Natural Heritage & Endangered Species Program

www.mass.gov/nhesp

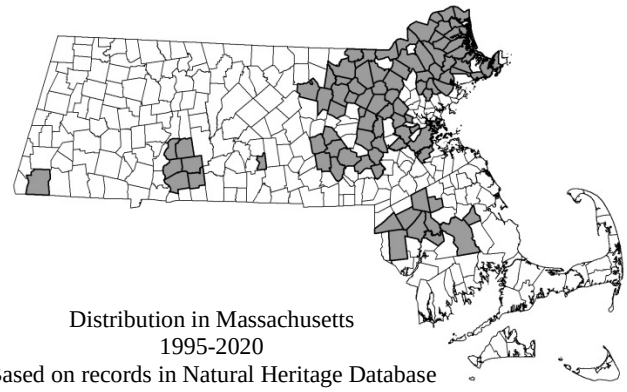
Massachusetts Division of Fisheries & Wildlife

Blue-spotted Salamander
Ambystoma laterale

State Status:
Threatened (Pop. 2; Bristol/Plymouth counties)
Special Concern (Pop. 1: remainder of state)
Federal Status: **None**

DESCRIPTION: Blue-spotted Salamander is a medium-sized salamander with conspicuous markings of randomly distributed, sky-blue spots, blotches, and flecks on a base color of dark gray to black. While the blue markings are abundant over the entire body in juveniles, they tend to be more concentrated along the sides and on the limbs in adults. Adults measure 3–5 inches (7.5–13 cm) in total length. The tail is laterally compressed (especially in sexually active males) and is proportionally longer in males than in females. Blue-spotted 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.

Larvae have bushy, external gills and a broad caudal fin that extends well onto the back. Young larvae are not easily distinguished from those of other *Ambystoma* species. Older larvae can still be difficult to identify, but they are generally characterized as brownish with a yellowish lateral stripe, whitish/unpigmented undersides, and a heavily dark-mottled caudal fin.



Distribution in Massachusetts
1995-2020
Based on records in Natural Heritage Database
Map updated 2020

Blue-spotted Salamander
Photo by Leo P. Kenney

SIMILAR SPECIES: Blue-spotted 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 (*A. jeffersonianum*) and Blue-spotted Salamander, and a group of unisexual *Ambystoma* of a hybrid lineage. Unisexual *Ambystoma* in this complex have variable nuclear genomes consisting of complements of both Blue-spotted Salamander and Jefferson 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 Blue-spotted Salamanders and Jefferson Salamanders and are able to perpetuate through complicated reproductive mechanisms involving the use

A Species of Greatest Conservation Need in the Massachusetts State Wildlife Action Plan

Massachusetts Division of Fisheries & Wildlife

1 Rabbit Hill Rd., Westborough, MA; tel: 508-389-6300; fax: 508-389-7890; www.mass.gov/dfw

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 Blue-spotted Salamander and Jefferson Salamander, falling somewhere within a continuum between the black base color, prominent blue spots/blotches, and narrow snout of pure Blue-spotted Salamanders, to the grayish-brown coloration, diffuse blue flecks, and wide snout of pure Jefferson Salamanders. The pure vs. unisexual forms of Blue-spotted Salamander can often (but not always) be distinguished in the field by size and coloration; adult unisexuals tend to have a gray to gray-brown base color (instead of jet black) and are noticeably larger (typically ≥70 mm snout-vent-length, ≥7 g) than pure Blue-spotted Salamanders (typically ≤60 mm, ≤6 g).

Unisexual (top) and pure (bottom) forms of Blue-spotted Salamander.
Photo by Jacob E. Kubel

Some people confuse the lead/gray color phase of Eastern Red-backed Salamander (*Plethodon cinereus*) for Blue-spotted Salamander. However, Eastern Red-backed Salamander is much leaner in overall appearance and, although it has a rather uniform peppering of minute, light-colored flecks along its lower sides, the pattern is quite inconspicuous relative to the larger, bolder, randomly distributed spots/blotches of Blue-spotted Salamander. An easy way to tell the two species apart, though, is to examine the toes. They are very short and stubby in Eastern Red-backed Salamander, but long and fingerlike in Blue-spotted Salamander.

RANGE: Blue-spotted Salamander is largely restricted to glaciated areas of North America. The species ranges from Newfoundland, Quebec, and the Maritime Provinces south to northern New Jersey and west to eastern Iowa, Minnesota, and southeastern Manitoba. Within Massachusetts, Blue-spotted Salamander is distributed primarily throughout Essex, Middlesex, and eastern Worcester counties. Scattered populations occur in the Brookfields and in Norfolk, Plymouth, northern Bristol, eastern Hampden, and eastern Hampshire counties. Only five populations west of the Connecticut River have been confirmed (all in Sheffield). Populations of Blue-spotted Salamander in Bristol and Plymouth counties appear to consist exclusively of the genetically pure form, representing a very rare population type in the eastern United States. Elsewhere in Massachusetts, all populations are presumed to contain both pure and unisexual individuals, with the latter often predominant.

HABITAT: Adult and juvenile Blue-spotted Salamanders inhabit relatively mature deciduous and mixed deciduous-coniferous forests and woodlands with sandy to loamy soils. In Massachusetts, lowlands are preferred, often in association with former glacial lakes, glacial deposits, extensive swamp forests (cedar or maple), and swampy or marshy river floodplains. Vernal pools, shrub swamps, wooded swamps, and riverine swamps and marshes are used by adults for breeding and by larvae for growth and development. Although there is considerable variability among individual wetlands known to be used in Massachusetts, Blue-spotted Salamanders seem to prefer those having relatively long hydroperiods, dark water, and moderate to high densities of multi-stemmed shrubs (especially *Cephalanthus occidentalis*). In some situations, dense emergent vegetation also seems important. Abundant detritus and absence of predatory fish (or presence of dense vegetation providing refuge from fish) are additional characteristics of typical breeding sites.

