota. The northern forests were historically comprised primarily of pine and other evergreen species, however due to extensive logging, clearing and development, only about 20 percent of these areas remain intact. Across much of northern Michigan, Wisconsin, and Minnesota, deciduous species such as red maple, aspen, and paper birch have become more dominant in forests that were historically coniferous. The mixed forests that remain today include a succession from quaking aspen, paper birch, and jack pine to white spruce, black spruce, and balsam fir. Pine forest in this region includes Great Lakes pine forest (white pine, red pine, paper birch, aspen) and jack pine forest (jack pine, red pine, oak, hazel). Human intervention has also impacted the ponderosa pine forests of the Black Hills ecoregion of South Dakota, primarily in the form of suppression of natural fire regimes.

Coniferous forests are comprised of predominately evergreen species that can tolerate cold temperatures and dry, acidic soil. Their root systems are generally shallow, which leads to the formation of windthrow (tip-up) mounds and pits that provide extensive wildlife habitat. The subterranean passageways created by these windthrow mounds, as well as decomposing logs and other woody materials provide critical microhabitats for many species of amphibians and reptiles.


Scott Gibson

The relatively open conditions of some pine stands in the Midwest provide ideal basking conditions for several species of reptiles, such as Western Foxsnakes and Eastern Hog-nosed Snakes.

Compared to deciduous forests which develop on moister, more organic soils, coniferous forests tend to have a lower diversity of herbaceous vegetation, shrubs, and understory trees.

Diverse structure and a mosaic of microhabitats in coniferous forests will support a higher diversity of herps than a forest with uniform environmental conditions. Amphibians will generally favor moister microhabitats that help maintain critical skin moisture, whereas reptiles are more apt to exploit a range of conditions, including drier, sunny canopy openings as well as moist, cooler areas.

Jackie Grant

CHARACTERISTIC SPECIES:
Spotted Salamander, Four-toed Salamander, Eastern Red-backed Salamander, American Toad, Canadian Toad, Woodhouse's Toad, Spring Peeper, Gray Treefrog, Cope's Gray Treefrog, Boreal Chorus Frog, Wood Frog, Common Gartersnake, Terrestrial Gartersnake, Milksnake, Red-bellied Snake, Smooth Greensnake

Scott Gibson

Pure coniferous stands are rare in the Midwest. Stands of White Pine, such as this one in Michigan's Upper Peninsula, are intermixed with deciduous species such as sugar maple, aspen, and birch.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY:
Timberlands, Hunt Clubs, Farmlands, Ranches, 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 materials 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 off road vehicles (ORVs).** *Limiting human access will reduce the number of places 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.*
- **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 coniferous forests. High deer density also facilitates sugar maple invasion of hemlock stands. Removal of moss and duff layer by deer could eliminate local salamander populations.*
- **Where possible, maintain forest canopy cover in its natural, unmanaged state.** *Canopy cover helps maintain cool temperatures and moist envi-*

Greg Lipps

Eastern Red-backed Salamanders are a common resident of forest litter in deciduous, coniferous, and mixed-coniferous forests in the eastern portion of the Midwest. In most populations, the species can occur in two color phases, one with a red stripe (red-back phase) and one without the stripe (lead-back phase), as shown above. Eastern Red-backed Salamander populations are negatively affected by loss of forest litter.

Greg Lipps

Common Gartersnakes are another common resident of many forests. They prefer sunny areas where the canopy is relatively open , and are also often observed hunting around small streams and ponds within forests.

ronments 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 recovers to later succession stages.*

Nick Bieser

The structural complexity and moist soil conditions on the floor of this white cedar stand in Michigan provides habitat for Wood Frogs, Pickerel Frogs, and Blue-spotted Salamanders. Massasaugas have also been observed to occasionally use these areas.

Mike Graziano

Andrew Berger

The Red-bellied Snake is a small, secretive species that spends much of its time under leaf litter and woody materials. Their diet is primarily comprised of slugs, earthworms and other invertebrates. They typically have a brown back (at left) and the belly is red (as their names implies – see picture at right). Leaving woody materials, and other forest floor cover, in place will benefit this species.

Nick Bieser

Nathan Engbrecht

Vernal pools in cedar swamps, such as the one shown above left, provide important breeding areas for salamanders and frogs. For example, vernal pools with mounds of sphagnum moss growing near the water appear to provide favored nesting conditions for Four-toed Salamanders (at right). Four-toed Salamanders are vulnerable to activities that degrade or destroy aquatic breeding sites and surrounding forested habitat. Landowners and land managers can benefit this species by protecting aquatic breeding sites and surrounding upland habitats and by restoring corridors of natural habitat between breeding sites and forest patches.

- **Minimize fragmentation of large tracts of forest.** *Fragmentation creates small populations with all the problems of inbreeding and susceptibility to disease and predation. Where possible, place roads and other barriers around rather than through forests tracts.*
- **Whenever feasible, thin plantations, extend rotation age, and use prescribed burning to maintain some herbaceous ground cover.** *Canopy openings are important to maintain herbaceous groundcover (i.e., grasses, sedges, and forbs), important wildlife foods. Light gaps are important in managed conifer forests because reptiles use them for basking. Herbaceous groundcover is important in managed conifer forests because amphibians rely on the shade and moisture they provide. In those areas adapted to fire, periodic burns will help to stimulate persistence of many native plants.*
- **On sites where options exist, favor site preparation techniques that minimize soil disturbance, such as fire and chemical site prep.** *If bedding is to be used, consider wider bed spacing (12 to 15 feet) to retain undisturbed areas between beds. Mechanical site prep techniques such as shearing, root raking, disking, and bedding can damage the soil structure in which fossorial (i.e., burrowing) herpetofauna (e.g., Tiger Salamander, Hog-nosed Snake) occur.*
- **When possible, harvest during drier periods and/or 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 materials following timber harvests.** *Many amphibians and reptiles require woody materials and stump holes for shelter, nesting, and foraging.*
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs, fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves.** *These microhabitats are important for breeding sites, foraging areas, and hibernacula. Without them several species of amphibians and reptiles will not be present.*

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 ORVs.** *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.*

Alan Resetar

American Toads are one of the most widely distributed species in the Midwest, occurring in a variety of habitat types. They often seek shelter in leaf litter or under logs or rocks, but are frequently observed after it rains. American Toads need access to suitable breeding sites that include shallow ponds and pools.

- **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. Plant native trees in old fields and recovered agricultural lands.*
- **Maintain or restore downed woody materials on the forest floor.** *Allow limbs and snags to stay in place and decompose naturally. Salamanders and their prey use such microhabitats extensively.*
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs, fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves.** *Provide connectivity of these habitats to remaining forested habitat. Many coniferous forest-associated species require these embedded habitats for part of their life history needs (e.g., for breeding, foraging, and hibernation). Both the embedded habitats and the surrounding conifer matrix must be present for such species to persist.*
- **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.*
- **Thin existing even-aged plantations, extend rotation age, manage toward uneven-aged stands, and restore historic fire frequency and seasonality to allow stands to remain relatively open.** *Canopy openings and, in many areas, fire are both vital to the health and survival of herbaceous groundcover. Grasses, sedges, and forbs are important wildlife food sources in most conifer forests. Light gaps and herbaceous groundcover are especially important because they provide basking sites and moist, shaded microclimates.*
- **Restore natural fire frequency, seasonality, and (where feasible) intensity.** *Growing season burns mimic lightning-caused spring and summer fires that historically occurred under natural conditions. In many areas, fire is a normal part of the ecology and helps maintain open canopy conditions and promote growth and survival of herbaceous ground cover. Embedded seasonal wetlands are unlikely to burn during the dormant season (i.e., winter) because they are more likely to contain water at that time. All amphibian and reptile species that occur in pine-dominated habitats are adapted to periodic growing season fires.*

This is the Coniferous Forests module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Mike Graziano

The diet of Milksnakes is comprised predominately of small mammals. These brightly colored snakes lay eggs in summer, depositing them under woody materials on the forest floor, dry vegetation, or in shallow holes in the soil. The eggs develop in the warm conditions of the "nest" and hatch after 6-9 weeks. It takes 3-4 years for Milksnakes to reach sexual maturity. Landowners and land managers can help protect these beneficial predators by leaving woody debris in place or adding it to areas where it has been removed.

Scott Gibson

Pines are not native in many areas of the Midwest and exist as planted, even-aged stands. In the Hoosier National Forest in southern Indiana pines were originally planted to help control soil erosion. Today these stands are being infiltrated by native hardwood species.

Nick Bieser

WOODLANDS AND SAVANNAS

Woodlands and savannas were once common in the Midwestern landscape as transitional zones between forest and grassland. They would have been the dominant habitat at the grassland-forest border of Minnesota, Wisconsin, Iowa, Illinois, Indiana, Michigan and Ohio, in the Prairie-forest Border and Northern Central Tillplain ecoregions. Scientifically, savannas are defined as having 12 or fewer trees per acre or 10-25% tree cover. For this document, we use the term more broadly to apply to grasslands with a few trees as well. Woodlands contrast with savanna in that tree cover is more substantial - 25-75% canopy cover. Nevertheless, tree canopy gaps are extensive and the understory well-developed. Tree species typical of savannas and woodlands in the Midwest include burr oak, white oak, pin oak, black oak, and jack pine. Although tree diversity in these areas is typically low, often with just one or two species, the open canopy in savannas allows for a great diversity of grasses, wild flowers, and shrubs.

Conversion to farm fields and ranches, coupled with fire suppression, substantially reduced the range of savannas. Today, less than one percent of the upper Midwest's pre-settlement savannas remain, making it one of the most rare, highly fragmented, and critically endangered habitat types within the region. Soil type and the frequency of fire once determined the density of trees in an area. In more recent times, fire suppression and the growing demand for timber products has led to much of the remaining savanna acreage being converted into forests and woodlands. Fire suppres-

Jennifer Anderson-Cruz

Today, much of the savanna habitat of the Midwest occurs as small, isolated patches. Savannas have very open canopies with only a scattering of trees, and the understory is often comprised of grasses.

sion continues to threaten remaining savannas as tree densities increase through natural succession.

There are no amphibian or reptile species that are savanna or open woodland specialists. However, the diversity of amphibians and reptiles is high in these habitats, because they harbor species characteristic of both forest and grassland. For example, in areas of northwestern Indiana, the Plains Leopard Frog and Northern Leopard Frog, Eastern Box Turtle and Ornate Box Turtle, Common Gartersnake and Plains Gartersnake, might all occur not too far from one another, or at least once did.

Bob Brodman

CHARACTERISTIC SPECIES:
Eastern Tiger Salamander, Northern Leopard Frog, Spring Peeper, Western Chorus Frog, Gray Treefrog, Fowler's Toad, American Toad, Ornate Box Turtle, Slender Glass Lizard, Common Gartersnake, Western Foxsnake, Gophersnake (Bullsnake), Smooth Greensnake, Eastern Hog-nosed Snake, Milksnake

Alan Resetar

Fowler's Toads occur in open woodlands and other habitats with sandy soils, where they often burrow to escape hot and dry conditions. Temporary pools, ditches, and other shallow bodies of water within these habitats provide suitable breeding areas.

MANAGEMENT GUIDELINES

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

Jennifer Anderson-Cruz

Woodlands have a more substantial tree cover than savannas.

- **Leave stumps, some logs, dead standing snags, and other coarse woody materials following timber harvests.** *Many amphibians and reptiles require woody materials and stump holes for shelter, nesting, and foraging.*
- **Favor site preparation techniques that minimize soil disturbance, meet or exceed existing Best Management Practices for sediment and erosion control, and when possible, harvest during drier periods or when the ground is frozen, and use low-pressure tires.** *Soil disturbance and erosion affect soil compaction, nutrients, and moisture, and increases sedimentation of streams. Harvesting during dry periods or when the ground is frozen minimizes rutting and disturbance to soil structure.*
- **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.*

Mike Graziano

Restricted entirely to the upper Midwest, Western Foxsnakes inhabit drier areas such as pine/oak woodlands. Small mammals are a favored prey for this species. When threatened, this harmless snake will vibrate the end of its tail, creating a "rattling" noise in dried vegetation.

Alan Resetar

Jack Pine barrens, such as the one shown in this photograph, form in areas with sandy soils and a history of fire. These areas provide important habitat for several species of amphibians and reptiles such as American Toads, Fowler's Toads, Eastern Hog-nosed Snakes, and Smooth Greensnakes.

- **When using fertilizers and pesticides, follow label directions and adequately buffer aquatic habitats.** *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. If herbicides need to be used near water or to control wetland plants, then it is safer for amphibians and other aquatic wildlife to use fall applications and formulas that are approved aquatic use.*
- **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 the turtle and bird nesting and deer fawning seasons are over (generally safe after mid-July).*
- **Prescriptively graze livestock to prevent overgrazing.** *Over-grazing eliminates grass and foliage 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 savannas by humans and their vehicles can trample microhabitats used by amphibians and reptiles and increases erosion.*
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs, fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves.** *Provide connectivity of these habitats to remaining woodland and savanna habitat. These microhabitats are important for breeding sites, foraging areas, and hibernacula. Without them many species of amphibians and reptiles will not be present.*

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 savanna and open woodland cover.** Maintain a diversity of canopy cover ranging from 10-50%.

OAK SAVANNA DECLINE: AN ECONOMIC AND ECOLOGICAL THREAT.
Oaks are valuable to humans as a timber source and to wildlife as a food source. In the Midwest, there was a loss of 99.98% of oak savannas and woodlands from settlement to 1985. They are listed globally as critically endangered ecosystems. The loss of oak savannas in particular has serious implications for many wildlife species in the Midwest, 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 increase higher-quality oak savannas.

Jim Harding

Smooth Greensnakes prefer moist, grassy habitats such as savannas, but can also be found in drier woodlands. The diet of these small snakes consists mostly of insects and they are particularly fond of grasshoppers and crickets. Because of their diet, pesticides are thought to be related to documented declines of this species in the Midwest.

Nathan Engbrecht

Compared to other salamander species Eastern Tiger Salamanders can be found in drier habitats such as savannas, but they still require aquatic habitats for breeding. Outside of the breeding season they spend much of their time underground in burrows they may have dug themselves.

- **Maintain or restore downed woody materials on the forest floor.** Allow limbs and snags to stay in place and decompose naturally. Salamanders and their invertebrate prey use such microhabitats extensively.
- **Avoid fragmenting large blocks of savanna and open woodland forests with roads, field crops, developments, and other barriers.** Habitat fragmentation creates small population sizes that are subject to a host of problems, especially if individuals cannot migrate between patches. Some species will not cross open spaces, and those that try are subject to exposure, desiccation, and predation.
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs, fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves.** Provide connectivity of these habitats to remaining woodland and savanna habitat. These microhabitst

Dan Fogell

Slender Glass Lizards are often misidentified as a snake because they lack legs. In contrast to snakes, and in common with most lizards, they have external ear openings and movable eyelids. The open and relatively dry conditions of woodlands and savannas provide ideal conditions for this species. Loss of woodlands and savannas to development and succession to more closed-canopy conditions may threaten populations in some areas.

are important for breeding sites, foraging areas, and hibernacula. Without them many species of amphibians and reptiles 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 woodland obligates are a concern, consider leaving patches of large trees. Woodland habitat can serve as refugia for animals from which they can more easily disperse and repopulate harvested areas as they mature. Where grassland obligate species are a concern, clearcuts may be preferred. Where both grassland and woodland species are present, a patchwork of harvest practices may be appropriate.
- **Manage deer populations so that savannas and open woodlands will maintain understory structure crucial to amphibians and reptiles.** Too many deer can have negative impacts on the herbaceous and shrub layers in woodlands, destroying microhabitats beneficial to herps.
- **Ensure that the woodland floor structure is maintained in as natural a state as possible.** Leave logs, snags, leaves, and other woody materials on site; replace as needed.
- **Minimize or eliminate barriers to dispersal across the landscape between savanna and woodland fragments. Leave or add windbreaks and hedgerows through disturbed areas.** *Many species risk exposure to predation and desiccation if they try to cross open spaces.*
- **Maintain the open nature of the habitat - promote a spatially variable or sparse tree canopy cover appropriate for the area.** *Larger, older trees may be desirable in grassland dominated areas because the canopy they create provides*

Carl R. Brune

The dry, relatively open conditions of some woodlands provide ideal habitat for racers. North American Racers are active hunters and may forage with their head and neck raised off the ground. Rodents are a favored prey item of adults. Racers, as their name implies, rely on their speed to escape predation, and curious humans. Because of their propensity to move extensively, racers are vulnerable to the loss and fragmentation of habitat through agricultural and urban development.

Scott Gibson

The pattern and coloration of juvenile racers is distinctly different to that of adults. It is not until an individual is in its 2nd or 3rd summer that the pattern fades and they resemble the coloration of an adult.

a variable microclimate as well as structures used by some species of reptiles, such as snakes and lizards.

- **To the extent possible, mimic natural disturbance patterns such as windthrows and fire when conducting forest management activities.** *Such actions promote natural processes that open the canopy and alter the forest structure, thus making the habitat more attractive to species that could not survive in a closed canopy forest.*
- **Avoid locating trails through core and embedded habitats like wetlands.** *Public access to such areas via trails increases the chances for habitat disturbance, 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.*
- **If herbicides are necessary to control invasive plants in or near potential amphibian breeding sites, then use formulations approved for aquatic use.** *Tadpoles and salamander larvae are sensitive to many forms of herbicides that reach water. Aquatic herbicides are designed to be less toxic to amphibians and other aquatic wildlife.*
- **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 instead create mats, thus preventing use of the area by some amphibians and reptiles.*
- **Limit or prohibit off-road vehicle access.** *Trampling of grasslands will likely kill individual animals and destroy essential microhabitats.*

Greg Lipps

Fire is an important management tool for the restoration and maintenance of savannas and woodlands as it helps maintain the "open" character of these habitats. Prescribed fire is being used in the restoration of this oak savanna habitat in Ohio.

Bob Hay

Woodlands and savannas are one of the many habitats used by American Toads. However, toads also require access to aquatic breeding sites, such as ditches, shallow ponds, and slow-moving streams, to persist in these habitats. During dry periods American Toads will bury down in soil (they dig in using their hind feet), and will remain buried until conditions improve (e.g., until it rains).

Mike Graziano

Eastern Hog-nosed Snakes have a very specialized diet, feeding almost exclusively on toads. Enlarged teeth in the snake's upper jaw allow them to "pop" toads that have filled up with air (which they do as a defensive measure), and swallow them whole.

