MASSACHUSETTS FORESTRY CONSERVATION MANAGEMENT PRACTICES FOR MESA-LISTED MOLE SALAMANDERS

Version 2007.1 revised December 2016



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CMPs are meant to serve as guidelines for landowners and consulting foresters to aid in development of M.G.L. Chapter 132 Forest Cutting Plans that are compliant with provisions of the Massachusetts Endangered Species Act (MESA) (M.G.L. 131A) and its implementing regulations (321 CMR 10.00). In some cases, actual practices required for compliance with MESA may differ from published CMPs. Adherence to CMPs during forestry projects shall not necessarily constitute compliance with other state laws, or with local and federal laws.

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TABLE OF CONTENTS

SUMMARY

The MESA-listed Blue-spotted, Jefferson, and Marbled salamanders are in the same family of mole salamanders (Ambystomatidae) as the common Spotted salamander and are often thought of in association with their aquatic breeding habitat, which is primarily in ephemeral vernal pools. Although these aquatic habitats are essential for reproduction, Ambystomatid salamanders are only in the breeding pools for a few days to a couple of weeks per year. It is the surrounding upland forest habitat where the juvenile and adult salamanders spend 90% of their lives. Breeding migration to and from aquatic habitat occurs in the early spring for Blue-spotted and Jefferson Salamanders, while for Marbled Salamanders it occurs in the late summer and fall. Outside of these breeding periods, the adult salamanders reside in underground burrows and tunnels and beneath moist coarse woody debris.

The primary concern about forestry practices within MESA-listed mole salamander habitat is habitat alteration of the upland forest around vernal pools and other potential wetland breeding sites, and the possible mortality and decreased abundance of salamanders. Direct mortality of adults from motorized equipment and soil compaction during harvesting operations is also a concern, particularly during breeding migrations. To avoid habitat alteration that would render forested habitat inhospitable for mole salamanders, a 50-foot no-cut buffer is required to be left around specified vernal pools and other potential wetland breeding sites. Additionally, >65% canopy cover must be retained within 70% of the area that is 450 feet from the breeding site. Access and operation of motorized equipment within 450 feet of specified Blue-spotted and Jefferson Salamander breeding sites must occur before March 1st and after May 16th of any given year, access and operation within this area cannot occur between March 1st and May 15th. Access and operation of motorized equipment within 450 feet of specified Marbled Salamander breeding sites must occur before August 14th and after October 16th of any given year, access and operation within this area cannot occur between August 15th and October 15th. Winter harvesting for all three species, particularly when the ground is frozen or snow-covered, is recommended in order to minimize direct mortality, soil compaction, and disturbance to the forest floor.

The Role of Forestry in the Conservation of Mole Salamanders

Maintaining forested land is vital to conserving viable populations of mole salamanders. In addition, timber harvesting is often essential for private forestlands to remain economically viable, and if public and private forestlands are to supply renewable wood products to sustain local economies. However, forest managers need to recognize that harvesting can potentially result in a significant decrease in local salamander abundance, and should look to conserve mole salamanders and other rare species proactively, in order to maintain the integrity of forest ecosystems.

For foresters and forest landowners who are interested in receiving additional guidance on how to incorporate rare species into their planning process, the Natural Heritage and Endangered Species Program recommends filing a Forestry Information Request Form and pre-filing consultation request to discuss the intended forest management and rare species at a given site with a review biologist by contacting Brent Powers, NHESP Review Biologist at, 508-389-6354. For more information please see the links below to the program's website.

Forestry Review under the MESA - http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/regulatory-review/forestry-rare-species-review/

Forestry Information Request Form - http://www.mass.gov/eea/docs/dfg/nhesp/regulatory-review/forestry-info-request-form.pdf

CONDENSED VERSION OF THE FORESTRY CONSERVATION MANAGEMENT PRACTICES FOR MESA-LISTED MOLE SALAMANDERS

For the full version of the forestry conservation management practices including the management objectives and the rationale supporting them, see page 21.

Species Identification and Biology – Mole salamanders are medium-sized salamanders. Adult Jefferson Salamanders are the longest of the three MESA-listed mole salamander species in Massachusetts. Their background coloration is dark gray with lighter flecking on the limbs and sides of the body. Blue-spotted Salamanders have more defined bluish-white spots. Marbled Salamanders are the stockiest of the three with white banding across the back on a background coloration of black. These species primarily use vernal pools for breeding. Jefferson and Blue-spotted Salamanders breed in the early spring and Marbled Salamanders breed in the late summer to early fall. Outside of the breeding period, which lasts 2 – 4 weeks, mole salamanders are found in forested habitat underneath logs or in underground burrows and tunnels.

