Pennsylvania Natural Heritage Program

information for the conservation of biodiversity

WILD HERITAGE NEWS

Spring 2024

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Photo Banner
Seepage wetland
Mary Ann Furedi

Exploring the Seepage Wetlands of Pennsylvania

by

Mary Ann Furedi, Ecological Assessment Manager

Wetlands have been the focus of a multitude of projects undertaken by PNHP scientists. Our research interests have been wide ranging, from understanding the aquatic organisms of vernal pools to detecting shifts in plant communities in peatlands due to climate change. Years have been spent surveying bird usage of wetlands and inventorying the plants and plant communities that make up these important aquatic resources. From this body of work, we have a greater understanding of the different types of wetlands in Pennsylvania, insight into the flora and fauna that use them, and how wetlands change over time. Even with all this effort, there is still much more to learn about the wetlands in our state.

Over the past four years, PNHP ecologists have embarked on yet another exploration of a unique group of wetlands classified as seepage wetlands. Commonly known as seeps and springs, seepage wetlands are typically small; usually less than a half-acre. They occur in a variety of landscape settings including wetland borders, floodplains, at or near the base of slopes, and on benches in upland forests. Seepage wetlands occur where groundwater naturally comes to the surface due to fractures in the bedrock, perched water tables, or seepage from exposed confined aquifers (Bushnell 1989; Podniesinski 1998; WPC & TNC 1998). Since they are groundwater fed, soils in seepage wetlands usually remain saturated for most of the year. The water chemistry of seepage wetlands is often influenced by the underlying bedrock.

Mary Ann Furedi

Skunk cabbage is a good indicator of groundwater seepage.

Why are seepage wetlands important?

Seepage wetlands provide unique habitats and add to the biodiversity of the landscape. They are often found in areas, like upland forests, where you would not expect to see a wetland. Because of their localized, saturated soils, they often support a greater diversity of plant species compared to the surrounding vegetation. Herbaceous water-loving plants typically dominate these wet areas.

Mary Ann Furedi

Saturated conditions from groundwater discharge allow wetland plants and bryophytes to thrive in seepage wetlands.

The diversity of species that live in seepage wetlands can be high and include aquatic and semi-aquatic insects, amphibians, and crustaceans. Birds and mammals also use these wetlands for food, water, habitat, or as movement corridors. Seepage wetlands do not typically freeze in temperate regions and provide a more constant aquatic environment for organisms. They also serve as water sources for animals during the winter months.

Pete Woods

An isopod found in a seepage wetland in Pennsylvania.

Seepage wetlands are also important to the larger aquatic network in a watershed. As components of headwater systems, these wetlands contribute to stream base flow and help in the regulation of stream temperate. They serve as spawning sites and nursery habitats for aquatic invertebrates that help feed fish populations further downstream. The assemblages of wetland plants provide necessary dissolved and particulate organic matter to the larger river system as well.

Why are we studying seepage wetlands?

Mary Ann Furedi

The vegetation in a seepage wetland looks very different compared to the surrounding forest.

We recognize the biological and ecological roles that seepage wetlands play. However, we have a lesser grasp on how abundant they are in Pennsylvania, where they are found, and which plant communities they support. National Wetland Inventory (NWI) maps are great guides for locating larger wetlands but are far less effective for finding smaller ones like these seepage types. Given their small size and frequent occurrence in forests and on slopes, seepage wetlands are also more difficult to distinguish on aerial imagery. The best way to identify them is to go for a hike and actively search for them. Because the vegetation in these systems is very different from the surrounding landscape, a better understanding of their plant community composition would aid in on-the-ground identification of these aquatic resources.

Our knowledge of the plant communities of seepage wetlands in Pennsylvania can be traced back to a few directed studies and the many years of field observations from past and current ecologists in Pennsylvania. In 1998, a study was conducted to develop a more complete understanding of calcareous

and circumneutral seepage wetlands in Pennsylvania (WPC & TNC 1998). These projects contributed to the community types described for seepage wetlands (Zimmerman et al. 2012). Visit our website to learn more about the seepage communities described in the Terrestrial and Palustrine Plant Communities of Pennsylvania (https://www.naturalheritage.state.pa.us/Communities.aspx).

Our recent seepage wetland project built on the methods and findings of the previous plant community classification work. The goals of this effort were to add more detail to the current community descriptions, expand our understanding of the distribution of seepage wetlands in the state, and possibly describe new plant communities associated with these wetlands.

Mary Ann Furedi

PNHP ecologists Ephraim Zimmerman and Jaci Braund sampling a Seepage Meadow in Tioga State Forest.

Results of recent seepage wetland work

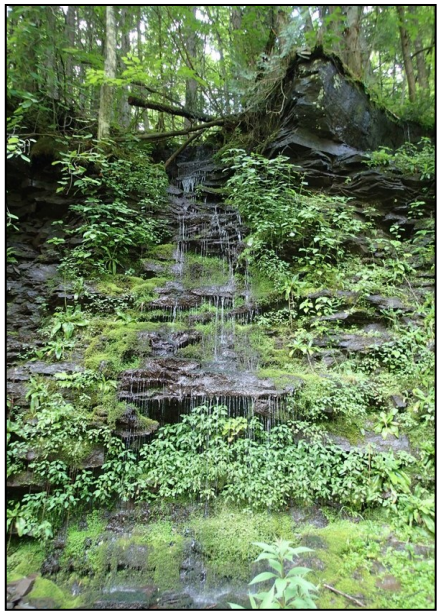
Since previous seepage wetland work focused on plant communities associated with calcareous and circumneutral bedrock, we directed this effort towards sampling sites with more acidic underlying bedrock to determine if there were differences in plant community composition. We found that the plant communities at some sites were similar in composition to what has already been described in Pennsylvania's plant community classification. Many of the sites sampled in the Laurel Highlands classified as Golden Saxifrage – Pennsylvania Bittercress Spring Run. Skunk-cabbage – Golden Saxifrage Seep was another type that we commonly encountered across the state.

Mary Ann Furedi

A Skunk-cabbage – Golden Saxifrage Seep found in Lehigh Gorge State Park.

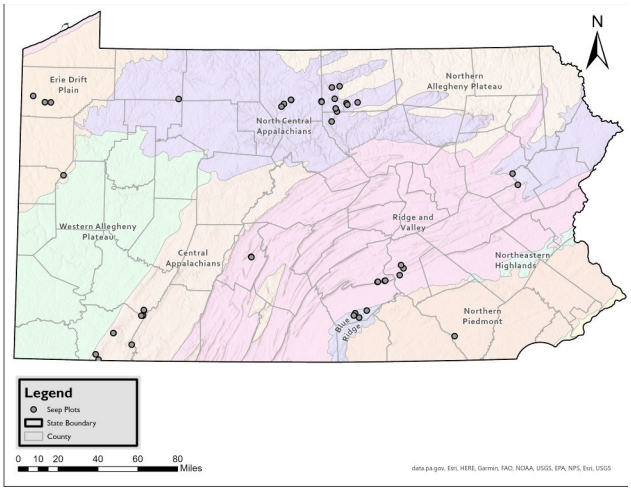
We sampled some sites where the assemblage of plant species did not fit well into our existing plant community classification. These sites were located on forested slopes and at the base of slopes on floodplain terraces. The herbaceous layer was variable from site to site but orange jewelweed (*Impatiens capensis*) and wood-nettle (*Laportea canadensis*) were always dominant. For now, we classified this type as the provisional Seepage Meadow but more sampling and analysis work needs to be done before adding this type to our current classification.

