Natural Heritage & Endangered Species Program

www.mass.gov/nhesp

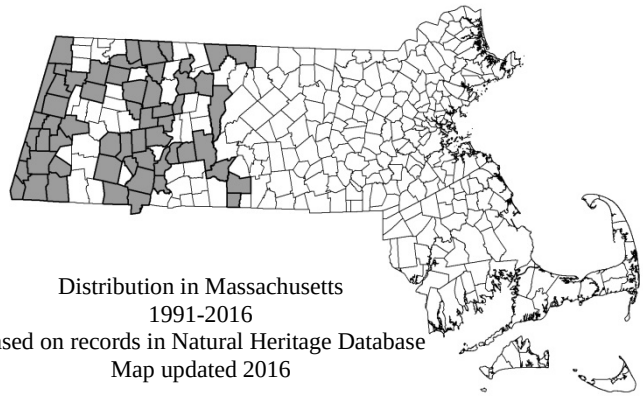
Massachusetts Division of Fisheries & Wildlife

Jefferson Salamander (complex) *Ambystoma jeffersonianum*

State Status: **Special Concern**
Federal Status: **None**

DESCRIPTION: Jefferson Salamander is a large, gray to brownish-gray salamander with fine markings of light blue to silvery flecks on the limbs, lowers sides, and tail. Adults measure 4–7 inches (10–18 cm) in total length. The tail is laterally compressed (especially in sexually active males) and is approximately the length of the body. Jefferson Salamander is in the family of mole salamanders, and so it has distinctively long toes and a stockier build relative to other groups of salamanders in our region. Males tend to be smaller than females and have conspicuously swollen vents during the breeding season.

Larvae have bushy, external gills, a wide head, and a broad caudal fin that extends well onto the back. Young larvae are not easily distinguished from those of other *Ambystoma* species, but they do appear to have more prominent markings of golden yellow on the sides of the head, neck, and dorsum contrasting with a dark, olive-green to brownish base color. Older larvae can still be difficult to identify, but they are generally characterized as having grayish bodies, whitish/unpigmented undersides, and a heavily dark-mottled caudal fin.



Distribution in Massachusetts
1991-2016
Based on records in Natural Heritage Database
Map updated 2016

Jefferson Salamander
Photo by Bill Byrne

SIMILAR SPECIES: Jefferson Salamander is a member of an intricate group of salamanders known as the *Ambystoma jeffersonianum* complex. In Massachusetts, the complex consists of two bisexual species, Jefferson Salamander and Blue-spotted Salamander (*A. laterale*), and a group of unisexual *Ambystoma* of a hybrid lineage. Unisexual *Ambystoma* in this complex have variable nuclear genomes consisting of complements of both Jefferson Salamander and Blue-spotted Salamander, and a mitochondrial genome derived from Streamside Salamander (*A. barbouri*), a species currently occurring in Kentucky, Ohio, Indiana, Tennessee and West Virginia. The original species pairing that led to the hybrid unisexual lineage is not yet known, but studies suggest that today's unisexual *Ambystoma* and *A. barbouri* from western Kentucky share a maternal ancestor from ~5 million years ago. The unisexual *Ambystoma*, whose populations almost always consist entirely of females, co-occur with local populations of genetically pure Jefferson Salamanders and Blue-spotted Salamanders and are able to perpetuate through complicated reproductive mechanisms involving the use of sperm from males of either of those two species. The resulting offspring are unisexuals having varying ploidy levels (usually 3-4 sets of chromosomes, but occasionally 2 or 5) and varying

complements of *A. jeffersonianum* vs. *A. laterale* nuclear genomes (depending on which of the species is present at a given site, and which reproductive mechanism plays out for a given egg). Unisexuals are not recognized as distinct species or susbspecies; rather, they are considered hybrid forms of whatever species with which they are breeding. Across the entire geographic range of the lineage, unisexual *Ambystoma* are known thus far to breed with 5 different mole salamander species.

Unisexual *Ambystoma* are very similar in appearance to pure forms of Jefferson Salamander and Blue-spotted Salamander, falling somewhere within a continuum between the grayish-brown coloration, diffuse blue flecks, and wide snout of pure Jefferson Salamanders, to the black base color, prominent blue spots/blotches, and narrow snout of pure Blue-spotted Salamanders. Unlike in Blue-spotted Salamander, pure vs. unisexual forms of Jefferson Salamander cannot usually be distinguished in the field by size and coloration. However, one can assume with high probability that any male specimen observed in most parts of the Jefferson Salamander range is, indeed, the pure form of that species.

