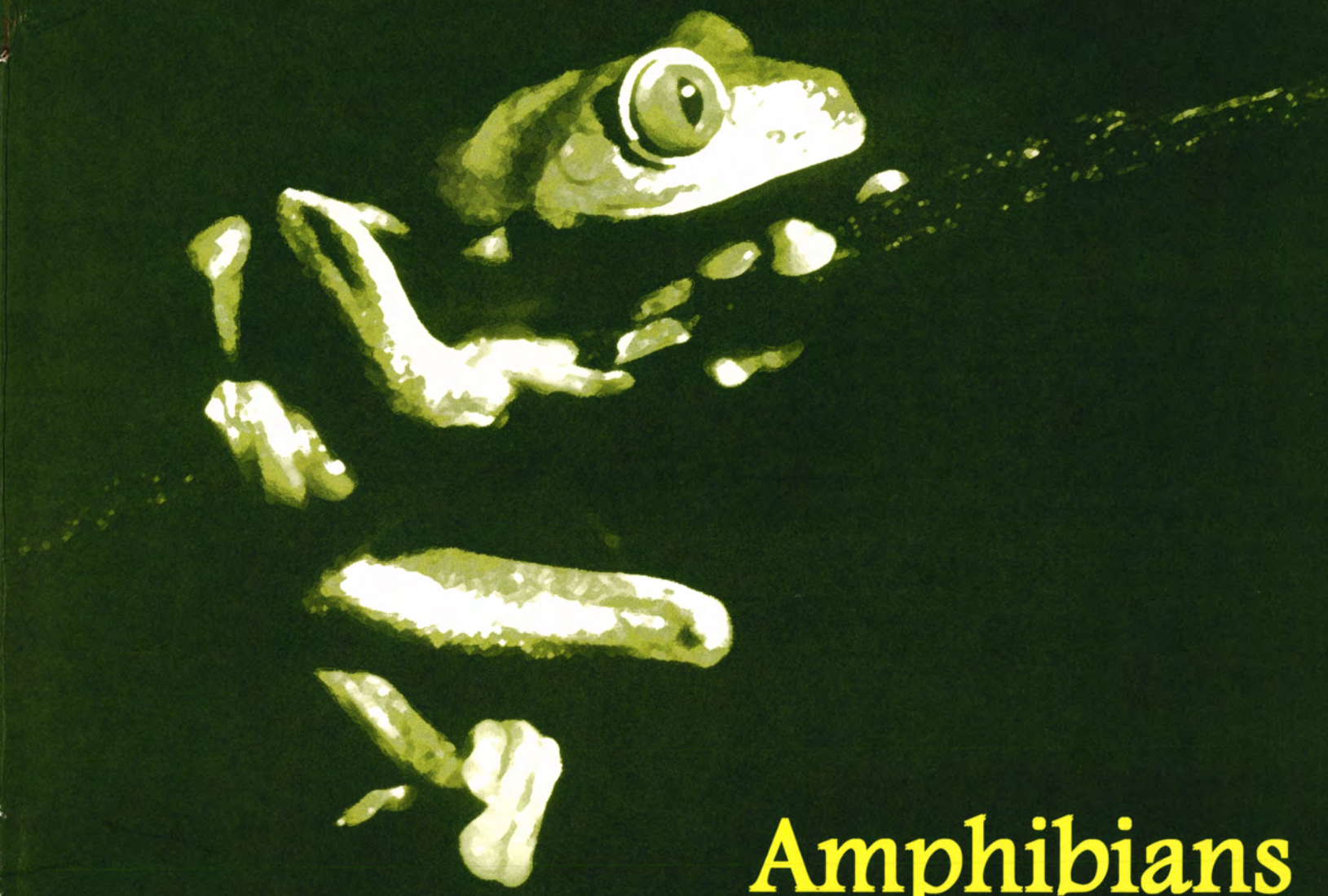
Nature Study

A Journal of Environmental Education and Interpretation



Amphibians

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American Nature Study Society

President's Letter

Steve Melcher

I don't know what idiot coined the term "stay-at-home Dad." I spend most of my time not at home but in the car shuttling kids around. I may be changing a diaper one minute and reviewing someone's dissertation the next. Some days find me trapped behind a computer in the morning and kayaking on the Erie Canal with my daughter in the afternoon. Truly a double life. An amphibian. The topic of this issue of Nature Study is amphibians — creatures with two lives.

I want to thank John Serrao for his role as guest editor for this issue. John, like many ANSS members, is a generalist, a true naturalist. He could have chosen any number of topics from Nature Photography to Outdoor Leadership Skills for a journal. Naturalists, like many species of amphibians, are unfortunately disappearing. Not that they are lost in the jungles of Panama but rather the number of naturalists or generalists has diminished. Naturalists may have their "area of expertise" but have chosen to view the world as a whole, to know, intimately, the plants and animals in their neighborhoods. Naturalists find themselves as excited about seeing an eclipse of the moon as finding a red-backed salamander under a rock.

The ANSS has proposed to nurture that excitement in young naturalists and to maintain or rekindle that flame in working scientists and educators. Most children are naturalists at heart, thinking it perfectly normal to collect armfuls of leaves or wonder what lies beneath a decaying log. However, that interest in local phenomena seems to dissipate somewhere in the upper elementary grades. A ten-year old girl may be able to name more dinosaurs on a website than trees in her neighborhood. That same student can recognize a species of lemur from Madagascar but be unable to identify the vocalizations of an American toad. The disparity continues as the child's education moves to high school and college. Today's scientific funding practices favor lab-oriented projects. Consequently, it is becoming increasingly difficult to fund field-oriented research. A graduate student living on pizzas and a thirst to learn will find funding for manipulating genes in a lab more readily available than for a project that researches the use of amphibians as bioindicators. The ANSS, through its journal, workshops and correspondence with funding sources, hopes to guide more money and interest toward field-oriented projects.

I remember as a child the deafening night chorus of Spring peepers. My brother and I would venture out, armed with flashlights and curiosity, in search of the elusive amphibian ventriloquists. Sometimes, we were lucky enough to catch the impossibly expanding balloon beneath the tiny creature's chin shining in the crossfire of our lights. We were in awe. We were in awe of the din created by such a small critter as well as by the numbers in the chorus. Today that chorus has grown quiet in many of our neighborhoods. We are struggling to save the ephemeral ponds and wetlands where these boisterous songsters lay their eggs.

Please share this copy of Nature Study with a colleague or better yet with a budding naturalist. You may save someone from a life in the lab. Help them to go outside and enjoy what brought them to the natural sciences in the first place. Naturalists are a disappearing breed. Children of the present generation need to be encouraged and nurtured to continue their interests in nature. That generation needs you, the trained, educated, knowledgeable chorus, to sing out to those with the curiosity and vigor to carry on the quest.

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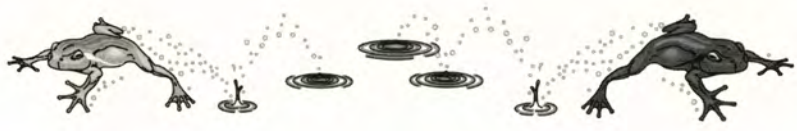
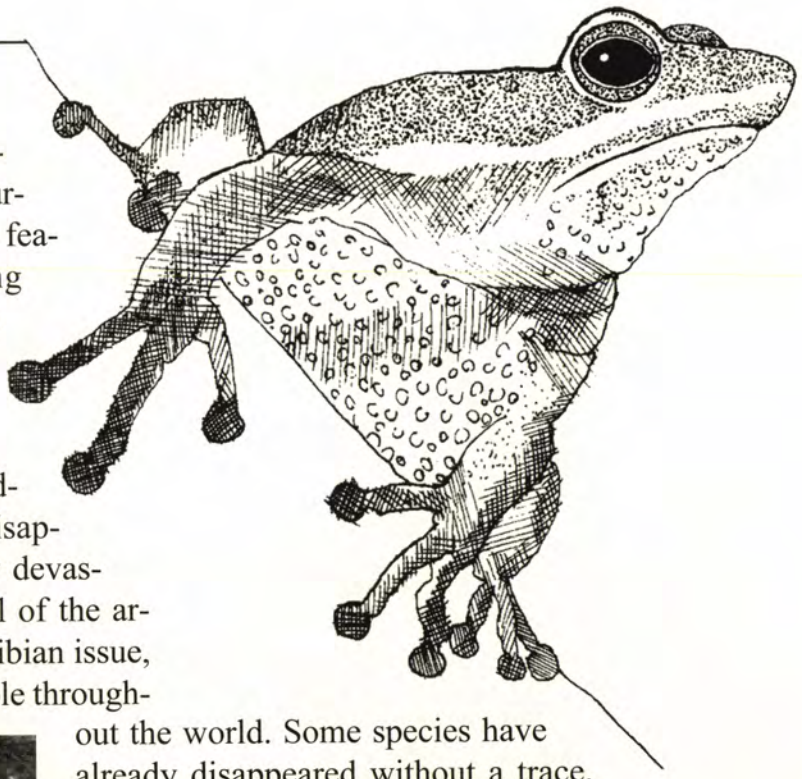
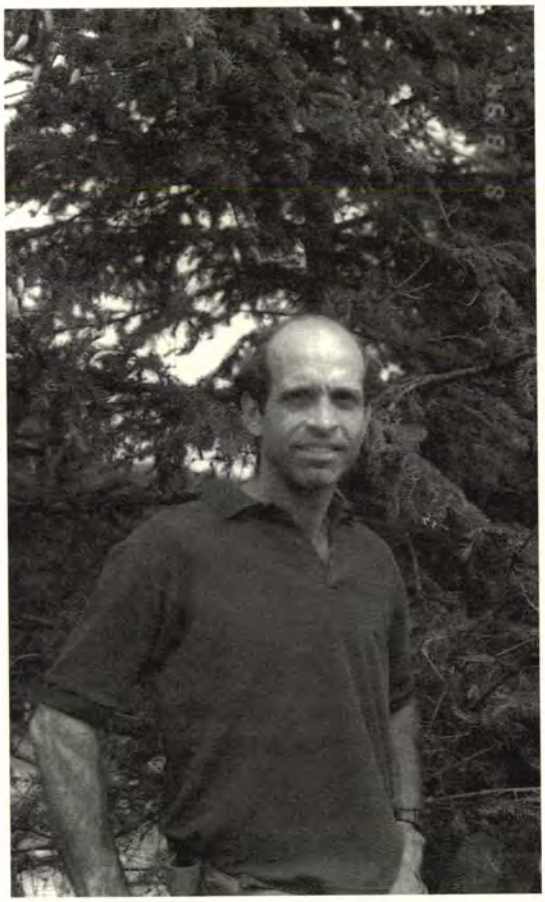


From the Guest Editor

John Serrao



Over the past few years, there probably hasn't been a single scientific journal or popular magazine that hasn't featured a story about "disappearing frogs." Frogs and toads – and to a lesser extent, salamanders – are among our most familiar and beloved creatures, ones to which we've all been exposed since childhood. To imagine their possible disappearance from our world is simply devastating. Yet, as evidenced by several of the articles selected for this special amphibian issue, amphibians are indeed in deep trouble throughout the world. Some species have already disappeared without a trace, while others – in Asia, South America, Australia, and the United States – seem to be heading toward extinction.



The authors for this issue of *Nature Study* are all experienced, knowledgeable naturalists and biologists who have worked with amphibians in their programs or research projects. Their articles provide excellent background materials about amphibians. They include topics on amphibian biology, breeding mechanisms, taxonomy, defensive behaviors, phenology, winter freezing, and population declines, as well as a few articles highlighting well-known individual species.

There are also articles about vernal ponds, those ephemeral wetlands, that are vitally important to several frogs and salamanders; habitat restoration and management for amphibians at a New Jersey nature sanctuary; the ongoing Pennsylvania Herpetological Atlas that is currently yielding thousands of new records for occurrence of

herptiles in that state, as well as an interview with Professor Art Hulse, the coordinator of Atlas; the international Declining Amphibian Population Task Force, an organization of scientists studying the disappearance of frogs and salamanders throughout the world; and more.

Originally, this issue was going to include both reptiles and amphibians. When we realized the enormous amount of information available about amphibians and, especially, their current importance to scientists studying their worldwide declines, we decided to restrict this ANSS Journal to amphibians. Perhaps a future issue will cover the reptiles.

Please enjoy the following collection of articles about these universally beloved creatures.

John Serrao is a naturalist and photo-journalist in Pennsylvania's Pocono Mountains. He is the resident naturalist at Skytop Lodge, conducts weekend nature workshops at the Pocono Environmental Education Center, and has written a weekly nature column – "Pocono Outdoors" – for the Pocono Record since 1988. His fourth book – The Reptiles and Amphibians of the Poconos and Northeastern Pennsylvania — was published in June, 2000.)

What are Amphibians?

by Thomas C. LaDuke, Ph.D.

Most amphibians are small, unobtrusive creatures that are for most of the year all but invisible to the casual observer. Yet, these animals are among the most significant players in the trophic pyramid of some northeastern forests in the United States. The diversity of species found the world over attests to their evolutionary success. Some amphibians may grow to more than five feet in length, while others are toxic enough to kill. Surely, these animals are worthy of our attention, if not our undivided fascination.

Today, people all over the world are concerned by the fact that amphibian populations and species are becoming extinct at an alarming rate. Other amphibian populations have been found with freakish developmental deformities. The causes of these declines and deformities have not been easy to determine. Many hypotheses have been advanced, but little conclusive evidence to support or refute them is available. In an attempt to provide context for understanding their lives, this article examines some basic biological features of amphibians and some of their more remarkable characteristics as well.

What is an Amphibian?

Taxonomists currently place living amphibians into three groups (orders). Each is about as different from the others as a bird is from a lizard. This is due to their ancient ancestry and long independent evolutionary history.

The most familiar group is the frogs (*Anura*).

Green Tree Frog with Moth © John Serrao

With over 4,105 species, this is the most successful group of modern amphibians. Their most important features, around which the rest of the adult animal seems to be organized, are their voices and their elongated hind legs, designed for leaping or hopping.

Many species of frogs have taken to the trees, and, in some countries, even lay their eggs high above the ground or water. The Puerto Rican rain frogs, or coquis, climb trees to feed at dusk, then parachute down to hide in the leaf litter before dawn. From Borneo, Wallace's flying frog even has folds of skin between its legs and extensively webbed feet for gliding downward.

Centrolenella fleischmanni © T. LaDuke

Worldwide in distribution and conspicuously vocal when breeding, frogs are familiar to most people. Several species are typical classroom and laboratory animals, while a few colorful species have become icons of tropical beauty. The largest frog is the Goliath frog of Africa. The champion leaping record was 17.5 feet (5.3 m) on a single jump. This champion jumper can grow to 12 inches (30 cm) from snout to vent. The largest frog in the United States is the familiar bullfrog, whose maximum length is eight inches (20.6 cm). The smallest frog recorded is a Cuban species of rain frog (*Eleutherodactylus*) which grows to an average size of 3/8 of an inch (1 cm).

Another amphibian group is the salamanders. With only about 420 species world wide,

they are much less diverse than frogs, but in certain habitats, they may be very abundant. It is estimated by many scientists that salamanders in forests of New England and much of the Appalachians exceed birds and mammals in both numbers and biomass. The salamanders are organized around a basic tetrapod body plan, with a head, four limbs and a tail. They are usually secretive, hence less familiar to most. They are however diverse and abundant in few regions globally, including the eastern United States and the highlands of middle America. Here they have successfully evolved into scores of fully terrestrial species, including many with prehensile tails and "suction-cup" feet. Some live entirely in the epiphytic canopy of the tropical forests. The largest salamanders are the Japanese giant salamanders (*Andrias japonicus*), which reach lengths to 1.8 m. The largest salamander in the United States is the related hellbender, which can reach lengths of 29 1/8 in. (74 cm). The smallest salamanders in the world are the minute *Thorius* from the Mexican highlands. These salamanders may have average adult male sizes as small as 3/4 in. (18.2 mm).

Bolitoglossa robusta © T. LaDuke

The third group of amphibians, the caecilians, are poorly known and rarely seen. They are strictly tropical, and can be found in Central and South America, Africa, and Asia. Limbless, underground burrowers, these animals are rarely encountered, even where fairly abundant. Their skin is divided into segments called annuli that encircle the body, which give them an appearance that is remarkably like that of an earthworm. On the side of the face, caecilians have a retractable sensory tentacle. There are only about 166 known species. The smallest caecilians are about three inches (75 mm) in length, while the largest may reach sizes of about 5 feet (1.5 m).

Amphibian Evolution

Amphibians were the earliest tetrapods to evolve. They play a pivotal role in vertebrate evolution because they allowed otherwise aquatic organisms to invade, and eventually dominate, dry land. We can readily separate modern amphibians from ancient groups that represent the first land-dwelling vertebrates. Many of these earliest amphibians had the approximate size and appearance of a crocodile, with long jaws, a flattish head and a simple body plan with four legs and a tail. Yet the fossil record shows that at least some of them had aquatic larvae. These ancient amphibians arose in the late Devonian Period, about 360 million years ago and flourished with a great deal of speciation and evolution. Then, in the Lower Jurassic Period, primitive amphibians died out. However, they did not die without issue, because somewhere along the way, they gave rise to the ancestors of modern amphibians. Fossil remains of modern amphibian types are few in the ancient strata of the early Mesozoic Era, but well-preserved skeletons are known from among the earliest fossils of each group.

The earliest amphibian with clear ties to modern types was *Triadobatrachus massinoti*. It is known from a partial skeleton form found in the Lower Triassic of Madagascar (245 million years old). This frog-like creature is close to the ancestry of modern frogs.

Next to appear were the caecilians. Well-preserved skeletons of early caecilians were found in early Jurassic sediments of Arizona. Interestingly, these fossils are clearly caecilians, but have tiny legs.

Salamanders do not appear in the fossil record until the middle Jurassic, about 160 million years ago. The earliest salamander fossils are fragmentary, but a complete salamander skeleton from the Middle Jurassic, named *Karaurus sharovi*, is known from Russia.

Defining Features

Amphibians differ from other tetrapods (four-limbed vertebrates) in many fine points of their anatomy, but three especially important features distinguish them from other tetrapods. 1) Amphibians usually have a moist slimy skin. The structure of

this organ has broad ramifications for the biology of amphibians, often restricting them to specialized habitats, yet providing them with many abilities not enjoyed by other tetrapods. 2) Developmentally, amphibians have a primitive egg that is more like that of a fish than those of other tetrapods. This egg form has no hardened, protective shell, and, for most amphibians, must be in water to survive. 3) Another important developmental characteristic is the presence of an aquatic larva that must undergo metamorphosis before it can reach maturity.

Jefferson Salamander © John Serrao

The Skin

The skin of amphibians is very thin, with aquatic forms having only a few layers of epidermal cells. Terrestrial forms generally have more epidermal cell layers, but the cells are not well keratinized. Thus, the skin is a poor shield from the external environment, and allows many chemicals to pass easily through. This is very important to the biology of amphibians because many of them depend on the skin as a respiratory structure and also for the transport of water into the body and some excretory wastes out. In fact, most amphibians do not drink at all in the traditional sense, but simply absorb water through the skin. Many kinds of terrestrial frogs have a specialized "seat patch" on their posterior belly that is served by a large number of blood vessels specifically arranged to help take in water that has been absorbed through the skin. The seat patch allows a toad or spadefoot to absorb water even from soil that is barely damp.

