

THEY MIGHT BE GIANTS

“You could walk right past them and never know they’re there,”

Andrew Herberg

SALAMANDERS ARE AMONG THE HEAVY LIFTERS IN MINNESOTA’S FOREST ECOSYSTEMS

Talk about a needle in a haystack. How do you inventory—much less, protect—a rare animal that is generally solitary, silent, 2-4 inches long, weighs in at less than 1.5 grams on a heavy day, and is most likely found *inside* a sphagnum moss hummock? As if that were not enough, place the hummock among other, virtually identical hummocks in small, isolated wetlands surrounded by mature forest. “You could walk right past them and never know they’re there,” says MN DNR Nongame Wildlife Program biologist Andrew Herberg. Of course, from the salamanders’ point of view, that’s just fine.

Herberg is speaking of the micro-habitat favored by nesting four-toed salamanders in Minnesota, as evidenced by the settings where surveyors have documented females with eggs. The wetland might be a seasonal vernal pool where snowmelt or rain gathers in the low spots of rolling glacial terrain, or the moat-like open water that rings a conifer swamp or other shallow, semi-permanent



Four-toed salamander on a hummock of sphagnum moss in Carlton County
Photo by Andrew Herberg, MN DNR

wetlands nestled within mature forests—but the sphagnum moss component is key. “The species is a real habitat specialist when it comes to nesting,” says Herberg. Females migrate from overwintering sites to small wetlands where they typically lay their clutch of eggs within a hummock of sphagnum moss. A female will often stay with the eggs for at least part of their roughly 40-day incubation period, in many cases attending her own clutch of eggs along with those of others who “lay and leave.” When the larvae hatch, they need only wriggle down the mossy slope of the hummock and drop into the open water below.

It’s an exquisite life strategy, provided that the female has selected a well-placed hummock, and the water

body isn’t too ephemeral. “It can take roughly six weeks—we don’t know precisely how long—depending on environmental conditions for the larvae to complete their development to the point where they become terrestrial,” says Herberg. “So, the length of that hydro-period really matters. The water can’t dry up too soon.” When it happens, as it sometimes does, the opportunity to replenish the local population that year is missed. To persist, the species relies on redundancy: numerous wetlands distributed across its range where—over time—enough larvae meet with success.

“What we know about salamanders as a group is fascinating: and there is so much that’s still to be learned about their abundance, basic ecology and habitat use here in Minnesota.”

ANDREW HERBERG,
Nongame Wildlife Program Biologist



Nongame Wildlife Program Biologist Andrew Herberg holding an Eastern newt (pictured in its larval aquatic stage) which is designated as a Species in Greatest Conservation Need
Photo by Spencer Rettler, MN DNR



Ross Hier

Species shown, from top:

- Four-toed salamander
- Blue-spotted salamander
- Eastern red-backed salamander
- Eastern newt (juvenile, left, and aquatic adult, right)
- Spotted salamander
- Tiger salamander
- Mudpuppy

Temporary wetlands in forested settings are also vital habitat for another salamander species listed as Special Concern in Minnesota: the spotted salamander. The comparatively larger (albeit still less than 7” long) spotted salamander bypasses the transitional lodging in moss hummocks and deposits its egg masses directly in water. The spotted is considered a vernal pool obligate, explicitly depending on these seasonal water bodies, whereas the four-toed is a vernal pool “facultative” species, using them opportunistically but not exclusively.

It seems a risky business. Why would a species evolve to rely on temporary wetlands for reproduction? One likely factor is that larger, more permanent wetlands pose an even greater risk to amphibian eggs and larvae: the presence of predatory fish.

While the Nongame Wildlife Program works to sustain all eight salamander species found in the state (see inset), it prioritizes efforts benefiting designated Species in Greatest Conservation Need. They’re a diverse

lot that includes the little all-terrestrial red-backed salamander, along with three species listed as Special Concern: the four-toed salamander, the spotted salamander and the all-aquatic mudpuppy. The mudpuppy is the only known host for the larval form of the rare salamander mussel, a threatened species in Minnesota. Fishermen who make an accidental catch of a mudpuppy are encouraged to release them without delay. They are both harmless and beneficial.