A male Jefferson Salamander captured from the bottom of a vernal pool in Sunderland, Massachusetts during the breeding season.
Photo by Jacob E. Kubel

Some people confuse the lead/gray color phase of Eastern Red-backed Salamander (*Plethodon cinereus*) for Jefferson Salamander, as the two species have a grayish base color peppered with light-colored flecks along the lower sides. However, Eastern Red-backed Salamander is much smaller and leaner in overall appearance. Perhaps the easiest way to tell the two species apart is to examine the toes. They are very short and stubby in Eastern Red-backed Salamander, but long and fingerlike in Jefferson Salamander.

RANGE: Jefferson Salamander ranges from southern Ontario through New York and western New England south and west to northern Virginia, West Virginia, Kentucky, and eastern Illinois. Within Massachusetts, Jefferson Salamander is distributed throughout parts of Berkshire, Franklin, Hampshire, and Hampden counties. All populations of Jefferson Salamander in Massachusetts are presumed to contain unisexuals.

HABITAT: Adult and juvenile Jefferson Salamanders inhabit relatively mature deciduous and mixed deciduous-coniferous forests and woodlands. Circumneutral to calcareous sites at higher elevations seem to be preferred, with many known populations being associated with rich hillsides and ridges. Jefferson Salamander is somewhat selective with its breeding habitat in Massachusetts, as the species breeds almost exclusively in isolated vernal pools and shrub swamps. Abandoned agricultural ponds and other man-made impoundments are used in some situations, but Jefferson Salamanders tend to avoid other wetland types (e.g., red-maple swamps, floodplain marshes, beaver impoundments) used frequently by other mole salamander species. Vernal pools and shrub swamps nested between upland ridges (“saddle pools”) are used often. The most productive breeding pools appear to be those that are relatively large (0.2–0.5 acres), are deep (3–5 ft), and have patches of multi-stemmed shrubs (e.g., *Cephalanthus occidentalis*, *Cornus* spp.) Abundant detritus and absence of predatory fish are additional characteristics of typical breeding habitat. Water clarity seems unimportant, as Jefferson Salamander does not

exhibit a strong preference for pools with dark, tannic water as does Blue-spotted Salamander.

A classic saddle pool used for breeding by Jefferson Salamander.
Photo by Jacob E. Kubel

In the terrestrial environment, thick leaf litter, abundant coarse woody debris, loose soils, predominantly closed-canopy tree cover, and abundant rodent tunnels are trademarks of good-quality microhabitat for adult and juvenile Jefferson Salamanders. Most adult individuals reside within several hundred meters of their breeding wetland. Research suggests that local salamander distribution around a breeding site may be influenced by habitat integrity, with salamanders residing closer to a wetland (on average) in intact forest, but occupying areas farther from the wetland when a forest patch is fragmented (e.g., by development). Of course, variability in the distribution of high-quality microhabitat around a breeding site is also likely to influence the distribution of individual salamanders around the wetland, as is the availability of other suitable wetlands within the patch of upland habitat.

LIFE CYCLE/BEHAVIOR: As the family name "mole salamander" implies, adult and juvenile Jefferson Salamanders spend most of their time underground or hidden beneath rocks, logs, leaf litter, or other debris. During rainy or otherwise humid nights in warmer months of the year, individuals may occur on the ground surface for purposes of foraging, dispersal, or migration to breeding sites. However, most time is spent under leaf litter, in rodent tunnels, or in other subsurface cavities. Winters are spent below the frost line, presumably in vertical rodent tunnels or root channels.

During March or early April (depending on the timing of winter thaw and warm rains in a given region and year), adult Jefferson Salamanders emerge from their underground retreats and migrate en masse to their breeding pools. Migrations are typically triggered by a steady rain with ambient air temperature holding above 40°F. Given those conditions, salamander movement may begin shortly after sunset and continue through the night, with peak activity occurring between an hour after sunset and midnight. Not all individuals can complete their journey in a single evening. Therefore, migrations may occur over the course of several nights to a couple of weeks, depending on the timing, duration, and frequency of suitable weather conditions. If nocturnal rains are slow to materialize during the normal migratory period, the salamanders may settle for drizzle or a low fog, or even migrate beneath the cover of leaf litter (still moist from snowmelt or ground thaw).