During this project, we also took a closer look at the rock cliffs associated with headwater streams in Tioga and Lycoming counties. These rock cliffs remain wet throughout most, if not all, of the year from groundwater seepage from bedrock fractures and/or seepage from the overhead forests. Other regions of the country include these "hanging gardens" or "wet cliffs" but we do not currently address them in our community classification. After exploring them over the last few years, we definitely need to consider a Vertical Seep type for Pennsylvania!



Mary Ann Furedi

A vertical seep in Tioga State Forest



Jaci Braund

Locations of seepage wetlands sampled in 2019-2022.

What can we do to help seepage wetlands?

As our work on seepage wetlands continues, we recognize the many biological and ecological contributions of this wetland type. We also realize the threats that these aquatic resources face. Because seepage wetlands are groundwater fed, activities that affect the water table, like groundwater extraction and development in watersheds, can have a profound, negative impact. Given their small size and that they may not be mapped as wetlands, they may be prone to damage by land-disturbing activities like logging, agriculture, development, and recreation. Invasive species can also degrade the biodiversity of the plant communities that make up these wetlands.

Mary Ann Furedi

One threat to seepage wetlands is invasive species. Japanese knotweed is becoming established in this seep.

The first step in conserving these aquatic resources is to recognize their presence on the landscape. Become familiar with wet areas on your property and the vegetation associated with seepage wetlands. If you identify seepage wetlands, work to eliminate threats and avoid destruction. One way is to maintain buffers around these wetlands. Buffers help to keep excess sediments, nutrients, and other pollutants out of seeps, headwater streams, and ultimately larger river systems. Another way, is to remove invasive plants using appropriate measures for an aquatic system. Together, we can help protect these tiny yet vital wetlands.

About the Author

Mary Ann has worked with the Pennsylvania Natural Heritage Program for 17 years as a community ecologist and currently serves as the Ecological Assessment Manager. She received her B.S. in Biology from Fairleigh Dickinson University and her Ph.D. in Biology from West Virginia University. Her projects generally focus on characterizing the current conditions of natural systems in Pennsylvania and understanding how these systems change over time.

Rediscovery and Recovery of the Lost Lake Erie Cisco

by

Doug Fischer, Ichthyologist/Nongame Fisheries Biologist, PFBC

The Pennsylvania Fish and Boat Commission (PFBC) has been actively working to assess the feasibility of restoring Cisco (*Coregonus artedi*) to Lake Erie in partnership with the United States Geologic Survey (USGS), United States Fish and Wildlife Service (USFWS), and the Great Lakes Fisheries Commission. Cisco are currently listed as endangered in Pennsylvania and they are an important forage item for larger gamefishes, in particular Lake Trout (*Salvelinus namaycush*).

In 2016, PFBC Bureau of Fisheries staff rediscovered wild populations of Cisco and Lake Trout in an inland lake found in the northeastern part of the state. This lake was once open to public fishing, but has since been restricted to private access. Sometime in the late 1800s or early 1900s, the Pennsylvania Fish Commission (PFC), predecessor to the PFBC name, stocked Lake Trout and Cisco in some of the northeastern lakes to create angling opportunities. The shorelines of most of these lakes became developed over the years and water quality suffered to the detriment of their fish populations. Both Lake Trout and Cisco populations were extirpated from Lake Erie likely sometime in the mid-1900s. The existence of wild populations of these species in an inland lake within the Lake Erie region begged the question of whether they could benefit from recovery efforts in Lake Erie. Additional investigations would be necessary to determine if these fish populations were native to Lake Erie and if they could contribute to conservation actions.

Rob Wnuk

Doug Fischer holding the first Shallow Water Cisco to be caught in a fisheries survey within Pennsylvania in many decades.

Doug Fischer

Aaron Frey in November 2016 holding the first wild Lake Trout caught in a fisheries survey within Pennsylvania since the 1960s.

We initially focused on determining the source populations of the Cisco and Lake Trout that would have been utilized by PFC hatcheries in the late 1800s or early 1900s. Available information in historic PFC annual reports indicated that the Cisco were, indeed, likely sourced from Lake Erie for hatchery operations and there was no clear source indicated for the Lake Trout. In 2016, genetic material was collected from individuals of both species and sent to the USFWS Northeast Fisheries Center. Initial genetic results for Cisco indicated a need for more samples and the Lake Trout samples have not yet been sequenced. In 2021, the PFBC collected 27 Cisco specimens for traditional morphometric and meristic analysis, in addition to

Doug Fischer

Fisheries biologists Kyle Clark and Dakota Raab retrieving a frosty gillnet during a Cisco collection effort in December 2021.

collecting more genetic material. Multivariate statistical analyses of the morphometrics and meristics indicated that these Cisco aligned with the "shallow water" Cisco (*Coregonus artedi albus*) unique to Lake Erie and western Lake Ontario. The genetic material is still being processed by the USGS and will be compared with archival scale samples collected from Lake Erie and Lake Ontario in the early 1900s.

Doug Fischer

Cisco collected in 2021 for morphometrics, meristics, and genetics.

The population size present in the lake was also a question that needed to be investigated. During the summer of 2022, USGS and PFBC personnel conducted a hydroacoustic survey to develop a rough estimate of the density and biomass of the extant Cisco population. The USGS concluded that a best estimate of the population is 1500-2000 Ciscoes. In 2024, we plan to collect individuals that can be transported to a state or federal hatchery to initiate aquaculture production and create a redundant source population in case something catastrophic were to happen to the wild population.

Future work will include final genetic analyses, determining the long term viability of a reintroduced Lake Erie population, and additional hatchery operations.

About the Author

Doug Fischer is the ichthyologist/nongame fisheries biologist at the Pennsylvania Fish and Boat Commission, where he has worked since 2005. His primary duties concern taxonomy, fish ecology, and rare fish conservation. He earned degrees in environmental resource management (B.S) and fisheries science (M.S.) from Penn State University. He began studying fishes in 2000 and is a co-author of the book, *The Fishes of Pennsylvania* (2016). He has worked on numerous rare fish life history, aquaculture, and reintroduction research projects.

Vernal Pool Critter Deep Dive

by

Betsy Leppo, Invertebrate Zoologist

The exuberant noise and abundance of amphibians at a vernal pool on a rainy spring night is an unforgettable experience. The magical appearance of quacking wood frogs and spotted salamanders as long as our hands on the "big night" of amphibian mass migration draws some of us into the still-sleeping forest to catch a glimpse of these secretive creatures. Let's take a deep dive into the world of one of the most charismatic vernal pool denizens, the spotted salamander (*Ambystoma maculatum*).