Bufo peniglenes © T. LaDuke

The skin of amphibians is typically well vascularized, facilitating the exchange of respiratory gasses between the atmosphere and bloodstream at their interface. Studies have shown that the spotted salamander, for example, may take in as much as 68% of its respiratory oxygen from its skin. Aquatic salamanders, such as the siren and mudpuppy, typically absorb about one-third of their respiratory oxygen through the general skin surface. Terrestrial frogs, too, rely on their skin for from 23% to about 45% of their oxygen intake. Surprisingly, the lungless black-bellied salamander barely acquires 10% of its oxygen through the skin, relying instead on the mucous membrane lining its mouth and pharynx for oxygen uptake. On the other hand, this species does rely on cutaneous respiration to expel as much as 89% of the carbon dioxide it excretes.

Thin skin may be very useful in a pristine environment, but there are two potential drawbacks. One of these is ease of infection by pathogenic organisms, and the other is ease of transmission of environmental toxins into the body. Amphibians have a very effective method of dealing with the former problem in nature, but, as this journal indicates elsewhere, the latter problem has brought about the demise of many populations with the advent of human pollution and effects on climate.

Toxins

All amphibians have two types of glands in their skins. Mucuous glands help keep the skin moist by secreting a layer of mucous that helps retard evaporative water loss. Poison glands secrete a variety of complex chemical substances whose functions are only just beginning to be understood. One of the functions of the poison gland is to serve as an antimicrobial agent. Obviously, a moist bit of exposed tissue of any kind is an ideal site for bacteria and fungi to colonize. To protect against these pathogenic invaders, amphibians include several types of peptides in the products of their poison

glands. These are effective in killing bacteria, fungi and protozoan parasites. Only when stressed by rough handling or poor captive conditions does this defense break down.

Many people are also familiar with the importance of amphibian skin toxins in deterring predators. These secretions vary in potency among species, but some kinds of amphibians produce toxins that can be quite lethal, even in small doses. Most, however, are much milder. The four main classes of skin toxins are known as amines, peptides, alkaloids and bufodienolides. Frogs that secrete alkaloids, such as many of the poison dart frogs (*Dendrobatidae*) are among the most toxic of the amphibians. In fact, poison dart frogs get their name from the fact that some South American native tribes used poison derived from the skin of two species of these frogs to poison the tips of their blowgun darts. The poisons were extracted by heating the frogs or their skin over a flame. Although most of these frogs can be handled directly, some researchers have discovered the hard way that handling the most toxic species without gloves can lead to poisoning directly through the skin of the hands. Most poison dart frogs have brightly colored skin that helps to protect them by warning predators not to attack, lest they be poisoned. This is known as aposematic coloration. The same principle applies to the monarch butterfly, and, like the monarch, there appear to be mimicry complexes consisting of less toxic frogs, often from other families, that mimic the more toxic species. Oddly, poison dart frogs that are raised in captivity lose their ability to produce toxins. This has led to the discovery that they require specific molecular precursors in their diet in order to produce the toxins. The specialized diet of these frogs, primarily ants and other small arthropods with chemical repellents of their own, is necessary for them to produce their toxins. The most toxic amphibians in the United States include the toads and the newts. When attacked by predators, true toads can secrete various toxins from large parotoid glands and warts on their backs. In some species, such as the giant cane or marine toad (*Bufo marinus*) the toxins can kill dogs and cats, while other species can produce hallucinations if ingested by humans.

Mud Puppy (Neotenic Salamander) © John Serrao

The cornucopia of chemicals that amphibians can secrete may be used for protection in a variety of other ways as well. One South American dendrobatid, known as the skunk frog (*Aromobates nocturnus*) is not particularly poisonous, but produces an extremely foul, skunk-like smell by secreting mercaptan-like chemicals from its skin when handled. Recent studies of the skin toxins of African clawed frogs (*Xenopus*) by George T. Barthalamus and others have shown that many of the chemicals secreted by this frog have properties similar to those of certain neurotransmitters such as serotonin, or other mood altering and antipsychotic drugs. In humans and many other animals tested, these drugs are known to induce the following responses: yawning, mellow moods, satiety of appetite, and hypertension, among others. When tested on snakes that do not normally feed on these frogs, the drugs induced yawning and jaw adjustment behaviors (of obvious benefit to potential prey), loss of aggressiveness, temporary loss of appetite, and a climbing response. The latter appeared to be an attempt on the snake's part to try to reduce blood pressure to the brain and heart by adopting a vertical posture, but which resulted in driving the snake out of the frog's aquatic habitat! Some snakes that occur in Africa have evolved immunity to these poisons and feed on the frogs anyway, much as our own garter snakes have evolved varying degrees of immunity to the toxins of local frogs, toads and newts. It is undoubtedly this immunity which drives the evolution of stronger and stronger skin toxins. The array of chemicals secreted by each amphibian species is unique, but many of them perform similar functions to those reported for the African clawed frog.

Amphibian Life History Strategies

Amphibians may have a complex life cycle that includes an egg, a larval form, and an adult form. The larva may occupy different habitats and consume completely different kinds of food from the adult. On the other hand, many species have lost parts of their life cycle. Some, such as the rain frogs of the American tropics and many lungless salamanders, have dispensed with the larval stage. Almost all species of salamanders in the New World tropics belong to the *Plethodontidae* or lungless salamander family, and all are fully terrestrial. Their offspring develop directly from egg to small adult form. Others, such as the

Hyla rufitella (blotched morph) © T. LaDuke

American mudpuppies, sirens and the Texas cave salamander appear to have lost the adult stage, retaining the outward appearance of larvae, but with full reproductive abilities. A few species (*Nectophyrynopides occidentals* and *Eleutherodactylus jasperi*), have even lost the egg phase and give birth to fully formed young.

Clearly amphibians display great plasticity of life history. They are also highly malleable as regards other characteristics as well. For example, they have remarkable powers of regeneration. Salamanders, especially, are known for their ability to regrow a lost tail or even limbs.

Another trait of amphibians is their ability to withstand genetic rearrangements. Most vertebrates are adversely affected by chromosomal aberrations in their genetic makeup. An extra chromosome in a human spells death or some form of impairment, such as Down's Syndrome. Not so the amphibians. Many instances are known in which amphibians with an entire extra set of chromosomes live and reproduce quite successfully. In fact, entire triploid species have been described which result from hybrid matings between two well-defined diploid species. This is the case in the Jefferson's salamander complex. Hybrid matings between Jefferson's salamander and the blue-spotted salamander have, at some point in the past (probably multiple times), resulted in the production of triploid offspring. Amazingly, all individuals of these triploid species are females! A variety of genetic phenomena allow these unisexual populations to produce offspring. These may also be triploid and identical to their mothers, or may have other ploidy levels. Although unisexual triploid populations were once recognized as separate species, their variability and apparent multiple origins has prompted researchers to refer to them as biotypes, identifiable only by determining the number of sets of chromosomes from each parent species.

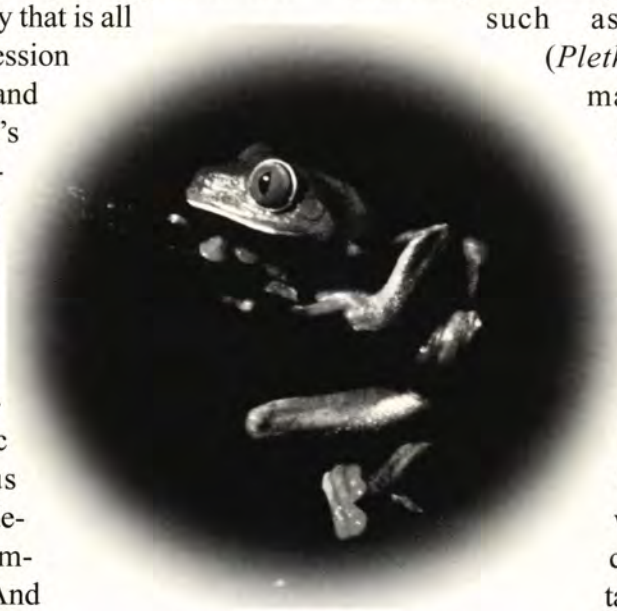
Metamorphosis

Amphibians are exceptional tetrapods because they have a free-living larval stage. Salamander larvae are aquatic and have external gills and sensory structures called lateral line organs, or neuromasts. Lateral lines are used for detecting waterborne vibrations and otherwise are only found in fish. The transformation from aquatic to terrestrial form in salamanders is not so remarkable, for it entails only the loss of external gills and tail fins, and the development of lungs for breathing air. (Exceptions of course are the lungless salamanders, all of which lack lungs as adults and many of which lack any aquatic larval stage.)

Metamorphosis in frogs, on the other hand, is one of the most astonishing transformations to

Narrow Mouthed Toad (eats ants) © John Serrao

be found in the vertebrate world, commensurate with the remarkable metamorphosis of a caterpillar into a butterfly. Consider an aquatic organism with no paired limbs or fins, no true teeth, nor even any bone in its skeleton, a small mouth with a cornified beak that allows for only a scraping and suction-filtration method of feeding, largely vegetarian diet (in most species), and a body that is all but absent, giving the impression of a large head with a tail, and that's it! This is a tadpole. It's fluttering, wobbly swimming does not impress one with speed or agility. No wonder most of them prefer not to live with predatory fish. This creature will turn into a terrestrial, tailless, four-legged, athletic leaper, with an enormous mouth. It will have a well-developed bony skeleton complete with teeth (in most). And finally, it will be entirely carnivorous, feeding on insects and other small animals, eating almost anything that moves and can be overpowered and swallowed.



Agalychnia callidryas © T. LaDuke

Metamorphosis typically occurs at the end of a brief larval period that may occupy no more than a single season. True toads for example, may have a larval period of no more than a few weeks, and in Couch's spadefoot toad, it may take only nine days from the time the eggs are deposited to the departure of newly transformed toadlets from the water. Some amphibians, however, remain larval for a longer period. Summer breeding frogs, such as the bullfrog and the green frog may have tadpoles that overwinter and may take as many as one to two years to metamorphose. The red spotted newt has a brief aquatic larval phase, but metamorphoses into a terrestrial juvenile form called the eft, which may exist for as much as five years or more before metamorphosing again into an aquatic adult.

At the other extreme are paedomorphic salamanders that have truncated life histories, retaining the external appearance of larvae throughout life. Paedomorphosis has evolved repeatedly in the salamanders. Many of the most paedomorphic lineages have produced the largest salamanders. The hellbenders and Asian giant salamanders, amphiumas, sirens and mudpuppies all reach lengths of 12 inches or more. All of these are aquatic throughout life, retaining gill openings and larval skin characters. Some of them even retain the external gills.

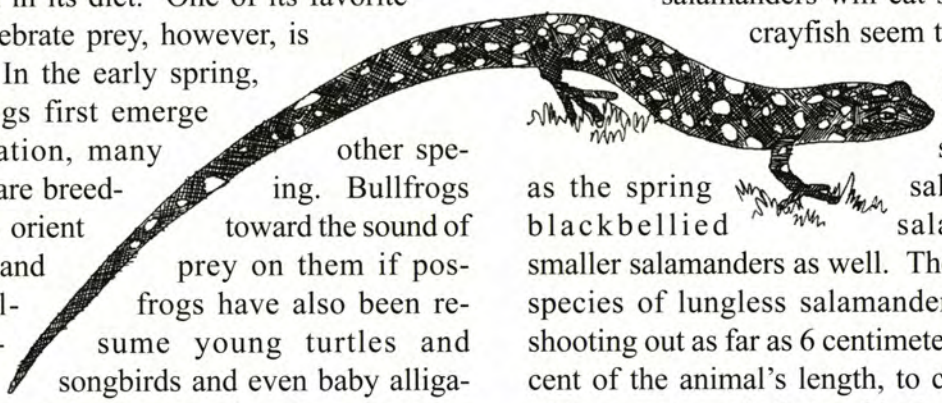
There are also paedomorphs among the traditionally metamorphosing salamander families, such as lungless salamanders (*Plethodontidae*) and mole salamanders (*Ambystomatidae*). Some paedomorphic species, including the European olm and the Texas blind salamanders live in caves and deep subterranean streams. These species have adapted to darkness by losing their eyes and their pigmentation, living now as blind, spindly-legged sprites of the underworld. In addition, some species have populations of facultative paedomorphs that may or may not produce metamorphs, depending on climatic conditions. This occurs, for example, in the tiger salamander and the red-spotted newt.

It is particularly fitting that amphibians, whose name means two-phased, occupy such a pivotal role in the evolution of vertebrates. The normal life cycle of typical amphibians mirrors the evolutionary transition from aquatic to terrestrial vertebrate that took place with the origin of the group. Furthermore, the evolution of the terrestrial egg-laying habit, which marked the evolutionary transition from amphibian to reptile, has occurred repeatedly within existing lineages of amphibians.

Diet

Amphibians feed primarily on small arthropods. Typical frogs and salamanders are indiscriminate predators, feeding on anything that is large enough to get their attention and small enough to be overpowered and swallowed. Stomach contents analyses of many frogs, toads and salamanders show a diet in which the proportion of each prey species in the stomach is comparable to its proportion in the environment. Since the majority of amphibians are small, it is no surprise that most feed primarily on insects. The large species, however,

are known to prey on vertebrates, and some are particularly well adapted to this task. The American bullfrog is well-known as a predator on other vertebrates, including small mammals, birds, reptiles and even fish in its diet. One of its favorite forms of vertebrate prey, however, is other frogs. In the early spring, when bullfrogs first emerge from hibernation, many other species of frogs are breeding. Bullfrogs are known to orient toward the sound of calling frogs and prey on them if possible. Bullfrogs have also been reported to consume young turtles and snakes, mice, songbirds and even baby alligators. Vertebrate-eating frogs are found on other continents as well, and include such species as the African bullfrog (*Pyxicephalus adspersa*), and the Central American green frog (*Rana vaillanti*), both of which prey on other frogs. In addition, the horned frogs (*Ceratophrys*) of South America, and their kin, are specialized frog predators.



A few amphibians are not indiscriminate predators, but demonstrate selectivity in their diets. One of the most common dietary specializations among frogs is myrmecophagy, or ant eating. Many species of the frog families *Microhylidae* (narrowmouthed toads) and *Dendrobatidae* (poison dart frogs) are ant and termite specialists. The Mexican burrowing toad (*Rhinophyrynus dorsalis*) is also an ant specialist. There are ant and termite specialists in Africa and Australia as well. A common feeding strategy for these frogs is to find the opening to an ant nest, sit next to it and pick off every ant that emerges from the opening. Often, a single frog of this type can consume hundreds of ants at one sitting.

Gymnopis multiplicata (Caecilian) © T. LaDuke

Indiscriminate predation is the rule among salamanders as well, but there are a few vertebrate predators. The hellbender and other large aquatic salamanders will eat small fish, though crayfish seem to be the preferred prey. Some of the larger streamside salamanders such as the spring salamander and the blackbellied salamander eat smaller salamanders as well. The tongues of some species of lungless salamanders are capable of shooting out as far as 6 centimeters, or fully 80 percent of the animal's length, to capture insects via sticky tongue-pads that reel in the prey in a few milliseconds. The array of adaptations exhibited by amphibians is truly remarkable and their diverse behaviors and life histories make them one of the most fascinating groups of organisms. Scientific studies today reveal that there is much to be learned about biology from these animals and that the study of their skin toxins can lead to the development of commercially useful pharmaceuticals and other products. It would be tragic indeed if many more of these creatures were allowed to go extinct without any effort to save them.

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Reproductive Variability in Amphibians

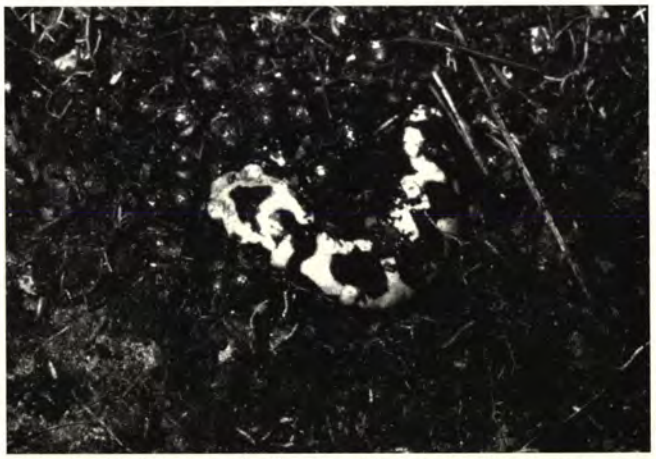
by Charlie Muise

Amphibians are an exceptionally diverse and numerous group of organisms, and in many areas they are the most numerous of the five classes of vertebrates. In parts of North America, the biomass of amphibians is greater than that of mammals, birds, reptiles and fish combined. How is this so? Why are these creatures — most of whom we rarely, if ever, see — so integral to the ecosystem? In a word, variation — variation in food utilized, in placement, and especially in reproductive strategies.

Amphibians consist of three groups known as caudatans, anurans and caecilians. Caudatans are animals with tails, commonly called salamanders and newts. Anurans are the toads and frogs. The least known and most primitive group is the caecilians. Although it is impossible to generalize the habits, chronology and other aspects of amphibian reproduction, there are some traits they do share.

Unlike most vertebrates, amphibians go through metamorphosis, a process in which the body undergoes a major transition to adulthood. This includes changes in color or body proportions, as seen in many birds and mammals, but is much more substantial in amphibians. Metamorphosis in amphibians may include loss of a tail or gills, the addition of legs or lungs, or a complete change of eating habits. For example, most frogs are herbivores as larvae but carnivores as adults. Metamorphosis may even cause a complete change of habitat use. The red-spotted newt (*Notophthalmus viridescens*) is one species that experiences a sort of double metamorphosis. In changing from larva to adult it gains

legs and loses external gills, then leaves the body of water in which it hatched. This stage, called a red eft, is bright orange – a warning to predators that it is unpalatable. It remains in this form for three to seven years. In becoming an adult, it turns green and the tail becomes strongly keeled which help it survive its second major change of habitat – back to the water, where it will remain for the rest of its life. Amphibians do not generally practice long-term monogamy. In fact, many are eruptive breeders that respond to some stimulus in large numbers and mate in communal areas, often with multiple partners in one night. One of these, the smooth newt (*Triturus vulgaris*) of Europe demonstrates sperm competition. When the female mates with one or more males, there is actually a question as to which males' sperm reaches the ova first, thus passing on his genetic inheritance. Like fish, amphibians produce eggs that lack the tough outer shell found in reptiles and birds. These eggs, like the adults themselves, must be kept moist because they are very prone to desiccation. These few similarities are far outweighed by the differences within this fascinating class.



Marbled Salamander (female with eggs) © John Serrao

In order to keep eggs moist, amphibians deposit them in a wide variety of locations. Some species such as the bullfrog (*Rana catesbiana*) lay eggs in large, reliable bodies of water such as lakes and streams, where predation replaces desiccation as a primary mortality factor. Many amphibians in the eastern United States make use of ephemeral or temporary pools, where there are fewer or no fish, giant water bugs, or other predators. In Panama, some frogs will lay eggs in pools as small as an animal hoof print. The locally famous tire ruts at Jug Bay Wetlands Sanctuary in southern Maryland often have hundreds of wood frog, leopard frog, spotted salamander and American toad egg masses at one time. Using ephemeral pools is a gamble however, as reduced predation can be offset in some years by premature drying of the pool. In 1999 virtually none of the amphibians breeding in the Jug Bay tire ruts survived to adulthood, due to the severe drought.

Some tropical frogs are completely arboreal, and will affix eggs to leaves of trees and shrubs or lay eggs in orchids, or other epiphytes filled with water, high above the ground in a location that also protects them from land-borne predators. Other amphibians lay their eggs in rotting vegetation, tree holes, or moist soil.