A typical buttonbush shrub swamp used by Blue-spotted 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 Blue-spotted Salamanders. Most adult individuals reside within several hundred meters of their breeding wetland. Data from one site in Massachusetts suggest that approximately half of adults inhabit forest >100 m away from the breeding wetland, with females wintering disproportionately farther from the wetland than males. Other 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.

LIFE CYCLE/BEHAVIOR: As the family name "mole salamander" implies, adult and juvenile Blue-spotted 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, as has been observed in other mole salamanders.

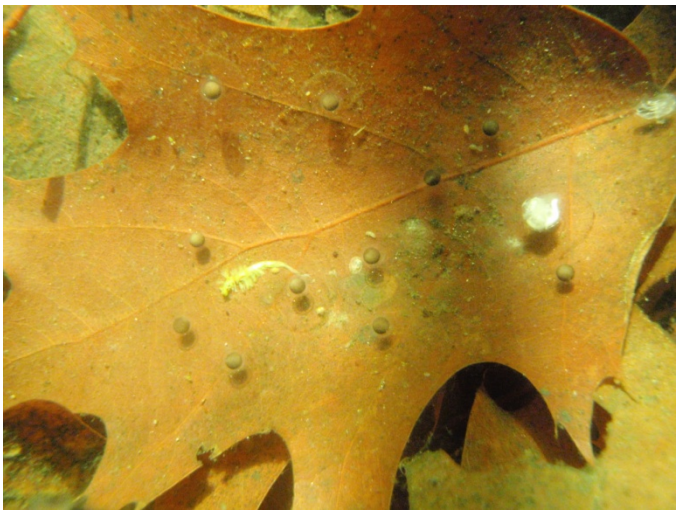
Sometime between late February and early April (depending on the timing of winter thaw and warm rains in a given region and year), adult Blue-spotted Salamanders emerge from their underground retreats and migrate en masse to their breeding wetlands. Breeding migrations are typically triggered by a steady 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 wetland, Blue-spotted Salamanders engage in an elaborate courtship similar to that of Jefferson Salamander. Various stages may be repeated or abandoned multiple times when a female is not receptive to a male, or when competing males disrupt or otherwise interfere with one another, but courtship generally proceeds as follows. The male Blue-spotted Salamander approaches a female, orients his body perpendicular to hers, and nudges her side with his snout several times. He then swims over the 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 chin over her snout in a side-to-side motion and vibrates or rubs his hind limbs along her sides. He then releases the female, moves forward while vibrating his body, and arches and undulates his tail. She follows and noses his cloaca. The male then deposits one to several spermatophores on the bottom substrate of the wetland. The female moves over the spermatophore and picks up its seminal fluid (or even the entire spermatophore) 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. Most commonly, 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.

After mating, a female Blue-spotted Salamander may deposit her eggs singly or in small clusters nested within a loose, clear, gelatinous matrix (egg mass). Salamanders of the pure form always deposit eggs singly, whether in isolation or in small groups of 2-5 eggs deposited consecutively, side-by-side. Salamanders of the unisexual form, however, deposit eggs singly or in masses. The masses typically contain 5–15 eggs each, though some may contain as few as 2 or as many as 30 eggs. In both forms eggs and egg masses are usually attached to the twigs of submerged shrubs or to leaves, twigs, and other detritus on the bottom of the wetland. Eggs may also be attached to submerged grass blades or simply scattered on the bottom substrate. Blue-spotted Salamanders tend to produce up to several hundred mature ova, and so a single individual can account for multiple egg masses found at a wetland.



Blue-spotted Salamander eggs at the bottom of a vernal pool.
Photo by Jacob E. Kubel

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 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 will reside in the forest, feeding on snails, earthworms, beetles, and other small invertebrates. Upon reaching sexual maturity in approximately 2 years, most individuals will return to their natal wetland to breed, starting the cycle anew. Others will have sought out new ground, joining another segment of the local breeding population, or pioneering a new one of their own.

Maximum life expectancy of Blue-spotted 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 salamanders held in captivity suggest a possible lifespan greater than 10 years.

POPULATION STATUS IN MASSACHUSETTS:
Blue-spotted Salamander (including the unisexual form) is legally protected pursuant to the Massachusetts Endangered Species Act (M.G.L. c. 131A) and implementing regulations (321 CMR 10.00); populations in Bristol and Plymouth counties are listed as Threatened, whereas populations everywhere else in the state are listed as Special Concern. As of January 2020, approximately 160 local populations have been documented among 86 towns since 1995. Primary threats to Blue-spotted 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. 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 Blue-spotted 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 Blue-spotted 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.

Populations of Blue-spotted Salamander that do not contain unisexual *Ambystoma* are very rare in Massachusetts (and in the eastern United States, in general). Therefore, identification and protection of these "pure populations" is considered a high conservation priority. 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 Blue-spotted 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.

Blue-spotted Salamanders are not readily visible to motorists when crossing roads. *Photo by Jacob E. Kubel*

Citizens are encouraged to assist with conservation of Blue-spotted Salamanders in additional ways. For example, observations of Blue-spotted 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 indirectly affords 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.

Regosin, J.V., B.S. Windmiller, R.N. Homan, and J.M. Reed. 2005. Variation in terrestrial habitat use by four pool-breeding amphibian species. *Journal of Wildlife Management* 69:1481–1493.

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

A Species of Greatest Conservation Need in the Massachusetts State Wildlife Action Plan