Forestry Practices – These management practices are based on the recognition that mole salamander conservation requires maintenance of shaded, cool, and moist forested conditions surrounding vernal pool and other wetland breeding sites.

R – required management practice **G –** guideline or recommended management practice

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R No harvesting can occur in Certified and uncertified vernal pools in MESA-listed mole salamander Priority Habitat.

R *0 - 50 ft. from breeding pool high water mark*: Retain a no-cut filter strip

R *50 – 450 feet from breeding pool high water mark*: (Mole Salamander life zone) Retain ≥70% of the area with ≥65% canopy cover, or equivalent basal area, of trees greater than or equal to 30 feet in height (see Appendix for residual basal area requirements). Any portion of this area that is cut to <65% canopy cover shall retain ≥10 square feet of basal area per acre of dominant or co-dominant live trees at least 10 inches dbh.

Management Zone	20-foot diameter vernal pool (Acres)	100-foot diameter vernal pool (Acres)
vernal pool depression	0.01	0.2
50-foot no-cut filter strip	0.25	0.5
450-foot mole salamander life zone	15	17
70% with 65% or greater canopy cover	10.5	12
30% with less than 65% canopy cover	4.5	5

Table 1. Sample acreage within 50 and 450-foot management zones surrounding hypothetical vernal pools 20 and 100 feet in diameter.

R Within the 450-foot mole salamander life zone, the areas with <65% canopy cover shall not be concentrated disproportionately close to the vernal pool.

R If any harvesting is to be done within 450 feet of specified vernal pools or isolated shrub swamp and marsh breeding habitat within mole salamander Priority Habitat then a forester licensed to practice forestry in Massachusetts under M.G. L. Ch 132 s 47-50 shall prepare the cutting plan. The cutting plan shall include:

- a narrative explaining the existing forest conditions and the silvicultural prescription
- a description of how the condition of the residual stand meets MESA-listed mole salamander habitat requirements such as presence of course woody debris, moist soils and talus slopes
- a map indicating the areas within 450 feet of the breeding pool that will fall below the 65% canopy cover threshold

Within the harvesting area, the boundary of the 50 and 450-foot management zones from the vernal pool shall be clearly identified by flagging or marking paint prior to cutting plan approval and harvesting. The trees that will be harvested within these management areas shall also be marked prior to cutting plan approval and harvesting.

R If the entire area within 450 feet of specified vernal pools or isolated shrub swamp and marsh breeding habitat within mole salamander Priority Habitat is left uncut then a licensed forester is not required to prepare the forest cutting plan and no additional narrative or map is required.

R New landings and skid roads must be located at least 100 feet and farther away if possible, from MESA-listed Mole Salamander breeding pools, including both Certified and uncertified vernal pools.

Blue-spotted and Jefferson Salamanders

R Motorized vehicle use, consistent with the Massachusetts Forestry Best Management Practices, may occur between 50 and 450 feet of the high water mark for a breeding pool or other potential wetland breeding habitat between May 15th and February 28th. All motorized vehicles shall be excluded from this area between March 1st and May 14th.

Marbled Salamander

R Motorized vehicle use, consistent with the Massachusetts Forestry Best Management Practices, may occur between 50 and 450 feet of the high water mark for a breeding pool or other potential wetland breeding habitat between October 15th and August 15th. All motorized vehicles shall be excluded from this area between August 16th and October 14th.

All Three Salamander Species

G Where feasible, extending the management zone beyond 450 feet to 600 feet or even greater would be beneficial for the conservation of mole salamanders.

G Where feasible, retaining more than 70% of the 450-foot management zone with ≥75% canopy cover would be beneficial for the conservation of mole salamanders.

G Patch cuts, new landings, and new skid or woods roads, should not be located between vernal pools when vernal pools are grouped in a cluster. The forested areas between vernal pools are important dispersal and migration corridors for mole salamanders.

G Where feasible and in accordance with other regulations, leave two snags/acre or older/dying trees uncut in order to provide a future source of large woody debris that will provide shelter and cover. Small patches of uncut trees around snags would avoid possible safety issues.

G Leave sections of downed wood 5 inches in diameter and 15 inches long or larger to provide microhabitat areas of shelter and cover.

G Avoid disturbing fallen logs as they are important microhabitat features that provide shelter and cover.