Some amphibians hold the eggs within the adult body for a period of time. Ovoviviparous animals retain the eggs within the female reproductive tract until after they hatch. The larva has no placenta, but remains within the adult until its yolk sac is consumed. All caecilians are presumed to fertilize internally. Unlike other amphibians, most or all caecilians are viviparous, which means they have a placenta and give birth to live young, like mammals. They have a year-long gestation in which they emerge from underground to mate during the rainy season of one year, then give birth the following rainy season. This solves the desiccation problem for offspring and adults alike.

Many of the lungless salamanders lay eggs in rotten logs or forest leaf litter and guard them until they hatch into fully terrestrial miniature salamanders. Anurans in the tropics have developed a number of interesting strategies to protect eggs from both desiccation and predation. In 1973, C.J. Corben and G.J. Ingram were surprised when they handled what is now known as a gastric brooding frog (*Rheobatrachus silus*) from Australia. The frog spat out several juveniles from its mouth. They later learned that the female holds eggs in a "large, thin-walled dilated stomach" until they have completed the larval stage. She stops producing stomach enzymes prior to ingesting the eggs, and is not able to eat until the young are deposited in water. Unfortunately, this remarkable species has not been seen since 1979. Male Darwin's frogs (*Rhinoderma darwini*) ingest the fertilized eggs, which develop in the large throat pouches usually used for croak-

ing. Unlike most anurans, which produce hundreds of eggs, this species averages up to 15 young. The male is able to eat during this brood period.

Perhaps the most intriguing is the Surinam toad, *Pipa pipa*, an eight-inch, one-pound giant from northern South America. The Surinam toad's fertilized eggs are carried in individual pockets on the female's back. This is accomplished with an acrobatic series of loops and turns during amplexus, in which the female releases a few eggs at a time. The eggs are caught between the two frogs. The male allows them to fall out at a specific turn, and they fall onto the back of the female, where they become adhered as the male fertilizes them. Over a course of several days the fertilized eggs sink into small pits in the dorsum of the female. Flesh then grows over the incubating eggs. Small but completely developed froglets emerge up to 136 days later. The marsupial treefrog (*Gastrotheca riobambae*) of Peru and surrounding countries is similar except that there is a single pouch for all the eggs, and the young leave as tadpoles, not froglets.

Gray Tree Frogs Mating
© John Serrao

Amphibians also differ with respect to the timing of mating. While many temperate species breed in spring or early summer, in Louisiana, the mole salamander (*Ambystoma talpoideum*) breeds in winter, following a cooling trend. In the Middle Atlantic states spotted salamanders (*A. opacum*) use the same habitat as the closely related marbled salamanders (*A. tigunum*). Competition for mating sites is reduced because spotted salamanders mate only in spring, and marbleds mate in the fall. Each species spends the non-reproductive portion of the year underground. In tropical areas, many frogs breed year-round, and produce several clutches. If drought or other conditions cause one clutch to be lost, it is likely that a different clutch will survive.

In order for timing to work successfully there must be some stimulus to which many individuals respond when they are not in contact. Here again there is no set rule. Wood frogs (*Rana sylvatica*) often mate as early as February in the eastern United States, but since they require warm rains as a stimulus, will sometimes mate as late as August. Whenever they mate, wood frogs are eruptive breeders. Their breeding season is often so short, a naturalist who ventures into the field a week late may go the entire season without seeing an adult. The only evidence of this is in the form of many hundreds of eggs in local woodland pools. Many amphibians are stimulated by the photoperiod, or length of daylight. Some are stimulated by availability of food, with an increase in nutrition stimulating oocyte development. Still others respond to temperature or to rainfall. This includes subterranean species that come up when the ground becomes saturated, like Couch's spadefoot which, after staying underground for 10 to 11 months, emerges by the tens of thousands within minutes after July rains in the Sonoran desert. All their breeding (and feeding) takes place in 2 to 4 weeks, then they return underground.

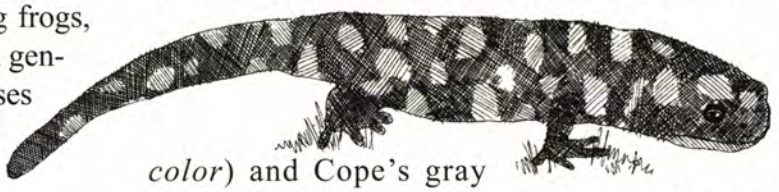
Recent evidence has come to light that some species have an as yet undefined internal stimulus. When individuals of these species are subjected to consistent climate, food availability and moisture in a laboratory setting, they will continue to breed at the same time of year as their wild populations. One species has females that are reproductive year round, but males whose gonads are only functional from May through September. Researchers believe the ovulatory cycle of the nocturnal Javan toad (*Bufo malanostictus*) is stimulated by the lunar cycle.

Toad Eggs in May © John Serrao

Even the physical process of fertilization varies greatly among amphibians. Nearly all anurans fertilize their eggs externally, for the most part through a process called amplexus, which some naturalists have coined "till death (or ejaculation) do us part." Rare exceptions to this rule include the unique tailed frog (*Ascaphus trueii*), one or more species of egg-laying tropical coquis (*Eleutherodactylus*), and a few live-bearing frogs, all of which exhibit internal fertilization. In general, amplexus is initiated when the male senses pheromones released by a ripe, or ready to mate, female. The male mounts the female and begins to rub her with his forelimbs. The exact position, the pattern, and location of rubbing, are determined by species or even subspecies. This is a very strong urge in the male, and he will not stop amplexus until he has released sperm, which will not happen until he senses a second set of pheromones, which the female releases along with the eggs. Thus, if he does not "rub her the right way," she will not release eggs — and the associated pheromones — and he will not release sperm, and thus will not let go. In some cases, there is a problem when the male chooses a female of the wrong species, or he mistakenly mounts a female who is not ripe or has already lain. In some unfortunate but interesting cases, a male will mistakenly perform amplexus upon another male, a different species, or even an inanimate object such as the tripod of a photographer! This sometimes continues until the male, or the object of his desires, or both, perish.

Red Eft (Red Spotted Newt) © John Serrao

Anurans compete for mates, and males are generally territorial during the breeding season. They mark their territory with vocalizations that are often heard over one mile away. With some species, such as the American bullfrog, females are attracted to males that "sound bigger," and these big males may mate with most of the available females. Studies with Fowler's toads have shown that males often attempt to sound larger by calling from colder sites, which alters the qualities of their voices. Frog vocalizations are tremendously variable. Some sound like other animals, some sound mechanical. In addition to the stereotypic croak, there are whistles, grunts, clicks and other sounds. These calls cover the human hearing range in frequency. For every species of frog in the world, there is a different sound. This proves helpful to humans in the case of the common gray treefrog (*Hyla versicolor*) and Cope's gray treefrog (*H. chrysoscelis*), as the two nearly identical species can only be told apart by their calls. In 1988, the Ramsey Canyon Leopard Frog - one of the biggest anurans in the United States - was discovered in Arizona. For three years after its discovery, the Ramsey Canyon Leopard Frog was believed to be unique in that researchers had never heard it vocalize during breeding. In 1991 herpetologist James Platz borrowed electronic surveillance equipment from the US Navy - equipment similar to that used to track submarines. Using this equipment in the appropriate streams during the frog's mating time, Platz heard an absolute cacophony. Within three years, a second underwater singer was discovered in the Pacific Northwest. Though not related, these two frogs have one habitat component in common: they both live in and around fast-moving loud water. Additionally this behavior may be an adaptation to foil predators. A very large frog making a lot of noise alongside a small stream would be an easy target, but three feet of water acts as a buffer through which the sound does not travel appreciably.



Approximately ninety percent of caudatans fertilize eggs internally, although most do not have an intromittent or penis-like organ. In many cases the male and female do not even have to come in contact with one another. Males leave a pheromone trace near the breeding area, sort of like leaving messages that tell a later traveler which turns to

make. Along the way, the male deposits spermatophores, which are essentially small packets of sperm. A female that finds one of these will squat upon the spermatophore, taking into her cloaca, where it dissolves. The sperm then move up the reproductive tract and fertilize the eggs.

Amphibian reproduction is not a topic that can be generalized. It is done everywhere, at every time of year, using myriad strategies. It is a study full of surprises, and one that has taught researchers not to assume anything. This introduction covers only a fraction of the reproductive methods displayed in this diverse class, and there is much more to each story mentioned above. With such great diversity, it is no wonder so many ecologists and zoologists find amphibians so fascinating. With all of the problems that amphibians are currently facing — from ultraviolet light and acid precipitation, to habitat loss and predation by introduced species — diversity and its resulting flexibility may be all that stands in the way of extinction for the majority of this class.

Slimy Salamander © John Serrao

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Awakening Amphibians

by John Serrao

A fascinating ancient spring ritual is performed under the cover of darkness each March. The players in these acts possess smooth, moist skin rather than feathers, and instead of winging their way back north from warmer southern areas, these creatures emerge on cue from the cold, thawing soil where they spent the winter months. They are the amphibians, five species of which reawaken during the first warm, rainy weather in March in the northeastern United States. Ice remains on the northern lakes and snow lingers in the ravines, but now it begins to disappear as daytime temperatures approach 50 degrees Fahrenheit. Once the ground thaws out, the renewed growth of vegetation and the damp soil give the balmy air that unmistakable earthy aroma of early spring.

Spotted Salamander © John Serrao

The stage is now set for the arrival of the earliest amphibians to the swamps, small woodland pools and shallow, marshy borders of ponds and wetlands. Their biological clocks tell them that the time to emerge into the outside world is near. These same clocks have prevented them from being fooled into premature reawakening and emergence during midwinter thaws when the breeding season was still weeks away. But now the winter portion of their clocks has run out, and the newly warmed earth tells them that winter is indeed ending. Only one more environmental signal is required to bring these creatures out of hiding: the first March rains, which soak through the thawed forest soil where they have spent the winter months in suspended animation. Then they emerge en masse — thousands of frogs and salamanders hopping and crawling across the moist earth, usually at night, bound for the same waters where they were spawned in previous years.

Studies in New York, Pennsylvania and Connecticut have concluded that once the air temperature reaches a certain critical level, the emergence of the spotted salamander — one of the earliest amphibians to breed throughout most of the Northeast — always coincides with either the first rainfall of early spring or the rapid melting of the snow cover. The critical temperature required to precede this event is from 45 to 55 degrees Fahrenheit, depending on the location. According to a ten-year study in Missouri these amphibians apparently need to feel that the ground temperature at the surface has become warmer than that of their burrows, which lie about 12 inches below the ground. Similar studies in southern Michigan also have found that these salamanders migrate to their breeding areas during the first rain following the disappearance of snow and the thawing of the ground. During their journey from forest to wetland pools, the spotted salamanders are often accompanied by other early amphibians that have been awakened by the same spring rains and that have the same instinctive urge to enter the water. The closely related but more localized and uncommon Jefferson's salamander, the wood frog, and the spring peeper all emerge at this time, while the red-spotted newt is already in the water, having spent the winter months beneath the ice of ponds. The environmental cues that guide these amphibians as they migrate as much as a half mile back to their watery birth places include the earth's magnetic field, the open horizon of the ponds, and — probably in the case of the spotted salamanders — an imprinted memory of their own birth place and route home. The wood frog's sense of direction is attributed to its ability to detect the odor of its natal pond. Each pond or swamp has its own complement of algae living in

it, and thus a unique odor resulting from this combination. Algal odors seep into the wood frog egg masses that are deposited in the water. These odors are imprinted on the tadpoles that hatch from these eggs, and the memory of those odors remains with them until after they transform into frogs, drawing them briefly back to their birth places each spring.

I have found that the average date for the first emergence of spotted salamanders and wood frogs in the New York-New Jersey-Pennsylvania region is March 16. The earliest date was March 5, after an extremely mild February (1976), while the latest date was March 28, during a late, cold spring. Similar dates have been recorded by others in Connecticut, while farther north in the Albany, New York, region near the Vermont border, the dates range from about the middle of March to the first week in April.

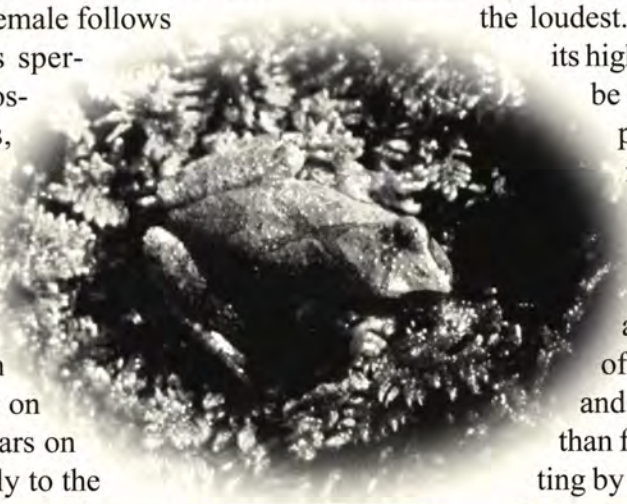
Why do these cold-blooded animals emerge to breed at such early dates, while the waters are still ice cold? The answer is related to the breeding habitat: small, shallow, generally temporary woodland ponds and swamps that fill up with rain and melting snow in winter and spring. By breeding in these small, isolated habitats rather than in the larger permanent ponds and lakes, their tadpoles are spared predation by turtles and fish. Moreover, these shallow temporary waters experience a rich, explosive growth of algae which serves as food for the frog tadpoles and as the base of a complex food web of macroinvertebrates. But the amphibians are forced to reproduce at the earliest possible dates to ensure that their aquatic descendants have enough time to metamorphose into air-breathing, terrestrial frogs and salamanders before the ponds and swamps dry out in late summer.

Returning to the water to reproduce has apparently been a condition of their lives for over 300 million years, ever since amphibians evolved from fish to become the earth's first air-breathing, land-dwelling vertebrates. Despite all those millennia and their divergence from those first primitive forms into today's 4,000-plus worldwide species of frogs, toads and salamanders, amphibians as a group still depend on the earth's wet places. Because of their thin, permeable skins and varying degrees of cutaneous respiration, they are regulated to ponds, streams, swamps, damp soil and rotting wood. Although many tropical species have developed interesting exceptions to this rule, the great majority of this country's amphibians must return to the water each year to lay eggs. From these eggs develop tiny gill-breathing larvae or tadpoles. After an underwater existence that varies from a few weeks to a couple of years, depending on the species, the amphibians lose their gills and emerge into the air as adult frogs, toads or salamanders with lungs (except for the lungless family of salamanders, which breathe entirely through their skins and mouth linings).

At 8 or 9 inches in length and resembling a thick, black rubber toy decorated with bright yellow spots, the spotted salamander is one of the north's largest terrestrial salamanders. Slow moving on land, it performs unusual underwater "nuptial dances" once it enters the breeding pond. In groups of up to forty or fifty individuals the males gyrate their bodies, fan their tails, and nudge and rub against the females in an attempt to arouse their interest, with the aid of some stimulatory chemicals secreted into the water. If sufficiently excited by this foreplay, a receptive female then follows a male as he swims away from the group and deposits spermatophores (small, gelatinous packets of sperm) onto the underwater debris. Taking one of these into her genital opening, the female becomes fertilized. Within a few days she deposits on underwater sticks one to three jelly-like clumps, each containing fifty to one hundred black eggs and swollen almost to the size of a tennis ball. Within two or three weeks, these adult salamanders (as well as their close cousins the Jefferson's salamanders, which have been breeding in a similar fashion in the same ponds) leave the water and return to the woods for an underground, molelike existence until next year's March rains bring them out again. In the water their eggs hatch in five to six weeks into tiny, gilled larvae that feed on aquatic life and metamorphose into miniature spotted salamanders, which leave the water by fall.

Another species of salamander, the small red-spotted newt, is also breeding at this time, in permanent lakes as well as temporary woodland ponds. Unlike its larger relative, the male newt actually grasps the female during his courtship act.

The pair may remain in this position beneath the icy waters for hours, the male clasping the female from above with his two hind legs, fanning pheromones with his tail, undulating his body and rubbing his mate's snout with special mating glands on his face. Like the spotted salamander, fertilization results if the released female follows the male and picks up his spermatophore. Eggs are deposited on submerged plants, singly rather than in clumps, and they hatch into tiny, gilled larvae which transform by summer's end into the familiar terrestrial, bright orange "efts" often seen walking in the woods on rainy days. After 3 to 7 years on land, efts return permanently to the water to become greenish newts like the parents which produced them several springs earlier.



Spring Peeper © John Serrao

In their breeding activities, frogs rely on sound rather than dance. The males of each species possess a unique mating call that attracts only the females of their own kind. The two earliest frogs in our region have entirely different calls. The call of the 3-inch wood frog sounds remarkably like a quacking duck, and a pond full of these brown, black-masked frogs in March has probably fooled many people into believing that a flock of mallards was present in the water. The only frog found as far north as Alaska and Labrador, the wood frog, is truly a species of the northern woods. Remaining in the icy waters for only about two weeks, the wood frogs return to the forest after leaving large, tapioca-like clumps of eggs attached to sticks just beneath the surface of the water. Unlike salamanders, frogs fertilize their eggs externally (like fish). The male clasps the female's waist from the back (the amplexus position) and spreads his sperm onto the eggs as she voids them into the water. As many as one thousand tiny black eggs are contained in a single wood-frog clump, and they hatch in two or three weeks into tadpoles, which transform into frogs by late summer.

Wood Frog Egg Mass in Pond © John Serrao

The spring peeper, the smallest frog in the Northeast at only one inch in length, is also one of the loudest. Used to attract the female, its high-pitched, birdlike whistle can be heard a half mile away. The peeper's loudness results from its ability to distend its throat into a huge bubble almost as big as the frog itself, essentially creating its own sound amplifier. (The vocal pouches of a male wood frog are smaller and expand from its sides rather than from beneath its throat.) Spotting by the light of a flashlight one of these shy, diminutive treefrogs blowing its bubble while thousands of its invisible companions produce an ear-ringing, almost deafening, chorus from the marsh vegetation is certainly one of the thrills of visiting a northeastern wetland on an early spring night.

Unlike the wood frog and spotted salamander, the peeper continues its breeding activities until the end of spring when it finally returns to the woods to climb among the shrubs. As a result, it shares its aquatic habitat with other amphibians that follow in an orderly, predictable sequence as water temperatures warm up and become more conducive to each species' specific temperature preferences. In mid-April the spotted pickerel frogs and northern leopard frogs begin breeding. By the end of April, after a few 70-degree days, the American toads enter the waters for just a few days, filling the air with musical, sustained, birdlike trills created in their huge throat bubbles. The toads leave their eggs in long, ribbon-like strings rather than big clumps. In May, the shorter, melodious trills of the gray treefrogs burst through the air, especially

Spotted Salamander Egg Mass © John Serrao

on humid or rainy nights. The last two frogs to breed — the green frog (which makes a sound like the plunking of a banjo string) and the big bullfrog (named for its deep, loud, bellowing calls) — don't reproduce until the water temperatures are in the seventies, bringing the progression of the amphibians to a close in June.

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A Spring Night's Chorus

by John Serrao

Reprinted from his "Pocono Outdoors" column in the Pocono Record 5/26/96

Standing knee deep in my hip boots in the middle of the marsh, I was surrounded by countless eerie sounds coming from the clumps of aquatic grasses and from the open waters. On this warm night in late May, I was drawn to the wetland behind my house by a loud chorus of amphibians. When most folks were relaxing at home watching television or reading, I decided to observe this rare congregation of several different kinds of frogs simultaneously calling for mates. Most people (even die-hard naturalists) rarely treat themselves to experiencing nature in the darkness.