Truth is, many people could count the number of encounters they’ve had with salamanders on no hands. The lives of these amphibians rarely intersect with ours, beyond the occasional individual that turns up in a window well or under an upturned log. Even on rainy nights when they sometimes stream like dark ribbons across country roads, they can easily go unnoticed.

It’s high time we start seeing salamanders. They’re owed some serious credit for the heavy lifting they do, despite their size. Gram for gram, salamanders are among the most efficient converters of bio-mass

in forest ecosystems. They consume high volumes of invertebrates (snails, worms, fairy shrimp) and convey much of that accumulated energy up the food chain when they become prey for larger mammals and birds. In their reliance on freshwater environments, they remind us of our own. Like waterfowl in prairie potholes, they are indicators of how well we are stewarding the state's natural resources—not only biodiversity but also the ephemeral ponds critical to groundwater recharge.

According to Herberg, who has been among those biologists in the field with water overtopping his boots, carefully peering through strands of sphagnum moss in search of four-toed salamanders, they're also just plain cool. "What we know about salamanders as a group is fascinating: and there is so much that's still to be learned about their abundance, basic ecology and habitat use here in Minnesota."

Herberg is excited to be leading the charge on a monitoring effort kicked off in 2022 focused on four-toed salamanders in the Laurentian Forest Province counties of Mille Lacs, Kanabec, Pine, Carlton, Cook, St. Louis, Aitkin and Itasca. "The main driver for the project is to ask: How are Minnesota forest management practices impacting four-toed salamanders?" says Herberg. Modeling efforts utilized historical locations of the species and associated habitat attributes to inform the process of defining sample plots across the study area for monitoring at a scale that will hopefully be able to detect changes in occupancy. The study utilizes a "Before and After Control Impact," or BACI, design, in which control plots (where forest management will not occur) will offer a basis for comparison to plots where forest management occurs. This calls for coordination with state forestry officials to know where and when harvests are planned within the study area.

Minnesota's salamanders

- Blue-spotted Salamander (*Ambystoma laterale*)
- Eastern Tiger Salamander (*Ambystoma tigrinum*)
- Spotted Salamander (*Ambystoma maculatum*)
Special Concern and Species in Greatest Conservation Need (SGCN)
- Western Tiger Salamander (*Ambystoma mavortium*)
- Four-toed Salamander (*Hemidactylium scutatum*)
Special Concern and SGCN
- Eastern Red-backed Salamander (*Plethodon cinereus*)
SGCN
- Eastern Newt (*Notophthalmus viridescens*)
- Mudpuppy (*Necturus maculosus*)
Special Concern and SGCN



Ventral patterning can be used to identify individual four-toed salamanders.
Photo by Andrew Herberg, MN DNR

The issue of detectability factors into the number of plots monitored—that is, how likely surveyors are to be able to find a salamander that is present. “Little to no detectability data exists for this species, especially in Minnesota,” says Herberg, “Accordingly, a pilot year in 2022 focused on gathering baseline data to better determine the number of monitoring plots needed to detect changes in occupancy over time.”

Monitoring (which included surveying for larvae during the pilot year) will be done for at least two years pre-harvest and two years post-harvest, and control sites annually. The varied land ownerships across the study area create welcome opportunities for future collaboration with the Chippewa National Forest, Fond Du Lac Band (pending), Leech Lake Band, counties, St. Cloud State University and other partners. It’s a truly massive undertaking that will not only offer insight into impacts of forest management practices on this rare salamander, but also metrics on nest selection, upland habitat use, and baseline occupancy data that will hopefully lay the groundwork for future long-term population monitoring.

In the midst of the study, slow and steady work continues to map the seasonal wetlands across the region that offer existing and potential habitat for the salamanders, using leaf-off aerial photography and LiDAR (Light Detection and Ranging) images followed up by ground-truthing in the field. Herberg is also excited about what can be learned through potential identification of individual salamanders using the patterning of their ventral (belly) sides, which, like fingerprints, appear to be unique. He is not alone in his enthusiasm. These salamanders definitely have their champions. Says Herberg, “The interest is out there, and the Nongame Wildlife Program is committed to these efforts. It’s labor intensive, so we’ll need sufficient staffing levels and funding to make the progress we’d like to make.”