G Leave limbs and tops in the forest, consistent with other laws, regulations and forestry best management practices, in order to provide a source of woody debris that can be used as cover and shelter objects.

G Harvesting during the winter when the ground is frozen or snow-covered is preferred in order to reduce soil compaction, rutting, and disturbance to the forest floor habitat.

SPECIES BIOLOGY

Species Identification

BLUE-SPOTTED SALAMANDER

Blue-Spotted Salamander Biology
Quick Reference Chart

Average adult size: 4 - 5½ in (10 - 14 cm) total length

Hatchling size: $^{5}/_{16}$ - $^{3}/_{8}$ in (8 - 10 mm) total length

Metamorph size: 1 - 1 ½ in (2.4 – 3.8 cm) snout to vent length (SVL)

Adult coloration: Reminiscent of antique blue enamel-ware – dark body with bluish white blotches

Hatchling/larvae coloration: Larvae are brownish and difficult to differentiate from other mole salamander larvae.

Metamorph coloration: Dark with some yellowish spotting

Time to maturity: 2 years

Life span: probably a decade

The Blue-spotted Salamander (*Ambystoma laterale*) is a small, slender salamander with relatively short legs. It has an antique enamel-ware type coloration that makes it quite distinct. The body coloration is dark gray to grayish-black with large bluish-white blotches. The underside is dark gray or brownish-gray with scattered light spots on the belly and throat. Determining the sex of any species of mole salamander is easiest to do during the breeding season in the spring. Males can be distinguished from females by their swollen vents (the common orifice through which the contents of the digestive, reproductive and urinary systems are discharged). All mole salamander hatchlings have very similar coloration, external gills, and balancers. Balancers are a fleshy appendage on either side of hatchling salamander's heads. The coloration of hatchlings when they first emerge from their egg masses is dark brown on top with yellowish bars of color. Older aquatic larvae are brownish with a yellowish strip along the side that fades with age. The dorsal fins of older larvae are heavily blotched and mottled with black. Newly metamorphosed salamanders (metamorphs) have yellowish spotting.

Figure 1. Adult Blue-spotted Salamander. The appearance of Blue-spotted and Jefferson salamanders can be similar but Blue-spotted Salamanders will typically have more defined spots.

JEFFERSON SALAMANDER

Jefferson Salamander Biology
Quick Reference Chart

Average adult size: 5 – 7.5 in (12 – 18 cm) total length

Hatchling size: $^{3}/_{8}$ – $^{9}/_{16}$ in (10 - 14 mm) total length

Metamorph size: 2 - 3 ¼ in (5.0 – 9.0 cm) total length

Adult coloration: Dark gray or brownish with light bluish-gray or silvery flecks on the limbs and lower side of the body and tail.

Hatchling/larvae coloration: Larvae are brownish and difficult to differentiate from other mole salamander larvae.

Metamorph coloration: Gray with a spotted pattern, lighter ventrally

Time to maturity: 2-3 years

Life span: probably a decade

Jefferson Salamanders (*Ambystoma jeffersonianum*) are long, slender salamanders that are dark gray to brownish gray in coloration. They can have light bluish gray or silvery flecks of color on their limbs and the lower side of their body and tail. Older individuals can have a uniform brownish black coloration. They have elongated limbs and toes and the tail is vertically flattened and nearly as long as the body. When hatchlings emerge from their egg mass, they are olive-green to brown above with tinges of yellow on the sides of the neck, head and dorsal fin. Older larvae have grayish bodies with broad dorsal fins that are mottled. The coloration of the belly is silvery or white. Newly metamorphosed salamanders are gray or brownish above with brownish specks on their sides.

Figure 2. Adult Jefferson Salamander. The coloration of Jefferson and Blue-spotted Salamanders can be similar but Jefferson Salamanders tend to be larger than Blue-spotted Salamanders and their bellies typically have lighter coloration than their backs. This photo shows the costal grooves which number 12-13, while the potentially similar-looking lead-back phase of the Red-back Salamander (*Plethodon cinereus*) has 18-22 costal grooves. Costal grooves are the lines seen on the side of the salamander in this photo; they indicate the position of the ribs.

MARBLED SALAMANDER

Marbled Salamander Biology
Quick Reference Chart

Adult size: 3½ - 4¼ in (9 - 10.7 cm) total length

Hatchling size: $^{3}/_{8}$ – ¾ in (1.0 – 1.9 cm) total length

Metamorph size: 1 $^{1}/_{8}$ – 1 ½ in (3.0 – 3.8 cm) snout to vent length

Adult coloration: Black body with variable white or gray banding across the head, back and tail

Hatchling/larvae coloration: Older marbled salamander larvae can sometimes be distinguished from other mole salamander larvae by darkly colored throats but this characteristic is not always reliable and these larvae are typically difficult to differentiate from other mole salamander larvae.

