

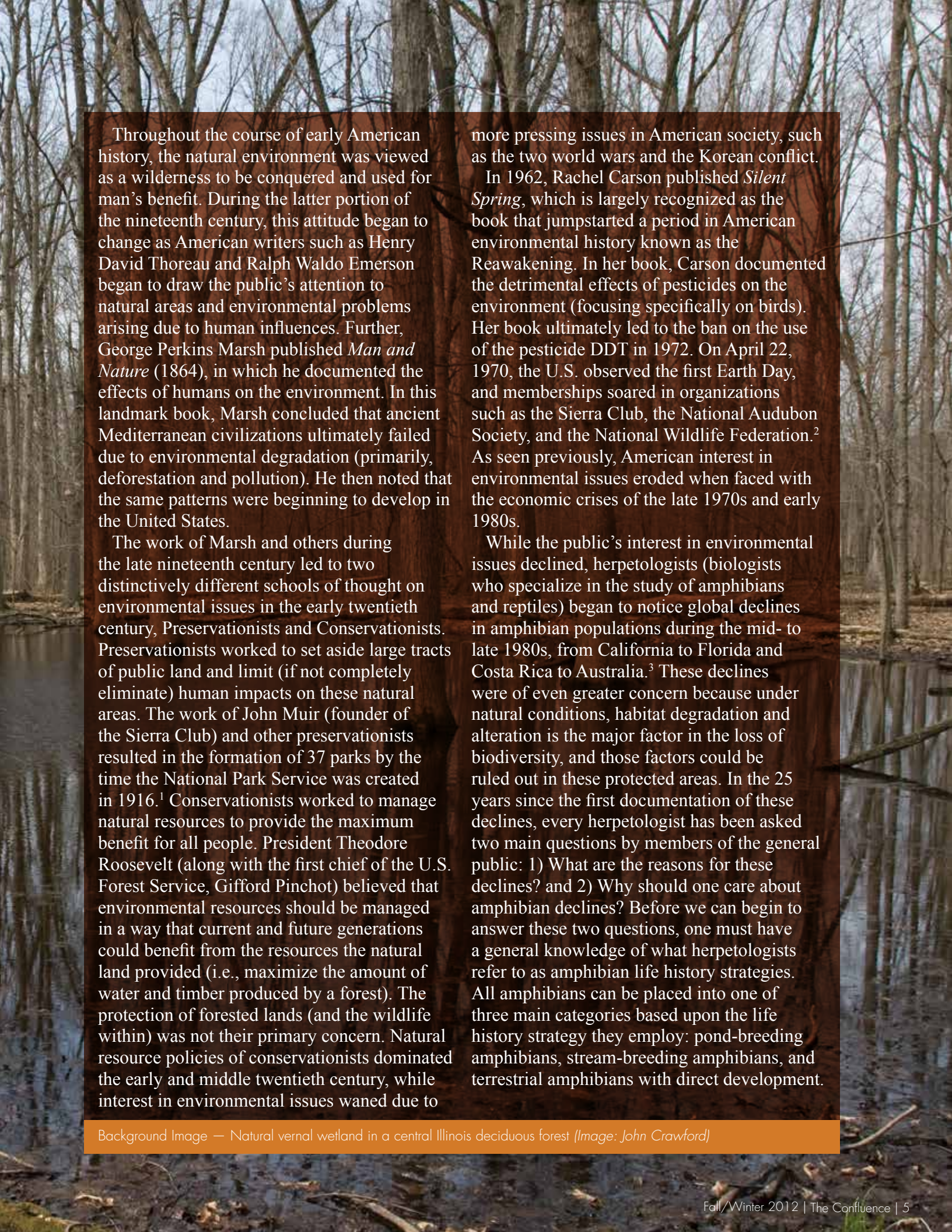


Spotted salamander, *Ambystoma maculatum* (Image: Bill Peterman)

# Modern Day CANARY *in the Coal Mine*

BY JOHN A. CRAWFORD





Throughout the course of early American history, the natural environment was viewed as a wilderness to be conquered and used for man's benefit. During the latter portion of the nineteenth century, this attitude began to change as American writers such as Henry David Thoreau and Ralph Waldo Emerson began to draw the public's attention to natural areas and environmental problems arising due to human influences. Further, George Perkins Marsh published *Man and Nature* (1864), in which he documented the effects of humans on the environment. In this landmark book, Marsh concluded that ancient Mediterranean civilizations ultimately failed due to environmental degradation (primarily, deforestation and pollution). He then noted that the same patterns were beginning to develop in the United States.