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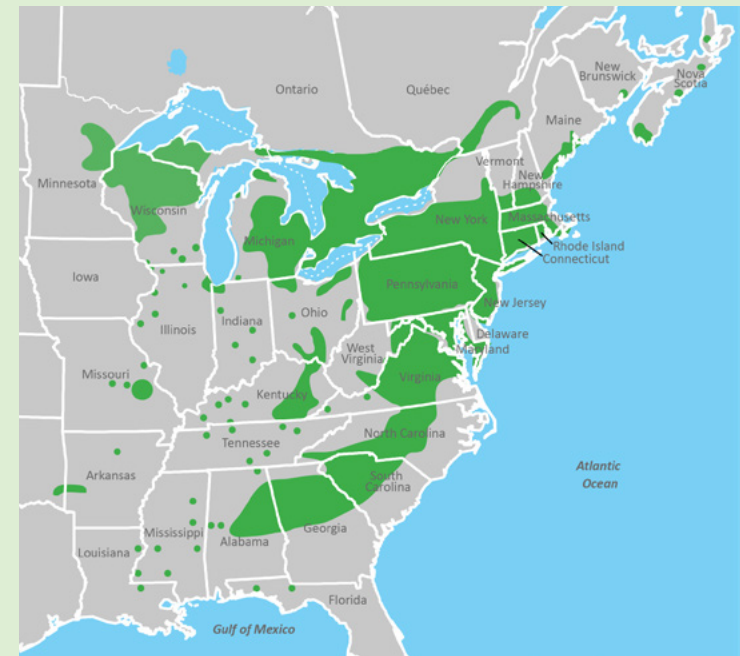
It wasn't until 1994 and 2001, respectively, that the four-toed salamander and spotted salamander were even known to occur in the state. Carol Hall recalls those discoveries well. Hall is a herpetologist with the Minnesota Biological Survey, the MN DNR program tasked with the county-by-county survey of the state's native plant and animal species. "The four-toed was not even on our radar during surveys in central Minnesota, since the closest records were across the border in Wisconsin. We had just finished surveys in southeast Minnesota in 1993 where we thought it was possible we could find them but hadn't." Instead, the species unexpectedly turned up in a drift-fence bucket during surveys conducted in Itasca County, where the Minnesota Biological Survey was cooperating with the Chippewa National Forest documenting amphibians and reptiles within different Land Type Associations. "At first, we weren't sure what we were seeing," says Hall. "We had to look through a microscope to confirm that it had four toes on

each of its hind limbs." (Minnesota's other terrestrial salamanders have five). As Hall relates, it was seven years later that the first record of spotted salamanders began as a promising egg mass in the Nemadji State Forest and was confirmed only after the eggs were collected and reared. The discoveries changed the range maps for these species. For example, Minnesota is now at the northwesterly edge of the four-toed salamanders' U.S. range (see figure 1).



MN DNR Minnesota Biological Survey
Herpetologist Carol Hall

Figure 1. Four-toed salamander range map, showing Minnesota as the northwesterly edge for the species



Range map of four-toed salamander from Peterson Field Guide to Reptiles and Amphibians of Eastern and Central North America, Fourth Edition. 2016. Robert Powell, Roger Conant, Joseph T. Collins. Houghton Mifflin Harcourt, ISBN 9780544129979. https://commons.wikimedia.org/wiki/File:Hemidactylium_scutatum_map.svg



Nongame Wildlife Program Biologist Gaea Crozier and Specialist Cheyanne Rose survey for forest salamanders. Photo by Clara Brown, MN DNR

Subsequent surveys by the Minnesota Biological Survey documented additional occurrences of the four-toed in Itasca, Aitkin, Mille Lacs, Pine, Carlton and St. Louis counties, with a recent (2021) record by staff from the Chippewa National Forest extending the species' known distribution in the state to Cass County. The spotted salamander is thus far known to occur only in Pine and Carlton counties. "Surveys by the Minnesota Biological Survey generally assess presence of a species—not population size or viability—but records (which can consist of one or more individuals or egg masses) provide an index of relative abundance across counties," says Hall, "as well as locations where management practices or monitoring efforts can be focused."

Even in many areas of seemingly suitable habitat across their range, four-toed salamanders are rarely found, having a patchy distribution. Thus far, the same holds true here

in Minnesota. "You can search one wetland after another, not finding them, but when you do, it's really a rush," says Hall. "You have this awareness of the entire community—that it's woven together with the wetlands, the upland forest and the sphagnum—all of that being necessary within a certain area to make that population viable."