Paul Dennehy , iNaturalist

An adult spotted salamander (*Ambystoma maculatum*)

The spotted salamander is a large dark mole salamander with yellow spots in two rows down their back, and pale blue dots freckling their legs and lower sides. The dorsal yellow spots vary in size and shape and can be used to distinguish individuals. Some adults have reduced or no spots at all and even more rare are part (leucistic) or full albino individuals.

They spend most of the year in subterranean burrows made by small mammals. These burrows keep the salamanders moist and protect them from predators, high heat, and freezing temperatures. The salamanders feed underground on invertebrates such as worms, snails, spiders, millipedes, and centipedes. They occasionally come to the surface to forage, but generally stay under the cover of decaying logs or wet leaves. Adults are long-lived, often living a decade or two in the wild or in captivity. The oldest documented salamander in the wild was 32 years old!

Stephen John Davies, iNaturalist

Differences in size , shape, and arrangement of spots makes it possible to distinguish individual salamanders from each other.

Nick , iNaturalist

This adult has reduced spotting. The swollen vent visible just behind his hind legs indicates this is a breeding male.

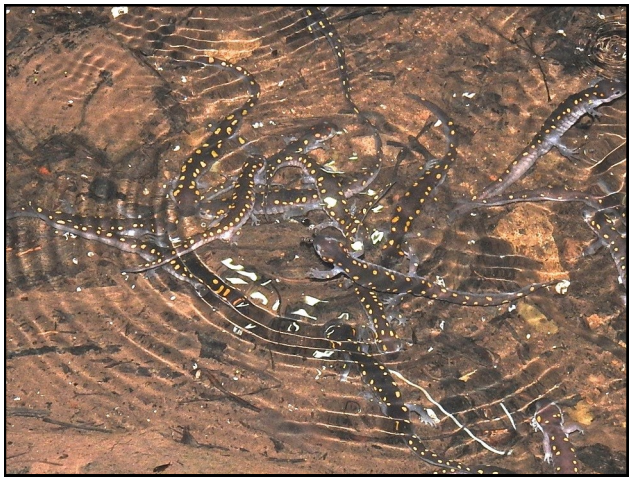
macklooksatstuff, iNaturalist

This leucistic male named 'Calvin' has been photographed at a site in Ontario, Canada since 2010, and is estimated to be 16 years old.

Spring fever: Once a year in late winter and early spring, spotted salamanders leave their safe burrows to migrate to vernal pools where they breed and lay eggs. Males outnumber females at the breeding pond, so they arrive a few days or weeks early, sometimes crawling over snow and slipping under ice on the pool, to increase their chances of courting a female.

megamishy, iNaturalist

An adult spotted salamander walking across snow, heading for its breeding pond.



Desmond MacNeal, iNaturalist

Spotted salamanders forming a breeding congress or "liebesspiel."

Once the females arrive, they join the males in a nuptial dance or "liebesspiel." Courtship begins as night falls, and the salamanders materialize from the leaves on the bottom of the pool. Males serpentine across the leaves and use their snouts to bump, nudge and woo the females. Females nudge and bump the males in return to indicate their interest. During this energetic dance, the adults frequently surface to grab a breath of air.

JoAnn Albert

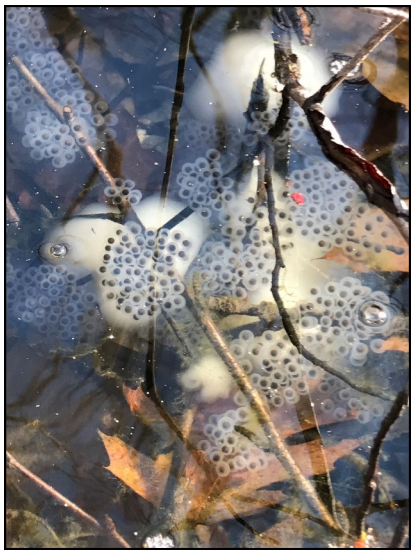
Male spotted salamanders produce their sperm in little 'to-go' packages called spermatophores.

Once a male has the attention of a female, he deposits a series of spermatophores on small branches or leaves in the pool. A spermatophore is a little gelatinous plug with a sperm capsule on top, and a male produces an average of 40 of them on his first night of breeding. The female follows along behind, picking up the sperm packets with her cloaca and storing them in a specialized organ called the spermathecae. A female may collect a total of 15-20 spermatophores from multiple males, therefore giving her offspring the advantages of diverse genetics.

A few days after mating, a female spotted salamander lays several egg masses, either individually, in small clumps, or in a communal site shared with other females. The egg masses may be attached to small sticks or clumps of aquatic vegetation, or laid in the leaves on the pond bottom. Each egg mass usually contains between 50 and 200 individual eggs, and is encased in a layer of firm gelatinous jelly. The thick outer layer protects the eggs from freezing and drying if they get temporarily exposed during

Josh Vandermeulen, iNaturalist

A female spotted salamander in the process of laying an egg mass around a small stick .



David Skelly, iNaturalist

Clear and cloudy spotted salamander egg masses from multiple females laid together in a communal site.

fluctuations in water levels, and also protects them from solar radiation, pathogens, and predation. Some spotted salamander females produce a clear jelly, others produce a cloudy white jelly. The reason for the different colors of jelly is not fully known, though studies have found subtle advantages of each color form in different situations, which could benefit a species that utilizes highly variable habitats.

Once breeding and egg laying is done, the adults leave the vernal pool and return to the forest. Some live near the pool, while others travel hundreds or thousands of feet to their upland territory. Spotted salamanders spend their lives moving between aquatic and terrestrial realms, and are integrated into the food webs of both habitats. They produce and recycle significant amounts of energy and nutrients in and between breeding pools and the adjacent forest.

Pete Woods

New spotted salamander embryos developing in the egg.

Larval development and metamorphosis. Spotted salamander embryos develop over a period of 8-60 days before hatching. The development time varies by population and region, and is largely influenced by temperature. The larvae hatch into the water and breathe through frilly external gills on the sides of their heads. They develop quickly, feeding on small zooplankton like ostracods, copepods, and cladocerans. As they grow, they tackle larger prey like mosquito and midge larvae, and help to keep these insect populations in check.

Jay Heiser, iNaturalist

A larval spotted salamander with frilly external gills.

Larvae may start transforming into air-breathing juveniles as soon as 6 weeks after hatching in a quick-drying pool, but typically take 2-4 months. The speed of larval development varies based on food availability, competition, pool hydroperiod, and other environmental factors. The larvae may overwinter in the pond if it stays wet, however, the longer they spend in a pool, the greater their chance of being eaten by another predator or running out of food.