Perhaps we've all been conditioned to stay at home once night falls — after all, what's the sense of exploring woods and wetlands when you can't really see anything? But a flashlight, a pair of hip boots (if you visit a wetland), and a healthy dose of curiosity are all you need to produce a unique and wonderful night with nature. Once I entered the water and stood in the midst of all that deafening sound, I felt transported back to a more primeval time when insects, frogs and toads were the only animals capable of making sounds, and the earth was dominated by swamp-dwelling amphibians.

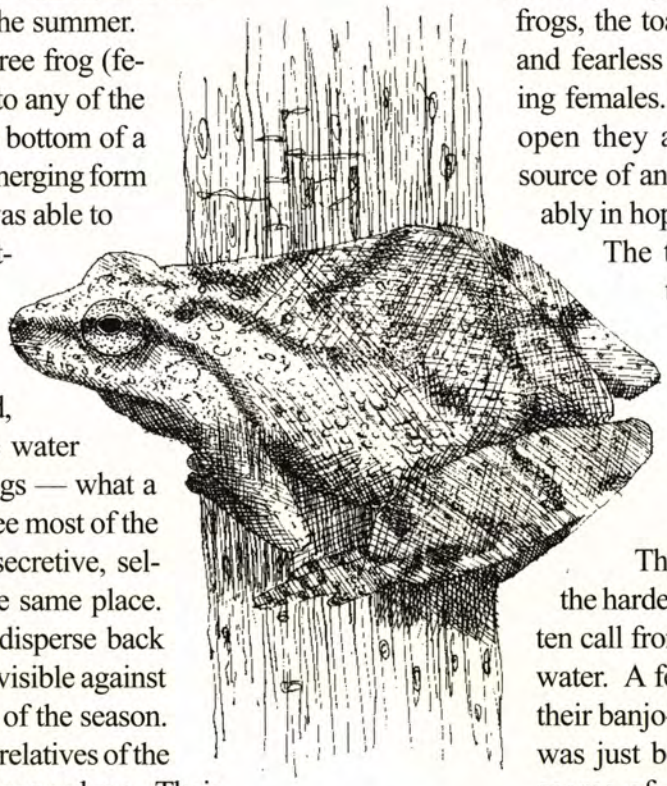
As I waded into the marshy waters I tried to locate the sources of the myriad sounds surrounding me in the darkness. Although my ears were actually ringing from their voices, I found it difficult to zero in on a single frog. Every time I moved, the voices in my immediate area stopped while all the others continued.

After changing my pace to a slow, almost imperceptible movement, however, I was able to find the frogs, which now continued to sing even after they were illuminated by my flashlight. It took only a short time for the amphibians to get accustomed to my searching efforts.

The loudest calls came from gray tree frogs,

which were in the water for their first and only time of the year. These tree-dwelling, three-inch masters of camouflage visit the watery places of their birth for only a few days in late May or early June to lay eggs, and then return to the upper branches of the forest for the remainder of the summer.

Each singing male tree frog (female frogs don't contribute to any of the choruses) was hidden in the bottom of a clump of sedges or grasses emerging form the water. The only way I was able to locate one was by its pulsating throat bubble, which expanded tremendously like bubble gum every time the frog called in its loud, woodpecker-like trill. The water was alive with gray tree frogs — what a treat to be able to hear and see most of the area's population of these secretive, seldom seen amphibians in the same place. In a few days, they would disperse back into the forest and remain invisible against the bark of trees for the rest of the season.



Spring peepers, tiny relatives of the gray tree frog, were also all around me. Their whistling, high-pitched calls had been emanating from the wetlands since early April (an unusually long breeding season for a frog) but soon they would also leave the water for another year. Less than an inch in size, they were even more difficult to locate than their larger cousins — again, their huge throat bubbles (almost as big as their entire bodies) revealed their hiding places, but only after the most careful searching.

On the other hand, toads made no attempt to hide. The males sang their loud, ringing, prolonged (10 seconds or longer) trills right from out in the open waters. Compared to the peepers and tree frogs, the toads seemed absolutely bold and fearless in their attempts at attracting females. Besides singing out in the open they actively swam toward the source of any nearby movements, probably in hopes of it being a female toad. The toads were so absorbed in their activities that I had no difficulty reaching down and touching them while they were singing.

There were also pickerel frogs calling in their very low, "snoring" voices. These spotted amphibians were the hardest ones to find, since they often call from beneath the surface of the water. A few green frogs "plunked" in their banjo-like voices, but their season was just beginning. In a few weeks, scores of other green frogs will join these early risers to fill the wetlands and ponds with their throaty calls.

And the final frog species to breed — the bullfrog, our largest amphibian — was also present, but only a very few, and these were completely silent as they patiently awaited their turns in spring's glorious explosion of life in the wetlands.

"The world will never starve for want of wonders, but only for want of wonder. Men have gone around the world and have found no greater marvels than a ditch contains."

G. K. Chesterson

Vernal Ponds: Life in the Fast Lane

by Sandy Bonardi

Vernal Pond in Early Spring © John Serrao

Late one evening two co-workers are at their office working on a project. In need of a break, they decide to go for a walk. It's raining, but big deal, lots of people like to walk in the rain. Oh yeah, it's also chilly, it's March 14th, their office is in the middle of the woods, there's no phone, no electricity, no people, it's muddy, they're wearing boots and headlamps and — here's the weird part — they're loving every minute of it. In fact, they're hoping to be joined by scores of slimy little creatures, the non-human kind. Strange? No, they're naturalists. And in the middle of March this is normal naturalist behavior. Their destination? A vernal pond.

Now the average vernal pond is not much to look at; small, shallow, mucky, sometimes with small trees growing in the middle of it and, of course, the one word that has been used in every article ever written about a vernal pond — temporary. Formed by melting snow and spring rains, they dry up by midsummer. Yet to a whole host of amphibian species, these seasonal pools are the central points of their annual cycles, for this is where they will gather to court, mate and lay their eggs. Their very existence depends on it.

The species that breed in vernal ponds vary by geographic location. In the Northeast, they include spotted, Jefferson's, marbled and blue-spotted salamanders and wood frogs. Other species will use vernal ponds as well as larger more permanent bodies of water. These include red-spotted newts, spring peepers, gray treefrogs and American, Fowler's and Spadefoot toads.

For most of the year these animals live some distance away from their breeding sites; in leaf litter, under logs and rocks or in underground burrows. But the first warm rains of early spring will set in motion a parade of web-footed wanderers to the nearest vernal pond. In most cases it's the same pond every year — the pond where they were born. How do they do it? It's a known fact that frogs and toads are attracted to their breeding ponds by cueing in on the vocalizations of the males. But some little guy has to get there first. Who's calling him? There is a lot of evidence to suggest that odors are major orientation factors for both frogs and salamanders. No. Not the scent of a woman, more like the scent of an alga. Each vernal pond may have its own biochemical "smell" imprinted somehow in the memory of its children. Vision may also come into play. These animals frequently use the same routes to their natal ponds and so may be cueing in on familiar landmarks. Additionally, they may be using celestial bodies, the sun, moon and stars, to navigate although since most migrations take place on rainy nights, they would need to get oriented before sunset. It has recently been demonstrated that red-spotted newts use the earth's magnetic field to point them in the right direction. Most likely, as is often the case in nature, amphibians use a combination of cues. For example, frogs may use olfactory or visual cues while they are still some distance from their pond until they come to within hearing range of their breeding chorus.

Spotted Salamander © John Serrao

But why would a pond that isn't going to be there by the end of July be such a draw for this crowd? I think Woody Allen put it best in Love and Death when he said: " To me, nature is spiders and bugs

and big fish eating little fish and plants eating plants and animals eating...it's like an enormous restaurant." You see, it's really all about food—how much of it's there and who's doing the eating. Imagine for a moment that you are a newly hatched tadpole (it's a stretch, but work with me). What are your chances of survival when you've got a large-mouthed bass following you around all day? It's not looking hopeful. But, wait a minute, you're in a vernal pond! There are no fish! Life is good. But, wait a minute, you're in a vernal pond! In

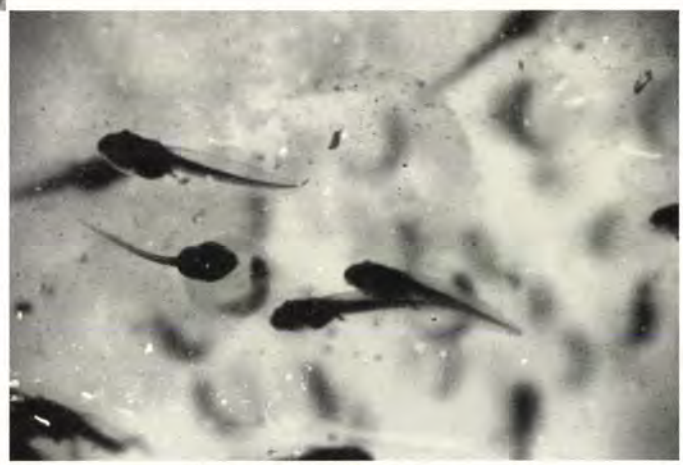
Toad Tadpoles in Vernal Pond © John Serrao

a few months, there'll be no water! It puts a new spin on things. This is life in the fast lane and you've got to grow up real quickly. Fortunately, vernal ponds are rich in the nutrients required for rapid growth.

It all begins with fallen leaves and other bits of detritus that collect in the dry pond's basin. As the decaying process begins and the pond fills with water, nutrients are released and several key events take place. Tiny invertebrates, that have spent the dry, cold season buried in the moist soil of the basin, hatch or awaken to complete their life cycles. These include fairy shrimps, snails, fingernail clams, water fleas and copepods. At the same time, insects, like mosquitoes and midges, are laying their eggs in the water. These will soon hatch into wriggling larvae. And, finally, the increasing amount of sunlight reaching the shallow depths of the pond causes an explosive growth of algae. All perfectly timed so that the amphibian eggs will hatch into a veritable stew of nutrients; an invertebrate smorgasbord for the voracious, predatory salamander larvae, an algal feast for the frog tadpoles.

Included on that menu, however, are the amphibians themselves, for although there are no fish, other inhabitants or visitors to the pond like dragonfly and diving beetle larvae, backswimmers, birds, snakes, turtles and raccoons are fond of amphibian meat. Amphibians also eat other amphibians. Red-spotted newts dine on spotted salamander eggs and larvae; marbled salamander larvae prey heavily on both wood frog tadpoles and spotted salamander larvae. The eggs of the marbled salamander are actually laid in autumn, under rocks and leaves, in the dry vernal pond basin. As soon as the pond starts to fill with water, the eggs begin to develop. By the time the other early spring amphibian egg masses are just beginning to hatch, the hungry teenaged marbled salamander larvae are lying in wait. Timing, as they say, is everything.

Cannibalism, which has been documented in over 1,300 animal species worldwide, is even known to occur. Spotted salamander larvae will eat larvae of their own kind as will some species of treefrogs, bullfrogs and toads. This behavior may have several benefits: hey, it's a meal and in a crowded competitive little pond, that alone is reason enough. And then there's the "do it to him before he does it to you" school of thought — also valid. But there may be another important reason to eat your own kin: it's the perfect diet. Get back into the tadpole mode, you've survived egghood, infancy and childhood, now you're at that awkward stage, the point of actual metamorphosis. You're neither tadpole nor



Wood Frog Tadpoles © John Serrao

frog. You have tiny little limbs that impede your ability to swim quickly and then there's that annoying half-a-tail you're still dragging around. You couldn't hop on land if your life depended on it and apparently, it does. Studies have shown that this is the most vulnerable period of a frog's life. Transforming frogs are easy prey for snakes, birds and, yes, even smaller tadpoles. So what does this have to do with cannibalism? Well, again, it's been shown that young tadpoles who feasted on their larger transforming brothers and sisters did not metamorphose any more quickly when their time came. Apparently (and thankfully) that process already occurs at breakneck speed and can't go any faster. However, the little beasts were bigger for having fed on their siblings and therefore are less likely to be eaten themselves.

In a perfect world, the vernal pond would contain some water until the last salamander or froglet crawled from its depths. It doesn't work that way. Most will get eaten, some will dry up before they get a chance to metamorphose. For each species, probably fewer than 10% will make it to adulthood. That's the way it should be with a perfectly balanced life equation that was calculated eons ago. But there's a problem. Amphibian species are declining worldwide. Among the postulated reasons for this are global warming, depletion of the ozone layer, pathogenic fungi, pesticides, acid rain, the introduction of non-native species and habitat destruction. In this last regard, vernal ponds are particularly vulnerable. Think about it. We're talking about a little habitat which, for half of the year, isn't even there! And even at its height, a vernal pond may look like nothing more than a large, stagnant, mosquito infested puddle, not highly regarded by the average human being. Consequently, vernal ponds are in constant danger of being "improved," that is, paved over, drained, filled in or given over to agriculture.

Wood Frog Eggs © John Serrao

Fortunately, this shortsighted attitude may be changing. Education is the key. In Massachusetts, citizens and school children, in conjunction with the state Natural Heritage and Endangered Species Program, the New England Herpetological Society and Massachusetts Audubon, are learning to identify vernal ponds. In the dry season it's possible to do this by examining the leaf litter, tree trunks (for high water marks), types of tree and shrub species present and, most importantly, the characteristic dark, mucky soil. Once a site is identified, it is then certified as a vernal pond and protected. California has a similar program. Herptile Atlases, such as the ones currently being undertaken in New Jersey and Pennsylvania are also helpful because they locate breeding sites and, again, you can't protect something unless you know where it is.

In the end, it is really up to us, the naturalists and environmental educators, to get the word out about these ephemeral little ponds that guard their secrets so well.

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Greenbrook Vernal Ponds: A Case History

by Nancy Slowik

Greenbrook Sanctuary, a 165-acre nature preserve located in the New Jersey Palisades, was historically known as a significant breeding area for amphibians. The vernal woodland ponds in the sanctuary were well documented as prime breeding areas for both spotted salamander (*Ambystoma maculatum*) and wood frog (*Rana sylvatica*). By the 1960's, these breeding sites were naturally succeeding into drier, terrestrial habitats. Severe successive droughts in the mid-1960's contributed to the decline and the subsequent loss of the wood frog from the sanctuary.

Vernal Pond on Palisades © John Serrao

Beginning in 1978, four amphibian breeding sites were restored. Utilizing hand tools and heavy equipment, all sites were deepened from .6 meter to 1 meter and two were lined with 20 ml. vinyl. Egg masses of wood frogs and spotted salamanders were reintroduced in the spring of 1983 and 1984. Today, three of the four vernal ponds remain productive. The fourth pond, located near the old museum, had declining numbers of egg masses in the early 1990's and has had no sign of wood frogs since 1996. One possible explanation may be related to the steep slope of the bank, which may not provide amphibians easy access. The other three vernal ponds remain productive, making this restoration project enormously successful in terms of the reproductive success of amphibians as well as the environmental teaching potential it provides.

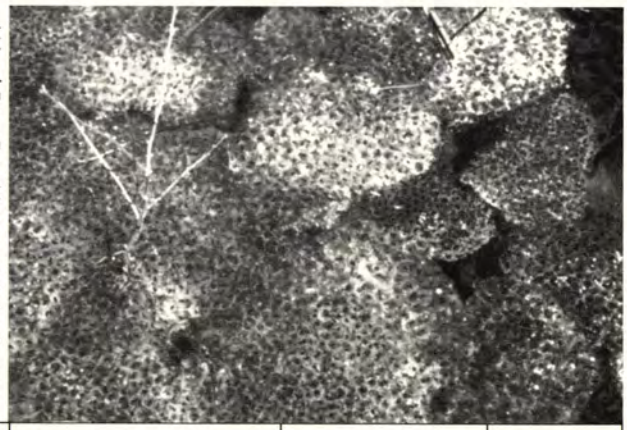
Each spring the ponds are monitored and the egg masses counted (see Table 1). As hoped, the amphibian population steadily increased over the years until 1992. By 1995 the number of wood frog egg masses declined to a total of eight. Since all wild populations are subject to fluctuations in number, we decided to see if their numbers would rebound rather than reintroduce additional wood frog egg masses. The following year the number of egg masses increased significantly and continues to increase in number.

Maintenance of the vernal ponds has become an important part of our summertime routine. Vernal ponds are placed on a routine schedule so that each gets cleaned every third or fourth year. The maintenance routine consists of carefully removing excess leaf litter in late summer. By this time most amphibians have metamorphosed and left the vernal pond. All leaf litter is carefully sifted, searching for any spotted salamander larvae. During the late breeding seasons, we have documented spotted salamander larvae in August. These animals will overwinter as larvae and are returned to the vernal ponds after cleaning. Additionally, we submerge thin branches of surrounding vegetation into the deeper sections of the pond. This enables amphibians to attach their eggs to submerged vegetation. Finally, we check for and relocate predators such as bull frogs, which often invade these ponds during the early summer months.

The maintenance practice of adding pond water during prolonged period of drought in June and early July was discontinued in 1992. Utilizing a gas powered pump, this practice was initiated during a period of severe drought in 1987. It was agreed that it was counter-productive to add pond water, with all its potential predatory invertebrates, to a closed biological system such as a vernal pond.

Today, the restoration of these historic vernal ponds in Greenbrook Sanctuary, and the subsequent reintroduction of the wood frog population remains one of the most anticipated rites of spring. Visitors to the sanctuary eagerly await these early

spring residents. Unfortunately, and for reasons still not completely understood, our American toad population continues to decline in number, reflecting the worldwide trend of so many other amphibians.



Wood Frog Egg Masses © John Serrao

AMPHIBIAN CENSUS 1999

Wood Frog Egg Masses

Year	Pond Shallows	Bog	Vernal Pond L	Vernal Pond Mus.	Kettle Pond	Total
1983	0	37	4	0	13	54
1984	0	9	45	0	15	69
1985	0	14	40	0	44	98
1986	0	6	47	0	28	81
1987	0	25	35	8	22	90
1988	0	27	37	24	34	122
1990	0	12	41	12	48	113
1991	0	14	38	4	62	118
1992	0	4	49	0	34	87
1993	0	20	30	0	12	62
1994	0	5	13	1	8	27
1995	0	1	4	1	2	8
1996	0	13	47	1	6	67
1997	0	17	16	0	12	45
1998	0	59	55	0	23	137
1999	0	76	29	0	31	136

Spotted Salamander Egg Masses

Year	Pond Shallows	Bog	Vernal Pond L	Vernal Pond Mus.	Kettle Pond	Total
1983	4	20	8	0	20	52
1984	3	3	9	0	8	23
1985	9	28	25	0	21	83
1986	10	54	43	0	25	132
1987	2	42	41	0	20	105
1988	1	65	20	0	20	106
1990	2	23	40	0	18	83
1991	0	26	29	0	0	55
1992	0	41	9	0	14	64
1993	1	19	24	0	10	54
1994	2	17	31	0	3	53
1995	0	33	23	0	14	70
1996	0	20	18	0	9	47
1997	0	22	38	0	3	63
1998	0	41	34	0	16	91
1999	0	33	27	0	9	69

Nancy Slowik has been the Director-Naturalist of Greenbrook Sanctuary, in Alpine, N.J., since 1989.

A Large Breeding Congregation in the Catskill Mountains, NY

by Robert Dirig

The American toad (*Bufo americanus americanus*, *Bufonidae*) is common on the southeastern edge of the Catskill Mountains, but prior to the observations recorded herein, I had noticed only one or a few pairs of toads nocturnally mating in temporary puddles formed during a heavy spring rain.