- **Maintain or restore connectivity between similar habitats and between complementary but dissimilar habitats.** *Amphibians and reptiles will move great distances between habitats. Natural corridors provide routes that minimize mortality from predation and desiccation.*
- **In extensive woodlands and savannas, restore natural fire frequency, intensity, and seasonality where appropriate.** *Fire-adapted plants regenerate quickly from burns and form a diverse habitat favored by many herp species.*
- **Whenever feasible, prescribed burns in small patches and areas with sensitive herps should restricted to the winter (November-February) or when high temperatures do not exceed 40º F.** *Amphibians and reptiles are safer from burns while they hibernate underground, or in water. Amphibians and reptiles are particularly in danger from fire during migration, breeding, and nesting seasons.*
- **Slow-traveling backburns should be used to the fullest extent possible.** *These fires should provide herps with the greatest chance of finding refuge in front of the flames.*
- **Maintain or restore natural hydrological cycles.** *Many types of savanna and open woodland have embedded wetlands, seepages and small, perennial streams. Avoid altering these hydrological features. Amphibians do best in habitats with clusters of wetlands with varying hydrology (ranging from seasonal to permanent).*

Nathan Engbrecht

When threatened, hog-nosed snakes possess the best bag of "tricks" you'll ever see. If flaring out their neck (appearing 'cobraesque'), and striking (with their mouth closed!) doesn't deter a predator (or an amused herpetologist), these fantastic snakes will roll over and play dead, complete with their tongue hanging out. If one tries to right the "dead" snake, it will dutifully roll over and die again.

Scott Gibson

Western Chorus Frogs can be found in woodlands, provided that suitable aquatic breeding habitat (such as fish-free ponds and pools) is available. These frogs remain close to aquatic sites years round, and are rarely encountered outside of the breeding season, as they spend much of their time buried under leaf litter or other ground debris. Land managers can help Western Chorus Frog populations by protecting aquatic breeding sites within woodlands.

Nathan Engbrecht

Spring Peepers are found in woodlands with suitable breeding sites, such as ponds and ditches. Large congregations are often heard calling from these aquatic sites during the breeding season in early spring. Outside the breeding season Spring Peepers disperse into surrounding woodlands where they seek refuge in leaf litter and other ground cover (e.g., logs). Land managers can help ensure the continued presence of this species by protecting aquatic breeding sites and the woodland habitat that surrounds them.

This is the Woodlands and Savanna module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

GRASSLAND AND PRAIRIES

Healthy grasslands and prairies are dominated by a wide diversity of native grasses and herbaceous plants (forbs). These open, expansive habitats once blanketed much of the central United States from the western slopes of the Rockies east through western Indiana in areas where precipitation was inadequate to support significant tree or shrub cover. This region supports a multitude of grassland types, each being influenced by precipitation and soil characteristics. For example, the Northern Great Plains Steppe and Central Shortgrass Prairie ecosystems within the western portion of the prairie range support mostly Mixed-grass/Shortgrass Prairie, while the Central Tallgrass Prairie ecosystem that extends into western Indiana supports predominately Tallgrass Prairie. The once ubiquitous coverage of these habitats is evident when one considers that grasslands and prairies are represented in half of the ecoregions of the Midwest.

Conversion to agriculture since European settlement has had a significant impact on these natural communities, and today only about one percent of pre-settlement prairies remain. Prairies are considered to be one of the world's most endangered ecosystems.

Prairie ecosystems vary from wet to dry. Wet prairies often develop in depressions where the water table is close to the surface. These areas often support a diversity of sedges, forbs such as boneset, Joe-Pye weed, New England Aster, and cord and blue-joint grasses. Dry prairies typically have shallower, well-drained soils with reduced capacity to retain moisture.

Grassland and prairie habitats once covered much of the Midwestern landscape. These habitats have been largely lost to agricultural development. Today, prairies are considered one of the world's most endangered ecosystems.

Flora composition in these systems may include big and little bluestem grasses, Indian grass, sideoats grama, porcupine grass, compass plant, black-eyed susan, purple coneflower, and butterfly weed.

Aquatic features embedded within grassland and prairie ecosystems, such as the prairie potholes of North and South Dakota, Iowa, Minnesota, and Wisconsin, provide important habitat for many species of amphibians and reptiles. In areas devoid of these oases, snakes and lizards are more typical inhabitants. As most amphibians require water for breeding, they are typically found only where aquatic refuges are nearby.

The remaining intact grasslands and prairies of the Midwest are now isolated islands in a sea of agriculture and urban development. Suppression of fire and encroachment by nonnative species such as brome and quack grass has reduced the quality of many remaining grassland and prairie areas. Towards the eastern edge of the prairie range, where rainfall is greater, fire suppression has also resulted in the loss of grasslands/prairies as the result of increased closed canopy habitat.

Bob Hay

CHARACTERISTIC SPECIES:
Eastern Tiger Salamander, Plains Leopard Frog, Plains Spadefoot, Ornate Box Turtle, Slender Glass Lizard, Common Five-lined Skink, Plains Hog-nosed Snake, North American Racer, Gophersnake (Bullsnake), Prairie Rattlesnake

Bob Hay

Within the Midwest, Ornate Box Turtles are distributed in dry, sandy grasslands and open savannas. Mortality from automobiles, lawn mowers, and farm machinery, as well as loss of suitable habitat have contributed to population declines across much of the species range.

Dan Fogell

A remnant of glaciation, prairie potholes are depressional wetlands found in North and South Dakota, Wisconsin and Minnesota. Some prairie potholes hold water year-round, while others are temporary in nature. Unfortunately, prairie potholes are threatened by draining and development from agriculture, and the EPA has documented that more than half of all prairie potholes have been drained or altered. Prairie potholes provide important habitat for waterfowl, as well as several species of amphibians and reptiles.

PRAIRIE POTHOLES: DUCK FACTORIES AND AMPHIBIAN MAGNETS

The prairie pothole wetlands of North America are characteristic of the recently (thousands rather than millions of year ago) glaciated landscapes of the northern Great Plains and the northwestern Midwest. Potholes range in size from shallow, seasonal wetlands that dry in the late summer of wet years and may not form at all during droughts, to the deep (> 40 m), permanent basins exemplified by the lakes of the Okoboji Region in Northwest Iowa, known as "duck factories." Prairie potholes are among the most productive ecosystems on earth. Fishless prairie potholes are magnets for amphibians and reptiles. Amphibians such as Great Plains Toads, Plains Leopard Frogs, Plains Spadefoots, and Eastern Tiger Salamanders breed and develop in these basins. Painted Turtles, Snapping Turtles, and Blanding's Turtles, Common Gartersnakes, Gophersnakes (Bullsnakes), and Red-bellied Snakes call them home. Prairie potholes are continuously being threatened by human agricultural and aquacultural activities. They have also been the focus of intense conservation efforts by a wide-range of game and non-game organizations. – *Michael Lannoo*

USFWS

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

- **Where mowing and haying are goals:**
  - *if possible 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). In addition to reducing reptile injury and mortality, increasing the mowing deck height can benefit landowners and land managers by reducing wear on machinery, reducing soil erosion, and increasing soil humidity.*
  - *if mowing during the active season is necessary, do first cutting after wildlife breeding (turtle and bird nesting, fawning) season is over (generally safe after mid-July), mow during the warmest part of the day on sunny hot days (>88ºF), and mow only a portion of contiguous habitat at one time (less than 50%).*
  - *Using mowing systems which do not create suction will help minimize mortality.*
- **Restrict the use of heavy machinery for brush and tree cutting to late fall and winter.** *Heavy machinery can rut and compact soils, and kill reptiles and amphibians.*
- **Use livestock prescriptively to prevent over-grazing.** *Over-grazing eliminates grass cover used by amphibians, reptiles, and other wildlife, and it increases erosion on slopes. Try to maintain adequate grass cover of over 8 inches on average.*
- **When possible, closely control grazing and watering of livestock in and near sensitive aquatic habitats embedded in grasslands.** *Livestock can trample eggs, and waste products will cause eutrophication, oxygen depletion, and amphibian larval death. Consider fencing livestock out of at least some of these sensitive areas.*
- **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.*

Dan Fogell

Mowing and haying activities can result in injury and mortality to amphibians and reptiles. Impacts may be minimized by consulting with local experts to determine the most appropriate timing for these activities.

Greg Lipps

Western Chorus Frogs will inhabit grassland and prairie habitats as long as suitable breeding areas (such as prairie pothole wetlands) are available.

Jeff Briggler

A grassland inhabitant of the Great Plains, the Great Plains Skink is the largest skink in the United States. To escape hot conditions, this species will burrow into loose soil, or seek shelter under rocks.

Nathan Engbrecht

Access to suitable aquatic breeding sites (e.g., permanent and semi-permanent wetlands, such as prairie pothole wetlands) limits the distribution of Eastern Tiger Salamanders in grassland and prairie habitats – they are absent from grasslands and prairies that do not contain suitable breeding sites. Land managers can benefit Eastern Tiger Salamanders by protecting wetlands and the upland habitat that surrounds them.

Nathan Engbrecht

The cryptic pattern and coloration of the Bullsnake affords excellent camouflage in the prairie habitats they inhabit. Their diet is primarily comprised of rodents and other small mammals. Midday heat will drive Bullsnakes to seek shelter underground in mammal burrows or old root systems.

Tom R. Johnson

The Plains Spadefoot is a resident of grassland and prairie habitats with loose soils that allow for easy burrowing. Because of their mostly subterranean lifestyle (they spend much of their life burrowed underground) they are rarely encountered, except when they emerge to breed. Heavy rainfall stimulates emergence for breeding, which typically occurs in temporary ponds and pools. During drought years they may not emerge at all.

- **When using fertilizers and pesticides, follow label directions and adequately buffer aquatic areas.** *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 vegetative buffer to prevent runoff. If herbicides need to be used near water or to control wetland plants, then it is safer for amphibians and other aquatic wildlife to use fall applications and formulas that are approved for aquatic use.*
- **Consider placing roads in strategic locations were they can double as fire breaks.** *Situate roads away from wetlands or other sensitive aquatic habitats.*
- **Disking is discouraged.** *It causes direct mortalities and disrupts soil structure.*
- **Provide aquatic connectivity by assuring that culverts under roads are properly designed.** *Culverts should be as large as possible and placed such that herps can enter and exit easily.*
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs, fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves.** *Provide connectivity of these habitats to remaining grassland and prairie habitat. These microhabitats are important for breeding sites, foraging areas, and hibernacula. Without them herp biodiversity will not be as great.*

TIMING PRESCRIBED BURNS

Prescribed fire is a useful tool for helping to impede successional change and control invasive plants. Consequently it is also valuable for increasing suitable habitat for herpetofauna. However, fire may also be damaging to resident populations of reptiles and amphibians. Most of the Midwest's herpetofauna have a quiescent period in the winter based on photoperiod and environmental temperatures when they are out of the "reach" of fire. This offers a window of opportunity for burning.

Greg Lipps

This Eastern Box Turtle was killed during a burn. Many such species cannot tolerate additional losses of adults.

However, pond-breeding salamanders may emerge late winter, some frogs may also be out early, and warm periods lasting days may induce emergence by many species as well, even in mid-winter. Burns around wetlands as early as February may impact salamander breeding migrations by removing the detritus upon which they rely for cover. Forest burns in March may harm Eastern Box Turtle populations, and burns in meadows and old fields after mid-May through early July will impact turtles laying eggs. Land managers should always use adaptive management principles, and adjust the timing and frequency of burns based on the effects to wildlife, not just plants.

When spring and summer burns are needed to maintain floristic diversity and community stability, burns should be predominantly backburns, and under conditions leading to very low rates of spread. Burn conditions should also be selected to lead to patchy burns. In areas with sensitive herp species, consult your state herpetologist for guidance, or see if someone in PARC can assist you.

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 trees may be desirable in a grassland community because it provides a variable microclimate and structures used by some species of reptiles.*
- **Promote diverse, native grasses, legumes, 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 creates mats, thus preventing use of the area by some amphibians and reptiles.*
- **Limit or prohibit off-road vehicle access.** *If off-road vehicle access cannot be prohibited, manage access through a well planned trail system that avoids sensitive habitats and predictable migration corridors. Uncontrolled off-road vehicle access can trample grasslands and will likely kill individual animals and destroy essential microhabitats.*

Scott Ballard

Six-lined Racerunners prefer open habitats such as grasslands and use scattered shrubs, rocks, and burrows as retreat sites. As their name implies these lizards are difficult to catch due to their speed. Use of prescribed fire to help maintain healthy grasslands and prevent shrub and tree encroachment may benefit this species.

- **Maintain or restore connectivity between similar habitats and between complementary but dissimilar habitats.** *Amphibians and reptiles will move great distances between habitats to fulfill all of their needs. Natural corridors provide routes that minimize mortality due to predation and desiccation.*
- **Identify and protect embedded habitats such as seasonal wetlands, wet meadows, bogs,**

Dan Fogell

Dan Fogell

Fire can play an integral role in maintaining healthy and productive grassland and prairie habitats. Fire promotes the regeneration of many native grass and herbaceous (forb) species. The image at right shows new growth after a prescribed burn in a tallgrass prairie.

fens, small streams, springs, seeps, rock outcrops, glades, talus, and caves. *Provide connectivity of these habitats to remaining grassland and prairie habitat. These microhabitats are important for breeding sites, foraging areas, and hibernacula. Without them many species of amphibians and reptiles will not be present.*

- **Maintain native grassland cover around sensitive habitats such as wetlands embedded within grasslands/prairies.** *Grassland cover around wetlands provides shoreline structure for breeding, foraging, and refuge, and facilitates movement into and out of the wetland.*
- **Consider a range of management options before using pesticides or other chemical applications in or near wetlands.** *If they are required, carefully follow label directions and make sure there is an adequate buffer around wetlands. Do not rinse canisters or equipment in wetlands.*
- **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.*
- **Where fire is not possible, consider limited, controlled grazing, especially by herbivores such as goats and bison.** *Grazing can act like fire to encourage suppressed plant life.*
- **Maintain or restore natural hydrological cycles in wet grasslands.** *Many types of grasslands have embedded seepages and small, perennial streams. Avoid altering these hydrological features.*
- **Leave habitat structure such as woody materials, tree tops, and rock piles in place.** *Rocks, brush piles and other woody materials provide important shelter and refuge sites.*

Dan Fogell

Prairie Rattlesnakes are found in the western reaches of the Midwest, in the grasslands of the Great Plains, where they prey primarily on small mammals. Rock outcrops and ledges provide important shelter and overwintering locations for this species. Because of their reliance on these microhabitat features, loss of such structures will cause population declines.

Mike Graziano

As its name implies, the Plains Leopard Frog is a species of grassland and prairie habitats, but they are generally only found in close association with aquatic habitats, such as small streams and ponds. They are also known to use cattle/stock ponds. Aquatic sites are critical for breeding and hibernation. Loss or degradation of aquatic sites, and the grassland and prairie habitat that surrounds them, threatens populations. In areas where game fish and/or bullfrogs have been introduced, Plains Leopard Frog populations have declined.

This is the Grasslands and Prairies module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.


Elliot Stahl

CAVES AND KARST

When we look over the countryside, we are most aware of features such as forests, lakes, and agricultural fields. However, in many areas across the Midwest, a number of subterranean elements such as caves are important parts of the landscape. Over the millennia, water has been seeping through porous soil and gradually dissolving carbonate rocks such as limestone. The result of this geological process has been the creation of unusual surface and subterranean features. In the absence of disturbance, the features most characteristic of caves include total darkness, very little soil (mostly rock), relative permanence (in contrast to more ephemeral environments like a forest), and comparatively constant environmental conditions (temperature, relative humidity, minimal air flow). The long history of isolation helps contribute to the uniqueness of each—no two caves are alike in their physical, environmental, or biological features. Because caves and karst are embedded within other types of natural habitat, such as forest, they are greatly influenced by activities that occur within the larger habitat matrix. In the Midwest, caves and karst occur primarily in the Interior Low Plateau, Ozarks, Prairie-Forest Border, and Black Hills ecoregions.

The cave environment is a relatively "harsh" one. Deeper into cave systems, light diminishes and food supply becomes scarce. Because of this, the species that inhabit caves are highly specialized. There are only a handful of amphibians that inhabit these areas for a great part of their life cycle, and the majority of these are salamanders. No reptiles live solely in caves. Most amphibians found in caves are more commonly


Elliot Stahl

Some caves, such as this one in southern Indiana, contain delicate and fragile formations that that can be easily destroyed if not adequately protected.

observed near cave entrances or within the "twilight zone," where visible light still reaches within the cave. Other species of reptiles and amphibians may use caves in a more opportunistic manner. For example, some species of snakes, such as ratsnakes and Timber Rattlesnakes, may occasionally be found foraging around cave entrances, and ratsnakes have been known to hibernate in caves.

Carolyn Caldwell

CHARACTERISTIC SPECIES:
Long-tailed Salamander, Cave Salamander, Grotto Salamander, Green Salamander, Pickerel Frog, Gray Ratsnake, Common Gartersnake, Timber Rattlesnake

Mike Graziano

Cave Salamanders are found in limestone regions of the Midwest. While they are commonly found in the twilight zone of caves, they may also be found in the dark interior areas. Cave Salamanders have a prehensile tail which they use to assist with moving across the vertical and sometimes slippery surfaces of cave walls. Activities that pollute and degrade cave and spring habitats (such as runoff from roads, timber harvesting, and agricultural practices) will negatively affect this species.

MANAGEMENT GUIDELINES

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

- **Control cave access.** *Where cave access is permitted, limit human activity to times outside of greatest 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. Limit access to least sensitive areas.*
- **Establish natural buffers to protect caves and sinkholes from potential sediment sources such as timber harvest, agriculture, residential development, and other land-use activities in surrounding habitats.** *Cave amphibians and endemic invertebrates are highly sensitive to changes in the quality of their habitat. Buffers can help maintain the quality and quantity of water entering the karst aquifer by stemming sediment import and runoff that can destroy sensitive microhabitats used by cave amphibians.*

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:

Scott Johnson

Unfortunately cave entrances have often been used as dumping grounds for trash. Chemicals can leach from trash and adversely affect the cave environment, potentially contributing to poor water quality and groundwater contamination.

Scott Johnson

Although openings may seem small, the cave system found underground can be amazingly complex, and highly sensitive. Caves are extremely vulnerable to surface activities, such as runoff from roads, timber harvesting, and agricultural practices.

- **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/news2/mines/batsmines_38-45.pdf).*
- **Do not alter natural airflow patterns in and around the cave.** *Altering cave entrances will change airflow, temperatures, and humidity. Cave organisms are sensitive to rapid changes in their cave ecosystem.*
- **Consider the historical landscape in which the embedded cave once existed when making management decisions.** *Use old aerial photographs where possible. Restoring the surrounding habitat to its historical conditions is likely the best choice ecologically for the species that live in, or rely on, the embedded habitat.*
- **Maintain forest or natural vegetative buffers around all cave entrances.** *Natural vegetative buffers help prevent excess nutrients and sediment from entering caves and sinkholes.*
- **Protect water that flows into and out of caves.** *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, as well as destroy the integrity of these sensitive systems.*

Greg Lipps

The arboreal nature of ratsnakes makes them particularly adept at climbing cave walls (ratsnakes have been observed scaling the sides of buildings).