The work of Marsh and others during the late nineteenth century led to two distinctively different schools of thought on environmental issues in the early twentieth century, Preservationists and Conservationists. Preservationists worked to set aside large tracts of public land and limit (if not completely eliminate) human impacts on these natural areas. The work of John Muir (founder of the Sierra Club) and other preservationists resulted in the formation of 37 parks by the time the National Park Service was created in 1916.<sup>1</sup> Conservationists worked to manage natural resources to provide the maximum benefit for all people. President Theodore Roosevelt (along with the first chief of the U.S. Forest Service, Gifford Pinchot) believed that environmental resources should be managed in a way that current and future generations could benefit from the resources the natural land provided (i.e., maximize the amount of water and timber produced by a forest). The protection of forested lands (and the wildlife within) was not their primary concern. Natural resource policies of conservationists dominated the early and middle twentieth century, while interest in environmental issues waned due to

more pressing issues in American society, such as the two world wars and the Korean conflict.

In 1962, Rachel Carson published *Silent Spring*, which is largely recognized as the book that jumpstarted a period in American environmental history known as the Reawakening. In her book, Carson documented the detrimental effects of pesticides on the environment (focusing specifically on birds). Her book ultimately led to the ban on the use of the pesticide DDT in 1972. On April 22, 1970, the U.S. observed the first Earth Day, and memberships soared in organizations such as the Sierra Club, the National Audubon Society, and the National Wildlife Federation.<sup>2</sup> As seen previously, American interest in environmental issues eroded when faced with the economic crises of the late 1970s and early 1980s.

While the public's interest in environmental issues declined, herpetologists (biologists who specialize in the study of amphibians and reptiles) began to notice global declines in amphibian populations during the mid- to late 1980s, from California to Florida and Costa Rica to Australia.<sup>3</sup> These declines were of even greater concern because under natural conditions, habitat degradation and alteration is the major factor in the loss of biodiversity, and those factors could be ruled out in these protected areas. In the 25 years since the first documentation of these declines, every herpetologist has been asked two main questions by members of the general public: 1) What are the reasons for these declines? and 2) Why should one care about amphibian declines? Before we can begin to answer these two questions, one must have a general knowledge of what herpetologists refer to as amphibian life history strategies. All amphibians can be placed into one of three main categories based upon the life history strategy they employ: pond-breeding amphibians, stream-breeding amphibians, and terrestrial amphibians with direct development.



## AMPHIBIANS 101

### *Pond-breeding Amphibians*

Pond-breeding amphibians are defined as species that use a static body of water (e.g., wetland, pond, or lake) for at least a part of their life cycle. While a few species are permanently aquatic, most pond-breeding amphibians require both aquatic and terrestrial habitats to complete their life cycle. This biphasic life cycle is unique to amphibians (among the vertebrates) and requires aquatic habitats for egg and larval development before metamorphosis into the adult form, which persists on land. Further, the majority of pond-breeding amphibians will only use fish-free ponds since fish are major predators of both the eggs and larvae. In the state of Missouri, there are 35 species of pond-breeding amphibians, 11 of which are listed as species of conservation concern. In Illinois, there are 32 species of pond-breeding amphibians, 11 of which are listed as species in greatest need of conservation.<sup>4</sup>

### *Stream-breeding Amphibians*

Stream-breeding amphibians are defined as species that use a flowing body of water (creek, stream, river, etc.) for at least a part of their life cycle. As seen in the pond-breeding group, there are a few species of permanently aquatic stream-breeding amphibians, but the majority of species have an aquatic larval stage and an adult terrestrial stage. Only the largest species of stream-breeding amphibians (e.g., hellbenders and mudpuppies) will use streams and rivers that also contain fish. Most members of this group use smaller streams where fish are not present. In Missouri, there are six species of stream-breeding amphibians, three of which are listed as species of conservation concern. In Illinois there are also six species of stream-breeding amphibians, three of which are listed as species in greatest need of conservation.<sup>5</sup>

### *Terrestrial Amphibians with Direct Development*

Amphibians in this group are typically the least well known to the general public. Direct development simply means that species in this group do not have an aquatic larval stage and the young hatch out of the eggs as miniature adults. All direct developing amphibians in the U.S. are found in the salamander family *Plethodontidae*. Further, all salamanders in the family *Plethodontidae* (which includes both direct developers and some stream-breeders) are lungless, and thus highly dependent on moist, cool habitats to carry out dermal respiration (i.e., breathing through the skin). In Missouri, there are three species of direct developing amphibians, none of which is listed as a species of conservation concern. In Illinois, there are also three species of direct developing amphibians, none of which is listed as a species in greatest need of conservation.<sup>6</sup>