Surveys have tended to focus on the wetlands where these forest salamanders reproduce, given the opportunity afforded by the window of time when females are on eggs. But conservation management requires a broader view, one that takes into account the needs of these species throughout the seasons and throughout their life cycles. This includes not only fish-free wetlands (with a sphagnum moss component for the four-toed), but also the adjacent forested upland habitats, where they are less often detected but where most of their lives are spent.



Four-toed salamander nesting habitat in North Central Minnesota
Photo credit Andrew Herberg, MN DNR

To serve as good salamander habitat, this upland terrain will have certain characteristics. Chief among them are coarse woody debris and leaf litter (for refuge and food sources), and a forest canopy that offers sufficient shade to moderate temperature and

maintain moist conditions at ground level. At different scales of planning, other considerations come into play in promoting salamander survival (see inset), especially in areas of known or potential habitat for rare species.

Promote

- Closed-canopy, mature upland forest
- Coarse woody debris
- Moist soils
- Abundant leaf litter/duff
- Travel corridors offering connectivity between breeding sites and upland habitats, as well as opportunity for dispersal among breeding sites

Minimize/Avoid

- Herbicides
- Wide, high-use roads and trails
- Uses that cause soil compaction
- Erosion of sediment into wetlands
- Timber harvest or thinning that reduces original basal area by more than 20%



Four-toed salamander
Photo by Andrew Herberg, MN DNR

So, just how big is the universe of a four-toed or spotted salamander? What constitutes their home range, if they have one?

The scientific literature offers some insight. In their paper, *Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibians and Reptiles*, Raymond Semlitch and J. Russell Bodie summarized data from studies in multiple states to provide estimates of the biologically meaningful size of core terrestrial habitats used by local breeding populations surrounding temporary wetlands. For amphibians as a group, core terrestrial habitat ranged from 159 to 290 meters, with each figure being the radius of a circle with the wetland at its center. The area of these circles of core terrestrial habitat would therefore range from roughly 19 acres to 65 acres, respectively.

While not prescriptive—nor tailored to Minnesota’s environment—such data offers a starting point for the area within which resource managers might make considerations for salamanders in the interest of promoting stable populations. The MN DNR’s Minnesota Biological Survey has prepared a guidance document with management recommendations appropriate for sites having documented and potential use by rare salamanders. Ongoing research will continue to inform and refine that voluntary site-level guidance.

“As we think about the area to focus on for protective measures, ‘life zone’ is a far better term than buffer zone. It’s the area where these species live, where they need to be able to satisfy all their life requirements,” says Ed Quinn. Quinn has served as Natural Resources Program Supervisor for the MN DNR’s Parks and Trails Division for over two decades. He also happens to have a special interest in—and knowledge of—salamanders, which were the subject of his graduate work in Northeast Ohio. In his role with MN DNR’s Parks and Trails, he’s had plenty of opportunity to take the interests of salamanders into account.

“You don’t start with a blank canvas. You first identify the species that are there and their critical habitats, their life zone. Then, you have to think spatially as well as temporally—not only where impacts might occur, but when and how often.” For example, he notes, a forest road or trail that salamanders must cross between upland habitat and their breeding site could be seasonally closed to reduce mortality. Soil compaction could be reduced by limiting vehicle use (including recreational vehicles) to times of year

when the ground is frozen. With timber harvest, says Quinn, you need to seek a middle ground that protects enough of the local population before, during and after harvest.

“When canopy cover is reduced too much, one of the things that happens is that you have greater evapotranspiration out of these small wetlands, meaning they may not hold water long enough to support reproduction. And these salamanders are very philopatric—that is, tied to the pond they emerge from as larvae, tending to return there to breed. In our study in Ohio, we found salamanders returning to the site of a wetland that had been filled in, which was no longer there.” The limited mobility of salamanders, along with their reliance on water bodies that are often isolated from others, makes such local populations vulnerable to collapse. “From the standpoint of species conservation, it’s important to think at multiple scales, including the larger meta-population. There has to be suitable terrain between these small wetlands that makes it feasible for them to disperse and colonize new sites.”