Scott Johnson

Gates placed at cave entrances can help preserve and protect the unique physical structures found within caves, as well as sensitive wildlife that resides there.

- **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 to those areas with the lowest 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.** *They trample microhabitats and contribute excess nutrients to underground systems via fecal matter.*
- **Remove trash and debris dumped into caves and sinkholes.**

For additional information on cave conservation, visit the following websites:

National Speleological Society: *www.caves.org*

American Cave Conservation Association: *www.cavern.org/acca/accahome.html*

This is the Caves and Karst module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Mike Graziano

Green Salamanders live in crevices in caves entrances and in shaded and moist rock walls and cliffs in forests. They are quite arboreal and can also spend considerable time on tree trunks and in the canopy of trees surrounding rock outcrops. Green Salamanders are vulnerable to activities that degrade or destroy caves and rock walls, and the forest that surrounds these areas.

Greg Lipps

Long-tailed Salamanders are sometimes found in caves and mines, and in damp shale banks. They rely on cool water seeps and springs that can be associated with caves for breeding. Pollution of aquatic systems that flow into or out of caves can negatively affect Long-tailed Salamander populations.

Jeff Briggler

These beautiful rimstone pools in Missouri are home to larval salamanders and adult Grotto Salamanders.

Jeff Briggler

Grotto Salamanders inhabit caves that are fed by small streams and springs, and are found only in southern Missouri in the Midwest, in the Ozarks ecoregion. The aquatic larvae (shown) are found in the small streams and springs that flow into and out of caves (occurring both inside and outside caves). Grotto Salamanders are vulnerable to pollution and sedimentation of water that flows into and out of caves, and activities that degrade or destroy the cave environment itself.

Elliot Stahl

ROCK OUTCROPS, GLADES AND TALUS

Rock outcrops, talus and scree slopes, and glades represent relatively small habitats that are usually embedded within other types of natural habitat, such as forest or grassland. Within the Midwest these embedded rocky habitats are more abundant within the Black Hills, Great Lakes, Superior Mixed Forest, Ozarks, Interior Low Plateau, Western Alleghany Plateau and Prairie-Forest Border ecoregions. They are generally sparsely vegetated because of poor soil, periodic fires, and erosion. They have little or no soil and the underlying rock protrudes through the surface. Drainage is thorough, so the habitat is also dry. Poor growth conditions for plants means that sunny and warmer conditions will exist at ground level. These areas thus represent important areas for many reptiles.

Glades are rocky barrens that are largely dominated by grasses but usually contain some sparse woody vegetation. They are often situated with a south to western exposure, on moderately steep slopes, and are interspersed with rock fragments. Unfortunately fire suppression and forest management has caused many glades to shift towards closed canopy, and consequently their attractiveness to herps has diminished.

Cliffs, areas with steep, vertical exposures of rock, frequently occur along river bluffs. The rock ledges or shelves formed by cliffs are often sandstone or limestone. Sandstone escarpments support dominant tree species such as post oak, blackjack oak, red cedar, and winged elm, with canopies of oak and hickory on the more gradual slopes. Limestone escarpments

Zack Walker

Rock outcrops represent long-term habitats for amphibians and reptiles. Considering the historic conditions found at these sites can help with conservation and management efforts. For example, if the rock outcrop was once in an old growth forest, then it probably benefits salamanders by being cool and moist. Alternately if it once was in a savanna that has succumbed to invasive plants, then it might benefit snakes and lizards by being opened to sunlight.

support tree species such as buckthorn, dwarf hackberry, red cedar, and blue ash. At the base of these cliffs are large piles of broken and fragmented rock known as talus. In between the broken fragments, the many hollow pockets and channels act as refugia for a variety of amphibians and reptiles. Quarries are cliffs that have been created by humans through mining activities.

While amphibians are much less abundant than reptiles in these habitats, toads may be visible inhabitants, while other amphibians may be hidden underneath rocks on talus slopes, or in deep crevices and fissures within the face of a cliff. Many species of lizards and snakes use the exposed rocks of glades and cliff areas.

Scott Ballard

Mike Graziano

Not all rock outcrops should be managed to be dry and exposed. Green Salamanders live in the vicinity of damp, cool cliffs and rock outcrops, and may also be found in caves. Within the Midwest, the distribution of the Green Salamander is restricted to the Interior Low Plateau, Cumberlands and Southern Ridge Valley, and Western Allegheny Plateau ecoregions in southern Ohio, however disjunct populations have been recently found in southern Indiana. The species is state listed as endangered in both Indiana and Ohio.

Mike Graziano

Western Wormsnakes inhabit moist, rocky areas in forested habitats. This burrowing species is rarely observed on the surface and is usually found under rocks and logs.

CHARACTERISTIC SPECIES:
American Toad, Fowler's Toad, Spotted Salamander, Long-tailed Salamander, Cave Salamander, Green Salamander, Slimy Salamander, Narrow-mouthed Toad, Pickerel Frog, Six-lined Racerunner, Eastern Collared Lizard, Coachwhip, Copperhead, Timber Rattlesnake, Ring-necked Snake, Flat-headed Snake, Smooth Earthsnake, Western Wormsnake, Western and Gray Ratsnakes.

Chris Phillips

Glades are open areas found within forests. This rhyolite glade in the Ozarks of Missouri provides basking opportunities for several species of lizards and snakes, such as Eastern Collared Lizards, Eastern Fence Lizards, Common Five-lined Skinks, Coachwhips, and racers.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY:
Timberlands, Hunt Clubs, Farmlands, Ranches, 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 educated about any 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, as well as make poaching more difficult.*
- **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.*

Jeff Briggler

Eastern Collared Lizards are inhabitants of dry, hilly, and rocky areas. Rock piles and limestone ledges in open, sunny areas are favored hangouts. In the Midwest their distribution is restricted to southern Missouri and Kansas. These brilliantly colored lizards will defend their territory with impressive displays of aggression which can include head bobbing and push-ups. When threatened they have been observed to run away on their hind legs.

- **Remove invasive trees and shrubs around rock outcrops and glades.** *Some outcrops and glades are susceptible to forest shading from the edges and below as trees grow. If these areas were historically dry, plants may need to be removed to restore direct sunlight. If historically moist, care should be taken to keep the site shaded, and consequently as moist as possible.*
- **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:

- **Protect habitats adjacent to outcrops, glades, 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, glades, 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.*

Jeff Briggler

Pickerel Frogs may occasionally seek shelter in moist rocky outcrops, especially those that are located near cool, clear-water aquatic sites. These frogs eat a variety of insects, spiders, and other invertebrates, and may be active both during the day and at night. Pickerel Frogs produce skin secretions that make them extremely distasteful, and because of this they have few natural predators.

Mike Graziano

Copperheads inhabit rock outcrops and surrounding areas in dry, forested, hilly areas. Their diet is variable and includes small mammals as well as cicadas and moth larvae when they are abundant. Copperheads often hibernate communally with other snakes, including other copperheads and other species such as Timber Rattlesnakes, racers, and ratsnakes. Hibernation dens are very important to this species as they show high fidelity to the den and return every winter to hibernate. Loss of such structures can have serious negative effects on the snakes that rely on them.

Scott Ballard

Narrow-mouthed toads have a very unique appearance. They possess a round body, a pointed head, and a small mouth (as their name implies). This species is an example of where shaded conditions may be beneficial - narrow-mouthed toads prefer moist microhabitats, and often seek shelter under rocks and other materials.

Alan Resetar

In the eastern portion of the Midwest cliffs and large rocky outcrops are primarily restricted to riverine corridors and lake shores. Further west, exposed rock is more common, and is an especially prominent component of the landscape in areas like the Black Hills.

- **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.*
- **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: "Time Out – Overwintering Snakes").*
- **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.*
- **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.*
- **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.*
- **Monitor the long-term condition of reptile den sites and significant salamander locations.** *Snakes from an extensive area may hibernate communally at a single location year after year. 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.*
- **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.*
- **Consider the historical landscape that the embedded rock outcrop, cliff, talus, or glade once existed in.** *Use old aerial photographs, where possible. Restoring the surrounding habitat to its historical conditions is likely the best choice ecologically for the species that live in, or rely on, the embedded habitat.*

TIME OUT – OVERWINTERING SNAKES

Across the Midwest, virtually all amphibians and reptiles will become dormant for much or all of winter. Reptiles like snakes are reliant on external sources of heat to regulate body temperature (ectothermy), and good basking sites become scarce as the days get shorter. Snakes thus are unable to capture enough prey or to get warm enough to digest it. Because snakes are unable to warm up sufficiently during winter months they are unable to capture prey, or even digest it. The solution? Find some place to "lay low" until things warm up again. This period of dormancy is referred to as overwintering, or hibernation, although there is some argument about whether the latter term is appropriate given the limited evidence for depressed metabolic rates beyond the effects of cool temperatures.

Many snakes such as the Timber Rattlesnake (shown here) overwinter in rocky sites such as talus slopes, the bases of cliffs, or even in seams of rock largely underground. These embedded microhabitats provide "hibernacula" that are cold but do not freeze, promoting energy conservation within the safety of a stony hide-away.

Appropriate hibernacula may be few and far between, and so snakes may travel long distances to reach them and return to the same one year after year. Since other snakes in the area will face the same limitations regarding the availability of suitable hibernacula, these locations might be used by numerous snakes of different species all converging on the site from many directions, and then likewise dispersing each spring. The spring exodus of snakes from a hibernaculum can be quite a spectacle, with snakes seemingly "everywhere."

When hibernacula are scarce, the species and individuals that rely on them are particularly vulnerable to site discovery and loss. For example, if poachers become aware of hibernacula, they can collect many of the individuals of a population in a short amount of time, and potentially extirpate the population by over-exploitation. In addition, if hibernacula are destroyed, individuals may not know where else to hibernate, or they may not reach a suitable site before winter sets in. How are hibernacula destroyed? It can be overt, as by burying the site or developing the ground all around it. However, it can also be more insidious, as by gradual overgrowth by vegetation, often by invasive plants. When that happens, the thermal qualities of the site change. Excessive shading over and around hibernacula may not allow snakes to bask on emergence, making the site less suitable. Hibernacula should thus be protected from poaching, destruction, and overgrowth by shrubs and trees.

– Bruce Kingsbury

Nathan Engbrecht

This is the Rock Outcrops, Glades and Talus module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Jennifer Anderson-Cruz

AGRICULTURAL LANDS

The rich soils of the Midwest have proved to be ideal for agriculture. What initially began as small plots of plowed field imbedded in a forest or prairie landscape has become just the reverse—small plots of remnant prairie and forest dotting the agricultural landscape. The Midwest is the "Breadbasket" of the United States, with all of the Midwestern states represented in the "Grain Belt" or "Corn Belt" regions. Today a vast majority of the Midwest landscape is devoted to agriculture. Agricultural lands in the Midwest include row crops, pastures and hayfields, plantations, orchards, and cranberry operations, as well as outbuildings, barns, and abandoned fields. Because the majority of lands in the Midwest have been converted to agriculture, procedures for integrating agricultural lands into conservation plans are necessary to increase the effectiveness of managing the few remaining natural areas that are embedded within.

Depending on disturbance regimes, agricultural lands vary from moderate to severe in terms of challenges to amphibians and reptiles. For example, row crops present a more hostile environment than less intensively managed areas such as lightly grazed pastures. Few if any herps truly thrive in agricultural lands. Instead, most observations of herps in agricultural lands are individuals venturing out from remnant, more natural, habitat patches imbedded in the agricultural landscape. By protecting and maintaining the integrity of remnant patches of natural habitat within the agricultural landscape, and by providing and conserving corridors linking these remnant patches with each other, as well as with larger

Christine Barlow

Much of the Midwest has been converted to agriculture. In many areas natural habitat remains as only isolated patches within the broader landscape, with little or no connectivity between these patches. When seasonal wetlands and forested patches are disconnected, as shown in this aerial photograph, amphibians and reptiles may be unwilling or unable to travel between habitat patches and populations may become isolated.

natural habitats, the impact of agricultural practices on Midwestern amphibians and reptiles can be reduced. Consequently, management guidance for herps in agricultural areas focuses on such patches.

Without appropriate precautions, the use of fertilizers and pesticides can potentially increase the import of nutrients and chemicals into streams, affecting downstream water quality, and thus subsequently result in unintended impacts to some aquatic species including amphibians.

Paul Bartelt, Jay Rubinoff, and Bob Hay

CHARACTERISTIC SPECIES:
American Toad, American Bullfrog, Green Frog, Painted Turtle, Pond Slider, Snapping Turtle, Western Foxsnake, Northern Watersnake, Common Gartersnake, Gophersnake (Bullsnake).

Bob Hay

Farm ponds and other areas of standing water can provide suitable breeding habitat for American Toads. Females lay an astonishing number of eggs during the breeding season: between 4,000 – 8,000 tiny black eggs are laid in long double strands. Researchers have measured egg strands up to 66 feet in length!

Tim McCabe, USDA NRCS

Areas of large-scale agricultural production provide very little habitat for amphibians and reptiles. Small patches of natural habitat within agricultural lands, such as woodlots, wetlands, and drainage ditches, may provide refuge for less sensitive species such as American Toads, American Bullfrogs and Common Gartersnakes.

MANAGEMENT GUIDELINES

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

- **Protect, enhance, and buffer natural areas in agricultural landscapes.** *These are the areas where most amphibians and reptiles are found in agricultural landscapes.*
- **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. Vegetating and maintaining some areas may be eligible for financial incentives via USDA conservation programs. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **Consider restoring natural hydrological cycles to drained wetlands.** *Natural flood cycles and seasonal water retention may enhance breeding amphibian populations. As above, restoring these areas may come with financial incentives from the USDA.*
- **When possible, avoid mowing wetlands, shorelines, and ditches from mid-spring through mid-fall. When mowing fields, raise deck height to at least 8 inches.** *Raising the mowing deck height to 8 inches or more will leave important cover as well as reduce mortality of Eastern Box Turtles, Ornate Box Turtles, Wood Turtles and other herp, bird and mammal species. Increasing the mowing deck height in agricultural fields can also benefit farmers by reducing wear on machinery, reducing soil erosion, increasing soil moisture, and may even increase crop yields of subsequent harvest(s). Where possible, start mowing in the center and use a back-and-forth approach to avoid concentrating animals where they may be killed.*
- **Prescriptively graze livestock to retain groundcover vegetation as habitat for amphibians and reptiles.** *Livestock can disturb and compact soil, thus increasing erosion and runoff. Rotational grazing incentives may be available in some areas via USDA conservation programs. Livestock can be used to control invasive species in degraded wet meadows and fens.*

Lynn Betts, USDA NRCS

Jeff Vanuga, USDA NRCS

Unrestricted access to streams and wetlands by cattle can result in considerable trampling of surrounding vegetation and soil erosion, which in turn leads to declines in water quality and loss of herp habitat. Providing alternate water sources and fencing livestock out of sensitive habitats will benefit amphibians and reptiles.

- **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 CO2 levels, and affect aquatic amphibians and reptiles, especially tadpoles and salamander larvae.*
- **When using fertilizers, herbicides, and insecticides, follow label directions and adequately buffer aquatic areas.** *The directions on the labels are government mandated and have been tested for safety. Use the minimum amounts necessary to achieve management objectives. Follow all setback requirements to ensure there is an adequate buffer to prevent runoff. If herbicides need to be used near water, then it is safer for amphibians and other aquatic wildlife to use fall applications and formulas that are approved for aquatic use.*
- **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 tillage operations.*
- **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.*

Joanna Gibson

During the nesting season (between May and July) female Eastern Box Turtles may venture into agricultural fields to nest. The open canopy habitat and loose soil provides ideal nesting conditions. Unfortunately box turtles may be injured or killed by farm machinery, and due to an abundance of raccoons in these areas, nests are frequently destroyed. Providing box turtles with open sunny patches that are not farmed and are adjacent to forests may provide alternate nesting habitat.

Zack Walker

As long as small patches of natural habitat, such as woodlots, remain, and breeding habitat is available nearby, Western Chorus Frogs can persist in a wide variety of habitats, including those that have been modified by humans, such as agricultural and even residential areas. However, as with other amphibian species, chorus frogs are sensitive to pollution and populations will disappear from such areas. The breeding call of this species sounds similar to the noise produced by running finger nail along the teeth of a plastic comb.

Carl R. Brune

Ratsnakes like edge habitats and may be found along the border of woodlands and agricultural areas. These snakes may also be encountered in farm buildings. Ratsnakes are excellent guests in these settings as they primarily eat small mammals. Landowners can benefit their property and the snakes by maintaining forested edges. Forested edges reduce wind velocity and soil erosion, and also provide habitat and travel corridors for these beneficial predators.

- **Implement management strategies to increase native flowering plants.** *Plant a diverse array of flowering trees, vines, forbs and legumes to attract an insect prey base.*

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:

- **Restore agricultural lands to natural habitats.** *Even a fallow field is better habitat for herps than well managed cropland. Evaluate rationale for maintaining croplands. Research has highlighted that amphibians and reptiles will readily recolonize areas that have been actively restored to natural conditions. See the insert box on restoration efforts at TNC's Grassy Slough Reserve in Illinois. Many opportunities exist through USDA conservation programs that can provide financial benefits for retiring cropland. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **Consider enrolling in federal agricultural incentives programs, such as CRP, WRP, WHIP, or LIP that provide financial incentives to restore various habitats.** *Refer to Appendix C for more information.*
- **Maintain several hundred feet of natural upland habitat adjacent to the shorelines wetlands and streams.** *Many amphibians and reptiles use upland habitats around wetlands, streams, and rivers extensively, and as such it is "core" habitat. Vegetated buffers limit fertilizer and pesticide input from agricultural areas, and provide cover for these animals. Plant appropriate trees, vines, forbs, and legumes to provide insect foraging substrate. As for croplands, many opportunities exist through USDA conservation programs that can provide financial benefits for creating buffers around wetlands and along streams. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **Develop wide vegetative corridors between habitat fragments.** *Amphibians and reptiles will move along such habitats as they disperse to other areas.*
- **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 of many species inhabiting wetland shorelines and the areas around them.*

Bruce Kingsbury

Scott Gibson

Row crop fields often provide the least amount of cover, especially when modern agricultural technologies remove even modest amounts of "weeds" (see left photo). In these areas management practices that provide even patchy cover can benefit amphibians and reptiles. For example, movement data of Northern Leopard Frogs from northern Iowa indicate that frogs regularly used fencerows and grassy waterways (surface drainage areas such as the one shown in the right photo) to forage or move across landscapes. Thus, leaving natural vegetation along fences, ditches, and other such areas may provide the cover animals need to safely move about.

Raymond A. Saumure

Bob Hay

Turtles and snakes sometimes venture into agricultural fields to forage, nest, and seek shelter, where they are at risk of being killed by farm machinery. This Wood Turtle (at left) was killed in a hay field by a disc mower, and the Butler's Gartersnake (at right) was killed after farming equipment was used in the field it was located in. Elevating mower decks to at least 8 inches may help reduce such mortalities, and can also benefit farmers: raised blade heights reduce wear on machinery, reduce soil erosion, retain soil moisture, and can increase crop yields of subsequent harvest(s).