During the process of metamorphosis, the larvae grow legs, develop lungs, and lose their gills. New metamorphs typically leave the pool in mid to late summer. As the little salamanders move onto land they can easily overheat or dry out, so they seek moisture, shade, and shelter under downed logs, thick leaf litter, and in old small mammal burrows.

Spotted salamander eggs and larvae are a nutritious meal for a variety of predators. Less than 10% of the larvae typically survive to metamorphosis. The eggs are eaten by wood frog tadpoles, red-spotted newts, and invertebrates like the cigar-tube caddisfly (*Ptilostomis*). The larvae are consumed by foraging birds, aquatic insects like diving beetles, water boatmen, and

Amos Ludwig

Red-spotted newts readily eat vernal pool amphibian egg masses.

dragonfly nymphs, and the larger larvae of other mole salamanders. Spotted salamanders sometimes breed in permanent ponds and backwaters of slow-moving streams, but the survival of larvae in those habitats is low due to predation by fishes.

A balanced relationship between predator and prey helps maintain healthy populations of both. But sometimes that balance gets disrupted. For example, vernal pools can become acidified by acid rain. Spotted salamander embryos are stressed by lower pH and do poorly in acidic pools with a pH below 4.5. On the other hand, one of their predators, the cigar-tube caddisfly (*Ptilostomis*), is tolerant of low pH. Cigar-tube caddisfly larvae can reach high densities in acidic pools and prey heavily upon the already stressed spotted salamander egg masses.

The basic life cycle of spotted salamanders is fascinating, but some of their abilities would be considered superpowers if humans possessed them.

They ooze toxic chemicals: Spotted salamanders have large mouths and bright spots which give them a friendly, cartoonish appearance. But those gaping mouths are for devouring prey, and those cheerful spots serve as a warning. A spotted salamander under attack will assume a defensive posture, thrash its tail, ooze milky bitter fluids, and make sounds. The milky fluids are produced only by adults, from glands in the skin along their back and tail. The toxins aren't strong enough kill a predator, but it makes them taste terrible and deters many would-be predators. However, some animals can still stomach them, such as garter and hog-nosed snakes, short tailed shrews, mink, raccoons, barred owls, and red shouldered hawks.

Henry Seilheimer, iNaturalist

The spotted salamander's large mouth gives them a charming, smiling appearance, but that big grin allows them to swallow larger prey.

Deb Carleton Young

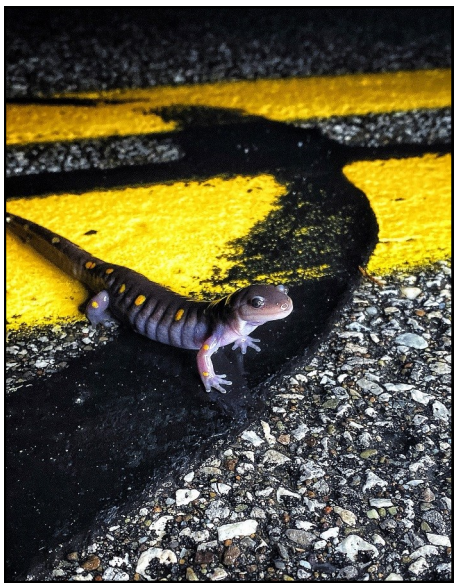
A mole salamander caught by a mink.

They can reproduce asexually: Some populations of mole salamanders are female-only and reproduce asexually. They utilize a special mode of parthenogenesis called 'kleptogenesis.' The females pick up sperm from closely related sexually reproducing species like the spotted salamander. The stolen goods are used to stimulate egg production, but do not fertilize the eggs, therefore the offspring are clones of the mother.

They have a loyal side-kick: Spotted salamander egg masses turn a greenish color as they develop. This is due to a photosynthetic green algae, *Oophila amblystomatis*, that colonize the egg masses. The algae produce oxygen which is taken up by the embryos, and the embryos provide nitrogen to the algae. The algae also help protect the embryos from damaging UV-B radiation from the sun. This relationship between salamander and algae is so close that the algae can enter the cells of the developing salamander embryos.

They can regenerate flesh, nerve, and bone: Spotted salamanders can regenerate limbs and tails after amputation, including bones, and nerves. Their famous cousin, the axolotyl (*Ambystoma mexicanum*), has been found to regenerate damaged appendages, and multiple internal organs including parts of the brain, heart, and spinal cord.

Threats: The spotted salamander is one of our most common vernal pool species. Despite their longevity and amphibian superpowers, they are threatened by changes humans are making to the environment. Vernal pool breeding habitats have been lost to development, agriculture, and other land uses that disturb the forests and soils needed by the adults and juveniles. Herbicides



Insectmyheart, iNaturalist

Road mortality can be high where adults are forced to cross roads that fragment their upland and breeding habitats.

and pesticides commonly used for lawns and agriculture can harm amphibians in all life stages. Roads create hazardous barriers to migrating salamanders, and road run-off can carry eroded soils, salts, trash, pesticides, and other pollutants into the pools.

Climate change is destabilizing the naturally variable wet-dry and thermal cycles of vernal pools. High temperatures in late winter, late freezes in spring, early droughts in spring and mid-summer, and extreme flooding, can interfere with migration, breeding, larval development, and metamorphosis. Newly transformed metamorphs are especially at risk. They are small and delicate, and prone to drying out and overheating, especially as they travel away from the vernal pool to find an upland territory. Climate change is also exacerbating the spread and prevalence of amphibian diseases that thrive in a warming climate.

Betsy Leppo

This vernal pool dried up before the frog and salamander larvae could fully metamorphose and leave the pool.

I hope this deep dive into the lives of spotted salamanders has also deepened your appreciation of these amazing creatures. The Pennsylvania Natural Heritage Program is committed to research that helps us better protect vernal pools and their special inhabitants.

Daryl Coldren, iNaturalist

A spotted salamander emerging from its safe house.

Thank-you

Our thanks to the iNaturalist community, and contributors who share their images through community commons licenses. We value your contributions to science, and your photos bring life to outreach pieces like this one.

Sources

- Petranka J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington.
- Virginia Herpetological Society. 2024. Spotted salamander. Accessed March 15, 2024 at virginiaherpetologicalsociety.com

About the Author

Betsy Leppo has worked with the Pennsylvania Natural Heritage Program for over 25 years and since 2005 as an Invertebrate Zoologist. Betsy conducts surveys for terrestrial and aquatic invertebrates, maintains in-house specimen collections and databases, and develops conservation recommendations for species and habitats.

Notes from the Field

Habitat Management for Wood Turtles

Kathy Gipe, Senior Non-Game Biologist/Herpetologist

Natural Heritage Program partners met in the field with other state and federal conservation partners to discuss ways that stream restoration projects could both avoid harm and bring benefits to the wood turtle. The wood turtle is not listed as threatened or endangered but is considered a state Species of Greatest Conservation Need in the Pennsylvania Wildlife Action Plan and is also prioritized as an At-Risk Species by the U.S. Fish and Wildlife Service (USFWS). Partners meeting streamside included the Pennsylvania Fish and Boat Commission, the Pennsylvania Game Commission, the USFWS, and the Natural Resource Conservation Service. The group examined structures built to decrease erosion and improve stream habitat diversity and discovered wood turtles using the created habitats. The partners all pledged interest in making efforts to continue to keep wood turtle conservation in mind when designing future projects and brainstormed ways to prioritize projects that would benefit the species.