On June 8, 1971, from a distance of several hundred feet, I heard a loud trilling coming from the basin of Barron's pond, a small farm pond nestled in a marshy old field. Arriving on the shore at 1:30 p.m., I found the perimeter teeming with hundreds of American toads. Starting at a marked point, I counted each toad seen during a complete circuit of the pond. There were 518 males singing or resting in shallow water within 10 feet of the shore, or sitting and hopping on the shoreline. An additional 30 males were approaching the pond through wetland herbage within 15 feet of the water's edge. Twenty groups were observed in amplexus[1]: thirteen pairs with one male attached to each female, four clusters with two males clamped on each female, two clusters with three males per female, and one cluster with four males clutching the legs and body of a dead female that may have been strangled by their attentions. Another dead female was floating in the water at the end of her paired egg ribbons. The total number of individuals observed was exactly 600, including 579 males and 21 females.

Three male toads fighting with one female beneath them
© John Serrao

The day was alternately sunny and overcast, the temperature around 90 degrees Fahrenheit, and the water warm. Many egg strings were submerged within 4 feet of the north shore, where water depth was 4-8 inches and some emergent plants grew. Several of the females in amplexus were laying eggs there.

The trilling of hundreds of male toads was almost deafening, with different individuals singing on slightly different pitches. Calling males were sitting partly submerged on rocks in shallow water, resting on the bottom in an inch of water, or sitting on the mud around the perimeter.

No unattended females were seen entering the water, but as one female (already in amplexus) moved through the pond, she was "mobbed" by several other males. Before sensing the presence of male(s) already in amplexus, the approaching males emitted a "hum-hum-hum-hum" vocalization quite different from their trill. I slowly dragged the end of a stick through the water near a large congregation of singing males, and it was similarly "mobbed," suggesting that males are strongly responsive to nearby movements when awaiting a mate.

Surprising color variation was exhibited in this large sample of toads; as males comprised 96.5 percent of the sample, greater variation was noted in this

American Toads Mating © John Serrao

[1] When mating, a male clasps a female with his forelegs around her body behind her forelegs and "rides piggyback" in a configuration known as *amplexus*. As the female lays her long string of eggs, the male releases sperm into the surrounding water to fertilize them.

sex. The predominant dorsal color of some males was brown, but others were bright yellow-orange, olive green, gray or almost black — colors not often observed when American Toads are encountered singly in gardens, yards or woodlands. The 21 females had a largely brown or brick red dorsal color. Some toads exhibited much heavier dark markings than others.

The foregoing observations were made between 1:30 and 3:00 p.m. I returned to the pond between 10:00 and 11:00 p.m. that night, but saw very few toads, although a thorough search of the perimeter was made with a flashlight. Fewer than 20 toads were evident, and none were actively mating. There were only occasional, abbreviated trills, and females remaining in amplexus were not laying eggs. I went back to the pond at 1:30 p.m. the next day, but did not see a single toad, although there were many egg strings in the warm water. These developed rapidly, the tadpoles hatching within a few days.

Pond Full of Toads (Breeding Congregation)
© John Serrao

Barron's Pond is located at an elevation of 1560 ft. in French Woods, Hancock Town, Delaware County, New York, 800 ft. west of Swope Road and 2000 ft. south of State Route 97. The pond is roughly triangular in shape, its greatest width being about 150 feet and its maximum depth 10 feet. Most of the toads were concentrated in relatively shallow water on the northern and northeastern shore, where a small brook enters the pond through a seepy marsh. Two overflow outlets on the northwestern and southeastern corners flow into a tributary of Bouchoux Brook, which drains into the Delaware River, approximately 4.5 miles to the south.

This pond was formed in the mid-1950s when a dam was bulldozed across a marshy field that had been cleared from virgin forest about a century earlier. Emergent and other wetland plants have since thickly vegetated the shore, including sedges (*Carex lurida*, other *Carex* spp., *Eleocharis* and *Scirpus* spp.), rushes (*Juncus effusus, J. gerardii*), Rice Cutgrass (*Leersia oryzoides*), willows (*Salix* spp.), Steeplebush (*Spiraea tomentosa*), asters (*Aster puniceus, A. prenanthoides*), Forget-me-nots (*Myosotis scorpioides*), Bur-reed (*Sparganium* sp.), and docks (*Rumex* sp.). Occasional beaver (*Castor canadensis*) colonization and intermittent grazing of dairy cattle have combined with natural vegetational succession to alter the shore habitats from time to time during the past 45 years. Black Grass (*Juncus gerardii*), a local species off the coastal plain, and Eyed Brown (*Satyrodes eurydice*) and Bronze Copper (*Hyllolycaena hyllus*) butterflies are among the less common denizens of the pond basin that seem to have disappeared in recent years. An extensive second-growth forest of hemlock (*Tsuga canadensis*), American beech(*Fagus grandifolia*), black birch (*Betula lenta*), yellow birch (*B. alleghaniensis*), paper birch (*B. papyrifera*) and sugar maple (*Acer saccharum*) grows a few hundred feet north and west of the pond.

Bob Dirig is the Assistant Curator and Curator of Lichens at the Liberty Hyde Bailey Hortorium at Cornell University.

The frog pool was square....There were frogs there all right, thousands of them.
Their voices beat the night, they boomed and barked and croaked and rattled.
They sang to the stars, to the waning moon, to the waving grasses.
They bellowed love songs and challenges.

from *Cannery Row*, John Steinbeck

Ode to the Toad

by John Serrao

The evening of May 1st was warm and drizzly, following several periods of rain throughout the day. As soon as the sun set, I heard the unmistakable musical trill of an American toad in a nearby lake. I had already heard a few toads singing in April (and one or two at the end of March — the earliest date I've ever recorded for their annual spring breeding calls), and I'd seen their long, string-like egg masses at the bottom of roadside puddles. But these toads represented the early vanguard of the population — the rest of them were waiting for just the right conditions of warmth and rain to emerge from their burrows in the woods and migrate to the ponds, lakes and wetlands to reproduce. On May 1, those environmental conditions were perfect, and I witnessed the largest mass migration of toads in my lifetime.

American Toad © John Serrao

As I drove along the roads at about 8:30 p.m., toads were everywhere — coming out of the woods, hopping slowly across the roads or just sitting on the wet asphalt in the glare of my headlights. Along a single one mile stretch of quiet back road in Monroe County, Pennsylvania I counted at least 75 big toads during one drive. There were also a few wood frogs, pickerel frogs, spring peepers, green frogs and even a huge, fat spotted salamander, but all these other amphibians were incidental to the large number of American toads that were all choosing this one perfect night to begin their annual episode of "explosive breeding." I stopped my car numerous times to rescue the amphibians by helping them across the road in their chosen direction — some had already been squashed by cars.

American Toad Trilling © John Serrao

The toads were still cold, lethargic and, in some cases, dirty — this may have been their first emergence from their underground hibernation burrows. Most were males, recognized by their darker throats and habit of chirping when picked up. There were also a few big, fat females whose bodies were full of thousands of eggs ready to be fertilized as soon as they were squeezed from their bodies into the water. The males that had already completed their journey to the water were trilling loudly to guide the others in the right direction. This ringing musical call is the toad's method of attracting females, just as it is with frogs, songbirds and even insects.

At 10:15 p.m., I drove the same one-mile stretch of road again and saw at least 50 more toads making their way across the road and towards the lake. I wondered how many would complete this journey throughout the rainy night. Then I turned onto a busier road, and over the next mile I counted another 45 toads — but in this case only five were alive. Forty toads were run over by cars.

While there are many environmental factors possibly causing mysterious declines and disappearances of frogs and toads throughout the world (depletion of the ozone layer, global warming, water pollution, introduced predatory fish, viral and bac-

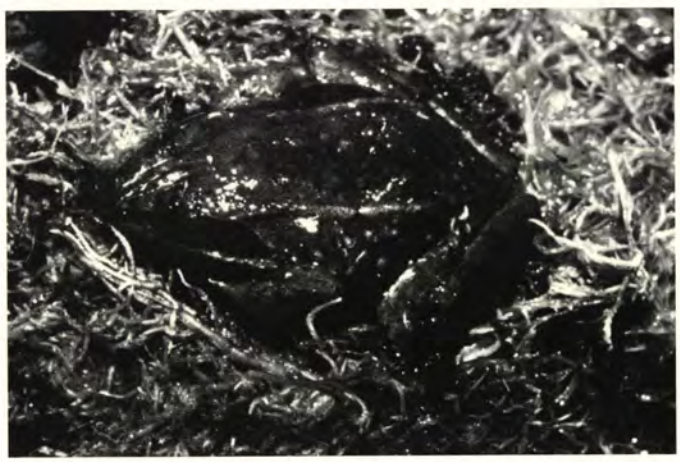
terial infection), in this particular case roadkill must be a major factor. Several colleagues of mine have notified me of the sad disappearance of toads in wildlife sanctuaries in New Jersey and Long Island, and I'm certain that automobiles must be considered a possible major factor. Toads move very slowly across roads and often stop on the asphalt to meet their demise beneath the tires of cars, especially in the spring breeding season when cooler temperatures slow down their movements. In some areas, the majority of toads may be killed as they attempt to make road crossings.

As more roads are constructed between lakes, forests and wetlands, and as more traffic builds up along existing roads, toads will continue to decline in numbers. Only along quiet country roads with very little traffic will toads continue to thrive. In some parts of the country, such roads are actually closed to traffic on certain nights when the local amphibians experience their mass breeding migrations, and some communities have successfully constructed underpasses so toads, frogs and salamanders are funneled in the appropriate directions beneath the killing highways. These options may be worth considering, especially in the areas where the alternate roads exist for cars. In the meantime, watch where you drive on wet nights. It would surely be a shame to lose such a lovable, harmless, legendary creature as the toad.

Sluggish Salamanders and Frozen Frogs

by John Serrao

For some species of wildlife in northern climates, once the cold weather arrives there is no other choice but to retreat to some protected burrow or den and to lapse into a state of dormancy. The cold-blooded vertebrates — fish, amphibians, and reptiles — have no wings with which to migrate to warmer climates. Nor do they have the ability to internally regulate their body temperatures, like the warm-blooded birds and mammals, and remain warm and active throughout the winter. As environmental temperatures drop, so do their body temperatures, bringing about a drastic reduction of their metabolic rates, a sudden slowdown of their activities, and the danger of being left out in the potentially lethal cold. The choices are very limited: either find some place to hibernate where the freezing temperatures can't reach them or somehow survive the winter in a frozen state until spring arrives. By late October, the days of activity for these animals quickly dwindle down to a precious few.

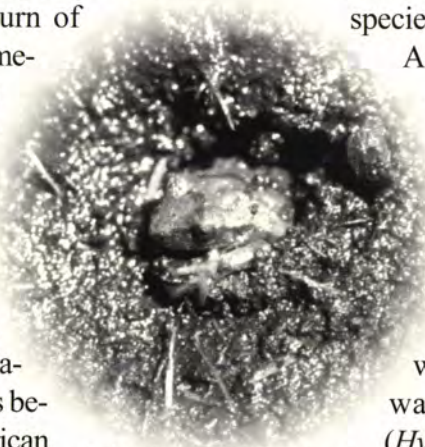


Frozen Wood Frog © John Serrao

Bullfrogs and green frogs sink to the bottoms of ponds and lakes and spend the winter in the muck, taking in what little oxygen they need during hibernation directly through their skins. Pickerel frogs often hibernate over winter inside moist caves where temperatures remain a few degrees above freezing all winter. A few aquatic amphibians actually may remain semi-active beneath the ice during the winter by becoming "cold tolerant," that is, by adjusting their metabolic rates upward after being in cold water for a certain amount of time. Ice skaters are sometimes surprised to see the salamanders known as red-spotted newts slowly wiggling in the frigid waters beneath the ice. This amphibian is one of the first to reproduce in spring: males and females beginning to pair off as soon as the ice melts away from the lakes and ponds. Stream salamanders like the two-lined and northern red salamanders spend the winter beneath stones and gravel in the icy flowing waters, where they may be active (but sluggish) in water temperatures as low as 35 de-

grees Fahrenheit. Another brook species, the northern dusky salamander, goes into hibernation under stones in the deeper pools and, like most northern amphibians, doesn't become active again until spring.

Terrestrial amphibians can't simply sink down into the soft mud and wait the return of warmer spring weather. They must somehow dig down into the soil or find ready-made burrows or rock crevices extending down deeply enough to escape the subfreezing temperatures that would turn their blood and body fluids to ice. Some salamanders, like the ubiquitous red-backed salamander, and the large subterranean spotted salamander, dig down as deep as 15 inches below the forest's leaf litter. The American toad may burrow as far as 18 inches below the woodland floor, and a more northern cousin, the Manitoba toad, has been known to dig 4 feet down into gopher mounds to escape the deadly Canadian freezing weather.



Spring Peeper © John Serrao

In recent years, some remarkable new details about the winter-survival adaptations of some amphibians in northern regions have been discovered. Instead of digging down deep below the frost line, a few species merely retreat below a rotten log or stump or cover themselves with a few inches of leaf litter for the duration of the winter. Somehow these creatures manage to survive the cold months even though the sub-freezing temperatures reach them. Like many overwintering insects, these amphibians are capable of "supercooling" — lowering the freezing point of their body fluids below 32 degrees Fahrenheit by eliminating plasma proteins, foreign bacteria, food particles, and other "nuclei," or "seed crystals," around which ice would form. In effect they stabilize the liquid state of their body fluids at temperatures that would normally freeze them solid. Some species also have been found to load their body fluids with glycerol, an antifreeze compound that further lowers their freezing point, just as it does in an automobile's radiator during winter — allowing the temperature of their internal fluids to fall well below 32 degrees Fahrenheit without turning into ice.

Wood Frog (*Rana sylvatica*) © John Serrao

Still more amazing is the discovery of four species of northeastern U.S. frogs and one Asian salamander that routinely survive the winter frozen solid like ice cubes! Instead of fighting the cold or resisting the deep freeze, these creatures turn into ice until the spring thaw. The wood frog, spring peeper, gray treefrog, and striped chorus frog all apparently have the ability to spend the winter with up to 65 percent of their body water ice. The Siberian salamander (*Hynobias Keryserlingii*) spends up to 9 months of the year frozen beneath rotten tree roots (young-of-the-year salamanders) or moss cushions near ponds (adults) where temperatures drop as low as negative 22 degrees Fahrenheit in winter. In their frozen state, these amphibians are characterized by no movement, breathing, blood circulation, or heartbeat — truly a state of suspended animation.

Research during the late 1980's and early 1990's has revealed some of the secrets of the seemingly impossible ability of these creatures to survive being frozen alive. Of crucial importance is keeping the formation of ice outside the cells to eliminate possible cell damage and death. By forming protein ("seed crystals") in the fluids outside the cells (extracellular spaces, blood plasma, abdominal cavity), these amphibians confine the formation of ice to the parts where it won't cause cellular injury and keep harmful ice crystals from growing inside the cells.

Furthermore, to prevent the rupture or collapse of cell membranes from their contents leaking out into the extracellular ice, these animals flood their bodies with massive quantities of glucose (or glycerol in the case of the gray treefrog) as soon as their skins begin to freeze in win-

ter. Protected by these "cryopreservatives," these amphibians remain dormant until the spring, with metabolic rates only 1 to 10 percent of normal levels. Then, as the snow melts and the ground thaws out, so do their body fluids, and they miraculously travel to the ponds and wetlands to begin another season.

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In the early years we are not to teach nature as science, we are not to teach it primarily for method or for drill: We are to teach it for loving – and this is nature-study. On these points I make no compromise.

Liberty Hyde Bailey

Amphibians Beware

by Karen N. Boyle

No matter what part of the world you are exploring or teaching about, amphibian species are an integral part of that ecosystem. You can be sure that when investigating an area on a rainy spring night or carefully uncovering rocks and logs, you'll either hear or see these fascinating creatures that have inhabited the earth for 300 million years. To think amphibians have survived well beyond dinosaurs and other species that have become extinct is amazing.

Unfortunately, over the last 30 or so years their ability to persist has changed dramatically. In the 1970's scientists began to notice that changes in amphibian populations were occurring worldwide. However, it wasn't until 1991 that the Declining Amphibian Population Task Force was formed. By 1995 this Task Force included more that 1000 researchers representing 40 regions of the world. A status report was released by the Task Force in 1995 that noted approximately 720 of the world's 4,500 known amphibian species were suffering from serious population declines. 140 countries, from Mexico and Canada to Ecuador and Hondorus to Kenya and India, reported declines.

By some estimates, nearly one third of U.S. frog and toad species are in danger. Only five of the 20 amphibian species found in Romania are not considered threatened by extinction. In Canada, one

third of the forty-two resident amphibian species are declining. In Australia, the gastric brooding frog discovered in 1973 and described as "abundant" three years later, suddenly vanished in 1980. And the famous golden toad of Costa Rica – extremely numerous in the 1970's and 80's – disappeared without a trace in 1989.

Some documentation dates even farther back than 20-30 years, like the 1915 study in Yosemite National Park by zoologists Joseph Grinwell and Tracy Stover. Of the seven species of frogs and toads found, four had declined seriously and three had disappeared by 1992. Oregon State University professor Andrew R. Blaustein and his graduate students have been studying western toads at Lost Lake in the Cascade Range since 1979. By the mid 1980's the toads were becoming exceedingly difficult to find and now they are nowhere to be found. Similarly the Wyoming toad is down to a single known wild population; California yellow-legged frogs have been rarely seen since the 1970's; the western spotted frog is nearly gone in Washington; and boreal frogs are missing or declining in five western states. These declines and extinction have occurred in urban as well as suburban areas, and in remote and "protected" areas. In fact, some of the biggest declines have been found in pristine parks like Yellowstone, Yosemite, and the Great Smokies.

There seems to be no rhyme or reason for these changes which makes the puzzle all the more frustrating to solve. What is known is that, generally, amphibians are mainly herbivores (plant eaters) and live in water for the first part of their lives and are terrestrial insectivores during their adult life. Since their skin is permeable, amphibians are susceptible to both airborne and waterborne toxins. Additional threats to amphibian populations include disease, pet trade, habitat loss and destruction, the gourmet food industry, automobiles, introduced predators, ultraviolet rays, and parasites. Even in areas where population declines have not been worrisome, mysterious deformities have made headlines: frogs with extra or missing limbs and eyes in Minnesota and Wisconsin.

Scientists and herpetologists have shed light on the seriousness of the situation and are slowly uncovering the "whys." Their findings, some feel, are especially important due to the fact that the amphibian is likened to "the miner's canary" as an indicator of a potential threat to the human population.

What will we ultimately learn from these dramatic changes in amphibian populations? By learning about unique ecosystems and their inhabitants, we will continue to learn about the impacts of human actions.

Karen Boyle has been a Naturalist and Environmental Educator at the Monroe County Environmental Education Center in Pennsylvania for 12 years. She has a degree in recreation from East Stroudsburg University, and has also worked for the National Park Service at the Delaware Water Gap National Recreation Area. Karen's real passion is educating people, from children to adults, about nature and the outdoors.

FROG

Said a little black Tadpole to another,
That happened to be his elder brother,
"Pray, what a strange creature is that I hear
Croaking so loud?" "A Frog, my dear,"
Said the brother, "and there he sits." "I ne'er
Saw an uglier monster, I declare,"
Cried little Taddy, wriggling his tail,
In an offhand fashion that could not fail
To show his contempt. "It's really a pleasure
And satisfaction, no words can measure,
To think that *we* are so smooth and slim,

So handsome, so — *very* unlike *him*."

"To be sure," said his brother,
bobbing and blinking,
"To be sure, I'm just of your way of thinking."
The air was mild and the sun was strong,
The Tadpoles were turned to Frogs ere long;
The little one croaked, the big one croaked.
At last said the younger,
" Of course, we — joked
That day in the ditch; for there's no denying,
And in fact it's a truth past all replying,
That whether in mere of marsh or bog,
The handsomest creature, by far, is a frog."
"To be sure," said his brother,
bobbing and blinking;
"To be sure, I'm just of your way of thinking"

Thomas Westwood

Reasons for Amphibian Declines

by Brian Hardiman

In recent years, across North America and the world, herpetologists have been documenting a downward spiral in amphibian populations. Some populations have already hit rock bottom and are gone entirely from areas where they were once found. The mystery of these disappearing amphibians has scientists searching for answers, a search made all the more difficult by a lack of basic life history information for many species and also by a lack of long-term population studies. Despite these obstacles, various reasons — some obvious and others not so obvious — for the declines have been put forth by the scientific community.