Once in their breeding pool, Jefferson Salamanders engage in an elaborate courtship similar to that of Blue-spotted Salamander. Various stages may be repeated or abandoned multiple times when a female is not receptive, or when competing males disrupt or otherwise interfere with one another, but courtship generally proceeds as follows. The male approaches a female, swims over her female, clasps her body behind her forelegs (with his own), and holds her for several minutes. During that time, the two salamanders may swim about as a clasped pair or just rest on the pool bottom. Eventually, the male (while clasping the female) begins rubbing his snout over her head, undulates his tail, and rubs his body and cloaca over her body in an increasingly vigorous manner. He then releases the female, moves forward while undulating his tail, and deposits one to several spermatophores on the bottom substrate of the wetland. The female follows him and noses his cloaca, eventually moving over the spermatophores and picking up their seminal fluid with her cloacal lips, drawing it into her body.

In the pairing of males and females of the pure form, reproduction proceeds via normal fertilization of the eggs by the sperm obtained from the spermatophore(s) (i.e., syngamy of haploid gametes). However, in the pairing of males with females of the unisexual form, reproduction proceeds via any of several possible mechanisms (collectively termed kleptogenesis) that do not involve traditional syngamy. In the most common mechanism, the unisexual produces unreduced,

polyploid ova, and the male's sperm merely activates embryonic development in the eggs without contributing any genetic material, thereby resulting in offspring that are essentially genetic clones of the unisexual mother. That unisexuals never produce offspring of the pure form is one reason why unisexual *Ambystoma* are believed to predominate in most local populations.

Jefferson Salamander ovipositing along a submerged twig.
Photo by Jacob E. Kubel

After mating, a female Jefferson Salamander deposits her eggs in one to several variably-sized clusters, each nested within a loose, clear, gelatinous matrix (egg mass). The egg masses typically contain 15–60 eggs each. Egg masses are usually attached to the twigs of fallen tree branches or submerged shrubs, but grasses, forbs, or the pool bottom may be used when twigs are unavailable. A recent study found that egg masses of pure vs. unisexual forms of Jefferson Salamander can often be distinguished via a simple photographic analysis of the spatial density of embryos in a mass.

Hatching occurs in 3–4 weeks, whereupon the bushy-gilled, fully-aquatic larvae spend the next 2–3 months in the wetland. The salamander larvae feed voraciously on zooplankton, insect larvae (e.g., mosquitoes), and other aquatic organisms, increasing in body size and developing front and hind limbs as spring advances into summer. Metamorphosis then occurs in July or August, depending on when the wetland begins to dry, when food resources become limited, or on other factors. At this time, the larvae develop lungs, resorb their gills, and seek cover beneath stones, woody debris, leaf litter, or other detritus in moist or saturated portions of the

Jefferson Salamander egg mass attached to a submerged twig.
Photo by Jacob E. Kubel

wetland basin. There, the juvenile salamanders will wait for an opportunity to leave the basin and disperse into the surrounding forest (typically during an evening rain).

Following dispersal from natal wetlands, juvenile salamanders reside in the forest, feeding on snails, earthworms, beetles, and other small invertebrates. Upon reaching sexual maturity in approximately 3 years, most individuals return to their natal wetland to breed, starting the cycle anew. Others seek out new ground, joining another segment of the local breeding population, or pioneering a new one of their own.

Maximum life expectancy of Jefferson Salamander is unknown. Mark-recapture studies of other mole salamanders indicate that adult survivorship is relatively high, and individuals may live for several years or more with regularity. Accounts of captive salamanders suggest a possible lifespan greater than 10 years.

POPULATION STATUS IN MASSACHUSETTS: Jefferson Salamander (including the unisexual form) is legally protected and listed as Special Concern pursuant to the Massachusetts Endangered Species Act (M.G.L. c. 131A) and implementing regulations (321 CMR 10.00). Approximately 131 local populations were documented among 51 towns between 1990 and 2015. Primary threats to Jefferson Salamander in Massachusetts are habitat loss, habitat degradation, road mortality, and emerging infectious disease. The most common types of habitat loss are the clearing of forests and the filling (or

draining) of vernal pools during residential, commercial, industrial, mining, or agricultural development.