- **Avoid precision land leveling where possible.** *Such practices eliminate shallow depressional wetlands that are primary breeding habitats for many amphibians. Some species are in decline because of this practice.*
- **Prevent livestock access to streams and wetlands.** *Use fencing or other means to keep livestock out of water bodies so they don't pollute them. Provide alternate water sources away from streams and wetlands. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **Avoid storing silage, manure, salt, and other possible contaminants near wetlands.** *Minimize contamination of water bodies from these sources.*
- **If pesticides and fertilizers are required, be sure to adequately buffer sensitive areas, use the correct formulation, and follow label directions.** *The directions on the labels are government mandated and have been tested for safety. Use the minimum amount necessary to achieve management objectives.*
- **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. Enroll low-production wet fields into the USDA Wetlands Reserve Program (WRP), which can have significant financial benefit. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **Reduce erosion from livestock and tillage.** *Use no-till and prescriptive grazing management. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **Learn effective nutrient management (timing, amounts, mechanics of spreading).** *Consider using crop rotation and burning to add nutrients to the soil rather than chemicals. Contact your local NRCS or Soil and Water Conservation District office for further information.*
- **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 them.*
- **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.*
- **Place piles of rock, concrete, wood, or logs near the edge of woodlots or other strategic locations to provide herps with opportunities for basking, hiding and hunting.**

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 mowing is necessary, do so outside of the turtle nesting season (after mid-July), and start in the center of the field and use a back-and-forth approach working outward to avoid concentrating fleeing animals where they may be killed or stranded. Elevating the mowing deck height to 8 inches or even higher will reduce mortality and will leave important cover. Visit the NRCS website for information about planting old fields with native grasses.

CASE STUDY: HERPETOFAUNAL COLONIZATION OF RESTORED WETLANDS

When source populations occur nearby, restored or created wetlands and adjacent uplands can be rapidly colonized by amphibians and reptiles. Consequently, wetlands established on retired cropland can provide suitable habitat for many amphibians and reptiles, and have the potential to expand existing herpetofaunal populations, including those of species of conservation concern.

The Nature Conservancy's Grassy Slough Preserve is an approximately 2775-acre former vegetable farm in the Cache River drainage of extreme southern Illinois. The land was retired from commodity production in the late 1990s and 15 Wetland Reserve Program wetlands, ranging in size from 8-118 acres, were constructed in coordination with the Natural Resources Conservation Service (NRCS). The shallow wetlands were constructed by impounding water behind short, earthen dams. The surrounding uplands were planted to bottomland forest trees, particularly oaks.

Examination of three of the newly constructed wetlands over a period of four years following wetland construction revealed use by a total of 35 species of amphibians and reptiles. Frogs comprised 31.5% of the species observed, followed by snakes (26%), turtles (20%), salamanders (17%), and lizards (5.5%). Sources of herpetofaunal colonists were on-site refugia and the adjacent Cache River State Natural Area. Previously unrecorded species were seen each year, suggesting continued improvement in biodiversity. Although most of the documented species were common in southern Illinois, four species of conservation concern were also encountered.

John Palis

-John Palis

More information on the Grassy Slough preserve and the Cache River Wetlands can be found at:
http://www.nature.org/wherewework/northamerica/states/illinois/preserves/art1124.html

This is the Agricultural Lands module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

Zack Walker

American Toads are often observed in agricultural lands. These beneficial predators should be considered welcomed guest as their diet is comprised of a variety of insects and insect larvae, slugs, snails, earthworms, spiders, centipedes, and millipedes.

Lynn Betts, USDA NRCS

URBAN AND RESIDENTIAL AREAS

Urban and residential areas vary greatly in size, character, and potential suitability for amphibians and reptiles. Habitat in urban areas can include parks, woodlots, backyard habitats and ponds, wetlands of varying quality, streams with narrow wooded buffer zones, golf courses, and plant nurseries. Unfortunately, these habitats typically occur as scattered patches that are much lower in quality than the habitat that existed prior to development. Barriers such as roads, storm drains, curbs, fences, buildings and channelized streams make amphibian and reptile movement difficult and dangerous if not impossible. Furthermore, dogs, cats, crows, blue jays, raccoons, opossums and other subsidized predators often thrive in urban systems. Ultimately, few herps can adapt to the urban environment, although populations of many amphibians and reptiles persist for years.

As urban sprawl continues and areas become increasingly developed, habitat becomes more fragmented and less suitable for many amphibians and reptiles. While most urban areas are capable of supporting populations of a few tolerant generalist species, in some cases rare species are able to hold on. Understanding the roles of amphibians and reptiles in urban ecosystems is increasingly important in our efforts to find environmentally friendly solutions for problems associated with urbanization. Urban and suburban areas containing suitable habitats, whether in patches or along stream and river corridors, offer many opportunities to study how and why some species adapt while others do not.

Nick Bieser

The manicured nature of many residential communities poses many barriers to amphibians and reptiles, and few species are able to persist in these settings.

Fortunately, public support for the conservation of open space and greenways is growing across the Midwest. Urban habitat patches can offer opportunities for enhancement, restoration, and creation projects that would greatly benefit some amphibians and reptiles. Innovative strategies in these areas may reduce the effects of human expansion on the natural environment and include opportunities to enhance urban areas for reptiles and amphibians. Urban environments also offer a unique forum to promote public information and education about native reptiles and amphibians, the environment they live in, and why it is important that exotic (non-native) species are not introduced.

David and Rachel Mifsud

CHARACTERISTIC SPECIES:
American Toad, Gray Treefrog, Green Frog, Eastern Red-backed Salamander, Snapping Turtle, Painted Turtle, Eastern Fence Lizard, Common Gartersnake, Dekay's Brownsnake.

Zack Walker

American Toads are often frequent visitors to urban backyards. Here these beneficial predators will feast on insects. American Toads will only persist in urban settings if suitable aquatic breeding areas are available.

Scott Gibson

Snapping Turtles occupy rivers, streams, ponds, and lakes in urban and residential areas throughout the Midwest. Nesting females often cross roads to reach suitable nesting sites, which may include backyard flower beds. Providing urban turtles with nesting areas near their ponds may prevent them from crossing roads and being killed by automobiles.

MANAGEMENT GUIDELINES

MAXIMIZING COMPATIBILITY:
Neighborhoods and industrial areas.
When benefiting amphibians and reptiles is secondary to other management objectives:

- **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.*
- **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.*
- **Encourage developers to design and plan their project so as to minimize habitat fragmentation, protect embedded habitats, stream corridors, and maintain natural vegetation around natural areas.** *Retention of natural areas will greatly enhance the capacity of neighborhoods and other urban developments to support amphibians, reptiles, and other native animals. Work with local planners early in the planning process to help minimize impacts on natural areas remaining in your area. Education of all persons concerned with urban development will greatly increase the chances that some natural areas will be set aside.*
- **Protect wetlands, stream, and habitat corridors, and representative terrestrial habitats during construction.** *Doing so will preserve what habitat is to be left after the project is done in the best condition and minimize population losses along the way.*
- **Eliminate stormwater discharge to wetlands.** *Often developers discharge stormwater into existing wetlands. This can lead to sediment, nutrient, and heavy metal loading, higher salinity, and altered hydroperiod. Design projects to maintain existing water budget or pretreat water in a vegetated detention pond prior to discharge into wetlands.*
- **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*

Jim Harding

Streams with natural shoreline vegetation and structure have greater value to amphibians and reptiles than those that are modified. Lowland riverine habitat was preserved along sections of this stream that flows through a city in Michigan, making it more hospitable to herps and other wildlife. Herpetologists have observed American Toads, Green Frogs, Common Gartersnakes, and the occasional Painted and map turtle along this stream.

Joanna Gibson

Rivers and streams that flow through cities are often modified to reduce erosion and flooding. Unfortunately the addition of rip-rap and creation of walls pose barriers to turtle movement.

extirpate more specialized native plant species. Plants like Phragmites (giant reed) and garlic mustard can quickly colonize and take over urban and residential natural areas. Control and eradication of these plant pests is necessary to preserve these urban and residential wildlife refugia.

- **Spay and neuter cats and dogs, and keep them indoors.** *Uncontrolled pets kill amphibians, reptiles, songbirds and other wildlife.*
- **Plant a diverse array of native flowering trees, vines, forbs and legumes.** *This will attract a consequently diverse insect prey base for local herps.*
- **Control subsidized predator populations.** *Raccoons, foxes, and other subsidized predators kill and eat many amphibians and reptiles, especially turtles and their eggs. Raccoon populations can become very dense in residential areas and are a major threat to amphibians and reptiles. Homeowners should limit access to food, garbage, and shelter for subsidized predators and work with local animal control officers and game wardens to find ways to reduce subsidized predator populations.*
- **Use the correct formulation of fertilizers, herbicides, and pesticides necessary to achieve management objectives, especially on lawns and golf courses.** *Do not over-apply and only use in those areas where needed. These chemicals are often applied in excessive amounts and run off may pollute water systems in the area and downstream, potentially causing unintended impacts to amphibians and other wildlife.*
- **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.*
- **Developers should consider rerouting planned or existing roads around, instead of through, sensitive natural areas.** *Work with local planners and Department of Transportation personnel to help minimize impacts on natural areas, including secondary effects such as winter salting.*

Mike Graziano

This gravid (or egg laden – note the bulging on the side of the abdomen) female Plains Spadefoot was observed on the curb of a road in a subdivision in Omaha, Nebraska. Unfortunately residential areas are often built around amphibian breeding areas and consequently populations are at risk from road mortality and the alteration of breeding sites.

Bruce Kingsbury

Northern Watersnakes may be found in and around many urban ponds and lakes. Unfortunately this non-venomous species is frequently killed as many people think they are Cottonmouths. While Northern Watersnakes are widely distributed throughout the Midwest (they are found in every state except North Dakota), the Cottonmouth has a very narrow distribution and is found only in very southwest Indiana, southern Illinois, and southern Missouri.

Scott Gibson

Bryan Eads

The steep sides and height of street curbing used in most urban and residential areas (left) is a barrier to the movement of salamanders and turtles. Such herps are often unable to crawl up and over this curbing and can become stuck on the side of the road. Gently sloping Cape Cod curbing (right) is a "herp friendly" alternative to typical curbing, and is easily navigated by reptiles and amphibians alike.

- **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.*
- **When stabilizing soil on construction sites use herp-friendly soil erosion measures.** *Traditional mesh can trap and kill snakes, salamanders and other wildlife. Use natural herp-friendly versions that have larger mesh to reduce risk of trapping. Also make sure silt fence is removed once construction is complete as it can act as a physical barrier for wildlife for a long time.*

IDEAL: Parks, Greenways, and Nature 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, and forested, riverine floodplains.** *These aquatic systems may be the only place where many species of amphibians live or breed. Seek ways to ensure that the natural functions of such places remain intact. Buffers around wetlands help control pollution input and provide additional habitat.*

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?

Common Gartersnakes, Dekay's Brownsnakes, Redbellied Snakes, and Eastern 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

Zack Walker

- **Maintain and develop corridors between habitat fragments.** *Movement of amphibians and reptiles across the landscape is necessary as they require different habitat components (i.e., breeding or hibernation sites) at specific times of the year.*
- **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.*
- **Maintain historical water regimes in streams and rivers.** *Urban and residential systems usually alter these systems. Seek to restore them to historic natural conditions.*
- **Avoid using non-native vegetation in landscaping, and encourage control of non-native species.** *In particular, avoid those commercially available species which are known to be invasive.*
- **Keep cats indoors, as they are well known to kill amphibians and reptiles, as well as birds.**
- **Plant a diverse array of flowering trees, vines, forbs, and legumes to attract a diverse insect prey base for resident herps.**
- **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.*
- **Consider a range of management options before using pesticides or other chemical applications near wetlands.** *If they are required, carefully follow label directions and make sure there is an adequate buffer around wetlands. Do not rinse canisters or equipment in wetlands.*
- **Install a garden pool.** *If you build it, frogs will find it. Don't stock it with fish or non-native animals, however.*
- **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.*
- **Provide ground cover such as rocks and logs in patches of natural habitats.** *Such microhabitats will be attractive to some amphibians and reptiles.*
- **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.*

Greg Lipps

Mike Graziano

Fish-free backyard garden ponds, of both simple (top image) and more elaborate construction (lower image), can provide refuge and breeding habitat for frogs and toads living in residential areas. Providing cover in the form of aquatic plants and rocks or logs will increase the attractiveness of these sites to frogs and toads. The top image of a backyard garden pond in Ohio is home to dozens of Green Frogs, and within one year of construction the pond shown at bottom, built in Omaha, Nebraska, had Plains Leopard Frogs, Gray Treefrogs, Woodhouse's Toads, and Western Chorus Frogs using it.

This is the Urban and Residential Areas module of the PARC publication, HMG-1, 2nd Edition. ISBN 0-9667402-8-9. Please visit ***www.parcplace.org*** for further information, copies of the complete document, or a web-based version of these guidelines.

APPENDIX A: DEVELOPING A MANAGEMENT PLAN

An important first step in managing habitats for amphibians and reptiles, regardless of the designated land-use, is development of a 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. You will also want to identify current habitat conditions, such as the presence of invasive plants, before initiating any 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 maps and imagery of their lands. 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, and plan buffers along waterways, construction of artificial wetlands, corridors between disconnected habitats, and reintroduction of natural fire regimes.

Dan Fogell

Omar Attum

A variety of techniques may be used by herpetologists to determine the species of amphibians and reptiles that may be present at a particular area. Drift fences (top) with pitfall traps and funnel traps are often used to capture amphibians and reptiles as they move across the terrestrial landscape. Another technique includes visual surveys (bottom), which can be effective for determining the presence of different species of aquatic turtles and snakes.

USGS

Aerial photographs detail the spatial arrangement of habitats within the landscape and can help identify potential locations for habitat restoration efforts. For example, many species of wildlife, including amphibians and reptiles would benefit by maintaining buffers around all of the wetlands shown above, and by installing corridors of natural habitat between wetlands and forest patches.

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 used to look like). Historical aerial photographs are available for viewing for most of the Midwest at county Soil and Water Conservation District offices. Maps and imagery may also be available at the Natural Resources Conservation Service (NRCS), the U.S. Geological Survey, the Forest Service, and on the Internet.

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 easily incorporate many of these habitat management guidelines, 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. Such experts can be found at local universities and county, state or federal wildlife agencies, local conservation organizations and landtrusts, or by tracking down contacts through PARC.

5. Measure your success and use adaptive management. 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. Remember that measurable changes in populations may take several years. Consult with local experts before making changes to your plans.

Jennifer Anderson-Cruz

Herpetologists from local universities can provide invaluable assistance to government agency staff and other land managers and landowners in amphibian and reptile conservation and management efforts.

APPENDIX B: AMPHIBIAN AND REPTILE SPECIES OF THE MIDWEST

Depending on how you count them, The Midwest supports at least 163 native species of amphibians and reptiles: 33 frogs, 38 salamanders, 20 turtles, 16 lizards, and 56 snakes. The following table presents species occurrence information for each state and habitat covered in this book. We used the most recent taxonomic information available, but the names used to describe some species is in flux as herpetologists continue to sort out relationships between species, and so they *will* change over time.

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 February 2011.

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 occurrences by Habitat are provided, and each habitat is qualitatively assessed as O (optimal), S (suitable), or M (marginal). "Optimal" habitats are those used by individual species where they prosper and which are characteristically most associated with them. "Suitable" habitats are other secondary habitats that may also be used by a species. "Marginal" habitats are other habitats where species might persist, but really are not most appropriate for the species.

Global and State ranks: We have used NatureServe's global (G) and state (S) ranks to provide a standardized measure of abundance 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 are expected to change over time as new information becomes available. More information about the NatureServe ranking system may be found at: *http://www.natureserve.org/explorer.*

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.

Bob Hay

Spiny Softshells inhabit every state of the Midwest HMG region, where they are often observed basking on the banks of lakes and rivers. When startled they are capable of a surprisingly swift retreat to water.

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.

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

NA = Conservation Actions Not Applicable within a state (applies here to introduced species).

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

U = unknown.

X = Species regarded as Extirpated.

NOTE: At the time of publication of this guide several species included in the table were not yet included in the NatureServe database, however they are recognized by state officials. Codes were assigned to these species and are denoted in the table by a subscript letter. Explanations for these subscript letters are detailed below.

a = NatureServe does not currently list these species as occurring in the specified state (in some cases this is a result of elevation to full species per Crother et al. 2008). State agencies do however recognize their presence. For those subspecies elevated to species in Crother et al. 2008 we applied full species coding from NatureServe.

b = *Eurycea multiplicata* has been omitted and replaced with *Eurycea tynerensis*, following genetic studies that concluded that Midwestern populations are *E. tynerensis*. NatureServe coding for *E. multiplicata* was applied to *E. tynerensis*.

Additional codes listed in the table:

?# = Occurrence in Illinois is based on a single specimen. It is unknown if this individual was a released animal, or if there was a population at the site that has long been extirpated.

?## = It is uncertain whether this species is native to, or introduced into Ohio.

NR* = Only the melanistic form is afforded protection in Ohio.

Federal Status: Endangered Species Act protection, according to U.S. Fish and Wildlife Service, as of January 2006. E = Endangered, T = Threatened, C = Candidate, and PE = Proposed Endangered, for the case of the Ozark Hellbender. Note: two species in the table are coded with superscript symbols. These symbols provide additional federal status clarification:

T‡ = Only applies to MI, OH, IN populations north of 40°N Lat.

C† = Only the eastern sub-species is a candidate for listing.

Information about Federally protected species can be found at: http://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 Endangered, Threatened, or Special Concern. NatureServe state ranks for any species that is considered at risk by the state and is conferred some level of protection according to state laws are given in boldface red. Check with your state natural resource agency for most up-to-date information on legal status (see Appendix C).

Nomenclature: Given its support by all of the major herpetological societies, we have elected to follow the naming scheme presented in Crother, B. I. (Ed) 2008. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, 6th ed. Society for the Study of Amphibians and Reptiles Circular 37. There are popular alternative resources that do not use identical names, and there are common or scientific names (*Bufo* as opposed to *Anaxyrus* in Crother 2008, *Clemmys* as opposed *Actinemys* in Crother 2008) that have a long history and familiarity in North America. We support the long term goal of broad agreement on common and scientific names and so do our best to stick with Crother, but we also include longstanding names in order to limit short-term confusion.

Mike Graziano

Gray Treefrogs occur in forests and wooded areas with nearby aquatic breeding sites. They spend much of their time perched in low-hanging branches of small trees and shrubs; few venture high into the canopy. Enlarged toe pads act like "suction cups," facilitating their mostly arboreal lifestyle. Gray Treefrogs can also be found in agricultural and residential settings where trees and shrubs are near suitable breeding sites. The trilling call of these frogs can be heard throughout their active season, especially following rain or during periods of high humidity.