Loss of habitat, especially wetlands, has had a negative impact on amphibian populations. Most amphibians depend on wetlands for breeding, and the destruction of these critical habitats results in the loss of toads, frogs, and salamanders as well as other wetland-dependent species. In the United States, according to the National Wildlife Federation, over 50% of all wetlands have been destroyed since the late eighteenth century.

In addition to the outright destruction of habitat, alterations to wetlands and other habitats play a role in the declining numbers of amphibians. Roads built near or through wetlands and forests, and increasing vehicle traffic, contribute heavily to amphibian mortality. Countless numbers of frogs, toads, and salamanders are killed as they cross roads on their nocturnal migrations to their breeding sites. In North Carolina, clear-cutting of forests has been blamed for enormous mortalities of salamanders that depend on moist leaf litter and a cool forest canopy.

Habitat loss and degradation, however, do not explain amphibian declines in undeveloped and relatively pristine areas. Recent research in the wild backcountry of California's Yosemite National Park revealed four native species of toads and frogs in serious decline and the complete disappearance of three other species. This study used historical data from a 1915 biological survey of the same area for comparison. In other parts of the American West, populations of the western toad have decreased or disappeared from mountainous areas. This problem is not exclusive to the United States. Similar amphibian declines have been recorded worldwide in reserves and isolated regions.

One explanation for amphibian declines in these seemingly pristine areas points to ozone depletion and the resultant increase in ultraviolet radiation reaching the earth. Oregon State University researchers have linked increased UV-B radiation (in humans this type of radiation can cause sunburn, skin cancer, and damage to the immune system) to mortality in the eggs of the western toad and Cascades frog, both species which lay their eggs in shallow water and in the open, exposed to sunlight. The research also suggests that UV-B radiation may increase the susceptibility of embryos to a damaging fungal disease. This disease may cause a breakdown of chemicals in the water into lethal or carcinogenic components, or may damage the amphibians' thyroid glands. Species living under the protection of the tree canopy, not exposed to damaging sunlight, are also declining, indicating reasons other than increasing UV-B radiation.

While some declines may be explained by one or more smoking guns, in other situations the reasons may not be so obvious and may involve a combination of factors working synergistically. Acid precipitation for example, is thought to increase the harmful effects of UV-B radiation on frogs and toads. And a ten-year study completed in 1995 at Penn State University indicated that low pH and high metal levels may be responsible for the reproductive failure of Jefferson salamanders.

Amphibians can be especially sensitive to environmental pollution. Their permeable skin absorbs contaminants from the water and soil. Aquatic habitats can act as sinks for polluted run-off, in-

creasing amphibians' exposure to chemicals and other contaminants. These conditions can contribute to amphibian deaths and deformities.

Pesticides have been linked to frog deformities, especially missing legs, in some areas of North America, and in Canada evidence suggests that DDT may be responsible for the disappearance of four species of anurans at a location in Ontario. Pacific Treefrogs living downwind from California agricultural areas have exhibited increased pesticide contamination.

In some cases, pesticides may not cause outright mortality, but their secondary effects can contribute to population decreases. Some pesticides have been shown to alter the normal behavior of tadpoles leading to increased predation of these offspring. Impaired immune systems and decreased reproduction in amphibians have also been traced to pesticide use.

Other types of pollution have been found to be the culprit in amphibian declines. Acid precipitation was responsible for wood frog losses in central Pennsylvania according to one report, and other research points a finger at "acid surges" from snow melt for damaging amphibian eggs in breeding pools.

Diseases and parasites are also thought to play a part in amphibian declines and deformities. In Australia, Central America, and the United States, a fatal skin fungus, called chytrid fungus, has been found on dead and dying frogs. Its exact role in these frog deaths is not fully known, but its sudden appearance and extreme lethal affect seem to indicate that it may have been very recently introduced and possibly spread by the feet of migrating birds. Recently, parasites were found to be responsible for frog deformities in several locations in the United States. Extra legs and missing hind legs on tree frogs were caused by a parasitic trematode. A recent "death wave" affecting frogs across Central America has been attributed to a lethal protozoan, which also may have been brought in by birds or tourists and may be the factor responsible for the mysterious, sudden extinction of the Costa Rican golden toad.

Climatic change and global warming affects amphibians as drier conditions prevail and droughts become more frequent. Amphibians and their eggs require certain moisture levels to survive. In Costa Rica, 20 of 50 amphibian species found in one location have declined and warmer, drier conditions are being blamed. In Oregon's Cascade Mountains, the lower lake levels have made eggs of the endangered Western Toad more suseptible to UV radiation, thus increasing their mortality from an aquatic fungus. In the western United States, including California's Sierra Nevadas, non-native fish introduced to lakes and ponds prey on the eggs, tadpoles, and adults of the resident amphibians and are a likely reason for population losses. Introduced trout have caused the demise of Mountain yellow-legged frogs over 90% of its range. Hatchery raised trout have been implicated in the spread of a lethal fungus transmitted to Western toads in Oregon lakes. Introduced species of non-native frogs can have the same impact on native populations (e.g. American Bullfrog in the Western United States and Cane Toads in Australia). In some parts of the world, frog populations have been reduced by collecting for use by restaurants, biological supply companies, and the pet industry. India has recently acted to rebuild its dwindling numbers of frogs by protecting them from the European restaurant demand: France consumes 2,000 to 4,000 metric tons of frog legs each year and it takes 20,000 frogs to produce a ton!

It is apparent that there is no single answer for the amphibian declines being documented worldwide. One or more reasons that may apply in one location may not be relevant in another case. As the human population exerts more and more demands on the environment, the earth's life-support systems and life forms are being stressed to their limits. Amphibian declines can be viewed as a red flag, signaling humans to put the brakes on environmental degradation.

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The Declining Amphibian Populations Task Force

by Tara L. Miller and Melanie K. Meier

Over the past 50 years herpetologists throughout the world have been investigating the decline of amphibian populations. In some cases, species of frogs, toads, salamanders, and newts are now on the verge of extinction. Herpetologists believe that adverse human influences have caused many of the declines. As the global population surpassed the 6 billion mark, humans continue to destroy rain forests at an alarming rate, drain wetlands for development, and add toxins to our rivers and streams. Runoff from the use of fertilizers, pesticides and herbicides to attain high crop yields and manicured lawns, pollute our waterways and contribute to disease and malformities in amphibians. Our actions are not without

consequence.

Amphibian declines are occurring in national parks and other sanctuaries that had once seemed isolated from human effects. Local factors, such as the introduction of non-native species of fish and construction of roads are believed to have altered amphibian ecosystems. Industrial factories and motor vehicles have contributed to our atmospheric pollution. This type of atmospheric pollution forms acid rain which falls within what was once thought to be 'protected' habitats. Acid rain and increased ultraviolet radiation are two examples of climatic and atmospheric changes that are affecting amphibians globally.

The first question from many may be, "Why should the decline of amphibian populations matter to us?" When an amphibian population begins to change, it is indicating a change in the Earth's ecosystem. Amphibians' moist permeable skin makes them especially sensitive to environmental pollutants. Amphibians are much more sensitive than humans to the local and global changes that are occurring. Changes that affect one member of an ecosystem in time will affect all its members.

In 1991, a task force was formed to collect data throughout the world on the decline of amphibians and its causes. The Declining Amphibian Populations Task Force (DAPTF), was established by the Species Survival Commission (SSC) of the World Conservation Union (IUCN). Several sections of the task force collect geographical data on amphibian declines and their causes. Other sections deal with disease and pathology, monitoring techniques, chemical contaminants and climatic and atmospheric change. Through this data, the DAPTF determines the geography and extent of the declines and disappearances of the amphibians. Scientists then work to determine the causes of those amphibian declines and disappearances. The information that is collected is put together in the DAPTF newsletter FROGLOG, and is distributed to over 2,000 scientists and other people interested in amphibian conservation.

Scinax boulengeri © T. LaDuke

The decline of the amphibian population is a national and global trend. Communication between nations has allowed herpetologists to compare and collaborate their findings. For example, recent deaths in endangered boreal toads in the Rocky Mountains have been linked to a chytrid fungus identified in 1998 as being responsible for mass amphibian mortalities in Australia and Central America. Scientists still do not understand other factors at work or why this fungus is so deadly to this species of toad. As Bruce Babbitt, Secretary of the Interior stated "We need to better understand the interrelationship in this environmental puzzle and what we can do to fix this situation."

Thermal and industrial pollution affects the species of amphibians that can exist in a specific habitat. For example, in Russia over the past 30 years thermal pollution has led to an active expansion in the number of the lake frogs. This increase has led to a decline of native amphibians. Lake frogs reproduce during warmer years; thus, thermal pollution has increased the frequency of the frogs' reproduction. In addition, the lake frog has a higher tolerance to industrial pollution which allows them to survive over less tolerant species of amphibians. By one species becoming more prominent, it deters other species from existing in that particular habitat.

The restructuring or destruction of habitat negatively effects biodiversity. In North Sumatra, Indonesia, researchers studied 94 sites in three different locations: an undisturbed stream in an undisturbed forest, a relatively undisturbed stream in a selected logging forest, and an undisturbed stream near a village and a saw mill. Research in the undisturbed habitat resulted in the highest variety and number of

species found. Even though the second category stream was only about 200 meters away from the first, the same variety of species were found in much lower quantities. Only three species were found at the third category stream. One hypothesis was that logging of forests causes leaf litter to be dry and thin. An undisturbed forest that is wet, decaying and filled with small insects is essential for the survival of amphibians. Alterations in habitat, such as logging can result in changes in the populations of amphibians.

Progress is being made, but there is much work to be done in order to reverse the trends of the declining amphibian populations. Organizations like DAPTF encourage scientists to collaborate and allow for sharing of findings and information through publications such as FROGLOG. On a national level we can support legislation such as the Clean Air Act, Clean Water Act, and the Endangered Species Act by writing letters to our Congressional representatives. As individuals, we can also support politicians who make the environment a priority. Locally, we can all take steps to minimize our personal effect on the environment. Schools and communities can become involved by volunteering to monitor local amphibians populations for state herpetological projects. As we continue to work together, we are able to place more pieces of the puzzle together to see a clearer picture of how human activities impact all life in the Earth's ecosystem.

Various issues of FROGLOG, the bi-monthly newsletter of the Declining Amphibian Populations Task Force, were used as references for this article. For further information on DAPTF and its newsletter contact: John Wilkinson, Department of Tsiological Science, The Open University, Walton Hall, Milton Keynes, MK7, 6AA, U.K.

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Tara Miller and Melanie Meier were Instructors at the Pocono Environmental Education center in Dingmans Ferry, Pennsylvania when this article was written.

Atlasing for Amphibians (And a few Surprises)

by Rick Koval

Pennsylvania Herpetological Atlas began in 1996 with the intent to last seven years. Within this time frame, hundreds of volunteers hope to survey most of Pennsylvania's habitats in search of the Commonwealth's reptiles and amphibians. When completed, this will be Pennsylvania's most detailed compilation of data used in determining the statewide populations and distributions of herptiles.

During the winter of 1996, I became a volunteer and as my interest grew I was assigned as a Regional Coordinator for the Atlas Project. Currently the volunteer support has not been comparable to the very successful and similar Pennsylvania Breeding Bird Atlas. Obviously our goal of statewide coverage is far from over. I have personally committed myself to survey all of Luzerne County, which is located in northeastern Pennsylvania. The survey area in Luzerne County is divided into at least 124 survey grid blocks that are approximately 9 square miles each. Pennsylvania

collectively has 4,928 grid blocks within 67 counties. An aggressive effort from volunteers will be needed to achieve uniform statewide coverage.

Following is a summation of current progress and accounts of some rare and uncommon amphibians that I have located within Luzerne County. Since 1996, I have submitted over 4,000 county field records. Several hundred more field records from Luzerne County were submitted from several other "Herp Atlas" volunteers. So far, Luzerne County has been the most thoroughly atlased county during the project. With this effort came rewarding results. All of the mentioned species were never before documented in Luzerne County and have been accepted as new county records. New county records and rare species have also been found and documented throughout Pennsylvania by many hard working and dedicated volunteers during this Herpetological Atlas.

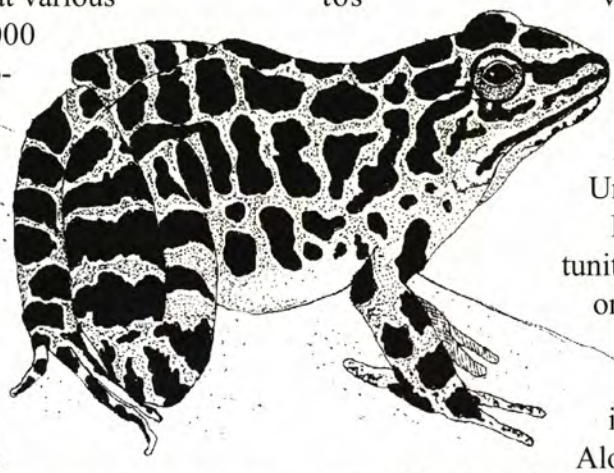
Marbled Salamander © James Hoyson

On March 3, 1997, in northwestern Luzerne County, while working cover objects along the edge of an ice-covered vernal pond for spotted salamanders (*Ambystoma maculatum*), I discovered a very large Jefferson salamander (*Ambystoma jerffersoniaum*). I never expected to find a Jefferson salamander here, as only scattered historic locations were reported throughout Pennsylvania. Subsequent visits at this location produced more *A. jeffersoniaum*. Also observed were numbers of *A. maculatum* that have delighted friends and myself with their underwater courtship displays. I have located two other grid blocks in Luzerne County that have breeding Jefferson salamanders. All of these locations were mountainous regions to 450 feet near the Susquehanna River. Additional efforts will be made with the hope of locating new *A. jeffersoniaum* breeding locations.

A very rewarding experience happened the Spring of 1999. While atlasing new grid blocks in southern Luzerne County on May 29th, I discovered a small, nearly dry vernal pool along the base of a steep mountain slope. Within the shallow water were numerous wood frog (*Rana sylvatica*) tadpoles. Suddenly a small *Ambystoma* larva darted. I was able to capture it and noticed that it seemed too large for *A. maculatum*. I placed it in a container and returned home. Upon closer investigation, I noticed the light yellow green specks on its side. Could this be a marbled salamander, never before known to occur in Luzerne County? *Ambystoma opacum* has become one of the rare and more underreported salamander species in Pennsylvania. This past September, I made diligent efforts to search many dry vernal pools that occur in Luzerne County. A total of four new breeding locations of *A. opacum* were found. They inhabited elevations from 450 to 1,100 feet. My friend and fellow Herp Altas volunteer, John Serrao, also discovered several marbled salamander breeding locations in Monroe and Pike Counties.

A nemesis of mine was finding a four-toed salamander (*Hemidactylium scutatum*). Luzerne County offers suitable habitat with its numerous sphagnum wetlands, but this species had never been documented. For two years I searched for *H. scutatum* without success. Many times I made repeat visits to possible habitats. I believe that success in finding this diminutive salamander is timing. Finally, last year from September 3rd to September 24th, I located numerous adult four-toed salamanders in seven different grid blocks in Luzerne County. And on October 3rd, while searching for salamanders at a small bog with Herp Atlas volunteers and friends Alan Gregory and Brian Hauge, we found two late-season four-toeds along with northern spring salamander (*Gyrinophilus porphriticus*), northern red salamander (*Pseudotriton ruber*), red-backed salamander

(*Plethodon cinereus*) and northern two-lined salamander (*Eurycea bislineata*). I have personally searched this same bog at least 12 times in the past two years specifically for *H. scutatum* without success! Four-toed salamanders do indeed occur throughout Luzerne County, at various elevations ranging from 1,000 feet to 2,100 feet. All were located hiding under cover objects in deciduous woodlands very close to sphagnum wetlands.



An intriguing discovery during the Pennsylvania Herp Atlas Project in Luzerne County was Fowler's toad (*Bufo woodhousii fowleri*). Fowler's toad was never before documented in Luzerne County, which happens to be quite north of its historic range in Pennsylvania. I have located viable populations of Fowler's toad exclusively along the Susquehanna River basin. *Bufo woodhousii fowleri* has been located in 18 different grid blocks in Luzerne County, the entire course of the Susquehanna River. There has been some hybridization occurring with American toad (*Bufo americanus*). Many hybrids exhibit characteristics of both species ranging from abdomen markings, cranial crests, parotoid gland placement, wart presence and vocalizations that sound like a raspy *B. americanus*. This hybridization should not come as a surprise since the two similar species' ranges overlap, and breeding seasons may occur at the same time due to unseasonable weather variables. (Fowler's toad characteristically breeds about a month after American toad).

The most surprising and unexpected discovery happened on September 9, 1999. After an unsuccessful search for four-toed salamanders at a large pristine bog in Luzerne County, I noticed several small pickerel frogs (*Rana palustris*) and Northern green frogs (*Rana clamitans*) hopping about. While attempting to catch and confirm one of the pickerel frogs, I noticed a small, strangely marked frog nearby. After several missed swipes and grabs, I finally managed to catch it. In my cupped hands was a northern cricket frog (*Acris crepitans*). This particular *Acris crepitans* was brightly marked dorsally and exhibited a dark triangle-patch between the eyes. Several others northern cricket frogs that I captured nearby displayed a more uniform dorsal coloration. *Acris crepitans* was last documented in Pennsylvania in 1989 and prior to that in 1959! Photos were taken on both variations and submitted to the Pennsylvania Herpetological Atlas Project Director, Dr. Art Hulse, at the Indiana University of Pennsylvania.

In conclusion, if the opportunity exists, I encourage everyone interested in reptiles and amphibians to participate in similar surveys or monitoring routes in your home state. Along with gathering important scientific data, these projects provide the participant with an awareness and appreciation of a healthy environment. New friends may be found more often than new species, but don't give up searching the appropriate habitat. It will be worth all the effort to feel like a young child asking yourself, "I wonder what's under that rock?," and then discovering the surprises that await you.

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Rick Koval is a Naturalist and volunteers his time towards many wildlife projects. He is a Regional Coordinator for the Pennsylvania Herpetological Atlas Project, and Pennsylvania Consultant and volunteer for the North American Amphibian Monitoring Program.

The Amphibians of Skytop Resort in Pennsylvania's Pocono Mountains

by John Serrao

View of Skytop Lodge and Lake from West Mountain © John Serrao

The thought of coming to a resort in Pennsylvania's Pocono Mountains to learn about nature may seem absurd to those whose images of this popular tourist destination include heart-shaped tubs, champagne-glass Jacuzzis, and honeymoon cottages. Skytop Lodge, however, has been in the nature business since first opening its doors in 1929. In addition to possessing all the amenities of an upscale, year-round resort (it was recently named one of the country's top ten Family Resorts by Diversion magazine), Skytop employs the services of a professional naturalist to study its wildlife and vegetation and to guide its guests along 30 miles of hiking trails, discovering the wonders of nature in this beautiful, diverse environment of northeastern Pennsylvania.