Illegal clearing of forest and filling of vernal pools is an ongoing threat to pool-breeding salamanders in Massachusetts.
Photo by Jacob E. Kubel

Habitat degradation typically occurs when development fragments habitat (e.g., creates gaps between forest habitat and breeding wetlands), chemical applications (e.g., pesticides, deicing salts, fertilizers) pollute breeding wetlands, or commercial logging operations disrupt forest ecology (e.g., compact soils, reduce leaf litter, introduce or increase growth of non-native, invasive vegetation). High road densities and traffic volumes tend to result in increased levels of adult salamander mortality; in extreme cases, road mortality functions as a barrier between upland and breeding habitats. Known and potential impacts of several pathogens/emerging infectious diseases (e.g., ranavirus, *Batrachochytrium salamandrivorans*) are not completely understood, but outbreaks could result in severe and widespread salamander mortality.

MANAGEMENT RECOMMENDATIONS: At a local scale, sites of known occurrence of Jefferson Salamander should be managed to develop or maintain mature forest conditions within approximately 1,000 feet of confirmed and potential breeding wetlands. Such management should aim to minimize forest loss/fragmentation, road traffic, soil compaction, and introduction/growth of invasive, non-native vegetation. Forest type should be maintained as deciduous or mixed deciduous-coniferous. Fallen trees, branches, leaves, and other detritus should be allowed to accumulate on the forest floor. Hydrology of breeding wetlands should not be altered in ways that might reduce hydroperiod within the March through August time period. Breeding wetlands should be protected from chemical pollution, and basin structure should not be altered without special permits from the Massachusetts Division of Fisheries and Wildlife and/or the Department of Environmental Protection. Breeding wetlands should not be filled or used for dumping of yard waste or refuse.

At the landscape scale, area of mature upland forest between local populations of Jefferson Salamander should be maximized to maintain dispersal corridors and, therefore, genetic exchange between populations. Land acquisition/protection efforts for maintaining habitat connectivity should prioritize areas with low road densities and traffic volumes. A land-protection strategy may best serve long-term persistence of local populations where they occupy relatively large, connected areas containing abundant breeding habitats. However, lands supporting small, peripheral, or isolated populations are also worth protecting for maintenance of genetic diversity at the state level.

“Pure” populations of Jefferson Salamander that do not contain the unisexual form are not known to occur in Massachusetts nor anywhere else in New England. Long-term viability of populations with a low ratio of pure to unisexual salamanders is not well understood. Therefore, identification and protection of populations with relatively high proportions of pure individuals is considered an important precaution in a changing environment. Biological inventory, research, land acquisition, and environmental regulation are several actions that should be utilized to help meet that goal.

Stronger controls are necessary to guard against the introduction and spread of amphibian pathogens and infectious disease. For example, national policy and enforcement regarding importation of exotic wildlife in the global pet trade should be improved to reduce and minimize the volume of diseased animals entering the country. Within Massachusetts, field biologists, anglers, and other outdoor enthusiasts should adopt and promote appropriate equipment-sanitation procedures when outdoor activities span wide geographic areas. A statewide amphibian monitoring program that includes sampling for pathogens and disease outbreaks is needed.

Active management of Jefferson Salamanders and their habitats is a developing interest. For example, construction of vernal pools to enhance breeding opportunities at sites where wetland habitats are scarce is a continuing line of research. Citizens play an active role in conservation by helping adult salamanders cross roads safely during their breeding migrations, thereby increasing survivorship and reproductive output.

Citizens are encouraged to assist with conservation of Jefferson Salamanders in additional ways. For example, observations of Jefferson Salamanders should be reported to the NHESP, as land-protection efforts for the species are dependent on knowing where local populations occur. Collection and submission of data for the certification of vernal pool habitat is another beneficial action, as it will afford certain legal protections to salamander habitats.

REFERENCES:

Andrews, K.M., J.W. Gibbons, and D.M. Jochimsen. 2008. Ecological effects of roads on amphibians and reptiles: a literature review. Pages 121–143 *in* J. C. Mitchell, R. E. Jung Brown, and B. Bartholomew, editors. *Urban Herpetology*. Society for the Study of Amphibians and Reptiles, Salt Lake City, Utah, USA.