Ed Quinn is the Natural Resources Program Supervisor for the MN DNR’s Parks and Trails Division and a salamander advocate.

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**ED QUINN, Natural Resources Program Supervisor,
MN DNR Parks & Trails**



Female four-toed salamander guarding eggs in Pine County
Photo by Melissa Boman, MN DNR

“This kind of thinking is regularly put to use in planning for state Parks and Trails where,” says Quinn, “our direction and statute require us to preserve and perpetuate the scenic, scientific, historic, and natural features that were present prior to European settlement.” He cites the construction of passages for salamander migration under a newly constructed bike trail at Sibley State Park, and a life zone surrounding a wetland at Itasca State Park protecting terrestrial habitat from the impacts of an aspen harvest conducted to restore a pine-hardwood community. But the same basic ideas can apply more broadly. “A county road engineer has certain challenges, such as maintaining sight lines, elevations, safety. Yet, within those parameters, there are choices that can be made in the interest of amphibians like salamanders and other wildlife.”

Quinn is thrilled at a recent endeavor involving the Minnesota Department of Transportation (MnDOT) that resulted in more wildlife-friendly erosion control materials and installation standards. “This was way more difficult

than it sounds;” says Quinn, “it took us a couple of years to work through changes to the MnDOT specifications manual.” Among the updates benefiting salamanders are a move away from use of plastic to more bio-degradable erosion-control materials and mesh with larger openings less likely to entrap reptiles, amphibians and small mammals.

Quinn’s MN DNR Parks and Trails work—like that of the Nongame Wildlife Program—requires navigating between natural systems and societal systems, and positive conversations among resource managers who may have different goals uppermost in mind, reflecting the range of values important to the people of Minnesota. With a salamander species designated as Special Concern, protection calls for a good faith effort on all sides to find some literal and figurative wiggle room.

On a day when May leans toward June in Minnesota’s north woods, Herberg is out in the field, moving from wetland to wetland, carefully following the protocols of the monitoring study. He’s been part of many of those conversations.

As he works, he notes that the same vernal pools and surrounding mature hardwood forests that support salamanders are also important to a host of other species, ranging from wood frogs and spring peepers to dragonflies and red-shouldered hawks. He knows that this biodiversity is no accident. It is rooted in specific qualities that this landscape has to offer through the seasons, through the years. He also knows that these species are entering an era when older forests on state lands, like those that offer habitat to the four-toed salamander, will significantly decline if target levels for timber harvest in the coming decades are met.

During the 2022 field season, Herberg and MN DNR colleagues visited 29 study plots and surveyed 94 wetlands. One single hummock in Pine County, he says, held multiple females and hundreds of eggs—more than he had ever seen. When the circumstances are right and only when it can be accomplished without degrading habitat, he will gently handle a salamander just long enough to get a weight and length, and snap a photo of its ventral pattern. “When I put them back, it’s really neat to see them crawl back down into the maze of moss, slipping back into this hidden world.” Walking away from a site where they’ve been found, it’s a mixed feeling. “There’s a certain satisfaction and excitement, knowing that this rare species is using this wetland and surrounding forest. But there’s also some anxiety knowing I’m walking away from a wetland where, in most of these plots, we know the forest is going to be harvested. So, this wetland dynamic is going to change. And will that change to the point where these secretive little creatures are going to disappear? Or can four-toed salamanders tolerate the disturbance that is going to come?”



Nongame Wildlife Program Intern Clara Brown assists with the search for four-toed salamander larvae.
Photo by Andrew Herberg, MN DNR



“Honestly, the best thing that could probably come from this study is that we learn that current forest management practices aren’t affecting their ability to occupy these sites. Or maybe we will learn that they’re more common in Minnesota forests than we think. So far, the data doesn’t point that way. But we’ll find out.”

While earlier surveys by the MN DNR Minnesota Biological Survey revealed that Minnesota’s natural heritage was two salamander species richer than we realized, the Nongame Wildlife Program’s current and ongoing monitoring will reveal what they need to continue to occupy the state’s forests. Most important of all is a question whose answer is not to be found in moss hummocks—the question of how we will act on the knowledge gained. 🐸

As the wetland dynamics in the forest change, will these secretive little creatures disappear?
Four-toed salamander in Carlton County
Photo by Andrew Herberg, MN DNR

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