In recent years, there has been an increase in the efforts of the local Pocono Mountain Vacation Bureau to emphasize the region's scenic beauty, abundant open spaces, and exciting wildlife—the very qualities that made the Poconos one of the northeast's foremost tourist destinations for city dwellers from Philadelphia, New Jersey, and New York City more than 100 years ago. Despite the fact that this area is the most rapidly developing part of the state, there are still in excess of 300,000 acres of public land in the Poconos set aside as state parks, game lands, forests, plus the Delaware Water Gap National Recreation Area. The Nature Conservancy recently established a Pocono office to protect thousands of additional acres after it designated the Poconos one of the world's "Last Great Places" because of its rare and unique plants, animals, and natural communities. Thus, plenty of opportunities exist for nature-lovers to have a rewarding outdoor experience in the Poconos, and facilities like Skytop Lodge have seen an increase in attendance at their nature programs.

More than 95 percent of Skytop's 5,500 acres are left in a wild, undisturbed state. Situated on the glaciated Pocono Plateau (between 1,400 and 2,000 feet in elevation), much of the terrain is characterized by wetlands: boreal tamarack bogs, mountain trout streams, rhododendron-maple-hemlock-swamps, vernal ponds, magnificent waterfalls, beaver marshes, large lakes, and abundant woodland springs. In addition to providing habitats to larger "charismatic" animals like black bear, river otter, beaver, mink, bobcat, bald eagle and a variety of waterfowl, these wetlands represent important breeding areas for amphibians. Skytop is truly a "hotbed" of local amphibian diversity: 18 of the 21 species found in the 2,000-square-mile Pocono region (7 out of 8 frogs and 11 out of 13 salamanders) inhabit Skytop's 5,500 acres.

Upper Falls - Habitat of Spring Salamander © John Serrao

Spring Salamander © John Serrao

As soon as winter nears its end and the first mild rains fall, Skytop's vernal ponds and woodland swamps fill with spotted salamanders, wood frogs, and spring peepers. Spring evenings fairly ring with the whistling calls of the tiny peepers, and the Lodge's guests often discover the mysterious jelly-like egg masses of the wood frogs and spotted salamanders after these two species complete their very brief reproduction rituals in the cold waters. Later in the spring, the lakes and ponds resonate with the loud, ringing mating calls of American toads and the low snoring of pickerel frogs, followed by the bird-like trills of gray tree frogs in early June and finally the banjo-string calls of green frogs and the loud bellowing of bull frogs.

A high quality trout stream flows for four miles through Skytop's forests and forms several magnificent waterfalls as it descends the Pocono Plateau. The waters of this stream are inhabited by four species of salamanders: the tiny, yellowish two-lined and larger brownish-gray northern dusky salamanders (both of which are very common); and

Marbled Salamander (*Ambystoma Opacum*) © John Serrao

the vividly colored northern red and huge spring salamanders, which are more secretive. On one nature walk last September, a half-dozen spring salamanders, each between six and seven inches long and ranging from flesh-pink to brownish-purple in color, were found beneath stones in one short stretch of the stream, much to the delight of the guests who had never even imagined the existence of such creatures.

Skytop's most productive amphibian habitat is a dark swamp in a low, level area at the base of a steep mountain. Shaded by dense growths of rhododendron, hemlock, yellow birch, blueberry, red maple, spruce, and tupelo, this sphagnum swamp has seven different species of salamanders, all of which have been uncovered on a single nature walk. Beneath moist, decomposing logs are numerous red-backed salamanders (both red-back and lead-back color forms), big slimy salamanders, colorful moun-

Goose Pond (amphibian habitat) © John Serrao

tain dusky salamanders, and lots of neon-orange efts. Huge spotted salamanders sometimes emerge from underground burrows, and in autumn, their close relative, the spectacular marbled salamanders (fairly rare in the Poconos), emerge in large numbers to reproduce at the edge of the water beneath logs and rocks. The rarest species of all—the small four-toed salamander—inhabits the dense mats of sphagnum moss in this small but remarkable wetland.

At Skytop, guests can explore the trails and search for wildlife on their own (or use several Self-Guiding Trail Booklets), but many elect to attend the nature walks conducted every Saturday and Sunday all year and almost daily during summer months. During these walks, children often accompany their parents who share the excitement of seeing and

touching frogs, toads, and salamanders, snakes, and insects discovered by the naturalist. Partly because of its history of offering these nature programs to its guests, and partly because of its great care in leaving most of its land in an undisturbed, wild state, Skytop was selected as the recipient of the "Save Our Planet" award in 1999 by the Pocono Mountain Chamber of Commerce.

For more information about Skytop and its nature programs, call (570) 595-7401 or visit its website. John Serrao has been the Naturalist at Skytop Lodge since 1989.

The Bullfrog

by John Serrao

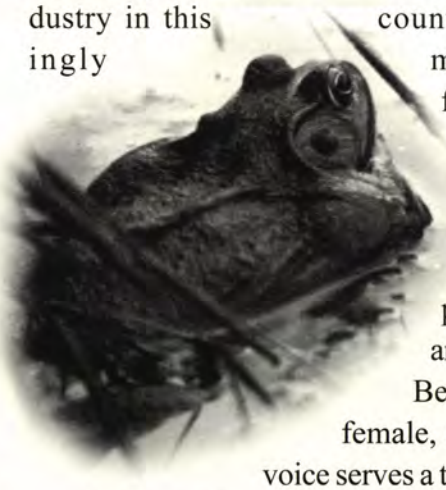
Bullfrog (*Rana catesbiana*) © John Serrao

Just as surely as the arrival of spring is announced by the whistling calls of our smallest frog, the spring peeper, the first long, warm days of summer are heralded by the deep, booming calls of our largest frog, the bullfrog, in the same ponds and marshes.

Starting in June and continuing through July, the bass, throaty "jug-o-rum" bellows of bullfrogs are as characteristic of warm summer nights as the flashing of fireflies over a lush meadow. Capable of carrying for over a mile on a still night, they are the loudest sounds to come from any cold-blooded animal in our country except the bellowing of alligators.

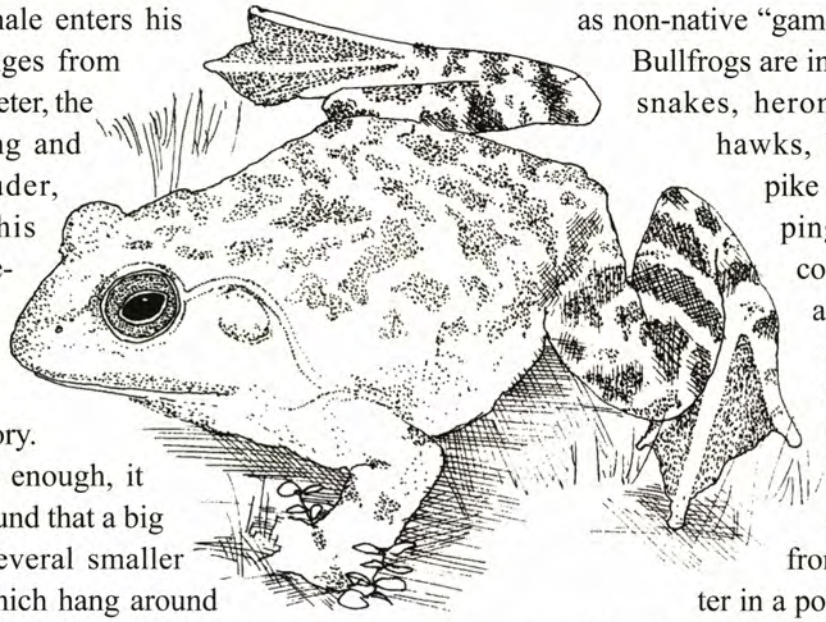
As with all frogs and toads, the male bullfrog's voice is meant to attract a mate. Females are drawn to the loudest calls that are uttered by the biggest males. A male grasps the female around the back and remains in this "amplexus" position for about 40 to 50 minutes while she deposits 10,000 to 20,000 eggs in the water. As the eggs come out, the male deposits sperm over them, and the entire frothy mass remains attached to aquatic plants for about four days before the tadpoles emerge.

These tadpoles eat algae and grow to as large as five inches over the next year or two before transforming into air-breathing bullfrogs. It takes another year or two for the frogs to reach sexual maturity, and they may not become full grown for another three or four years, at which time a big male may weigh over a pound and have a body eight inches long with an additional seven inches of back legs. Frog legs are a multi-million-dollar-a-year industry in this country, but surprisingly most of these bullfrog legs come from overseas – the American bullfrog was successfully transplanted to Europe and Japan.



Besides attracting a female, a male bullfrog's voice serves a territorial function. A big male will float on the surface with his bright yellow throat expanded, intimidating the other males in the pond with his loud bellows.

If another male enters his territory, which ranges from six to 20 feet in diameter, the male begins shoving and jostling the intruder, gouging it with his thumbs, locking forelegs and finally holding it under water until it escapes and leaves his territory.



Interestingly enough, it has recently been found that a big male may attract several smaller "parasitic males" which hang around the edges of this territory and try to intercept females drawn to his loud calls. Some of these smaller males may be successful and fertilize eggs, but the big males rule the pond. The largest ones may mate with six different females.

With its large eyes set far apart on the top of its head, a bullfrog has wide peripheral vision, and is capable of seeing with only the top of its head projecting above the surface of the water. But, like all frogs and toads, it can only detect moving objects and sees very little detail.

Non-moving prey is ignored. For a big bullfrog, prey may range from insects and crayfish to smaller frogs, birds and even mice. They have even been known to swallow baby alligators! Small prey is captured with a flick of its tongue in a fraction of a second, while larger animals are simply engulfed by the frog's cavernous mouth and pushed down the throat by the forelegs.

Predation by bullfrogs has been implicated as a possible cause of the depletion of populations of smaller species of frogs in California and other western states where bullfrogs have been introduced as non-native "game" animals. Bullfrogs are in turn eaten by water snakes, herons, red-shouldered hawks, barred owls, bass, pike and especially snapping turtles. Leeches consume bullfrog eggs and tadpoles often die from oxygen depletion at the end of a long winter when the ice cuts off the diffusion of oxygen from the air to the water in a pond. But such natural mortality factors have been present for millions of years, and that's why a female frog lays so many eggs. (It's estimated that only one egg in 10,000 will become an adult frog.)

More recently, overcollecting by humans has resulted in depletion of bullfrog populations from southern Ontario (the northern limit of their range) to Florida (their southern limit.) Daily bag limits, restricted seasons and licenses have been imposed in some cases to protect them. Experimental bullfrog farms have tried raising them in captivity. Protecting our valuable wetlands, however, remains the most important measure to ensure that the sound of the bullfrog continues to be an integral part of our summer nights.

Bullfrog © John Serrao

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The Red-Backed Salamander:

The Northeast's Most Abundant Terrestrial Salamander

by John Serrao

Adapted from his "Pocono Outdoors" column in the Pocono Record, 7/9/95

Turn over any log in a moist woodland of the northeastern United States and one creature more than any other is likely to be hiding there—the red-backed salamander.

In fact, in a recent scientific survey, this amphibian was named the most abundant terrestrial vertebrate in this region, outnumbering any salamander, toad, frog, snake, bird or mammal. Consequently, its importance in the food web, both as a predator of worms and insects and as prey for shrews, moles, birds, large mammals, ring-necked snakes, and even larger salamanders, must be enormous.

Female Red-backed Salamander with Eggs © John Serrao

The red-backed salamander doesn't always live up to its name. It comes in three distinct color forms. The typical red-back has a broad, straight-edged, reddish stripe down its back from head to tail, bordered by dark sides. The so-called "lead-back" form is uniformly dark gray to almost black, with no reddish at all. I've also come across a solid pinkish-red color form which is believed to mimic the toxic red eft.

All these color forms can be recognized as the same species by the mottled "salt and pepper" coloration on the bellies. Their total length is only two to four inches, much of which is a tail that easily breaks off when grabbed by a predator or human. The salamander then scurries away to safety while its shed tail wiggles around distracting the predator, and a new tail slowly grows back.

As a member of the Plethodon, or lungless woodland salamander group (which is the largest genus of salamanders, with about 215 species), the red-back has neither lungs nor gills. It breathes entirely through its skin, which must remain moist in order to absorb oxygen into its capillaries. The lining of the mouth is an important center for this type of respiration. The Plethodons are much more prevalent down in the southern Appalachians.

Because of their need to remain moist, these salamanders rarely ever venture out during the day but remain hidden beneath logs, rocks, moss and leaf litter. On rainy nights, however, they often come out and can be seen crossing roads.

Unlike most other amphibians, the red-backed salamander does not lay its eggs in water. Instead, the female deposits a small cluster of about eight eggs, each one resembling a pearl of jelly, in a rotting log, the forest leaf litter, or suspended beneath a stone like a cluster of tiny grapes. Then she remains wrapped around the eggs, guarding them and keeping them moist for up to two months until they hatch. And instead of hatching into gilled larvae like other amphibians, the eggs produce terrestrial babies that are miniature replicas of the living adults and fully capable of living on land.

The "tadpole" stage is actually passed while the babies are still inside the large eggs. Because they have completely dispensed with an aquatic phase to their life cycles, red-back salamanders are able to survive in areas where ponds, streams, and wetlands have been polluted or destroyed by development. Thus, they are still found in some urban areas — I once found one under a board in Weehawken, New Jersey!

Another consequence of their independence from bodies of water is their lack of any annual "com-

ing together" that is so typical of most amphibians that congregate once a year to mate and lay eggs in the breeding pond. Because of this factor, there exist many isolated colonies of red-back salamanders due to fragmentation by humans of formerly large woodlands across their range. These colonies can't share genes, and some may become sufficiently isolated geographically over time that new species may actually originate in remnant patches of woods. And so this small, common, easily overlooked salamander may become very important in the study of how new forms of life arise in our world.

Red-Backed Salamander © John Serrao

Although there is no annual breeding congregation, the red-backed salamander does exhibit territoriality and other social behavior. Individuals defend patches of moisture and prey (termites, springtails, fly larvae) beneath logs and rocks, and those that are successful in guarding these precious sites aren't forced to retreat underground during dry periods. Pheromones from the salamander's post-cloacal gland are dabbed onto the substrate or even its own feces as territorial markers. Two competing salamanders exhibit displays of threat (arched back) or submission (lying flat) when contacting each other, and the smaller one usually retreats. Similarly-sized individuals, however, may bite each other, resulting in a detached tail (which the "winner" may consume) or an injury to the vomeronasal system, destroying the "loser's" ability to smell odors.

Recent research also indicates that female red-backed salamanders sniff the feces of males, possibly to determine the quality of their diets and thus the worth of their territories, and their value as potential mates. And there is even some evidence that these salamanders may form monogamous pairs and "kin group" territories, with juveniles remaining in the vicinity of their parents for up to three years. Clearly, there is much more to the life of this abundant, ubiquitous amphibian than could ever be imagined by merely seeing one (or 100) hiding beneath logs in the forest.

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From the Past: 50 Years Ago

Reprinted with permission from: Amphibians
By Prof. Verne Rockcastle
Cornell Science Leaflet, Volume 54, Number 4, May 1961
Published by New York State College of Agriculture, Cornell University

Do toads give you warts? Does it ever rain frogs? Are salamanders the same as lizards? Children sometimes ask these questions in all seriousness. None of the answers is "yes," but amphibians do have some interesting and peculiar characteristics that you can see and study.

Amphibians (frogs, toads and salamanders) are common in most temperate and tropical countries where the climate is moist. They usually prefer cool shade to the sun because they like their skin to stay moist.

Some amphibians may look ugly but sing beautiful songs. Others that have some measure of beauty make almost no sound. Some are very secretive, creeping about only at night under wet leaves and damp wood. Others jump about in broad daylight where it is easy to see them. At least one lives where daylight never occurs.

A few amphibians have commercial value. On farms in the South, big bullfrogs are raised for market because their legs are a prized dish. Some frogs are used for bait, or for laboratory studies by zoology students. Large salamanders also are used in laboratories. Mostly, however, amphibians are just enjoyable harmless animals, interesting creatures that you can study at your leisure almost any time between early spring and late fall in most parts of the United States, except the arid Southwest. What is an amphibian?

Amphibians have skeletons as do fishes, lizards, birds and cats, but there the resemblance stops. Their moist, usually smooth skins, gilled young, and clawless feet make them different from all their backboned relatives.

Like fishes and reptiles, amphibians are cold-blooded. This does not mean that their blood is cold, but that they have no means of regulating its temperature the way birds and mammals can. An amphibian put in a cool place becomes cool. In a warm place it becomes warm. If an amphibian feels clammy, it may be because it was in a cool, moist place when you found it.

Amphibians usually spend the early part of their lives in water as gilled larvae (tadpoles). As adults, they usually live on land and breathe by means of lungs. Not all amphibians live on land as adults, but even those that remain in or return to the water usually breathe by means of lungs. You will read about some exceptions to this general rule, however.

Because many persons confuse amphibians and reptiles, the following table will help to show the main differences between the two groups:

	Amphibians	Reptiles
Skin:	Smooth, moist	Scaly, dry
Eggs:	Laid in water	Laid in soil or moist places or debris, not in water
Breathing:	By gills when young; usually by lungs later	By lungs only
Feet:	Toes without claws	Toes have claws
Ears:	No external opening	Some have external opening

Scientists recognize three main living groups or orders of amphibians. One is called the Anura (a-new'rah). The name comes from the words *ura*, meaning tail, and *an*, meaning not, so *An-ura* means without a tail. This order of amphibians includes the frogs and toads, because they ordinarily have no tails as adults. Another order is called the *Urodela* (yew-ro-del'lah). This name comes from the words ura, meaning tail, and *delos* meaning visible. *Urodela* means visible tails. This order includes the salamanders, of which there are more species in the United States than in any other country in the world. The third order is a small one, and has no representatives in either the United States or Canada. Its only members are blind and legless creatures that look like worms.

Amphibians appeared long before man, and even before the first reptiles. The earliest amphibians left their tracks in sand in Pennsylvania over 300 million years ago! They were strange creatures, with bony plates protecting their heads both on top and underneath. Some were nearly ten feet long, but most were considerably smaller.

With the appearance of reptiles and their fantastic rise to animal power about 100 million years later, the amphibians declined in size and in variety, until today only scaleless, small amphibians remain. These remnants of a once larger group, however, have successfully taken up quarters in lakes, streams, woods, and meadows where they are an important part of the moistland fauna.

Ere yet the earliest warbler wakes,
of coming Spring to tell,
From every marsh a chorus breaks,
a choir invisible,
As if the blossoms underground,
a breath of utterance had found.

Tabb

I'm nobody! Who are you?
Are you — Nobody, too? . . .
How dreary — to be — Somebody!
How public — like a Frog —
To tell one's name — the livelong June —
To an admiring bog !

Poet Emily Dickinson

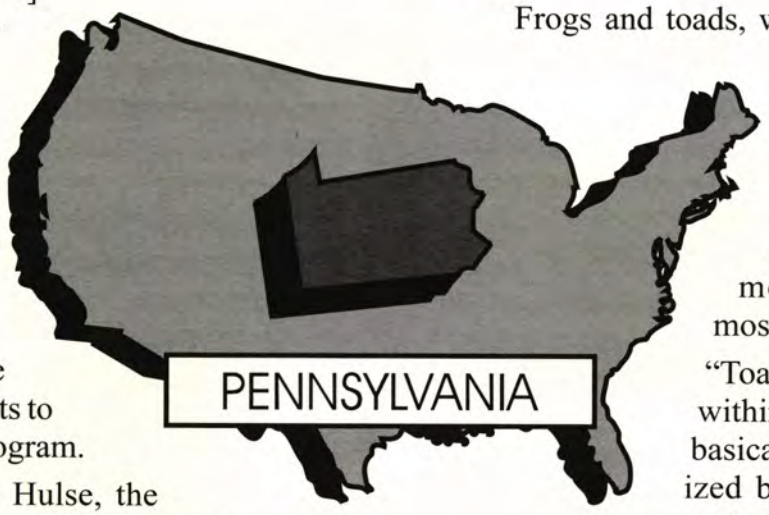
Naturalist in the Field: Art Hulse

by Sarah Bergey

For biology professor Art Hulse, amphibians and reptiles have been life-long passions. In his 25 years at Indiana University of Pennsylvania, Hulse has not only taught his students the wonders of these creatures, he is also leading the way to a better understanding of the amphibians of Pennsylvania.