Kathy Gipe

Conservation partners discuss stream habitat improvement projects in February 2024.

One of Pennsylvania's Rarest Crayfish Listed as Endangered

Dave Lieb, Senior Non-Game Biologist/Invertebrate Zoologist

The digger crayfish (*Creaserinus fodiens*) is a primary burrowing crayfish species that was not known from Pennsylvania until 2014 when it was collected from a roadside ditch in western Crawford County in the northwestern part of the state. PNHP biologists and colleagues from West Liberty University published their discovery in the *Northeastern Naturalist* and noted that the species is common in nearby Ashtabula County, Ohio, with records dating back to the 1800s and has long been known from ephemeral wetlands along the north shores of Lake Erie. The authors hypothesized that "*C. fodiens* populations in Pennsylvania immigrated from Midwestern populations in neighboring Ohio following retreating glaciers at the end of the last glacial advance."

Zachary Loughman

Digger crayfish

Historical accounts of Pennsylvania's crayfish fauna published by A.E. Ortmann in the early 1900s did not include the digger crayfish. This was likely because digger crayfish often occur in isolated populations, and areas where they are now known were not well surveyed and very difficult to access at the time of Ortmann's surveys due to the presence of extensive wetlands, swamps, and marshy areas (including the Pymatuning swamplands).

The discovery of digger crayfish in Pennsylvania prompted PNHP biologists and colleagues from West Liberty University to complete an intensive inventory of the species in the northwestern part of the state. We drove every accessible road (~330 miles of road) in an approximately 357 square mile area in the general vicinity of the original collection site in western Crawford and Erie counties in search of digger crayfish. A total of 456 sites across 673 square miles in northwestern Pennsylvania were surveyed for the species. We found digger crayfish in two disjunct, fragmented clusters of sites, both located in mature wet forests with ephemeral pool and roadside-ditch habitat within or immediately adjacent to protected lands. Seven digger crayfish sites were located in southwestern Erie County and northwestern Crawford

Tanya Khan

Digger crayfish chimney

County in the Lake Erie drainage; the remaining two sites were located in Crawford County approximately 12 miles to the south in the upper Ohio River drainage. Digger crayfish populations in Pennsylvania are fragmented and disconnected from populations in other states, limiting dispersal and gene flow, which will likely negatively impact the species over the long-term.

It seems probable that digger crayfish once occupied a larger more contiguous area in northwestern Pennsylvania but that logging, urbanization, and especially the ditching and draining of wetlands for agricultural purposes and the submersion of most of the Pymatuning Swamp to create Pymatuning Reservoir in the 1930s eliminated the digger crayfish from much of its former range in the state. It has been estimated that two-thirds of the wetlands that once occurred in the Lake Erie drainage of Pennsylvania have been lost, mostly due to agriculture practices and to a lesser extent residential development. This was especially true of areas between the two clusters of digger crayfish

Zachary Loughman

First digger crayfish collected from Pennsylvania.

sites where agricultural and developed lands are common. The digger crayfish was likely prevented from dispersing north and east of its current range in Pennsylvania by the presence of inhospitable habitat, which restricted the species to a relatively small area in the northwestern part of the state. Ultimately, habitat fragmentation resulting from land use alteration in combination with dispersal barriers, likely explains the restricted range of the digger crayfish in Pennsylvania to just 7.7 square miles.

Zachary Loughman

Dave Lieb extracts a crayfish from a burrow.

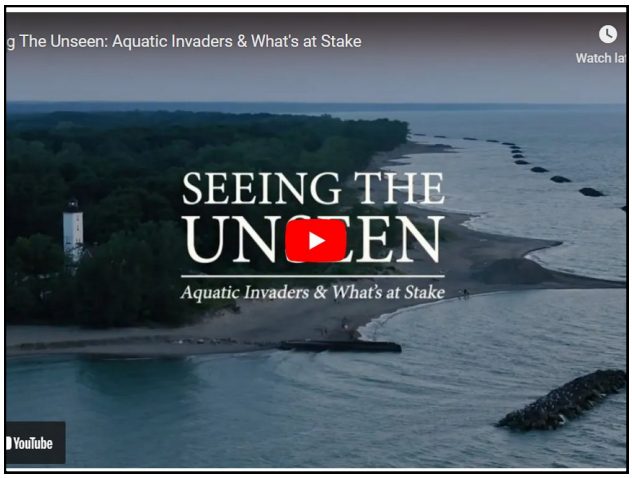
Because the digger crayfish has only been collected from sites within or adjacent to state protected greenspaces, it might be tempting to conclude that adequate protections are in place to safeguard extant populations. However, sites that are not wholly within those areas could be developed or altered for agricultural, residential, commercial, or industrial purposes or to accommodate transportation projects. Even those sites that are wholly within protected areas are located on the periphery, increasing the impact that development projects on adjacent lands could have on digger crayfish colonies. In addition, most digger crayfish colonies (even those within protected greenspaces) are located within or near roadside ditches and as such could be negatively affected by road maintenance (e.g., ditching, herbicide application) or deicing (e.g., road salt application) projects. Well-intended conservation efforts to reduce erosion from roadside ditches by lining them with rocky substrates could render roadside ditches uninhabitable to digger crayfish by preventing or altering burrowing activities.

Given these threats and their rarity, efforts began in early 2023 to add the digger crayfish to Pennsylvania's list of threatened and endangered species. This status provides species, including the digger crayfish,

protections afforded by Title 58, Chapter 75 of the Pa Code and all conflicts between digger crayfish colonies and development projects and other human activities would be fully reviewed through the Environmental Review permitting program. On March 2, 2024, nearly a decade after the digger crayfish was discovered in Pennsylvania, these efforts bore fruit and the digger crayfish was officially listed as endangered in Pennsylvania, becoming the first non-mussel invertebrate listed as endangered or threatened in the state. The digger crayfish's status as a state endangered species means that dedicated resources will be available to conserve and protect the species, hopefully allowing this important and fascinating species to persist in Pennsylvania for centuries to come.

Lights, Camera, Action: PNHP Makes a Film Spotlighting Aquatic Invasive Species

Mary Walsh, Invertebrate Zoology Manager



Great Lakes Media & Film

https://waterlandlife.org/seeingtheunseen

A new short film, ***Seeing The Unseen: Aquatic Invaders & What's at Stake***, produced by PNHP's Amy Jewitt and Mary Walsh, explores the threat of invasive species to the Great Lakes and the region's other waterways. Invasive species are organisms introduced to new locations outside of their native region that can displace native species and overtake natural habitats. Northwest Pennsylvania's biologically rich aquatic environments, including wetlands, rivers, and lakes, are degraded by infestations of non-native, invasive plants and animals. The impacts to birding, fishing, and boating in the beautiful Lake Erie watershed and beyond are illustrated by the 44-minute film, created by Emmy award-winning filmmakers Great Lakes Media, LLC.