Zack Walker

Green Treefrog

NatureServe State-level Rank and State Protection

		NATURESERVE GLOBAL RANK	FEDERAL (USFWS) STATUS	ILLINOIS	INDIANA	IOWA	KANSAS	MICHIGAN	MINNESOTA	MISSOURI	NEBRASKA	NORTH DAKOTA	OHIO	SOUTH DAKOTA	WISCONSIN	SEASONAL (EPHEMERAL) WETLANDS	PERMANENT WETLANDS	WET MEADOWS, BOGS, AND FENS	SMALL STREAMS, SPRINGS, AND SEEPS	RIVERS AND LARGE STREAMS	HARDWOOD FORESTS	CONIFEROUS FORESTS	WOODLANDS AND SAVANNAS	GRASSLANDS AND PRAIRIES	ROCK OUTCROPS, GLADES, AND TALUS	CAVES AND KARST	AGRICULTURAL LANDS	URBAN AND RESIDENTIAL AREAS	An image of this species can be found on the following pages
AMPHIBIANS: Frogs and Toads																													
Acris crepitans	**Northern Cricket Frog**	5		5	4	3	5	2	1	5	5		NR	1	1	S	0	S	S	M	S			M			S		51
Anaxyrus (Bufo) americanus	**American Toad**	5		5	4	5	5	5	5	5	1	NR	NR	U	5	0	0	S	M		0	0	0	S			S	S	83, 88, 107, 111,113
Anaxyrus (Bufo) cognatus	**Great Plains Toad**	5				4	5		4	U	5	NR		5		0	M							0			S		
Anaxyrus (Bufo) debilis	**Green Toad**	5					2									0			S				S	0			S		
Anaxyrus (Bufo) fowleri	**Fowler's Toad**	5		5	4	3		4		5			NR			0	0	S	S		S	S	0	S			S	S	85
Anaxyrus (Bufo) hemiophrys	**Canadian Toad**	4							4			NR		U		0	0	0	0		0	0							
Anaxyrus (Bufo) punctatus	**Red-spotted Toad**	5					2									0	0		0					0	0		S		
Anaxyrus (Bufo) woodhousii	**Woodhouse's Toad**	5				3	5			5	5	NR		5		0	0	S	S		S	S	S	S			S	S	
Gastrophryne carolinensis	**Eastern Narrow-mouthed Toad**	5		2			1			5						0	S	S			0	0		S	S				104
Gastrophryne olivacea	**Western Narrow-mouthed Toad**	5					5			3	2					S	S	S	S					0	S		S		
Hyla avivoca	**Bird-voiced Treefrog**	5		3												0	0		S	0	0								vi
Hyla chrysoscelis	**Cope's Gray Treefrog**	5		4	4	4	5	4	5	5	5		NR	2	5	0	0				0	0		M			M	S	11, 75, 125
Hyla cinerea	**Green Treefrog**	5		3	2					4						0	0				0	0						S	121
Hyla versicolor	**Gray Treefrog**	5		4	4	4	4	5	5	5		4	NR	2	5	0	0				0	0		M			M	S	120, 125
Lithobates (Rana) areolatus	**Crawfish Frog**	4		4	2	1	3			3						0	S		S				0	0			M		
Lithobates (Rana) blairi	**Plains Leopard Frog**	5		4	1	5	5			5	5			3		0	0	0						0			M		95
Lithobates (Rana) catesbeianus	**American Bullfrog**	5		5	4	5	5	4	4	5	5		5	5	3		0		S	S				M			S	M	53
Lithobates (Rana) clamitans	**Green Frog**	5		4	NR	4	1	5	5	5			5		5	M	0	S	0	S	S			S			S	M	53
Lithobates (Rana) palustris	**Pickerel Frog**	5		3	4	4	X	4	4	5			NR		3	S	0	S	0		0		S		S	S			58, 103
Lithobates (Rana) pipiens	**Northern Leopard Frog**	5		5	2	5		5	4	2	5	NR	NR	5	4	S	0	0	S					0			M		25
Lithobates (Rana) septentrionalis	**Mink Frog**	5						3	5						3		0	S	0	M	S								52
Lithobates (Rana) sphenocephalus	**Southern Leopard Frog**	5		5	4	4	5			5			NR			0	0	S	S		0	0	S	S			S	S	
Lithobates (Rana) sylvatica	**Wood Frog**	5		3	4			5	5	3		NR	NR	1	5	0	S				0					S		M	9, 35, 43
Pseudacris brachyphona	**Mountain Chorus Frog**	5											NR			0	0	S			0	0		M			S		
Pseudacris clarkii	**Spotted Chorus Frog**	5					5																	0					
Pseudacris crucifer	**Spring Peeper**	5		5	NR	4	2	5	4	5			NR		5	0	0	0			0	S	S	M			M		5, 89
Pseudacris feriarum	**Upland Chorus Frog**	5		4						5						0	S	S			0	0		S			M		
Pseudacris illinoensis	**Illinois Chorus Frog**	5		2						2						0	S						S	0			S	S	
Pseudacris maculata	**Boreal Chorus Frog**	5				4	5	1	5	5	5	NR		5	5	0	0	0						S					
Pseudacris streckeri	**Strecker's Chorus Frog**	5					2									0	0	0	S		0			M			S		
Pseudacris triseriata	**Western Chorus Frog**	5		NR	4			5					NR			0	S	0			0			S				S	15, 89, 92, 108
Scaphiopus holbrookii	**Eastern Spadefoot**	5		3	2					2			1			0					S	S	0	0			S	M	
Spea bombifrons	**Plains Spadefoot**	5				4	5			4	5	NR		5		0								0			S	M	93, 114
AMPHIBIANS: Salamanders																													
Ambystoma annulatum	**Ringed Salamander**	4								3						0	S				0	S	S					M	ii, 77
Ambystoma barbouri	**Streamside Salamander**	4			3								NR			0			0		0			S					65
Ambystoma jeffersonianum	**Jefferson Salamander**	4		2	4								NR			0	0		M		0	0		S				S	38, 41
Ambystoma laterale	**Blue-spotted Salamander**	5		3	2	1		4	5				1		5	0	M		M		0	0		M				S	75
Ambystoma maculatum	**Spotted Salamander**	5		4	4			4	4	5			NR		4	0	0	M	M		0	S	M					M	8, 43, 128
Ambystoma marvortium	**Barred Tiger Salamander**	5_a					5_a		4_a		NR_a	NR_a		NR_a		M	0						M	0			S		
Ambystoma opacum	**Marbled Salamander**	5		4	4			H		5			NR			0	M		M		0	M							43
Ambystoma platineum	**Silvery Salamander**	U_a		1_a	U_a			NR_a					NR_a			0					0							S	
Ambystoma talpoideum	**Mole Salamander**	5		3	1					2						0	0				0	S							
Ambystoma texanum	**Small-mouthed Salamander**	5		5	4	3	5	1		5	1		NR			0	S		S		0		S	S			S		
Ambystoma tigrinum	**Eastern Tiger Salamander**	5		5	4	5	2	3	5	U	5	NR	3	5	5	0	S				S	0	0	S			S		ii, 9, 12, 17, 42, 87, 93
Unisexual Ambystomatids	**Unisexual Ambystomatids**	NR_a		NR_a	NR_a			NR_a	NR_a				NR_a		NR_a	0	M		M		0	0		M					
Amphiuma tridactylum	**Three-toed Amphiuma**	5			U					2						S	0		M										
Aneides aeneus	**Green Salamander**	3			1								2						0		0	0			0				31, 99, 102

Jeff Briggler

Northern Zigzag Salamander

NatureServe State-level Rank and State Protection

		NATURESERVE GLOBAL RANK	FEDERAL (USFWS) STATUS	ILLINOIS	INDIANA	IOWA	KANSAS	MICHIGAN	MINNESOTA	MISSOURI	NEBRASKA	NORTH DAKOTA	OHIO	SOUTH DAKOTA	WISCONSIN	SEASONAL (EPHEMERAL) WETLANDS	PERMANENT WETLANDS	WET MEADOWS, BOGS, AND FENS	SMALL STREAMS, SPRINGS, AND SEEPS	RIVERS AND LARGE STREAMS	HARDWOOD FORESTS	CONIFEROUS FORESTS	WOODLANDS AND SAVANNAS	GRASSLANDS AND PRAIRIES	ROCK OUTCROPS, GLADES, AND TALUS	CAVES AND KARST	AGRICULTURAL LANDS	URBAN AND RESIDENTIAL AREAS	An image of this species can be found on the following pages
Cryptobranchus a. alleganiensis	**Eastern Hellbender**	3		1	1					1			1						0	0									vi, 68
Cryptobranchus a. bishopi	**Ozark Hellbender**	3	E							1									0	0									
Desmognathus conanti	**Spotted Dusky Salamander**	5		2													S	M	0	M	0								
Desmognathus fuscus	**Northern Dusky Salamander**	5			4			NR_a					NR				S	M	0	M	0								66
Desmognathus ochrophaeus	**Allegheny Mountain Dusky Salamander**	5											NR						0		0								
Eurycea bislineata	**Northern Two-lined Salamander**	5						NR_a					NR			M	M	S	0	S	0	M					M	M	
Eurycea cirrigera	**Southern Two-lined Salamander**	5		NR	4								NR			M	S	S	0		0	0							65
Eurycea longicauda	**Long-tailed Salamander**	5		4	4		2			5			NR				M		0		0	S			M	0			64, 99
Eurycea lucifuga	**Cave Salamander**	5		4	4		1			5			2						S		0	M			M	0			97
Eurycea spelaea	**Grotto Salamander**	4					1			2									0							0			100
Eurycea tynerensis	**Oklahoma Salamander**	3					U_b			4									0		0					S			
Gyrinophilus porphyriticus	**Spring Salamander**	5											NR						0		0	M				0			
Hemidactylium scutatum	**Four-toed Salamander**	5		2	2			4	3	4			3		3	0	0	0	M		0	M							60, 61, 82
Necturus maculosus	**Mudpuppy**	5		5	2	2	3	5	4	U		4	4	H	3		S		0	0									131
Notophthalmus viridescens	**Eastern Newt**	5		3	NR	2	1	5	4	5			NR		4	0	0	M	0	0	0	S		S	M		M	M	134
Plethodon albagula	**Western Slimy Salamander**	5								5									S		0	M			S	0			6
Plethodon angusticlavius	**Ozark Zigzag Salamander**	4								3									S		0	M			S	S			
Plethodon cinereus	**Eastern Red-backed Salamander**	5		4	4			5	4				NR		5						0	S			M			S	80
Plethodon dorsalis	**Northern Zigzag Salamander**	5		4	4																0	0							122
Plethodon electromorphus	**Northern Ravine Salamander**	5			4								NR								0	M							
Plethodon glutinosus	**Northern Slimy Salamander**	5		5	4								NR								0	S							
Plethodon serratus	**Southern Red-backed Salamander**	5								5									S		0	M			S	S			
Plethodon wehrlei	**Wehrle's Salamander**	4											H								0	0			S				
Pseudotriton montanus	**Mud Salamander**	5											2			S	S	0	0		0	0							i
Pseudotriton ruber	**Red Salamander**	5			H								NR				0	0	0		0	M							64
Siren intermedia	**Lesser Siren**	5		4	NR			H		5							0		0										
REPTILES: Turtles																													
Apalone mutica	**Smooth Softshell**	5		3	NR	4	3		3	3	5	U	1	2	3		M		M	0									
Apalone spinifera	**Spiny Softshell**	5		5	NR	NR	5	4	5	5	5	NR	NR	2	5		S		S	0								M	1, 54, 72, 119
Chelydra serpentina	**Snapping Turtle**	5		5	NR	5	5	5	3	5	5	NR	NR	5	5	S	0	S	S	0							S	S	17, 56, 113
Chrysemys dorsalis	**Southern Painted Turtle**	5		NR						4							0	M	S	S							S	S	
Chrysemys picta	**Painted Turtle**	5		NR	NR	5	5	5	5	5	5	NR	NR	5	5	S	0	S	0	S							S	S	5, 12, 50
Clemmys guttata	**Spotted Turtle**	5		1	2			2					3			0	0	0	S		S					M		48, 60, 132
Deirochelys reticularia	**Chicken Turtle**	5								1						0	0				0	S							
Emydoidea blandingii	**Blanding's Turtle**	4		3	2	3		3	2	1	5		2	1	3	0	0	S	S	M				0			M		44
Glyptemys insculpta	**Wood Turtle**	4				1		2	2						2	S	S	M	0	0	0			0			S		26,72,126,115
Graptemys geographica	**Northern Map Turtle**	5		4	4	4	2	5	5	5			NR		5		M		M	0									70
Graptemys ouachitensis	**Ouachita Map Turtle**	5		3	2	4	4		4	4			NR		5					0									
Graptemys pseudogeographica	**False Map Turtle**	5		4	NR	4	2		4	5	4	U	1	3	3					0									
Kinosternon flavescens	**Yellow Mud Turtle**	5		1		1	5			1	3					S	0		S	M				0			M	M	
Kinosternon subrubrum	**Eastern Mud Turtle**	5		3	2					5						0	0	M	S	M	0						M	M	
Macrochelys temminckii	**Alligator Snapping Turtle**	3		1	NR		1			2							S		S	0									70
Pseudemys concinna	**River Cooter**	5		1	1		4			4										0									123
Sternotherus odoratus	**Eastern Musk Turtle**	5		5	4	2	4	5		5			NR		4	M	0		M	0								S	53
Terrapene carolina	**Eastern Box Turtle**	5		5	3		4	3		5			4			S	M	S	S		0	0	S	S			S	M	iv, 8, 14, 18, 60,74,108,129
Terrapene ornata	**Ornate Box Turtle**	5		4	1	2	5			5	5			2	1	S		S					S	0			S		22, 91
Trachemys scripta	**Pond Slider**	5		5	4	3	5	NA		5			1			S	0		M	S							S	S	

Zack Walker

River cooter

Carl R. Brune

Eastern Fence Lizard

		NATURESERVE GLOBAL RANK	FEDERAL (USFWS) STATUS	NatureServe State-level Rank and State Protection												SEASONAL (EPHEMERAL) WETLANDS	PERMANENT WETLANDS	WET MEADOWS, BOGS, AND FENS	SMALL STREAMS, SPRINGS, AND SEEPS	RIVERS AND LARGE STREAMS	HARDWOOD FORESTS	CONIFEROUS FORESTS	WOODLANDS AND SAVANNAS	GRASSLANDS AND PRAIRIES	ROCK OUTCROPS, GLADES, AND TALUS	CAVES AND KARST	AGRICULTURAL LANDS	URBAN AND RESIDENTIAL AREAS	An image of this species can be found on the following pages
				ILLINOIS	INDIANA	IOWA	KANSAS	MICHIGAN	MINNESOTA	MISSOURI	NEBRASKA	NORTH DAKOTA	OHIO	SOUTH DAKOTA	WISCONSIN														
REPTILES: Lizards																													
Aspidoscelis (Cnemidophorus) sexlineata	**Six-lined Racerunner**	5		3	4	3	5	NR	4	5	5			2	2						M	O	O	O	O		S	M	94
Crotaphytus collaris	**Eastern Collared Lizard**	5					4			4													M	M	O			M	5, 103
Holbrookia maculata	**Common Lesser Earless Lizard**	5					3				5			2										O			S		
Ophisaurus attenuatus	**Slender Glass Lizard**	5		4	2	1	5			5	1				1			O					S	O					87
Phrynosoma cornutum	**Texas Horned Lizard**	4					3			2														O	S				
Phrynosoma hernandesi	**Greater Short-horned Lizard**	5									3	NR		2										O					
Plestiodon (Eumeces) anthracinus	**Coal Skink**	5			NR		3			4			1								S	S	O		O				
Plestiodon (Eumeces) fasciatus	**Common Five-lined Skink**	5		5	4	4	5	4	3	5	1		NR	U	3						O	S	O		O			S	12, 77
Plestiodon (Eumeces) laticeps	**Broad-headed skink**	5		5	4		2			5			NR								O	S	O					M	127
Plestiodon (Eumeces) multivirgatus	**Many-lined Skink**	5									5			1										O				M	
Plestiodon (Eumeces) obsoletus	**Great Plains Skink**	5				1	5			2	3													O	O			M	92
Plestiodon (Eumeces) septentrionalis	**Prairie Skink**	5				3	4		5	3	5	2		5	3									O	O				
Sceloporus consobrinus	**Prairie Lizard**	5_a					5_a			5_a	5_a			2_a							O	S	S	S	O		S	S	
Sceloporus graciosus	**Common Sagebrush Lizard**	5									1	4		2									S		O				
Sceloporus undulatus	**Eastern Fence Lizard**	5		5	4								NR								O	O	S	S	O			S	123
Scincella lateralis	**Little Brown Skink (Ground Skink)**	5		5	4		5			5			3								O	S	S		S				
REPTILES: Snakes																													
Agkistrodon contortix	**Copperhead**	5		4	3	1	5			5	2		NR								O	S	S	S	O		S	M	103
Agkistrodon piscivorus	**Cottonmouth**	5		NR	1		1			5						S	O		O	O									
Arizona elegans	**Glossy Snake**	5					3				1												O	O					
Carphophis amoenus	**Eastern Wormsnake**	5		5	4								NR								O	S		O					
Carphophis vermis	**Western Wormsnake**	5		3		2	5			5	2				1						O	S	S		S				102
Cemophora coccinea	**Scarletsnake**	5		?#	H					2											O	O	O		S				
Clonophis kirtlandii	**Kirtland's Snake**	2		2	2			1		1			2			O	S	O			S			O				O	58
Coluber constrictor	**North American Racer**	5		5	NR	5	5	4	3	5	5	NR	NR	5	2	S		S			S	O	O	O	O		M		88
Coluber (Masticophis) flagellum	**Coachwhip**	5		1			5			4	3											S	O	O	S				
Crotalus horridus	**Timber Rattlesnake**	4		3	2	3	3		2	3	1		1		2						O	S	S	S	O				9, 105
Crotalus viridis	**Prairie Rattlesnake**	5				1	5				4	NR		5									S	O	S				95
Diadophi punctatus	**Ring-necked Snake**	5		NR	NR	5	5	4	4	5	5		NR	2	2						O	S	S	S	O				77
Farancia abacura	**Red-bellied Mudsnake**	5		NR	H					2						O	O		S		O								
Heterodon gloydi	**Dusty Hog-nosed Snake**	5_a		2_a						1_a													S	O			M		
Heterodon nasicus	**Plains Hog-nosed Snake**	5_a		2_a		1_a	5_a		3_a	X_a	5_a	NR_a		5_a									S	O			M		
Heterodon platirhinos	**Eastern Hog-nosed Snake**	5		5	3	4	3	4	4	5	4		3	2	3						O	S	O	S	S		M		89
Hypsiglena jani	**Chihuahuan Nightsnake**	5					2																	O	O				
Lampropeltis calligaster	**Yellow-bellied Kingsnake**	5		5	4	3	5			5	2					S					S	S	O	O	M		S		
Lampropeltis getula	**Common Kingsnake**	5		NR	NR	1	5			5	2		NR								S		O	S			S		
Lampropeltis triangulum	**Milksnake**	5		NR	NR	4	4	5	4	5	5		NR	4	5						S	S	O	O	O		O	S	6, 12, 83
LeptoYphlops dulcis	**Texas Threadsnake**	5					3																	O	O				
Nerodia cyclopion	**Mississippi Green Watersnake**	5		1						X						S	O		M	S							M		
Nerodia erythrogaster	**Plain-bellied Watersnake**	5		NR		1	5			5						S	O		O	O	S								38
Nerodia erythrogaster neglecta	**Copper-bellied Watersnake**	5	T‡	2	2	1		1					1			O	O		O	S	S			M			M		38, 44
Nerodia fasciata	**Southern Watersnake**	5		H						4						S	O		O	S									
Nerodia rhombifer	**Diamond-back Watersnake**	5		5	4	2	5			5						S	O	S	S	O									
Nerodia sipedon	**Northern Watersnake**	5		4	4	5	5	5	4	5	5		NR	1	5	S	O	S	O	O				M			S	S	40, 114, 130
Nerodia sipedon insularum	**Lake Erie Watersnake**	5	T										1				O												
Opheodrys aestivus	**Rough Greensnake**	5		5	3		4			5			3			S	O	S	S	S	O		M	S					124
Opheodrys vernalis	**Smooth Greensnake**	5		3	2	3		4	4	X	1	NR	4	4	4	S	S	S			S			O			M		87