## REASONS FOR AMPHIBIAN DECLINES

Currently, extinction rates for plants and animals are estimated to be 1,000 times higher than background rates from the fossil record.<sup>7</sup> Of the vertebrate groups that have been completely evaluated (birds, mammals, and amphibians), the International Union for Conservation of Nature (IUCN) found that 12 percent of all bird species, 21 percent of all mammal species, and 30 percent of all amphibian species were at risk of extinction.<sup>8</sup> While a number of factors have contributed to these declines, it is widely accepted that the primary threat facing wildlife is habitat loss and degradation.<sup>9</sup> The major land use practices that affect amphibians (and other plants and animals) include agriculture, silviculture, and urban development; these processes typically result in the draining and/or filling of wetlands, clearing of forests and prairies, channelization of streams, and creation of impoundments. The majority of amphibians require both an aquatic habitat for a larval stage and terrestrial habitat for the adult stage. Further, these two distinct habitats must remain connected in order to maintain viable population sizes and conserve local and regional diversity. Unfortunately, both of these habitats are affected by human land use.

Although the general consensus is that habitat degradation and alteration is the primary cause behind amphibian declines, recent studies have shown other factors such as global climate change, chemical contamination of habitats (e.g., pesticides or herbicides), disease and pathogens, invasive species, and commercial exploitation are contributing to the declines. Additionally, each of the factors listed above can lead to synergistic effects that can exacerbate the overall negative effect on the population in question.<sup>10</sup>

## WHY PEOPLE SHOULD CARE ABOUT AMPHIBIAN DECLINES

Why should amphibian conservation be a priority? First, in his famous book, *A Sand County Almanac* (1949), Aldo Leopold wrote, “A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.” All organisms have a right to exist on this planet, and one could argue that humans have an ethical duty to protect and preserve diversity. Second, due to their unique life history features (discussed above) and semi-permeable skin, amphibians are excellent bio-indicators of ecological health.<sup>11</sup> Third, due to their extraordinary abundance and biomass, amphibians are critical for proper ecosystem function (consuming smaller invertebrates and serving as prey for larger vertebrates).<sup>12</sup> Considering their sensitivity to environmental degradation and overall abundance across the landscape, amphibians are now thought of as “canaries in the coal mine.” Dramatic declines of amphibians in an ecosystem are typically a precursor to catastrophic declines of other species and, eventually, an ecosystem collapse.



Eastern hellbender, *Cryptobranchus alleganiensis* (Image: Bill Peterman)

Within the Midwest, wetlands are critical for a number of ecosystem services that humans rely upon such as water filtration and storm water retention. Amphibian diversity and abundance in these wetlands are excellent indicators of overall wetland health and function. Across Illinois and Missouri the majority of amphibians are pond-breeding amphibians that rely upon seasonal and semi-permanent wetlands for reproduction (as well as appropriate upland habitat surrounding these wetlands).

Approximately 220 million acres of wetlands are estimated to have existed in the continental U.S. prior to 1700.<sup>13</sup> Since that time, over half of the original wetlands have been drained and converted to other uses. For example, in Illinois wetland conversion and drainage has been especially extensive; an estimated 90 percent of original wetland area has been lost.<sup>14</sup> Therefore, protection of remaining wetlands and creation of functional replacement wetlands to mitigate unavoidable losses is a high priority within the state. Seasonal wetlands (also known as vernal pools) are shallow, depressional wetlands that occur throughout the midwestern and eastern U.S. Distribution and abundance of seasonal wetlands are regarded as an indicator of overall ecosystem health and are especially important to numerous species of plants and amphibians. In addition to their biological importance, these seasonal wetlands play critical roles in hydrology (surface water storage and groundwater exchange), biogeochemical cycling, and energy exchange (via amphibian production and dispersal) to adjacent terrestrial habitat. Despite their ecological significance within the landscape, seasonal wetlands typically receive minimal regulatory protection at both the federal and state levels because they are often small (less than 0.5 hectares) and hydrologically isolated.<sup>15</sup>

## AMPHIBIAN SPECIES OF CONSERVATION CONCERN IN ILLINOIS AND MISSOURI

**Hellbender (*Cryptobranchus alleganiensis*)** – There are two subspecies of the hellbender (eastern hellbender – *C. alleganiensis alleganiensis*; Ozark hellbender – *C. alleganiensis bishopi*). The eastern hellbender is found in both Illinois and Missouri, while the Ozark hellbender is found in Missouri. The Ozark hellbender was listed as a federally endangered species in 2011 and the eastern hellbender is a state-endangered species in both Illinois and Missouri (the eastern hellbender is presumed to be extirpated in Illinois since it has not been seen in the state in 30 years). Hellbenders are found in fast-flowing rivers and streams that have not been impacted by sedimentation and chemical runoff. Adults and juveniles are largely nocturnal and hide under large submerged rocks and logs during the daytime. Reproduction normally occurs in early fall (August-October), and the male guards the eggs (in some populations males will guard juveniles for up to 1.5 years after hatching). Hellbenders discharge a toxic skin secretion that likely repels larger predatory fish.