Great Lakes Media & Film

The film captures Greg Kedzierski, French Creek Valley Conservancy, fishing in French Creek. The round goby, an aggressive invasive species, may be competing with other fish in French Creek.

Funded by the Great Lakes Restoration Initiative through a grant from USFWS, the film highlights the region's waterways, like French Creek, beloved by recreationists and where conservationists are working hard to ameliorate the damage from aquatic invasive species. The diverse darters and mussels are facing competition and predation from the introduced round goby. Unfortunately, there are few treatment options to control many aquatic invasive species, such as the introduced starry stonewort in the lagoons of Presque Isle Bay in Lake Erie. Jim Grazio, Great Lakes Biologist with the Pennsylvania Department of Environmental Protection, expresses his concern in the film that "Once a new species arrives, becomes established and begins reproducing, there is little, in most cases, that can be done to remove that species from the ecosystem."

Great Lakes Media & Film

Peter Schuster, PA DEP, holds a rake with the invasive macroalga, starry stonewort, at Presque Isle Bay, Lake Erie.

The film producers want viewers to take to heart the message that they can help keep invasive species out of their favorite boating or fishing spot by being responsible stewards. Cleaning gear after fishing, draining a boat before taking it to another launch, and proper bait disposal prevent new infestations of aquatic invasive species. Another way to help is to report sightings of invasive plants or animals to Pennsylvania iMapInvasives (paimapinvasives.org). In the film, Sara Stahlman, Extension Leader with Pennsylvania Sea Grant, says that taking invasive species threats seriously is important because "We want to make sure that these types of beautiful habitats, that are biologically diverse and unique, are still here for generations to come."

Great Lakes Media & Film

Draining your boat and removing plants will prevent unintentional transfer of aquatic invasive species to another waterway.

Barbara's Buttons by Any Latin Name Would Be as Gorgeous

Steve Grund, Senior Botanist

We have featured Barbara's buttons (*Marshallia pulchra*) in this newsletter before, and why not? It is very showy, it grows along the Youghiogheny River, and it is globally rare! This species was long known as *Marshallia grandiflora*, but Wes Knapp (Chief Botanist at NatureServe) discovered that some of the plants from North Carolina going by that name were not the same species as the rest of the populations. When what was once thought to be one species turns out to be two, one of the species needs a new name. Which one gets to keep the old name? The one that best fits the original description when the name was chosen, and the ultimate standard is matching what is called the holotype. A holotype is a single dried specimen upon which the description and name of a new species is based. The holotype specimen is housed at a museum for reference, and any plants that match the holotype are called by that species name.

Marshallia pulchra holotype

The holotype for *Marshallia grandiflora* was collected from North Carolina, and the North Carolina Heritage Program says it is no longer there, making *Marshallia grandiflora* an apparently extinct species. Wes had to choose a new Latin name for the rest of the populations, and he chose as the epithet *pulchra*, which is Latin for beautiful, so *Marshallia pulchra.* Grand flowered or beautiful, either is a great description of this plant with large heads of pink flowers. For the common name, we now use "beautiful Barbara's buttons."

Steve Grund

Marshallia pulchra

Curtis's Botanical Magazine is a very old journal in England that focuses on botanical illustrations. In 1998, they featured an illustration of *Marshallia* based on a plant grown from seeds collected along the Youghiogheny River and labeled it *Marshallia grandiflora.* Noticing that the name, considered to be correct in 1998, no longer applied to the subject of the illustration, PNHP botanist Steve Grund emailed the editor to let them know that it is now known as *Marshallia pulchra*, and was invited to publish a short paper telling the story. That paper, "Grand and beautiful, Barbara's buttons by any other epithet would be as gorgeous: *Marshallia pulchra* W. Knapp, D.B. Poind. & Weakley, a

note on the correct name for *Curtis's Botanical Magazine* t. 343 (1998)," is featured in the current issue of Curtis's Botanical Magazine.

Will we have to change the name again if it is determined that what we call *Marshallia pulchra* is actually comprised of more than one species? No, we will not! The holotype for *Marshallia pulchra* was collected in the Youghiogheny River Gorge, at the same site where the source material for the illustration in *Curtis's Botanical Magazine* grew, so the Barbara's buttons growing at Ohiopyle will always be *Marshallia pulchra.*

Meeting the Fungal Biodiversity of Pennsylvania

Hannah Huber, Conservation Mycologist

I started with the Western Pennsylvania Conservancy and the Pennsylvania Natural Heritage Program (PNHP) in November 2023. As Conservation Mycologist for PNHP, I'm rounding out the flora and fauna-dedicated personnel with a focus on the state's "funga" and paying particular attention to species that may be rare, declining, introduced, or new records for the state.

Garrett Taylor

Tim and Darlene Corio discovered this mushroom last June growing on wood submerged in the Pennsylvania portion of the Allegheny River.

Last year, three new species records were made. In June, Tim and Darlene Corio found a small gilled mushroom growing on wood submerged in the Allegheny River. Garrett Taylor from the Western Pennsylvania Mushroom Club assisted them in having the specimen DNA sequenced and it came back as *Psathyrella aquatica* or *Psathyrella fontinalis*, which may be two names for the same species (*P. fontinalis* is the older name so *P. aquatica* may be thrown out if more collections are DNA sequenced and determined not to be unique). Either way, there are only a handful of records of either name across the country.

Noah Yawn

PNHP Ecologist Noah Yawn found *Loreleia marchantiae* aka "liverwort navel" last November and posted it on iNaturalist where it was seen and noted as rare by a friend in the UK. John Plischke of the Western Pennsylvania Mushroom Club assisted in sending the specimen off for DNA sequencing.

In October, Mandie Quark found what I'd call an "MBM" or "medium brown mushroom" that is, actually, according to the DNA, *Thaxterogaster frondosomultiformis*, a species that previously was only known from two locations in Northern Italy. In November, PNHP's Ecologist Noah Yawn spied *Loreleia marchantiae*, the "liverwort navel," growing out of a *Marchantia polymorpha* liverwort on a boulder. Uncommon globally, Noah's find represents only the second georeferenced observation of the liverwort navel for all of eastern North America!

Pennsylvania has over 6,000 documented species of fungi. The exact composition of the list may change over time as DNA sequencing efforts reveal that species we have in eastern North America that have gone by their European names are actually genetically distinct and should have separate names. For example, the chanterelle *Cantharellus cibarius* is now known to be a European-only species, but in eastern North America we have the smooth chanterelle *Cantharellus lateritius* and several other similar species. In some cases, the species in Europe and the look-alikes we have in North America are the *same* species. For example, *Amanita phalloides*, the "deathcap," is believed to be an introduced species that has been spreading across the continent for the last century. Even similar-looking species between the west and east coast can be different species according to the DNA.