Jeff Briggler

Rough Greensnake

		NATURESERVE GLOBAL RANK	FEDERAL (USFWS) STATUS	NatureServe State-level Rank and State Protection: ILLINOIS	INDIANA	IOWA	KANSAS	MICHIGAN	MINNESOTA	MISSOURI	NEBRASKA	NORTH DAKOTA	OHIO	SOUTH DAKOTA	WISCONSIN	SEASONAL (EPHEMERAL) WETLANDS	PERMANENT WETLANDS	WET MEADOWS, BOGS, AND FENS	SMALL STREAMS, SPRINGS, AND SEEPS	RIVERS AND LARGE STREAMS	HARDWOOD FORESTS	CONIFEROUS FORESTS	WOODLANDS AND SAVANNAS	GRASSLANDS AND PRAIRIES	ROCK OUTCROPS, GLADES, AND TALUS	CAVES AND KARST	AGRICULTURAL LANDS	URBAN AND RESIDENTIAL AREAS	An image of this species can be found on the following pages
Pantherophis (Elaphe) emoryi	**Great Plains Ratsnake**	5		2			5			5	4										S	S	0	M	0	S			
Pantherophis (Elaphe) gloydi	**Eastern Foxsnake**	3						2					3				0				0			0			S	S	
Pantherophis (Elaphe) obsoletus	**Western (Texas) Ratsnake**	5				4	5		3	5	4										0	0	0	S	0	S	S	S	
Pantherophis (Elaphe) spiloides	**Gray (Black) Ratsnake**	5		5	3			3					NR		3						0		0	0	S	S	S	S	98, 109
Pantherophis (Elaphe) vulpinus	**Western Foxsnake**	5		5	4	4		4	4	1	5			2		0	0	0					0	0			M		34, 86
Pituophis catenifer	**Gophersnake (Bullsnake)**	5		4	NR	4	5		3	3	5	NR		5	2								M	0					20, 93, 115
Regina grahamii	**Graham's Crayfish Snake**	5		5		4	4			4	2					S	0		S	S									
Regina septemvittata	**Queen Snake**	5		4	4			3					NR		1				0	0									
Rhinocheilus lecontei	**Long-nosed Snake**	5					3																	0					
Sistrurus catenatus	**(Eastern) Massasauga**	3	C†	2	2	1	3	3	1	1	1		2		1	0	0	0			0			S					8, 61
Sistrurus miliarius	**Pygmy Rattlesnake**	5								4											0	S	0		0				
Sonora semiannulata	**Western Groundsnake**	5					3			3													M	0	S				
Storeria dekayi	**Dekay's Brownsnake**	5		5	NR	5	5	5	5	5	3		NR	1	5	0		0			0		0	0			M	S	
Storeria occipitomaculata	**Red-bellied Snake**	5		4	3	3	2	5	5	5	1	NR	NR	3	5	0					0	S	0	M	S		M	S	81
Tantilla coronata	**Southeastern Crowned Snake**	5			1											S	S				0							S	
Tantilla gracilis	**Flat-headed Snake**	5		2			4			4											M		0		0				
Tantilla nigriceps	**Plains Black-headed Snake**	5					4				1													0					
Thamnophis brachystoma	**Short-headed Gartersnake**	4											3					S						0				M	
Thamnophis butleri	**Butler's Gartersnake**	4			1			4					NR		3									0				0	
Thamnophis elegans	**Terrestrial Gartersnake**	5									4			4						0				0					
Thamnophis marcianus	**Checkered Gartersnake**	5					2									0	0			0				0			M		
Thamnophis proximus	**Western Ribbonsnake**	5		4	3	5	5			5	2				1	0	0	S	S		M			M	0		M		
Thamnophis radix	**Plains Gartersnake**	5		5	4	5	5		5	4	5	NR	1	5	2	0	0	0	S	S				0				S	
Thamnophis sauritus	**Eastern Ribbonsnake**	5		1	4			5					NR		1	0	0	0	0		0			0					
Thamnophis sirtalis	**Common Gartersnake**	5		5	4	5	5	5	5	5	5	NR	NR*	5	5	0	0	0	0	S	S		0	S			M	0	i, 12, 19, 81, 115
Tropidoclonion lineatum	**Lined Snake**	5		1		4	5		3	5	5			1									S	0	S			0	
Virginia striatula	**Rough Earthsnake**	5					1			5											0	M	0		0				
Virginia valeriae	**Smooth Earthsnake**	5		4	NR	3	3			5			2								0		0	M	S				
INTRODUCED SPECIES																													
Hemidactylus turcicus	**Mediterranean Gecko**	5					NA_a			NA_a																		0	
Lacerta viridis	**Green Lizard**	5					NA																					0	
Podarcis muralis	**Common Wall Lizard**	5			NA_a								NA															0	
Podarcis sicula	**Italian Wall Lizard**	5					NA_a																					0	

APPENDIX C: CONSERVATION PROGRAMS AND SOURCES OF INFORMATION

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, especially when the program names and goals change over time. Perhaps it is most important to know that a variety of options exist and that help is available to sort out what to do. Some of the more popular options are presented here.

Bob Hay

Many frog species can show an amazing diversity of coloration and patterning. Shown here are Cope's Gray Treefrogs and Gray Treefrogs all taken from one study site!

CONSERVATION RESERVE PROGRAM (CRP)
CRP protects erodible soils by removing them from agricultural production, and planting them to permanent cover (normally wildlife-friendly). 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 also available for establishing required 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: *http://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: *http://www.nrcs.usda.gov/programs/eqip*

GRASSLAND RESERVE PROGRAM (GRP)
GRP is a voluntary program that provides landowners the opportunity to protect, restore, and enhance grasslands on their property. The program is designed to conserve grasslands from conversion to cropland or other uses and to help maintain ranching operations. GRP provides both technical and financial assistance.
Website: *http://www.nrcs.usda.gov/programs/grp/*

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: *http://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: *http://www.nrcs.usda.gov/programs/whip*

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 the prairie wetlands. 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

Jim Harding

Habitat loss and over-collection have contributed to Wood Turtle population declines in the Midwest. Individuals do not reach sexual maturity until between 14-18 years. Once mature, females typically lay a single clutch of 4-18 eggs no more than once per year. Eggs and hatchlings face very low survival rates, particularly in areas with high raccoon densities. This image shows a hatchling Wood Turtle on the back, or carapace, of an adult Wood Turtle.

offered. This is a good way to help fund conservation practices specific to your needs and those of the resource.
Website: *http://www.fws.gov/partners/*

LANDOWNER INCENTIVE PROGRAM (LIP)

The LIP is a federal grant program, through the U.S. Fish and Wildlife Service, recently established within state fish and wildlife agencies. The LIP is designed to protect and restore habitats on private lands to benefit federally-listed, proposed or candidate species or other species determined to be at-risk. The program provides technical and financial assistance to private landowners for habitat protection and restoration. Locations where opportunities exist to provide financial assistance to landowners will be identified based on the number of benefited target species, the quantity and quality of habitat managed and the longevity of the benefits. Partnerships will be established through other state and federal agencies and non-governmental organizations in order to promote and execute projects. The USFWS requires a minimum 25% non-federal match for LIP grants.
Website: *each state's fish and wildlife agency website should have details.*

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 contains 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 (http://www.lta.org) for a list of land trusts in your area.

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.

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: *http://www.fs.fed.us/spf/coop/programs/loa/fsp.shtml*

ENDANGERED SPECIES PROGRAMS – WORKING WITH LANDOWNERS

Many federally listed amphibian and reptile species occur on private lands. Working with private landowners is essential to protecting and recovering endangered species. To recover species on non-federal lands, the U.S. Fish and Wildlife Service acknowledges that it is critical to protect landowners' interests in their land while providing incentives to manage those lands in ways that benefit endangered species. The U.S. Fish and Wildlife Service is committed to finding this balance between private property rights and endangered species protection, and several of the conservation options below are available.
Website: *http://www.fws.gov/endangered/*
(Look under the "For Landowners" tab).

CANDIDATE CONSERVATION AGREEMENTS (CCA)

Candidate Conservation Agreements are formal agreements between the USFWS and one or more parties to address the conservation needs of proposed or candidate species, or species likely to become

candidates, before they become listed as endangered or threatened. The participants voluntarily commit to implementing specific actions that will remove or reduce the threats to these species, thereby contributing to stabilizing or restoring the species so that listing will not be necessary. The USFWS has entered into many CCAs over the years, primarily with other federal agencies, state and local agencies, and conservation organizations, such as The Nature Conservancy. Some of these have successfully removed threats to species and listing was avoided.
Website: *http://www.fws.gov/endangered/what-we-do/cca.html*

CONSERVATION BANKING
Conservation banks are permanently protected privately or publicly owned lands that are managed for endangered, threatened, and other at-risk species. A conservation bank is like a biological bank account. Instead of money, the bank owner has habitat or species credits to sell. The U.S. Fish and Wildlife Service (FWS) approves habitat or species credits based on the natural resource values on the bank lands. In exchange for permanently protecting the bank lands and managing them for listed and other at-risk species, conservation bank owners may sell credits to developers or others who need to compensate for the environmental impacts of their projects.
Website: *http://www.fws.gov/endangered/landowners/conservation-banking.html*

SAFE HARBOR AGREEMENTS
Safe Harbor Agreements are voluntary arrangements between the U.S. Fish and Wildlife Service (USFWS) and cooperating non-federal landowners. This policy's main purpose is to promote voluntary management for listed endangered and threatened species on non-federal property while giving assurances to participating landowners that no additional future regulatory restrictions will be imposed. Following development of an agreement, the FWS will issue an "enhancement of survival" permit, to authorize any necessary future incidental take (i.e., accidental killing).
Website: *http://www.fws.gov/endangered/landowners/safe-harbor-agreements.html*

CONSERVATION STEWARDSHIP PROGRAM (CSP)
CSP is a voluntary program that provides financial and technical assistance to promote the conservation and improvement of soil, water, air, energy, plant and animal life, and other conservation purposes on Tribal and private working lands. It replaced the Conservation Security Program with the passage of the 2008 Farm Bill. Working lands include cropland, grassland, prairie land, improved pasture, and range land, as well as forested land that is an incidental part of an agriculture operation. The program is available in all 50 States, the Caribbean Area and the Pacific Basin area. The program provides equitable access to benefits to all producers, regardless of size of operation, crops produced, or geographic location.
Website: *http://www.nrcs.usda.gov/programs/new_csp/csp.html*

FAMILY FORESTS PROGRAM
In 2004, the Forest Stewardship Council (FSC) launched its new requirements for small and low intensity managed forests seeking FSC forest certification. Known at the international level as SLIMF, for Small and Low Intensity Managed Forests, in the U.S. it is called the Family Forests Program. Worldwide, this policy applies to forests that are 100 hectares or less. However, in the U.S., this policy applies to all forest management certifications covering less than 1,000 hectares (approximately 2,470 acres). Small-scale, indigenous peoples' and community forests form a significant part of forestry worldwide. In the U.S., 6.4 million forest landowners have forest holdings smaller than 40 hectares. In the past, many of these groups have found it difficult to obtain forest certification, in part due to technical and financial requirements. The purpose of the Family Forests Program is to help bring these communities into the FSC system.
Website: *http://www.fscus.org/standards_criteria/family_forests_program.php*

SUSTAINABLE FORESTRY INITIATIVE (SFI)
The SFI program is a comprehensive system of principles, objectives, and performance measures devel-

Scott Ballard

The Broad-headed Skink is an inhabitant of wooded habitats, and is considered the most arboreal species of skink in the United States. During the breeding season, the orange-red coloration of the male's head intensifies, and males often combat each other to defend their territory. This image shows a male Broad-headed Skink courting a female.

Zack Walker

Spotted Salamanders live in forested habitats with suitable breeding sites, such as fish-free seasonal wetlands. In early spring they migrate to aquatic sites to breed and then they return to the forest where they spend much of their time in underground burrows (e.g., mammal burrows). Loss of seasonal wetlands and surrounding forest has resulted in population declines across the species range. Land managers can help protect remaining Spotted Salamander populations by protecting and restoring remaining wetlands, and by restoring and enhancing terrestrial linkages between them.

oped by professional foresters, conservationists and scientists, among others that combines the perpetual growing and harvesting of trees with the long-term protection of wildlife, plants, soil and water quality. SFI program participants practice sustainable forestry on all the lands they manage. They also influence millions of additional acres through the training of loggers and foresters in best management practices and landowner outreach programs.

The SFI Standard spells out the requirements of compliance with the program. The SFIS is based on nine principles that address economic, environmental, cultural and legal issues, in addition to a commitment to continuously improve sustainable forest management
Website: *http://www.sfiprogram.org*

CONSERVATION ASSESSMENTS

Conservation Assessments, like Species Management/Information Guides, capture and condense all of the known information about the biology and ecology of a species. However, they tend to be more comprehensive and more in depth than Species Management/Information Guides. They include taxonomic, range, distribution, and habitat descriptions, but may also contain key information regarding potential items to consider when managing a site where the species occurs. In addition, they often identify important inventory, research, and monitoring information that may be relevant for further understanding of the species or for adaptive management purposes. Often, Conservation Assessments provide information on the entire range of the species. Conservation Assessments are not decision documents, but are useful tools to aid biologists and botanists in evaluating project impacts, determining future informational needs, and working with managers on recommendations regarding site management.
Website: *http://www.fs.fed.us/r9/wildlife/tes/ca-overview/*

CONSERVATION TILLAGE/BUFFERS

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 are 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.

NATIONAL FARMERS UNION – CARBON CREDIT PROGRAM

The National Farmers Union's Carbon Credit Program is a way for farmers and landowners to earn income by storing carbon in their soil by using no-till crop production methods, conversion of lands used for crops into grasslands or forest, and managing native rangelands sustainably. Methane capture from anaerobic manure digester systems can also earn carbon credits.
Website:*http://nfu.org/issues/environment/carbon-credits*

AMERICAN TREE FARM SYSTEM

The American Tree Farm System® (ATFS) is a network of more than 95,000 woodland owners sustainably managing 26 million acres of forestland. It is the largest and oldest sustainable family woodland system in America, internationally recognized, meeting strict third-party certification standards. The ATFS offers a certification program developed specifically for small woodland owners. An independent panel took care to ensure that the requirements were appropriate for the scale of management practiced on family woodlands across the U.S. The management plan requirements of the certification program help streamline the process for Tree Farm owners to participate in USDA conservation incentive programs and correlate with the US Forest Service guidelines for forest stewardship program forest management plans.
Website: *http://www.treefarmsystem.org/*

APPENDIX D: RECOMMENDED READING AND ONLINE RESOURCES

SUGGESTED READING FOR LANDOWNERS AND LAND MANAGERS

The 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. 33 pp. Note: Out of Print, but free copy available at: *http://www.wetlandsandstreamrestoration.org*

Biebighauser, T.R. 2007. Wetland Drainage, Restoration, and Repair. University Press of Kentucky, Lexington, KY. 252 pp.

Biebighauser, T.R. 2011. Wetland Restoration and Construction – A Technical Guide. The Wetland Trust. 180 pp.

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.

Buhlmann, K.A., T.D. Tuberville, and J.W. Gibbons. 2008. Turtles of the Southeast. University of Georgia Press. 252 pp.

Calhoun, A.J.K., and P. deMaynadier. 2004. Forestry habitat management guidelines for vernal pool wildlife. MCA Technical Paper No. 6, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York. 32 pp.

Calhoun, A.J.K., and M.W. Klemens. 2002. Best Development Practices, Conserving Pool-breeding amphibians in residential and commercial developments in the northeastern United States. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, NY. 57 pp.

Clevenger, A.P., and M.P. Huijser. 2009. Handbook for Design and Evaluation of Wildlife Crossing Structures in North America. FHWA. 212 pp. Available online at: *http://www.westerntransportationinstitute.org/documents/reports/425259_Final_Report.pdf*

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.

Galatowitsch, S.M., and A.G. van der Valk. 1994. Restoring Prairie Wetlands: An Ecological Approach. Iowa State University Press, Ames, Iowa.

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.

Hunter, M.L., Jr. (ed.). 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 Division of Fisheries & Wildlife, Westborough, MA. *(http://www.vernalpool.org/fldgide.htm)*

Klemens, M.W. (ed.). 2000. Turtle Conservation. Smithsonian Institution Press, Washington, DC. 334 pp.

Lannoo, M.J. (ed.) Amphibian Declines: The Conservation Status of U.S. Amphibians. University of California Press, Berkeley, California. 1094 pp.

Mack, J.J., M.S. Fennessy, M. Micacchion, and D. Porej. 2004. Standardized monitoring protocols and performance standards for wetland creation, enhancement and restoration, Version 1.0. Ohio EPA Technical Report WET/2004-6. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Joanna Gibson

This Eastern Box Turtle hatched from a nest that was protected with a steel mesh cover to deter raccoons. Despite the added protection, only two of the five eggs laid in this nest successfully hatched. One egg was not viable and did not develop, and two were destroyed by insects. The two surviving hatchlings now face considerable risk of predation.

Moll, D., and E.O. Moll. 2004. The Ecology, Exploitation, and Conservation of River Turtles. Oxford University Press. 393 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. *(http://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 habitat, not buffer zone. 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.