**Common mudpuppy (*Necturus maculosus*)** – The common mudpuppy is found in both Illinois and Missouri. It is listed as state threatened in Illinois and a species of conservation concern in Missouri. It is rarely seen in both states, so its status is unclear. Mudpuppies can be found in large lakes and ponds, but they are most often seen in fast-flowing rivers and streams with very little sedimentation. Adults and juveniles are nocturnal, feeding mostly on small fish and crayfish. Adults breed during the fall and are most active during the fall and winter seasons.





Common mudpuppy, *Necturus maculosus* (Image by: Matt Ignoffo)

**Spotted dusky salamander (*Desmognathus conanti*)**

– The spotted dusky salamander is found in isolated populations in Pulaski County, Illinois, (as well as one introduced population in Johnson County) and is listed as a state endangered animal. Spotted dusky salamanders are only found in headwater streams (lacking fish) that flow through dense forests. Adults and juveniles are nocturnal, becoming active on rainy nights when they can forage along stream banks for various invertebrates. During the day, these salamanders can be found under logs, rocks, and leaf packs within the stream bed. Mating occurs in late spring (April-June), and the female guards the eggs until they hatch during the fall (September-October). Larvae then move into pools of the stream until metamorphosis the following spring.

**Four-toed salamander (*Hemidactylum scutatum*)** –

The four-toed salamander is found in both Illinois and Missouri. It is listed as state threatened in Illinois and a species of conservation concern in Missouri. Its status seems to be secure in Missouri with a fair number of stable

populations, but there are only isolated populations in Illinois with relatively low population numbers. Adults are found within 50 meters of spring-fed streams or pools with an abundance of moss and logs, and they feed on a variety of forest floor invertebrates. Mating occurs during the fall, and eggs are laid in communal nests during the spring. One or more females guard the eggs until hatching. Larvae then wriggle into the water, which is usually just below nesting sites.



Four-toed salamander, *Hemidactylum scutatum* (Image by: Bill Peterman)

**Ringed salamander (*Ambystoma annulatum*)** – The ringed salamander is an Ozark endemic salamander found in Missouri; across its entire range it is only found in Missouri, Arkansas, and Oklahoma. Within Missouri it is listed as a species of special concern due to its restricted

Spotted dusky salamander, *Desmognathus conanti* (Image by John Crawford)

Female spotted dusky salamander with newly hatched larvae (Image by John Crawford)







Ringed salamander, *Ambystoma annulatum* (Image by: Bill Peterman)

range. Adults and juveniles can be found within high-quality oak-hickory forests where there are suitable breeding ponds (dries every 3-4 years) lacking fish. Adults make their breeding migrations to these ponds in early fall (August-October) during periods of heavy rain. Larvae hatch in late fall and overwinter in the breeding pond; metamorphosis occurs during the following year (May-June). Outside of the breeding season, ringed salamanders can be found in abandoned small mammal burrows and under rotting logs on the forest floor.

**Jefferson salamander (*Ambystoma jeffersonianum*)** – The Jefferson salamander is found in Illinois, where it is listed as a state threatened species due to a severely restricted range (found only in Clark and Edgar counties). Adults and juveniles are found in high-quality beech-maple forests with suitable vernal wetlands for reproduction. Within their range, Jefferson salamanders are typically the first pond-breeding amphibians to reach breeding ponds with migrations occurring in late winter

to early spring (February-March); it is not uncommon to catch breeding adults in ponds that are covered with ice. Eggs hatch within a month, and larvae remain in the ponds throughout spring and metamorphose in June. Jefferson salamander larvae typically prey upon other amphibian larvae during this period of development. Outside of the breeding season, Jefferson salamanders can be found on the forest floor under rotting logs.