Bi, K., and J.P. Bogart. 2010. Time and time again: unisexual salamanders (genus *Ambystoma*) are the oldest unisexual vertebrates. *BMC Evolutionary Biology* 10:238–251.

Bogart, J.P., and M.W. Klemens. 1997. Hybrids and genetic interactions of mole salamanders (*Ambystoma jeffersonianum* and *A. laterale*) (Amphibia: Caudata) in New York and New England. *American Museum Novitates* 3218:1–78.

Bogart, J.P., and M.W. Klemens. 2008. Additional distributional records of *Ambystoma laterale*, *A. jeffersonianum* (Amphibia: Caudata) and their unisexual kleptogens in northeastern North America. *American Museum Novitates* 3627:1–58.

Charney, N.D., A.T. Ireland, and B.R. Bettencourt. 2014. Mapping genotype distributions in the unisexual *Ambystoma* complex. *Journal of Herpetology* 48:210–219.

Croteau, M.C., N. Hogan, J.C. Gibson, D. Lean, and V.L. Trudeau. 2008. Toxicological threats to amphibians and reptiles in urban environments. Pages 197–209 *in* J. C. Mitchell, R. E. Jung Brown, and B. Bartholomew, editors. *Urban Herpetology*. Society for the Study of Amphibians and Reptiles, Salt Lake City, Utah, USA.

deMaynadier, P.G., and J.E. Houlahan. 2008. Conserving vernal pool amphibians in managed forests. Pages 253–280 *in* A. J. K. Calhoun and P. G. deMaynadier, editors. *Science and Conservation of Vernal Pools in Northeastern North America*. CRC Press, New York, New York, USA.

Douglas, M. E. and B. L. Monroe, Jr. 1981. A comparative study of topographical orientation in *Ambystoma* (Amphibia: Caudata). Copeia 1981: 460–463.

Faccio, S.D. 2003. Postbreeding emigration and habitat use by Jefferson and spotted salamanders in Vermont. Journal of Herpetology 37:479–489.

Fahrig, L., and T. Rytwinski. 2009. Effects of roads on animal abundance: an empirical review and synthesis. *Ecology and Society* 14(1):21. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art21/

Gray, M.J., D.L. Miller, and J.T. Hoverman. 2009. Ecology and pathology of amphibian ranaviruses. *Diseases of Aquatic Organisms* 87:243–266.

Karraker, N.E., and J.P. Gibbs. 2011. Road deicing salt irreversibly disrupts osmoregulation of salamander egg clutches. *Environmental Pollution* 159:833–855.

Kenney, L.P., and M.R. Burne. 2000. *A Field Guide to the Animals of Vernal Pools*. Massachusetts Natural Heritage & Endangered Species Program, Westborough, Massachusetts, and Vernal Pool Association, Reading, Massachusetts, USA.

Klemens, M.W. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut. Bulletin 112.

Madison, D.M. 1997. The emigration of radio-implanted spotted salamanders, *Ambystoma maculatum*. *Journal of Herpetology* 31:542–551.

McDonough, C., and P.W.C. Paton. 2007. Salamander dispersal across a forested landscape fragmented by a golf course. *Journal of Wildlife Management* 71:1163–1169.

Petranka, J.W. 1998. *Salamanders of the United States and Canada*. Smithsonian Institution Press, Washington, D.C., USA.

Rittenhouse, T.A.G., and R.D. Semlitsch. 2007. Distribution of amphibians in terrestrial habitat surrounding wetlands. *Wetlands* 27:153–161.

Semlitsch, R.D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. *Conservation Biology* 12:1113–1119.

Snodgrass, J.W., R.E. Casey, J.A. Simon, and K. Gangapura. 2008. Ecotoxicology of amphibians and reptiles in urban environments: an overview of potential exposure routes and bioaccumulation. Pages 177–196 *in* J. C. Mitchell, R. E. Jung Brown, and B. Bartholomew, editors. *Urban Herpetology*. Society for the Study of Amphibians and Reptiles, Salt Lake City, Utah, USA.

Williams, P.K. 1973. Seasonal movements and population dynamics of four sympatric mole salamanders, genus *Ambystoma*. Dissertation, Indiana University, Bloomington, USA.

Updated 2020