Hulse is currently directing two projects that attempt to document the distribution of amphibians throughout the state. He is Project Director for the Pennsylvania Herpetological Atlas Project. Additionally, his latest project, surveys of calling frogs from the Pennsylvania section of the North American Amphibian Monitoring Program (NAAMP), is carried out by volunteers who monitor a pre-determined route, four times a year.

"[The volunteer] goes along to ten stations and listens at each one for frogs, identifying what species are calling and also determining the intensity of the calls," Hulse said. Actually, he is looking for more Pennsylvania residents to participate in this program.



According to Hulse, the best way to find frogs and toads is to go around the likely habitats, along the margins of streams, ponds and lakes, and listen for them calling.

"In some species it's easy. You hear toads calling and it's no big deal to find them at all. But with things like spring peepers and chorus frogs you could be in a chorus of hundreds of them and it would still be a challenge in many cases to find even one because their calls are often ventriloquistic."

"Also if you make too much noise approaching the animals they stop calling."

Frogs and toads call during the time of reproduction, which varies from year to year.

Hulse states that "If you've got a spring that comes early and is warm and moist, you can have animals breeding as much as a month or more before they normally would. But by the same token you can have an extremely dry spring and have the animals not begin to breed until much later."

Another thing to observe in amphibians is color change.

"A lot of amphibians change color as a function of temperature — When it's colder they're darker; When it's warmer they're lighter," he said. "For example, the gray tree frog can be as green as grass."

Frogs and toads, which are both in the same group, the Anura order, differ most drastically in that toads have relatively dry skin rather than the typical moist skin found on most frogs.

"Toads are a single family within a single group that basically can be characterized by having permanent warts on various parts of the body like the back of the head, back and thighs, and fairly short hind legs," he said. "They also hop instead of jump."

According to Hulse, amphibians never evolved a covering to protect their moist skin. Moist skin is a definite detriment, and one of the reasons why amphibians are probably more susceptible to pollutants because chemicals can cross the boundary very easily. Also, as a consequence of that moist skin, most amphibians are fairly restricted in their range. You're not

going to find them far away from moisture, except for toads because of their dry skin.

"You may find a frog jumping around a good distance from a stream or lake when it's raining or humid, but if the skin starts losing moisture, it won't survive very long unless it's quickly hydrated," he said.

This means that amphibians must spend winters where the water is not frozen.

"In the winter frogs either enter the water and go down onto the bottom and remain there, relatively inactive while the pond or stream freezes over, or they burrow down into the leaf litter and the top layers of soil on the floor of forests and remain inactive there."

Hulse concentrates his studies on a rare amphibian, the hellbender, a large aquatic salamander, which can grow as long as two-and-a-half feet. Hellbenders can be found in Pennsylvania, Southern New York, West Virginia, Tennessee, Kentucky, Missouri, Kansas, and Western North Carolina. "They are found in fairly big streams, from about 12 inches deep to well over a person's head," according to Hulse. In many states they are extremely rare because of pollution, and habitat loss or destruction. Hulse studies hellbenders for his research by lifting rocks on the bottoms of streams, capturing the animals, taking the measurements he needs and then releasing them.

Hulse does not approve of keeping amphibians as pets, especially if the animal has not been bred in captivity. No one should release a captive amphibian back into the wild for several reasons, such as the transmittal of diseases. If it's a species that's not native to the area, it could have catastrophic effects on native species.

Hulse encourages people to spot amphibians in their natural habitats: "Anywhere there is standing water, amphibians can be found, unless it has been polluted or the area around it has been largely impacted."

People interested in volunteering for the NAAMP should contact Art Hulse via e-mail at: NTCC@GROVE.IUP.EDU.

Sarah Bergey was a student at the Park School of Communications at Ithaca College and an intern with the American Nature Study Society when this article was written.

Yet when a child
and barefoot,
I more than once, at morn,
Have passed, I thought,
A whiplash unbraided
in the sun,
When, stooping to secure it,
It wrinkled, and was gone.

Emily Dickinson

Book Reviews

Sharp Eyes - John Burroughs and American Nature Writing

Edited by Charlotte Zoe Walker
Syracuse University Press 2000

I was primarily interested in this text to determine any relationship between John Burroughs and Liberty Hyde Bailey. These gentle giants of the nature study movement were contemporaries influencing each other as well as the movement as a whole. Did Bailey ever visit Burroughs at Woodchuck Lodge or Slabsides? Did Burroughs ever visit with Bailey at Baileywick or in Washington D.C.? Although it is most probably true that they knew each other's works, I have found no records of their actual meetings. Both New Yorkers and naturalists, Bailey and Burroughs may very well have had met face to face. The influence of these men was confirmed in this book. Bailey and Burroughs are mentioned as being extremely influential in promoting nature study in schools.

'Sharp Eyes' edited by State University of New York at Oneonta's Professor Walker is a critical compendium of twenty-five contributors including our own past presidents Frank Knight and Ralph Lutts. Burroughs is discussed as environmentalist, poet, essayist as well as expounder of the religion of nature. Certainly not just for academicians, 'Sharp Eyes' will be valuable to those already familiar with Burroughs and searching for the viewpoints of others concerning this grandfather figure of nature writing.

Reviewed by Steve Melcher

Tree Frogs
A Lerner Natural Science Book
by Sylvia A. Johnson
Photographs by Modoki Masuda
Published by Lerner Publications Company, Minneapolis, 1986

This book was at first a little puzzling because I expected to find some of the more common North American treefrogs of the large family called *Hylidae* featured, such as *Hyla crusifer*, whose shrill, peeping voices is one of the delightful first signs of spring. Instead I discovers that the excellent photography of Modoki Masuda introduces the reader to other members of the *Hylidae* family that live in South America, Europe, and Asia. But the biggest discovery for me was to read about one family of frogs of Asia and Africa in a group known as *Rhacophoridae* that almost never leaves the their leafy home, and builds foam nests in trees. Masuda has photographs showing foam nests of forest frogs hanging in the trees. One photo shows a tadpole dropping from its foam nest into the water of a pond. I was totally unaware of foam nest in trees. I found the book full of interesting information that greatly expanded my knowledge of these special amphibians. There is a simple and clearly written glossary to help the reader with important special vocabulary. According to the Children's Book Review Service, this book was designed to hold the attention of very young readers and in fact it is a popular volume in the children's department of our public library. It is far more than one would expect in a young readers' science book.

Reviewed by Betty J. McKnight

Nature's Children – Frogs
By Bull Ivy
Published by Grolier Education,
Danbury, Conn.

This book was of special interest in that it is a series of books approved and recommended by The Federation of Ontario Naturalists. I found the book richly rewarding. Its colored photographs are outstanding and its text is written in an interesting conversational style. It is much like what you would hear if you accompanied an excellent naturalist into the favorite habitats of North American frogs.

Scanning the content titles is bound to capture the attention of the curious young naturalist who seeks to learn more of the lifestyle and biology of frogs. Titles include: A Frog's Eye View, Sharp Shooters, Peculiar Predators, Survival Skin and Deep Sleep. The 48-page book presents many interesting facts about the American frogs. It has a good glossary of relevant words such as spawn, hibernation and habitat. Overall, a good reference for children and other amateur naturists.

Reviewed by Betty J. McKnight

Frogs do for the night what birds do for the day: they give it a voice.

Archie Carr
author, naturalist, and herpetologist

The Reptiles and Amphibians of the Poconos and Northeastern Pennsylvania, by John Serrao. All photographs by John Serrao. 2000. Llewellyn and McKane, Inc., Wilkes-Barre, PA.

The Pocono Nature Guide is the definitive resource for naturalists at all levels wishing to learn more about the reptiles and amphibians of the Pocono region. The guide covers forty-nine reptiles and amphibians. All species contained in the guide have been seen and photographed in the Pocono region by the author. The guide provides an excellent introduction to the evolution of amphibians and reptiles, their life cycles, feeding and mating behavior, and the habitat where each species is most frequently found. The introduction concludes with an alarming look at the recent trends of disappearing and declining numbers along with the deformities of amphibians worldwide.

A full page of the guide is dedicated to each of the forty-nine reptiles and amphibians. Each page includes the common name, genus, species and a written narrative divided into five sections: Identification, Occurrence, Habitat, Breeding, and Comments. Each page also includes a full color photograph of each reptile and amphibian in its natural habitat. This guide is a must for the library of all herpetologists.

Reviewed by Jason Dittman, former Program Director, Pocono Environmental Education Center, Dingmans Ferry, PA.

Animal Ways: Frogs
by Dan Greenberg
Published by Benchmark Books,
Marshall Cavendish, New York

The author, Dan Greenberg has had a lifelong love affair with amphibians starting somewhere around the age of twelve. He has put together an excellent narrative in his seven chapters. He begins with a story of frogs as amphibians. He has world maps of frog habitats and even photographs of fossil evidence that the basic frog form has not changed for millions of years. He covers frog reproduction and has a chapter on the Frog, Inside and Out. In this chapter, there is a very informative description of how special pigment cells give rise to changing colors. The chapter called "Frog Ways" includes discussions of such topics as temperature and moisture control, hunting, defense tactics, and frog songs. The book has an excellent glossary, species checklist, and references for further research. I believe young readers and adult amateur naturalists will enjoy this book.

Reviewed by Betty J. McKnight

The grass divides as with a comb, a spotted shaft is seen, And then it closes at your feet, and opens further on.

Emily Dickinson

National Audubon Society First Field Guide: Amphibians
Written by Brian Cassie
Published by Scholastic Inc., New York
1999

This book is a must for your home library. It has the best overall design and user-friendly presentation of information of any of the numerous references I have used or reviewed. It has easy to read text and more than 450 color photographs and illustrations. It is really two books in one. The first part tells how to use the book, has a general discussion of the world of amphibians, amphibian families, senses, behavior, life cycles, diet, locomotion, and habitat. It begins with rules for amphibian watching and some suggestions on equipment and procedures for becoming a successful amateur naturalist. The second part of the book is a useful field guide to the amphibians beginners are most likely to see. It identifies 50 of the most widely found amphibians in North America. There is a consistent format of important information for each animal including a description, photograph, size, habitat and range. But one of my greatest delights was to have a description of the calls of each species. I finally got the name of the illusive tiny creature that I heard one night in the Kentucky mountains many years ago. The call sounded distinctively like sheep bleating on the edge of a marsh but I could not locate what turns out to be a one to one-and-a-quarter inch frog the has the appropriate common name "sheep frog." I highly recommend that you use this field guide if you have not yet had the pleasure.

Reviewed by Betty J. McKnight

At the Frog Pond
by Tilde Michels
Pictures by Reinhard Michl
Published by J.B. Lippincot, New York

This was a very brief book that was translated from German by Nina Ignalowicz. It first caught my attention because of the very attractive paintings of Reinhard Michl. Although it contains several important concepts, it does not contain a lot of facts, but rather it is a splendid invitation to wander out into a marsh or a small pond to personally "hear and see the wondrous ways of nature." I enjoyed the vicarious journey into the world of frogs, toads, muskrats, and pike.

Reviewed by Betty J. McKnight

The clever men at Oxford
Know all that there is to be knowed
But they none of them know one
half as much
As intelligent Mr. Toad!

from The Wind in the Willows
Kenneth Grahame

Recomendations

The following titles are excellent field guides for the identification of amphibians:

Amphibians of North America (a Golden Guide) by Hobart Smith. 1978, Golden Press, N.Y.

A Field Guide to Reptiles and Amphibians of Eastern and Central North America (A Peterson Guide) by Roger Conant. 1975, Houghton Mifflin, Boston.

The Audubon Society Field Guide to North American Reptiles and Amphibians (photographs rather than illustrations) by John Behler and F. Wayne King. 1979, Alfred A. Knopf.

In addition, *A Guide to Amphibians and Reptiles* (a Stokes Nature Guide) by Thomas Tyning (1990, Little Brown & Co. Boston) provides excellent natural history information of familiar species.

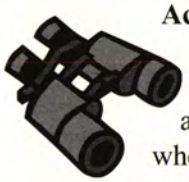
G. Kingsley Noble's classic, *The Biology of the Amphibia* (originally published by McGraw-Hill in 1931) was republished by Dover Publications.

Finally, for people living in the PA-NY-NJ tri-state area, John Serrao's photographic guide, *The Reptiles and Amphibians of the Poconos and Northeast Pennsylvania* (2000; 2113 Rosemont Drive, Tobyhanna, PA 18466) contains color photos, identification features, and natural history information about all 49 species in the region.

Educator Tips

Amphibian Research

provided by Betty J. McKnight



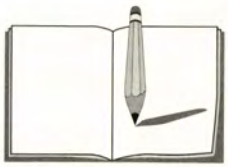
Activity 1

Have students design a large chart that can be used to keep a record of the amphibian individuals find, where, when time, date, weather conditions, and any special observations.

Class Record of Amphibians Observed					
Observer's Name	Location	Time	Date	Animals Seen	Additional Notes

Activity 2

Have students study local topographic maps and locate those sites they feel are most likely to be used by amphibians. Have students invite their parents to accompany them to one or more of these sites. Have students share oral, written and photographic reports with the class.



Activity 3

Make a class log of each of the reports. Give each student a copy of the class research and encourage individuals to revisit these sites at different times of day and/or seasons to gather additional information.

Frog Dice

provided by Pocono Environmental Education Center Staff

Objective:

1. Students will learn the different stages of metamorphosis for frogs and other amphibians.
2. Students will understand the environmental challenges of surviving from egg to adult.

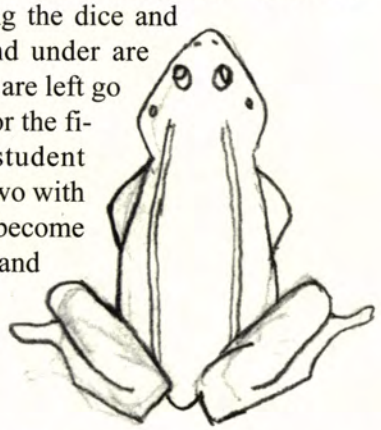
Materials: One set of dice

Procedure:

Before starting the lesson students should have a general understanding of metamorphosis and the life cycles of frogs (egg-tadpole-adult). Explain that frogs produce many eggs but only a few of them survive through to adulthood. Ask what possible dangers they could encounter along the way (predators, loss of habitat, pollution, competition for food, etc.). These challenges are encountered at every stage of the life cycle.

All students start as frog eggs. In order to survive to the next stage they must face one of the challenges. Announce to them the first challenge - this could be any one of the dangers discussed earlier. For example: "A turtle has found the eggs and eats almost half of them!" Have each student take turns rolling the dice. Anyone rolling a six and under is eliminated.

These remaining "eggs" hatch and become tadpoles. Discuss with students the characteristics and adaptations of tadpoles. Metamorphosis from tadpole to frog occurs in several stages. Legs develop, the tail begins to be absorbed, and lungs develop. The "tadpoles" are then faced with another challenge. Again, each student takes turns rolling the dice and those rolling a six and under are eliminated. Those that are left go on to become frogs. For the final challenge each student rolls the dice and the two with the highest total will become frogs. These two mate and lay eggs to start the next generation and the cycle begins again.



Life in a Hole

provided by Pocono Environmental Education Center Staff

Objective: Learn what type of habitat amphibians prefer.

Materials:

1. Pothole that will stay wet throughout the springtime
2. Flagging tape/rope
3. Branches, logs
4. Aquatic dip net
5. Paper and pencil or field notebook for each student or group

Time: 1.5 hours the first day and 30 minutes per observation period

Age Level: Suitable for all ages

Procedure: You must first find a pothole filled with water or a wet land area in early spring that is easily accessible to your students. The next step is to rope off the area with flagging tape. If flagging tape is not available you may also use a rope. Depending on your location you may choose to place a sign indicating that an experiment is in progress. You will now want to bring your students to the site and discuss habitats. You may ask the students if they think that this area is a suitable habitat for amphibians. If the students do not think it is suitable, ask what they would add. At this point separate the study area in half. Leave one side unaltered so that is can be used as a control. On the other side you can add logs and leaves to form a better habitat. After one week you can take the students back to the study site. Have them look in the water for signs of life. You may use the aquatic dip net to capture anything that is present. Compare both sides of the area. If animals are found and captured, be sure you do not harm them. If students are using their hands to pick up amphibians, be sure they wet them first. If any insects are caught they should not be touched with bare skin. A good way to pick up insects is to use plastic spoons. When you are done, place all of the animals back into their habitat. Your class should revisit the study site once a week for the remaining spring months and record what is found.

Recording the Data: List organisms seen during observation periods

Observation Period	1	2	3	4	5	6	7	8	9
Plain Habitat									
Modified Habitat									

Conclusion: You may find many different organisms living in your habitat. The goal is to attract as many different organisms as possible to your habitat. There are many different books that can help you identify what you have found. Some of our favorites are *Peterson's Field Guide to Reptiles and Amphibians* by Roger Conant and Joseph T. Collins, *A Golden Guide to Pond Life* by George K. Reid, and *Aquatic Entomology* by W. Patrick McCafferty and illustrations by Arwin V. Provonsha.

Create Your Own Field Guide

Main Idea: Students can create a field guide that is specific to "their" area.

Objective: Combine science, art, research, and writing skills as students create a **Field Guide to the Amphibians of Shelby County, Ohio** (or wherever).

Materials: Access to amphibian field guides and general amphibian information, paper, pen/ink, and ability to copy material in an 8 ½ x 11" format.

Activity: This is a fun and informative activity for students as they draw upon various skills to create an interdisciplinary product that has relevance in their own community. The students can create their own field guide to the amphibians that live in their area. The finished product can be presented to the local school and/or public library – the students will have learned a lot about amphibians in their area and have a finished product to present and feel good about.

Initially, students need to assemble as many field guides as possible for reference. Have the students look at the various sources to determine which amphibians are found in their area (reasonably *current* field guides are important as populations do change over time).

Once a list of amphibian species for "your" area is determined, students can be assigned or choose the species they wish to present. Students will need to use the collection of field guides and any other current material to determine the features and identifying characteristics, as well as pictures of their animal. Information will vary among sources so students will need to make decisions on the "facts" they deem most accurate to include. (The fact that the guides won't all agree will be an eye-opener for them as well!)

Have the students draw the amphibian as a simple ink-line drawing on an 8 ½ x 11" format that can be copied on a copier and then the final copy colored in by hand. The illustrations will be combined with the text of each species' information for the final field guide. These sheets can then be bound into a small field guide with a cover, title, list of authors, and whatever else you deem appropriate.

Some of the important information you may wish to include on each species can include:

- Identification (note differences between similar species, if any)
- Habitat (you may want to give directions to specific habitat sites)
- General range in "their" state
- Interesting information on the species (let the students come up with what they deem interesting and worth including)

We Shall Return

Although salamanders are harmless, the large Spotted Salamander can seem scary and is sometimes even called "poisonous lizard."

Spotted Salamander 7" (18 cm)

Spotted Salamanders live most of their lives underground, but in the spring they leave their burrows to collect in temporary pools and ponds for mating. Each year these amphibians, like salmon, migrate to the very waters in which they themselves hatched. If their ancestral waters are drained or covered by manmade structures, the salamanders may return for years, whether to a parking lot or office building, in a futile attempt to lay their eggs.

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