ADDITIONAL RESOURCES FOR LANDOWNERS AND LAND MANAGERS:

The Nature Conservancy's Wildland Invasive Species Program

This Web site provides excellent information on the identification of non-native plant species and information on weed control methods. The Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas by Mandy Tu, Callie Hurd, and John M. Randall can be downloaded from this Web site free of charge.
Website: *http://www.invasive.org/gist/handbook.html*

Midwestern Ephemeral Wetlands Brochure

Providing informative insights into this vanishing habitat, this illustrative brochure is an excellent resource for community organizations, local government, school groups, and other interested parties. You can download this brochure or obtain hard copies free of charge.
Website: *http://herpcenter.ipfw.edu/outreach/EphemeralWetlandsBrochure.pdf*

Critter Crossings: Linking Habitats and Reducing Roadkill

This site, provided by the Federal Highway Administration, discusses ways to minimize the barrier effects of roads and highways.
Website: *http://www.fhwa.dot.gov/environment/wildlifecrossings/index.htm*

Eric Mayer

Kristin Stanford

Educational programs and special events provide excellent opportunities for children, and adults, to learn about amphibians and reptiles. Such programs can provide a fun learning experience and help to ease public fears. They also facilitate greater awareness for species with particular conservation needs.

Restore Your Shore CD
Offers a guide to protecting and restoring shoreland habitat. View online for free.
Website: *http://www.dnr.state.mn.us/restoreyourshore/index.html*

AMPHIBIAN AND REPTILE IDENTIFICATION SOURCES

The 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 of Eastern and Central North America. Third Edition expanded. Houghton Mifflin Co., Boston, MA. xviii + 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.

Harding, J. H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, Michigan. 400 pp.

Lannoo, M.J. 1998. (ed.) The Status of Conservation of Midwestern Amphibians. University of Iowa Press, Iowa City, Iowa. 507 pp.

Moriarty J., and Bauer A.M. 2000. State and Provincial Amphibian and Reptile Publications for the United States and Canada. SSAR Herpetological Circular 28. 56 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.

Smith, H. M. 1978. Amphibians of North America: A Guide to Field Identification. Golden Press, New York. 160 pp.

Smith, Hobart M., and Edmund D. Brodie. 1982. Reptiles of North America: A Guide to Field Identification. Golden Press, New York. 240 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.

STATE

ILLINOIS

Hardcopy:

- Ballard, S.R. 1998. Snakes of Illinois. Illinois Department of Natural Resources, Springfield, IL.
- Phillips, C.A., R.A. Brandon, and E.O. Moll. 1999. Field guide to amphibians and reptiles of Illinois. Illinois Natural History Survey, Urbana, IL. Manual 8: 300 pp.
- Smith, P.W. 1961. The amphibians and reptiles of Illinois. Illinois Natural History Survey, Urbana, IL. Bulletin 28: 298 pp.

Electronic:

- Chicago Herpetological Society – *http://www.chicagoherp.org*

Jeff Briggler

The Mudpuppy is an entirely aquatic salamander that lives in a variety of permanent freshwater habitats including lakes, rivers, and streams. They are found in every state of the PARC Midwest region, except Nebraska. Because of their somewhat strange appearance the Mudpuppy has been falsely labeled as dangerous, and people that catch them while fishing often kill them. Water pollution may threaten populations in some areas.

Jim Harding

Jim Harding

Greg Lipps

Herpetologists often record various measurements on the species they study. Some species of turtle can be roughly aged by counting the number of annuli, or growth rings, on their carapace (back) or plastron (stomach). Additional measurements can also be important for classifying individuals as juveniles or adults, and in some cases can be used to help distinguish between different species.

- Field Guide to Amphibians and Reptiles of Illinois - *http://www.inhs.uiuc.edu/cbd/collections/AmphRept-Colln/herp_links/Field%20Guide/TOC.html*

INDIANA

Hardcopy:

- MacGowan, B., and B. Kingsbury. 2001. Snakes of Indiana. Purdue Extension, FNR-173. 50 pp. (Available for purchase online at *http://www.agriculture.purdue.edu/fnr/wildlife//enthusiasts/animalidentification.html*)
- MacGowan, B., B. Kingsbury, and R. Williams. 2005. Turtles of Indiana. Purdue Extension, FNR-243. 63 pp. (Available for purchase online at *http://www.agriculture.purdue.edu/fnr/wildlife//enthusiasts/animalidentification.html*)
- Minton, S.A. 2001. Amphibians and reptiles of Indiana. Revised 2nd Edition. Indiana Academy of Science, Indianapolis. 404 pp.
- Williams, R., B. MacGowan, Z. Walker, and B. Kingsbury. 2006. Salamanders of Indiana. Purdue Extension, FNR-261. 91 pp. (Available for purchase online at *http://www.agriculture.purdue.edu/fnr/wildlife//enthusiasts/animalidentification.html*)

Electronic:

- Frogs and Toads of Indiana – *http://www.in.gov/dnr/fishwild/3325.htm*
- Center for Reptile and Amphibian Conservation and Management – *http://herpcenter.ipfw.edu/*

IOWA

Hardcopy:

- Christiansen, J.L., and R.M. Bailey. 1986. Salamanders and Frogs of Iowa. Iowa Department of Natural Resources. Des Moines, IA.
- Christiansen, J.L., and R.M. Bailey. 1986. Snakes of Iowa. Iowa Department of Natural Resources. Des Moines, IA.
- Christiansen, J.L., and R.M. Bailey. 1988. Turtles and Lizards of Iowa. Iowa Department of Natural Resources. Des Moines, IA.

Electronic:

- Iowa Herpetology – *http://www.herpnet.net/Iowa-Herpetology/*

Greg Lipps

Warm summer evenings following rainfall provide excellent conditions for observing salamanders. Researchers are looking for Green Salamanders in the crevices of this moist rock face.

KANSAS

Hardcopy:

- Collins, J.T., and S.L. Collins. 1993. Amphibians and Reptiles in Kansas. Third Edition Revised. University Press of Kansas, Lawrence. 424 pp.
- Collins, J.T., and S.L. Collins. 2006. Amphibians, Turtles and Reptiles of Cheyenne Bottoms. Second ed. Publ. Sternberg Mus. Nat. Hist., Fort Hays St. Univ., Hays, Kansas. viii + 76 pp.
- Collins, J.T., and S.L. Collins. 2006. A Pocket Guide to Kansas Snakes. Publ. Great Plains Nature Center, Wichita, Kansas. 69 pp.
- Potts, G.D., and J.T. Collins. 2005. A Checklist of the Vertebrate Animals of Kansas. Third (Revised) Edition. Sternberg Museum of Natural History, Hays, Kansas. vi + 50pp.

Electronic:

- Kansas Herpetofaunal Atlas - *http://webcat.fhsu.edu/ksfauna/herps/*
- Kansas Anuran Monitoring Program - *http://www.cnah.org/kamp/*

MICHIGAN

Hardcopy:

- Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, Michigan. 378 pp.
- Harding, J.H., and J. A. Holman. 1992. Michigan Frogs, Toads, and Salamanders. Michigan State University, East Lansing, Michigan. 144 pp.
- Harding, J.H., J.A. Holman. 2006. Michigan Snakes. Michigan State University, East Lansing, Michigan. 74 pp.
- Harding, J.H., and J.A. Holman. 1990. Michigan Turtles and Lizards. Michigan State University, East Lansing, Michigan. 96 pp.

Electronic:

- Wildlife and Natural History of Michigan - *http://critterguy.museum.msu.edu*
- Michigan Natural Features Inventory (MNFI), Michigan State University Extension - *http://web4.msue.msu.edu/mnfi/*

MINNESOTA

Hardcopy:

- Oldfield, B., and J. Moriarty. 1994. Amphibians and Reptiles Native to Minnesota. University of Minnesota Press. Minneapolis, Minnesota. 256 pp.

Electronic:

- Minnesota Herpetological Society – *www.bellmuseum.org/herpetology/main.html*
- Reptiles and Amphibians of Minnesota – *www.herpnet.net/Minnesota-Herpetology/*
- Reptiles and Amphibians of Minnesota (MN DNR) - *http://www.dnr.state.mn.us/reptiles_amphibians/index.html*

MISSOURI

Hardcopy:

- Anderson, P. 1965. The Reptiles of Missouri. University of Missouri Press, Columbia, MO. 330 pp.
- Johnson, T.R. 1977. The Amphibians of Missouri. The University of Kansas Museum of Natural History, University of Kansas, Lawrence, KS 134 pp.
- Johnson, T.R. 1987. The amphibians and reptiles of Missouri. Department of Conservation, Jefferson City, MO. 369 pp.
- Johnson, T.R. 2000. The Amphibians and Reptiles of Missouri. Missouri Department of Conservation. Jefferson City, Missouri.400 pp.

Electronic:

- Amphibians and Reptiles of Missouri - *http://mdc.mo.gov/discover-nature/outdoor-recreation/nature-viewing/amphibians-and-reptiles*

NEBRASKA

Hardcopy:

- Fogell, D.D. 2010. A Field Guide to the Amphibians and Reptiles of Nebraska. Conservation & Survey Division, School of Natural Resources, University of

Nebraska – Lincoln. 158 pp.

- Gehlbach, F.R., and B.B. Collette. 1959. Distribution and biological notes on the Nebraska herpetofauna. Herpetologica 15:141–143.
- Hudson, G.E. 1942. The amphibians and reptiles of Nebraska. Nebraska Conservation Bulletin, Number 24, University of Nebraska, Lincoln, Nebraska. 146 pp.
- Lynch, J.D. 1985. Annotated checklist of the amphibians and reptiles of Nebraska. Transactions of the Nebraska Academy of Sciences 13:33–57.
- McLeod, D.S. 1999. A re-survey of amphibian populations in Nebraska after twenty years: a test for declines. Master's thesis. University of Nebraska, Lincoln, Nebraska.

Electronic:

- Reptiles and amphibians of Nebraska: *http://snrs.unl.edu/herpneb/*

NORTH DAKOTA

Hardcopy:

- Hoberg, T., and C. Gause. 1992. Reptiles and Amphibians of North Dakota.
- North Dakota Outdoors 55(1):7-19. (Also available digitally – see below)
- Wheeler, G.C., and J. Wheeler. 1966. The Amphibians and Reptiles of North Dakota. University of North Dakota Press, Grand Forks. 104 pp.

Electronic:

Reptiles and amphibians of North Dakota - *http://www.npwrc.usgs.gov/resource/herps/amrepnd/index.htm*

OHIO

Hardcopy:

- Conant, R. 1951. The Reptiles of Ohio. Second Edition. American Midland Naturalist 20: 1-284.
- Davis, J.G., and S.A. Menze. 2000. Ohio Frog and Toad Atlas. Ohio Biological Survey Miscellaneous Contributions Number 6. IV + 20 p.
- Davis, J.G., and S.A. Menze. 2002. In Ohio's backyard: frogs and toads. Ohio Biological Survey Backyard Series (3), Columbus, OH. 143 pp.
- Pfingsten, R.A., and T.O. Matson. 2003. Ohio Salamander Atlas. Ohio Biological Survey, Columbus, Ohio. 24 pp.
- Walker, C.F. 1946. The Amphibians of Ohio: Part I. The Frogs and Toads (Order Salientia). Ohio State Archaeological and Historical Society, 1(3). 109 pp.

Jeff Briggler

Eastern Newts have an amazing, but rather complicated life cycle. Their life cycle progresses from egg to aquatic larva, to the brilliantly colored, "leathery", terrestrial juvenile red eft stage shown above, then to aquatic adult! Juvenile red efts spend several years on land before returning to water and metamorphosing into adults. While the adults are aquatic, they do not have gills, instead they retain the lungs of the red eft stage.

- Wynn, D.E., and S.M. Moody. 2006. Ohio Turtle, Lizard, and Snake Atlas. Ohio Biological Survey Miscellaneous Contributions Number 10. iv + 80 pp.

Electronic:

- Ohio Amphibians - *http://www.ohioamphibians.com/*
- Reptiles and Amphibians of Ohio - *http://www.ohiodnr.com/Home/species_a_to_z/AZReptilesandAmphibians/tabid/17914/Default.aspx*

SOUTH DAKOTA

Hardcopy:

- Ballinger, R.E., J.W. Meeker, and M. Thies. 2000. A Checklist and Distribution Maps of the Amphibians and Reptiles of South Dakota. Transactions of the Nebraska Academy of Sciences 26:29-46.
- Bandas, S.J., and K.F. Higgins. 2004. Field Guide to South Dakota Turtles. SDCES EC 919, South Dakota State University, Brookings, South Dakota. 40 pp. (Freely available online: *http://gfp.sd.gov/wildlife/critters/amphibians-reptiles/default.aspx*)
- Fischer, T.D., D.C. Backlund, K.F. Higgins, and D.E. Naugle. 1999. Field Guide to South Dakota Amphibians. SDAES Bulletin 733, South Dakota State University, Brookings, South Dakota. 52 pp. (Freely available online: *http://gfp.sd.gov/wildlife/critters/amphibians-reptiles/default.aspx*)

Electronic:

- South Dakota Snakes - *http://gfp.sd.gov/wildlife/critters/amphibians-reptiles/default.aspx*

WISCONSIN

Hardcopy:

- Casper, G. S. 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. An Interim Report of the Wisconsin Herpetological Atlas Project. Milwaukee Public Museum, Inc.

- Christoffel, R., R. Hay, and M. Wolfgram. 2001. Amphibians of Wisconsin. Wisconsin Department of Natural Resources. Pub. No. ER-105 2001. 44 pp. (Accessible for viewing and available for purchase online: *http://dnr.wi.gov/org/land/er/publications/HerpBook.htm*)
- Christoffel, R., R. Hay, and M. Monroe. 2002. Turtles and Lizards of Wisconsin. Wisconsin Department of Natural Resources. Pub. No. ER-104-2002. 48 pp. (Accessible for viewing and available for purchase online: *http://dnr.wi.gov/org/land/er/publications/HerpBook.htm*)
- Christoffel R., R. Hay, R. Paloski, and L. Ramirez. 2008. Snakes of Wisconsin; Second Edition. Wisconsin Department of Natural Resources. Pub. No ER-100 2008. 32 pp. (Accessible for viewing and available for purchase online: *http://dnr.wi.gov/org/land/er/publications/HerpBook.htm*)
- Vogt, R.C. 1981. Natural History of Amphibians and Reptiles in Wisconsin. Milwaukee Public Museum, Milwaukee, WI.

Electronic:

- Wisconsin's Reptiles and Amphibians - *http://dnr.wi.gov/org/land/er/biodiversity/index.asp?mode=TaxaList&Taxa=A*

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/*

State Agency Websites

State wildlife and forestry agency websites are listed below. Information on common and locally protected amphibians and reptiles, conservation plans, educational materials, regulations, forest management assistance, and more can be found by visiting these sites.

Illinois Department of Natural Resources	*http://dnr.state.il.us/*
Illinois Division of Forest Resources	*http://dnr.state.il.us/conservation/forestry/*
Indiana Department of Natural Resources	*http://www.in.gov/dnr*
Indiana Division of Forestry	*http://www.state.in.us/dnr/forestry*
Iowa Department of Natural Resources	*http://www.iowadnr.com*
Iowa DNR – Forestry	*http://www.iowadnr.com/forestry/*
Kansas Department of Wildlife and Parks	*http://www.kdwp.state.ks.us*
Kansas Forest Service	*http://www.kansasforests.org*
Michigan Department of Natural Resources	*http://www.michigan.gov/dnr*
Michigan Forest Management Division	*http://www.michigan.gov/dnr*
Minnesota Department of Natural Resources	*http://www.dnr.state.mn.us*
Minnesota DNR - Division of Forestry	*http://www.dnr.state.mn.us/forestry*
Missouri Department of Natural Resources	*http://www.dnr.mo.gov/*
Missouri Department of Conservation	*http://www.mdc.mo.gov/*
Nebraska Department of Natural Resources	*http://www.dnr.state.ne.us*
Nebraska Forest Service	*http://www.nfs.unl.edu*
North Dakota Game and Fish Department	*http://gf.nd.gov/*
North Dakota Forest Service	h*ttp://www.ndsu.edu/ndfs/*
Ohio Department of Natural Resources	*http://ohiodnr.com*
South Dakota Game, Fish and Parks	*http://www.sdgfp.info*
South Dakota Div. of Res. Cons. and Forestry	*http://www.sdda.sd.gov/Forestry/*
Wisconsin Department of Natural Resources	*http://www.dnr.state.wi.us*
Wisconsin DNR Forestry Program	*http://www.dnr.state.wi.us/forestry/*

APPENDIX E: DISINFECTION GUIDELINES FOR INDIVIDUALS WORKING IN FRESHWATER HABITATS

While some invasive species are large and obvious, many are microscopic. The fungus *Batrachochytrium dendrobatidis*, cause of chytrid disease, and the viruses of the ranavirus group have provided new and devastating challenges to the amphibians of the Midwest. These pathogens can infect a broad range of host species, particularly in aquatic settings. Populations of amphibians may be destroyed by the arrival of these diseases or when novel strains appear.

Humans have been implicated as major transporters of these pathogens. While some of this transport is by persons engaged in every day affairs, some of it is a consequence of the activities of biologists, be they land managers moving machinery from project to project, or a fisheries biologist moving a boat from wetland to wetland. Herpetologists may themselves do the same thing as they move from site to site conducting surveys or research. Such transportations of pathogens are not only insidious in that the very people trying to help herps are harming them, but potentially particularly devastating as biologists may impact previously isolated and pristine sites.

To prevent the potential introduction and spread of pathogens during field work, we encourage all individuals who work in freshwater habitats to follow a disinfection protocol. We provide one protocol based on recommendations by USGS. We also include a table that was taken from Phillott et al. (2010). describing aspects of disinfection strategies suitable for killing *Batrachochytrium dendrobatidis* and ranaviruses in field studies. Information for *Batrachochytrium dendrobatidis* is adapted from Berger (2001), Johnson et al. (2003) and Webb et al. (2007), and for ranaviruses from Langdon (1989), Miocevic et al. (1993) and Bryan et al. (2009). A full list of these citations is available at the end of this Appendix. More information on amphibian diseases can be found at: *http://www.jcu.edu.au/school/phtm/PHTM/frogs/ampdis.htm.*

It is crucial to meet minimum concentrations and contact times. Overly diluted solutions or shortcuts on contact times will not be effective. Note also that solutions of sodium hypochlorite including bleach gradually weaken with time. Old bleach is not the same as new bleach.

There is also some controversy regarding the potential for mortality following handling of tadpoles with latex, nitrile, and to a lesser extent vinyl gloves (e.g., see Chashins et al. 2008 and Greer et al. 2009 in the references below). Given the benefits of gloves overall, it would seem prudent to use them, but minimize contact and pre-rinse or soak the gloves before going out in the field so as to minimize the presence and transfer of toxins to larval amphibians.