This field season I'm looking forward to returning to the sites where the new species were found to see if they show themselves again. I also plan to tag along and

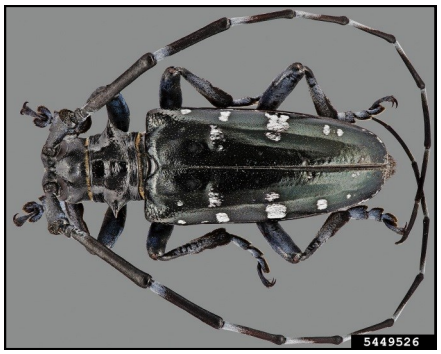
look for fungi on the other PNHP 'ologists' old growth and peatlands surveys. A list of underdocumented, potentially rare Pennsylvania fungal species will be forthcoming on the PNHP website. In the meantime, I suggest you visit the Fungal Diversity Survey's website and familiarize yourself with the species included in the Northeast Rare Fungi Challenge. Eight out of the 20 species have been documented in Pennsylvania and the others may be waiting for you to find them!

False Alarms and Misidentifications: Ensuring Data Quality in iMapInvasives

Brian Daggs, Invasive Plant Ecologist

iMapInvasives is a public clearinghouse for invasive species data and reporting, administered within Pennsylvania by PNHP. Recently, PA iMapInvasives received several reports of high-priority, early detection invasive species, which have fortunately turned out to be mistaken identifications of native look-alike species.

One user uploaded a potential sighting for Asian long-horned beetle (*Anoplophora glabripennis*), an invasive insect that damages trees and has never been found in Pennsylvania before. PNHP staff shared images with entomologists from the Pennsylvania Bureau of Forestry and the Pennsylvania Department of Agriculture, who were able to determine that the beetle in the pictures was actually a white-spotted pine sawyer, a native species that closely resembles the Asian long-horned beetle. The pictures originally uploaded to iMapInvasives were unclear, taken at an angle that obscures distinguishing characteristics. PNHP staff received additional pictures that clearly showed a large white spot on the beetle's scutellum, the small triangular plate between the wings, which left no doubt as to the identity of the insect.



Steven Valley, Bugwood.org

Asian long-horned beetle

Cassidy DeJonge

White-spotted pine sawyer with a clear view of the white scutellum

Royal Tyler, Bugwood.org

Nutria

Brian Kulig

Muskrat

Less than two weeks later, another report of a high-priority invasive species was submitted to iMapInvasives, this time for a sighting of nutria (*Myocastor coypu*), a large semi-aquatic rodent from South America. PNHP iMapInvasives staff reviewed the photos internally with PNHP zoologists and determined that the critter was a native muskrat, which is similar to nutria in both appearance and lifestyle, but is differentiated by its smaller size and darker whiskers. Escaped nutria have previously been found in Pennsylvania, but a population has never established in the state.

It may sound like a nuisance receiving numerous false reports and misidentifications of early detection invasive species, but it is actually a sign that the iMapInvasives program is working as intended. These false reports show that the public has become more aware of the threats posed by invasive species and of the high-priority

non-native species that are not yet established in Pennsylvania. They also provide valuable experience to PNHP's iMapInvasives team for understanding the best procedures for handling significant invasive species reports.

Invasive species cost the United States up to $26 billion annually in management efforts and economic losses, according to the U.S. Department of Agriculture. The early detection of new invasive species introductions is vital to reducing or preventing the impacts of those invasive species. Tools like iMapInvasives, in the hands of a public that is aware of the threats, are effective for sharing information about newly arrived biological invaders.

If you are unsure of an invasive species finding, please report it to www.paimapinvasives.org for help with identification.

Reviewing and Identifying Pennsylvania's Dichanthelium

Claire Ciafré, Ecologist

Dichanthelium, is a genus of perennial, cool season grasses known as witchgrasses or panic grasses native to North America. Many *Dichanthelium* are habitat specialists, and over a third of those found in Pennsylvania are currently of conservation concern. However, these grasses are notoriously difficult to identify and have been subject to a lot of taxonomic disagreements. Depending on which reference you use, Pennsylvania has between 27 and 35 *Dichanthelium* taxa (species, varieties, and subspecies). This disparity, and an abundance of misidentified herbarium specimens, makes it difficult to adequately track and conserve members of the genus in the state.

Claire Ciafré

The taxon on the left (*D. commutatum* var. *commutatum*) seems to be less common in Pennsylvania than the one on the right (*D. commutatum* var. *ashei*). The two have not been distinguished by many botanists, so it is currently unclear whether either should be considered for tracking.

A taxonomic update and review of herbarium specimens is therefore needed to better understand the rarity and distribution of Pennsylvania's *Dichanthelium.* To accomplish this, we sought and obtained funding from the Wild Resource Conservation Program (WRCP) to review and identify the majority of preserved specimens collected from the state. This work will be done in collaboration with Justin Thomas (Science Director, NatureCITE), who has spent years studying *Dichanthelium* and has conducted a similar project with the genus in Arkansas sponsored by the Arkansas Natural Heritage Commission.

Claire Ciafre

Rediscovered by Claire Ciafré last year, *Dichanthelium appalachiense* had not been seen in Pennsylvania since 1944. It is currently unclear whether it is a very rare species endemic to shale barrens or a spontaneously arising hybrid between *D. boscii* and *D. linearifolium.*

Work on this project recently began by identifying a collection of unidentified specimens not yet curated into the Carnegie Museum's herbarium. Specimen identification work will continue in the fall of 2024 at four primary herbaria which house approximately 75% of the over 6,000 *Dichanthelium* specimens collected from Pennsylvania. This study will ultimately culminate in a list of *Dichanthelium* taxa found in Pennsylvania, and provide range, habitat, rarity, and identification features for each. It will also identify data gaps which need to be filled by additional field work and will produce an identification guide to Pennsylvania's *Dichanthelium.*

This project builds on my interest in *Dichanthelium,* which was sparked 10 years ago by my collaborator Justin. I shared my knowledge of the genus with others at an identification workshop at the Pennsylvania Botanical Symposium last fall prior to receiving WRCP funding for this project.

Amphipod Collections Lead to Important Biodiversity Discoveries

Tom Sawicki, Associate Professor of Biology, Florida A&M University
Dave Lieb, Senior Non-Game Biologist/Invertebrate Zoologist

In August 2022, an amphipod crustacean belonging to the genus *Gammarus* was collected from a stream in Cumberland County, Pennsylvania by PNHP biologist Dave Lieb. These specimens immediately stood out as very different from the "common" *Gammarus* amphipods often seen by Dave during his sampling of watersheds in Pennsylvania. For instance, the specimens were relatively large (up to 17 mm), which is about 50% bigger than typical *Gammarus* amphipods, and possesses conspicuous striped markings, that dramatically contrast with the relatively dull yellow/orange/light gray pigmentation of the more common amphipods. In addition, this animal had not been observed elsewhere in Pennsylvania prior to this collection. In previous years, when needing to identify amphipods, Dave had collaborated with Dr. John Holsinger at Old Dominion University, a world-renowned expert in the taxonomy of amphipod crustaceans. Unfortunately, John passed away in 2017, and being that John had been my Ph.D. advisor, Dave called me to assess my interest in collaboration, and I excitedly jumped on board.