**Mole salamander (*Ambystoma talpoideum*)** – The mole salamander is found in the southern portions of both Illinois and Missouri. It is listed as a species of special concern in Missouri and a species in greatest need of conservation in Illinois; this is primarily due to its specific habitat requirements. Mole salamanders are found in bald cypress and tupelo swamps and adjacent sloughs. Adults move to breeding ponds (fish-free ponds or swamps) during late winter rains, with larvae subsequently metamorphosing in late summer. In certain portions of their range, some larvae will become sexually mature

Jefferson salamander, *Ambystoma jeffersonianum* (Image by John Crawford)

Mole salamander, *Ambystoma talpoideum* (Image by John Crawford)







Tiger salamander, *Ambystoma tigrinum* (Image by Bill Peterman)

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adults but will not undergo metamorphosis (neotenic individuals). As with other salamanders in this genus, mole salamanders can be found under rotting logs and in abandoned small mammal burrows outside of the breeding season.

**Tiger salamander (*Ambystoma tigrinum*)** – The tiger salamander is found in both Illinois and Missouri. While it is not officially listed in Illinois, it is listed as a species of special concern in Missouri. Its status in both Illinois and Missouri is largely unknown due to its patchy distribution and low population sizes. Tiger salamanders are the largest terrestrial salamanders in both Illinois and Missouri and can be found in both forest and prairie habitats with suitable fish-free vernal wetlands. Reproduction occurs in late spring (March-April), with adults making breeding migrations on warm, rainy nights. Larvae typically metamorphose in late summer (July-August), and occasionally tiger salamander larvae can become cannibalistic (in addition to feeding on amphibian larvae

of other species). These cannibalistic larvae can reach sizes of up to 10 inches in length.

**Crawfish frog (*Rana areolata*)** - The crawfish frog is found in portions of both Illinois and Missouri. It is listed as a species of special concern in Missouri and a species in greatest need of conservation in Illinois, primarily due to its specific habitat requirements. Crawfish frogs require high-quality prairies with an abundance of crayfish burrows and fish-free vernal wetlands. Adults breed during the spring (March-April) and can be readily identified by their breeding call, which is a loud, deep snore. Females can lay up to 7,000 eggs, and metamorphosis of tadpoles occurs during mid-summer. Outside of the breeding season, crawfish frogs remain in the same crayfish burrow all year and only emerge to feed on warm rainy nights, never moving more than 1-2 meters from their burrow. In some instances, crawfish frogs will migrate more than 1 kilometer from their burrow to a breeding pond, so large



areas of intact prairie are critical to the persistence of this species.

**Wood frog (*Rana sylvatica*)** – The wood frog is found in both Illinois and Missouri; it is listed as a species in greatest need of conservation in Illinois and a species of special concern in Missouri. The wood frog requires mature hardwood forests with an abundance of moist soil and leaf litter as well as fish-free vernal wetlands for reproduction. Breeding migrations begin in late winter (January-March) when warm rains begin to melt ice off of the wetlands. It is not uncommon to find breeding wood frogs in ponds still partially covered by ice. Females tend to lay their egg masses (up to 1,000 eggs) in the same area of the pond. Tadpoles grow rapidly and metamorphose by early summer (May-June). Outside of the breeding season, wood frogs can be found moving along the small creeks and ravines often greater than 1 kilometer from the breeding pond, so large areas of intact mature forest are critical to the persistence of this species.



Crawfish frog, *Rana areolata* (Image by Bill Peterman)

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Wood frog, *Rana sylvatica* (Image by John Crawford)





## WHAT CAN BE DONE TO HELP

Although there are a large number of amphibian species that are of conservation concern in Illinois and Missouri, one need not be a herpetologist to help. There are a number of ways to help with conservation of these unique animals and protection of environmental health:

- Became involved in a citizen-science project involving amphibians. Researchers throughout Illinois and Missouri have projects that are in need of volunteers for the collection of valuable data.
- Those who own a small piece of forest or prairie habitat can build a vernal wetland or two on their property.<sup>16</sup>
- Donating money to state wildlife research projects is another step in helping such efforts. Both Illinois and

Missouri have tax check-off programs through which individuals can donate a portion of their tax returns to wildlife research programs.

- Donating to the Saint Louis Zoo's WildCare Institute, Ron Goellner Center for Hellbender Conservation is another means of assistance.
- Joining a local or regional herpetological society such as the St. Louis Herpetological Society ([www.stlherpsociety.org](http://www.stlherpsociety.org)), Chicago Herpetological Society ([www.chicagoherp.org](http://www.chicagoherp.org)), Missouri Herpetological Association ([www.mha.moherp.org](http://www.mha.moherp.org)), or Central Illinois Herpetological Society ([www.centralillinoisherp.com](http://www.centralillinoisherp.com)) is also a venue through which one can assist with these efforts.

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Female wood frog with freshly laid egg masses in a vernal wetland (*image by John Crawford*)





## ENDNOTES

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