HYGIENE PROTOCOL

For Control of Disease Transmission between Amphibian Study Sites (USGS Feb. 2005) the following protocol should be completed between any sites that are not "water-connected" or that amphibians don't freely move between. The procedure should be completed on all gear/equipment that may have touched site water or used to handle amphibians, including but not limited to:

- Waders
- Shoes/boots
- Dip nets
- Rulers and other instruments
- Specimen bags/containers
- Traps

Materials that will be needed for disinfecting equipment include:

- Plastic bucket with handle for sterilization and holding cleaning gear
- Gallon of chlorine bleach (6% concentration of sodium hypochlorite)
- Two stiff scrub brushes with handles, one for sterilization, and one for cleaning off mud/dirt
- Rubber dishwashing gloves
- Spray bottle

Procedure:

1) Before leaving the site, wash off as much of the mud/dirt on equipment and gear, in the site water and remove any vegetation or detritus attached to gear by shaking, rinsing in water, and hand picking.
2) Do all sterilizing well away from streams or ponds.
3) Fill bucket with two gallons (eight quarts) clear water (from pond or spigot).
4) Add 12 capfuls (6 Tablespoons or 1/3 cup) of bleach (for a 1% concentration).
5) Stir to mix with brush.
6) Clean off any remaining vegetation or mud with brush that may have been missed earlier.
7) Dip and rotate folded Minnow traps in solution, shake off, open, and lay out in sun/wind to dry.

Application	Disinfection	Strength	Time	Target pathogen
Disinfecting surgical equipment and other instruments (e.g., scales, calipers)	Benzalkonium chloride	2 mg/ml	1 min	*B. dendrobatidis*
	Ethanol	70%	1 min	*B. dendrobatidis,* Ranaviruses
Disinfecting collection equipment and containers	Sodium hypochorite (bleach contains 4% sodium hypochorite)	1%	1 min	*B. dendrobatidis*
		3%	1 min	Ranaviruses
	Path X or quaternary ammonium compound 128	1 in 500 dilution	0.5 min	*B. dendrobatidis*
	Trigene	1 in 5000 dilution	1 min	*B. dendrobatidis*
	F10	1 in 1500 dilution	1 min	*B. dendrobatidis*
	Virkon	2 mg/ml	1 min	*B. dendrobatidis*
		1%	1 min	Ranaviruses
	Nolvasan	0.75%	1 min	Ranaviruses
	Potassium permanganate	1%	10 min	*B. dendrobatidis*
	Complete drying		>3h	*B. dendrobatidis*
	Heat	60^{o} C	30 min	*B. dendrobatidis,* Ranaviruses
	Heat	37^{o}	8 h	*B. dendrobatidis*
	Sterilising UV light		1 min	Ranaviruses only
Disinfecting footwear	Sodium hypochorite (bleach contains 4% sodium hypochorite)	1%	1 min	*B. dendrobatidis*
		3%	1 min	Ranaviruses
	Path X or quaternary ammonium compound 128	1 in 500 dilution	0.5 min	*B. dendrobatidis*
	Trigene	1 in 5000 dilution	1 min	*B. dendrobatidis*
	F10	1 in 1500 dilution	1 min	*B. dendrobatidis*
	Complete drying		>3 h	*B. dendrobatidis*
Disinfecting cloth (e.g., carry bags, clothes)	Hot wash	60^{o} C or greater	30 min	*B. dendrobatidis,* Ranaviruses

8) Dip shoes in solution and scrub, shake off and let dry in sun.

9) Either dip and scrub waders in bucket or lay waders on ground and pour solution on them while scrubbing. Spray bottle (with same solution concentration) can also be used to apply solution where needed.

10) Sterilize brushes in solution.

11) If possible, save any remaining sterilization solution in a sealable container for future use. If solution must be discarded, dispose of on asphalt, cement or hard roadbed, well away from any water bodies.

12) If at all possible, allow all gear and equipment to dry completely before reuse at next site. Alternatively, use a spray application of isopropyl alcohol (70%) or dry completely for over 3 hours.

Amphibian disease is a very active field, but with the caveat that readers should also search for more recent publications, we provide here some further readings on the topic:

Berger, L. 2001. Diseases in Australian Frogs. PhD Thesis, James Cook University, Australia.

Bryan, L. K., C. A. Baldwin, M. J. Gray, and D. L. Miller. 2009. Efficacy of select disinfectants at inactivating Ranavirus. Diseases of Aquatic Organisms, 84: 89-94.

Cashins, S. D., R. A. Alford, and L. F. Skerratt. 2008. Lethal effect of latex, nitrile, and vinyl gloves on tadpoles. Herpetological Review, 39(3): 298-301. Available electronically at: *http://www.parcplace.org/Cashins_etal_2008_glovesandtads%20.pdf*

Department of Environment and Climate Change (NSW) 2008. Hygiene protocol for the control of disease in frogs. Information Circular Number 6. DECC (NSW), Sydney South. Available electronically at: *http://www.environment.nsw.gov.au/resources/nature/hyprfrog.pdf*

DEH Australia. 2006. Threat abatement plan: infection of amphibians with chytrid fungus resulting in chytridiomycosis. Department of Environment and Heritage, Commonwealth of Australia. Available electronically at: *http://www.environment.gov.au/biodiversity/threatened/publications/tap/chytrid.html*

Greer, A.L., D. M. Schock, J. L. Brunner, R. A. Johnson, A. M. Picco, S. D. Cashins, R. A. Alford, L. F. Skerratt, and J. P. Collins. 2009. Guidelines for the safe use of disposable gloves with amphibian larvae in light of pathogens and possible toxic effects. Herpetological Review 40:145-147.

Johnson, M. L., L. Berger, L. Philips, and R. Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid Batrachochytrium dendrobatidis. Diseases of Aquatic Organisms, 57: 255-260.

Langdon, J. S. 1989. Experimental transmission and pathogenicity of epizootic haematopoietic necrosis virus (EHNV) in red fin perch, Perca fluviatilis L., and 11 other teleosts. Journal of Fish Diseases, 12: 295-310.

Miocevic, I., J. Smith, L. Owens, and R. Speare. 1993. Ultraviolet sterilization of model viruses important to finfish aquaculture in Australia. Australian Veterinary Journal, 70: 25-27.

Phillott, A. D., R. Speare, H. B. Hines, L. F. Skerratt, E. Meyer, K. R. McDonald, S. D. Cashins, D. Mendez, and L. Berger. 2010. Minimising exposure of amphibians to pathogens during field studies. Diseases of Aquatic Organisms, 92: 175-185.

Speare, R., L. Berger, L.F. Skerratt, R. Alford, D. Mendez, S. Cashins, N. Kenyon, K. Hauselberger, and J. Rowley. 2004. Hygiene protocol for handling amphibians in field studies. Unpublished report by the Amphibian Diseases Group, James Cook University, Australia. Available electronically at: *http://www.jcu.edu.au/school/phtm/PHTM/frogs/field-hygiene.pdf*

Webb, R., D. Mendez, L. Berger, and R. Speare. 2007. Additional disinfectants effective against the amphibian chytrid fungus Batrachochytrium dendrobatidis. Diseases of Aquatic Organisms, 74: 13-16

Joanna Gibson

To prevent disease transmission between freshwater habitats all equipment that comes into contact with site water, or amphibians, must be disinfected.

Joanna Gibson

Joanna Gibson

Following a hygiene protocol will prevent the transmission of diseases between freshwater sampling sites. An important component of the protocol involves removing all dirt and organic matter from footwear to ensure that disinfecting agents, such as bleach, work effectively.

ACKNOWLEDGEMENTS AND CREDITS

This guide would not have been possible without the help of numerous individuals and organizations. To give credit where credit is due, we need to follow the path of its development. The notion of the guides was an outcome of dialogue between Monica Schwalbach, chair of the Federal Steering Committee, and others, notably Kurt Buhlmann and Whit Gibbons. Regional conservation guidelines emerged as a potential tool to convey "best management practices" for herpetofauna to land managers. With start-up funding from the U.S. Forest Service, Kurt Buhlmann, Whit Gibbons, and Joseph Mitchell began work on what such a guide might look like, and using the Savannah River Ecological Laboratory property as the "region," developed an initial guide—a "straw dog" as Kurt called it. The PARC Management Steering Committee then went to work figuring out how to make the regional herpetofaunal conservation guidelines (HCGs) a reality.

The decision was made to bring an eclectic group of persons with a stake in herpetofaunal conservation together in one place to draft the guides. This would be the HCG workshop. The workshop was a production in and of itself. Through a series of meetings and teleconferences, the PARC Management Steering Committee developed the agenda for the meeting, identified and invited the participants, anticipated problems that might come up during the meeting, and sought solutions. Group members and affiliates that worked intensively on the meeting included Kurt Buhlmann, Erin Clark, Robert Fisher, Whit Gibbons, Randy Gray, John Jensen, Bruce Kingsbury, Joe Mitchell, Earl Possardt, Klaus Richter, and Monica Schwalbach. Illinois Department of Natural Resources hosted the workshop with the leadership of Brian Anderson, director of the Office of Scientific Research and Analysis. Illinois Conservation Foundation provided fiscal support, and a number of agencies and organizations provided funding for the workshop and the guide. Agencies contributing funds included Arizona Game and Fish, Conservation International, Illinois Conservation Foundation, Illinois Department of Natural Resources, Legacy Resource Management Program, U.S. Department of Defense, Minnesota Department of Natural Resources, Missouri Department of Conservation, National Fish and Wildlife Foundation, Oklahoma Department of Wildlife Conservation, South Carolina Department of Natural Resources, Texas Department of Parks and Wildlife, Tie Tracks, U.S.D.I. Fish and Wildlife Service, U.S.D.A. Natural Resources Conservation Service, U.S.D.A. Forest Service, and the West Virginia Department of Natural Resources. Monica is to be commended for keeping us on track throughout the many stages of the workshop and guideline development. At the meeting itself, some 85 individuals gathered and worked together over three days to hammer out draft HCG material.

For the Midwest habitat management guide, workshop team members included Scott Ballard, Paul Bartelt, Kimberlee Beckmen, Carolyn Caldwell, Gary Casper, Jaime Edwards, Ed Hammer, Carol Hall, Bob Hay, Cheri Ford, Bruce Kingsbury, Michael Lannoo, Chris Phillips, Ron Refsnider, Jay Rubinoff, Lori Sargent, Ray Semlitsch, John Shuey, Diane Tecic, and Kim Vories. Our thanks to them for their efforts in Chicago.

After the Chicago HCG meeting, work began in earnest on the series of guides themselves, which were renamed Habitat Management Guides (HMGs). The Midwest HMG you are holding is actually the second edition of the first HMG produced, and so our acknowledgement path leads us to a number of people who worked extensively on various sections of the first edition. Bob Hay was the lead on the Grassland and Savanna section, Paul Bartelt and Jay Rubinoff provided significant comments and improvements. Paul Bartelt led on Agriculture, assisted by Jay and Bob. Carolyn Caldwell was the lead on the Urban and the Caves and Springs sections. Scott Ballard reviewed Caves and Springs. Chris Phillips drafted Rivers and Streams. Carol Hall took the lead on Permanent Wetlands, and Chris Phillips helped review it. Scott Ballard authored the Primary section (now called "Rock Outcrops, Glades, and Talus"). John Roe drafted the Seasonal Wetlands, and Ray Semlitsch helped with the editing. Joanna and I lead the way on the Toolkit, incorporating additional material provided by Paul Bartelt. John Shuey, Paul Bartelt, Bob Hay, and Ellen Jacquart helped with editing and suggestions. I provided the initial drafts of the Forests, Introduction, and Habitat Fragmentation, and Joanna helped out greatly on these as well. In developing the Introduction and Fragmentation sections, I benefited from previous materials developed in the SREL straw dog document. This document came in handy a number of other times along the way as well. Joanna and I drafted the primer on herp biology. Joanna was primarily responsible for sorting and handling graphics. Joanna and I oversaw compilation of the document and substantially contributed to and edited all of sections. I especially thank Kurt Buhlmann, John Jensen, and Bob Hay for their critical final reviews which greatly improved the document. Hank Gruner, Linda Ulmer, and Dave Stratman also provided additional useful comments. We used the facilities of the Center for Reptile and Amphibian Conservation and Management at Indiana University-Purdue University Fort Wayne (IPFW) during guide development. IPFW Publications provided final layout and assisted with handling publication locally.

The first edition of the Midwest HMG came out in 2002, and this second edition in 2012. In the intervening years, the Southeast, Northeast, and Northwest guides came out. The authors and editors of each guide benefited from the activities of the authors and editors of those guides appearing earlier, with heartless plagiarism encouraged to ease the way and also provide consistency. Thus we must thank other HMG contributors, particularly the editors: Mark Bailey, Jeff Holmes, Kurt Buhlmann and Joe Mitchell for the Southeast HMG; Al Breisch, Joe Mitchell and Kurt Buhlmann again for the Northeast HMG; and Dave Pilliod and Elke Wind for the Northwest HMG.

The second edition had numerous old and new contributors, and thus the authorship of many contributions were complex. The principal authors for habitat type introductions, in the order of presentation, were Seasonal (Ephemeral) Wetlands: John Roe, Indiana – Purdue University Fort Wayne; Permanent Wetlands: Chris Phillips, Illinois Natural History Survey; Wet Meadows, Bogs and Fens: Mike Redmer, US Fish and Wildlife Service; Small Streams, Springs, and Seeps: Jeff Briggler, Missouri Department of Conservation; Rivers and Large Streams: Jeff Briggler, Missouri Department of Conservation; Hardwood Forests and Coniferous Forests: Jackie Grant, Penn State University; Woodlands and Savannas: Bob Brodman, St. Joseph's College; Grasslands and Prairies: Bob Hay, Wisconsin Department of Natural Resources; Caves and Karst: Carolyn Caldwell, Ohio Department of Natural Resources; Rock Outcrops, Glades and Talus: Scott Ballard, Illinois Department of Natural Resources; Agricultural Lands: Paul Bartelt, Waldorf College, Jay Rubinoff, Department of Defense, and Bob Hay, Wisconsin Department of Natural Resources; Urban and Residential Areas: David and Rachel Mifsud, Herpetological Resource and Management, LLC.

Review of and contributions to the species table and help with state herp resources included Doug Backlund, South Dakota Department of Game, Fish and Parks; Nathan Baker, South Dakota Department of Game, Fish and Parks; Scott Ballard, Illinois Department of Natural Resources; Jeff Briggler, Missouri Department of Conservation; Ken Brunson, Kansas Department of Wildlife and Parks; Bill Busby, Kansas Biological Survey; Carolyn Caldwell, Ohio Department of Natural Resources; Kathy Duttenhefner, North Dakota Parks and Recreation Department; Dan Fogell, Southeast Community College, Nebraska; Paul Frese, Iowa Department of Natrual Resources; Carol Hall, Minnesota Department of Natural Resources; Jim Harding, Michigan State University; Robert Hay, Wisconsin Department of Natural Resources; Daryl Howell, Iowa Department of Natural Resources; Sandra Johnson, North Dakota Game and Fish Department; Sarabeth Klueh, Indiana Department of Natural Resources; Yu Man Lee, Michigan Natural Features Inventory; Greg Lipps, Gregory Lipps, LLC; David Mifsud, Herpetological Resource and Management, LLC; Raymond Novotny; John Palis; Chris Phillips, Illinois Natural History Survey; Zack Walker, Indiana Department of Natural Resources and Joseph Collins. Jeff Briggler and John Palis provided critical review of matrix table.

Critical review was thorough. An early draft was submitted widely for peer review. Extensive review was provided by Robert Brodman, St. Joseph's College; Wendell Gilgert, Natural Resource Conservation Service; Jim Harding, Michigan State University; Barbara Hosler, US Fish and Wildlife Service; Greg Lipps, Gregory Lipps, LLC; David Stratman, Natural Resource Conservation Service; Ben Wigley, National Council for Air and Stream Improvement, Inc., and Jeff Briggler, Missouri Department of Conservation. We thank Michael Lannoo, Indiana University; Wendy Melgin, US Environmental Protection Agency; Lisa Mobley, Missouri Department of Conservation; John Palis, Assoc.; and John Roe, Indiana-Purdue University Fort Wayne for additional contributions and review.

After further editing, updating, and adding of photographs and captions, we passed it off to the "levelers" Kurt Buhlmann and Joe Mitchell. They provided additional valuable commentary and helped make the message consistent with the other regional Habitat Management Guidelines in this series. We then continued editing and photo substitutions until we obtained the final draft. Whew. Walker Printing provided layout services and constantly improved the draft, responding to our requests for edits from various parties, including a variety of agencies, organizations and businesses we courted for "buy-in" from as many partners as possible. During these efforts, Anders Johnson helped with monitoring layout revisions. Our national PARC partners Ernie Garcia, Priya Nanjappa and Terry Riley all helped us push the draft forward towards completion, including keeping a dialogue open with state, federal and industrial partners during the many stages of HMG development. Walker Printing then finalized layout, and supervised printing.

Numerous individuals contributed photos, and we thank them profusely. Each of them retain copyright privileges and they should be contacted directly for further use. Contributors were: Jennifer Anderson-Cruz, Omar Attum, Peter Badra, Scott Ballard, Christine Barlow, Lois Behrens, Kent Bekker, Andrew Berger, Lynn Betts, Tom Biebighauser, Nick Bieser, Angela Biggs, Jeff Briggler, Carl R. Brune, Kurt Buhlmann, David Cappaert, Gary S. Casper, Bryan Eads, Nathan Engbrecht, Bill Flanagan, Dan Fogell, Paul Frese, Alisa Gallant, Joanna Gibson, Scott Gibson, Mike Graziano, Carol Hall, Jim Harding, Bob Hay, Indiana TNC, Iowa USDA NRCS, Scott Johnson, Tom R. Johnson, Bruce Kingsbury, Lynn Kulver, Michael Lannoo, Yu Man Lee, Greg Lipps, Eric Mayer, Jonathan Mays, Brian MacGowan, Tim McCabe, Clark McCreedy, Lynda Mills, Stephen J. Mullin, Steve Paes, John Palis, Chris Phillips, Mike Redmer, Alan Resetar, Jerry Roach, Elizabeth Rodgers, John Roe, Kenneth Rouston, Joe Sage, Allen Salzberg, Catherine A. Saumure, Raymond A. Saumure, A. B. Sheldon, Elliot Stahl, Kristin Stanford, Kenneth B. Storey, David Surovec, Jeff Vanuga, Zack Walker, Wisconsin DNR, John White. We also acknowledge the use of public domain images that were sourced from the following organizations: NASA, USDA Farm Service Agency, USDA NRCS, North Dakota Fish and Game (NDFG), USFWS, and USGS.

I save my greatest expression of gratitude for my coconspirator, Joanna Gibson, who worked so hard on this project. Her energy, diligence, insistence and good humor made it possible for this wonderful guide to be completed. Thanks Jo.

—Bruce Kingsbury