Tom Sawicki

Newly discovered species from Cumberland County

The large, conspicuously marked *Gammarus* species found by Dave superficially resembles other North American *Gammarus* species such as *G. fasciatus*, and *G. bousfieldi*, and even some species from Europe and Asia. Given its superficial resemblance to other *Gammarus* species in North America, Asia, and Europe, and the seemingly sudden appearance of the species in the stream, two hypotheses were proposed 1) it could be a known North American species that had been introduced or naturally dispersed to the area, or 2) it could be an invasive species from Europe or Asia. I performed a preliminary analysis of both nuclear and mitochondrial genes, and the results suggested a completely different hypothesis, that the species was neither a known native, nor invasive, but may represent a new, undescribed species!

Subsequent limited surveys conducted by Dave in central Pennsylvania have failed to document this potentially new *Gammarus* sp. in other regional watersheds. However, these surveys documented the presence of other amphipod species, including the very common, and broadly distributed *Gammarus minus*. Interestingly, the preliminary genetic analyses conducted to date suggest that the nearest common ancestor to the new, large, and striped *Gammarus* species found in Cumberland County may be *Gammarus minus*.

Tom Sawicki

Gammarus minus

The type locality of *Gammarus minus* is a small stream at Gable's Woods in Lancaster, Pennsylvania. Unfortunately, Gable's Woods has been completely developed over the years. Dave and I were concerned that *G. minus* may have been extirpated from this small stream. To assess this, in the fall of 2023, Dave visited this location, and was able to successfully collect amphipods that I verified to be *G. minus*. Based on other collections of *G. minus* made by Dave in various watersheds across Pennsylvania, along with other data and genetic analysis of *G. minus* populations strongly suggests that Pennsylvania's watersheds may support significant endemic cryptic species diversity. In other words, what was once thought to be a single, common, widely distributed species, may in fact be a complex of local endemics. In the end, the happenstance discovery of a single unique species in Cumberland County, may result in the discovery of significant biodiversity within this understudied group of freshwater crustaceans.

Green Salamander

Ryan Miller, Zoologist

Ryan Miller

An arboreal green salamander

The green salamander in Pennsylvania has been known to use Pottsville Sandstone rock outcrops as its core habitat. Almost all of the green salamander surveys in the state in recent history have focused on the outcrops, boulders, and formations with fairly consistent success. Interestingly, some of the original publications on green salamander were before widespread timbering operations, and the descriptions of habitat suggest that the salamanders were found among the shaded, damp trees and decaying wood of old-growth forests associated with shaded rock outcroppings. Some of these descriptions don't even mention the salamanders being found in rock crevices, and subsequent researchers have suggested that the preferred habitat was tied to primeval forests, relying on rock crevices primarily for winter brumation. As forests were cut, populations likely hung on only by retreating to the limited rock crevices, confined for many decades until the forests mature and provide sufficient shade, moisture, and woody habitat allowing for the recolonization of surrounding forest. Surveyors in other states have begun to have success documenting green salamanders utilizing arboreal habitats within the past 25 years.

Knowing this, PNHP zoologists set out to survey trees adjacent to known occupied rock habitats. These surveys were successful in June 2023, when PNHP zoologists observed four individual green salamanders climbing on one large red oak tree. This was not the first time green salamanders had been observed using arboreal habitat in Pennsylvania, but it was the first documented successful targeted survey of trees for the salamanders in the state.

This discovery led to the funding of a Wild Resources Conservation Program Grant to study the arboreal habits of green salamanders in Pennsylvania in 2024. Data from this upcoming study will be used to inform landowners and land managers about occupied habitat use, appropriate forest buffers, and forest age preferences of this state threatened species.

MAPS: Monitoring Avian Productivity and Survivorship – Two New Stations in Western Pennsylvania

David Yeany, Avian Ecologist

The PNHP at the Western Pennsylvania Conservancy (WPC) was awarded funding through DCNR's Wild Resources Conservation Program to establish new MAPS (Monitoring Avian Productivity and Survivorship) bird banding stations at two WPC nature reserves. PNHP will collaborate with Bird Lab, a Pittsburgh-based bird conservation non-profit and partner through the Allegheny Bird Conservation Alliance, to initiate MAPS at Toms Run Nature Reserve in Allegheny County and Bear Run Nature Reserve in Fayette County during spring and summer 2024.

As a program operated under The Institute for Bird Populations, MAPS is a continental collaborative effort to collect important bird species demographic parameters or vital rates, including productivity, survival, and population recruitment. These vital rates are necessary for applications in bird population models

Annie Lindsay, CMNH

PNHP avian ecologist David Yeany and Bird Lab executive director Nick Liadis collect data and band a Swainson's warbler at Bear Run Nature Reserve.

and can help us understand which life stages may be most critical to population growth or decline. MAPS data can help guide and direct bird conservation efforts.

Since 1989, there have been more than 2.5 million bird capture records collected from more than 1,200 MAPS stations across North America. The MAPS program follows standardized sampling methods using bird mist-nets made from fine threaded mesh to band and record body measurements, age, health condition, and reproductive status on all captured birds. Our sampling will be conducted over eight 10-day periods from May through mid-August, during the avian breeding season in Pennsylvania.

The MAPS stations that Bird Lab and PNHP ornithologists will operate fill-in gaps in the MAPS network. This effort will also establish standardized monitoring of the first confirmed Pennsylvania breeding population of Swainson's warbler (*Limnothlypis swainsonii*) discovered by Bird Lab and PNHP at Bear Run Nature Reserve in 2023. The contrasting landscape settings between the two sites of urban/suburban Pittsburgh and the forested Laurel Highlands will offer opportunities for comparing productivity across bird species found at both sites and will contribute to Bird Lab's ongoing research of the effects of rural to urban landscape gradients on bird populations.

David Yeany

The North American wood thrush population has declined by 59% since 1970. MAPS efforts at WPC's Toms Run and Bear Run Nature Reserves will directly contribute to the conservation of this species, including a range-wide migratory connectivity project. This wood thrush was observed during PNHP bird surveys at Toms Run.

Finally, this effort also enables PNHP and Bird Lab to contribute to a range-wide, full annual cycle migratory connectivity study of wood thrush (*Hylocichla mustelina*) using Motus radio telemetry technology to tag and track 600 wood thrushes from across the eastern United States. We will deploy ten radio nanotag transmitters on wood thrushes captured during MAPS field work this year at Toms Run and Bear Run, adding important information for the conservation of a "common" forest interior bird, now a Species of Greatest Conservation Need that has suffered a 59% continental population decline since 1970.