Metamorph coloration: Brown or black with light flecks. Adult coloration develops 1-2 months after metamorphosis.

Time to maturity: 15 - 18 months

Life span: probably a decade

The Marbled Salamander (*Ambystoma opacum*) is a stout, medium-sized mole salamander. It is heavier set than the Jefferson or Blue-spotted Salamander. It has a black background color with white or light gray cross bands across the head, back and tail. The cross bands either run together or are interrupted and they tend to be broader along the sides of the body. Newly emerged Marbled Salamander hatchlings are blackish. Older larvae are brown or blackish and have a line of light spots along the sides of the body. Older larvae have more mottling on the body with light yellowish-green coloration and the throat is darkly pigmented. The dark throat is a good characteristic to use to distinguish this species from other mole salamander larvae. Newly metamorphosed salamanders are brown or black with light flecks. The adult coloration develops one to two months after metamorphosis.

Figure 3. Adult Marbled Salamander. This species of mole salamander can be differentiated from others by the dark background color and white or gray patterning on the back.

Life Span and Time to Maturity

Of the three MESA-listed mole salamander species in Massachusetts, the Marbled Salamander takes the shortest time to reach reproductive status, 15 to 18 months (Petranka, 1998). The Blue-spotted Salamander takes 2 years and the Jefferson Salamander 2 to 3 years. The life span of these particular mole salamander species has not been determined but if they are similar to other species in the same family, they probably live at least a decade. The closely related Spotted Salamander (*A. maculatum*) can live up to 30 years of age in the wild (Flageole & Leclair, 1992).

Similar Species

Jefferson and Blue-spotted Salamanders are similar in appearance. However, Blue-spotted Salamanders tend to be smaller than Jefferson Salamanders. The coloration of Blue-spotted Salamanders tends to be more conspicuously spotted, as the name implies, with more spots and flecks on the body than the Jefferson Salamander. The Blue-spotted Salamander also has a narrower head than the Jefferson Salamander and the belly of the Jefferson Salamander is always lighter in coloration than the back. . Jefferson salamander tails are vertically flattened, contrasting with the stouter tails of blue-spotted salamanders that are typically circular in cross-section. Blue-spotted Salamanders might also be confused with the lead phase of Red- back Salamanders.

To further complicate the process of differentiating Blue-spotted and Jefferson Salamanders is the presence of hybrid individuals in most, perhaps all, populations. These hybrids are intermediate in size, coloration, pattern, and other characteristics between pure Blue-spotted and Jefferson salamanders. Blue-spotted and Jefferson salamanders are not known to hybridize in the wild, nor do they occur together at the same breeding sites. The hybrids are the result of hybridization that occurred many thousands of years ago. Hybrids, which may contain two, three, four or five sets of chromosomes and are almost exclusively female, persist over the years by mating with male Blue-spotted or Jefferson salamanders that occur in the same breeding sites. Because these all-female hybrids produce only female offspring, the sex ratios of populations that contain hybrids are typically skewed in favor of females. In some cases males are so rare in these populations that a large proportion of females are unable to find mates and the eggs that they deposit fail to develop. It is not unusual to find breeding sites where over 50 percent of the egg masses are unviable. Two hybrid forms have been given species status: the silvery salamander (*A. platineum*) and Tremblay's salamander (*A. tremblayi*) but many scientists do not consider these to be valid species.

There are no other adult salamanders with the same coloration as the Marbled Salamander in Massachusetts. The Jefferson and Blue-spotted Salamanders are more slender in body shape without the white or silvery crossbands. The more common Spotted Salamander, another mole salamander species, has conspicuous yellow spots that make it easy to differentiate from the three state-listed species.

Mole Salamander Range

Blue-spotted Salamander

The ranges of the Jefferson and Blue-spotted Salamanders overlap. Populations of pure Blue-spotted Salamanders occur north of the hybridization zone with Jefferson Salamanders. The area of populations of pure Blue-spotted Salamanders and hybrids extends from the Canadian maritime provinces south along the Atlantic coast to northern New Jersey. The range extends westward through to northern Indiana and northeastern Illinois, through most of Wisconsin, eastern Minnesota and the southern half of Ontario. The known occurrences of Blue-spotted Salamanders in Massachusetts are shown in Fig. 4.

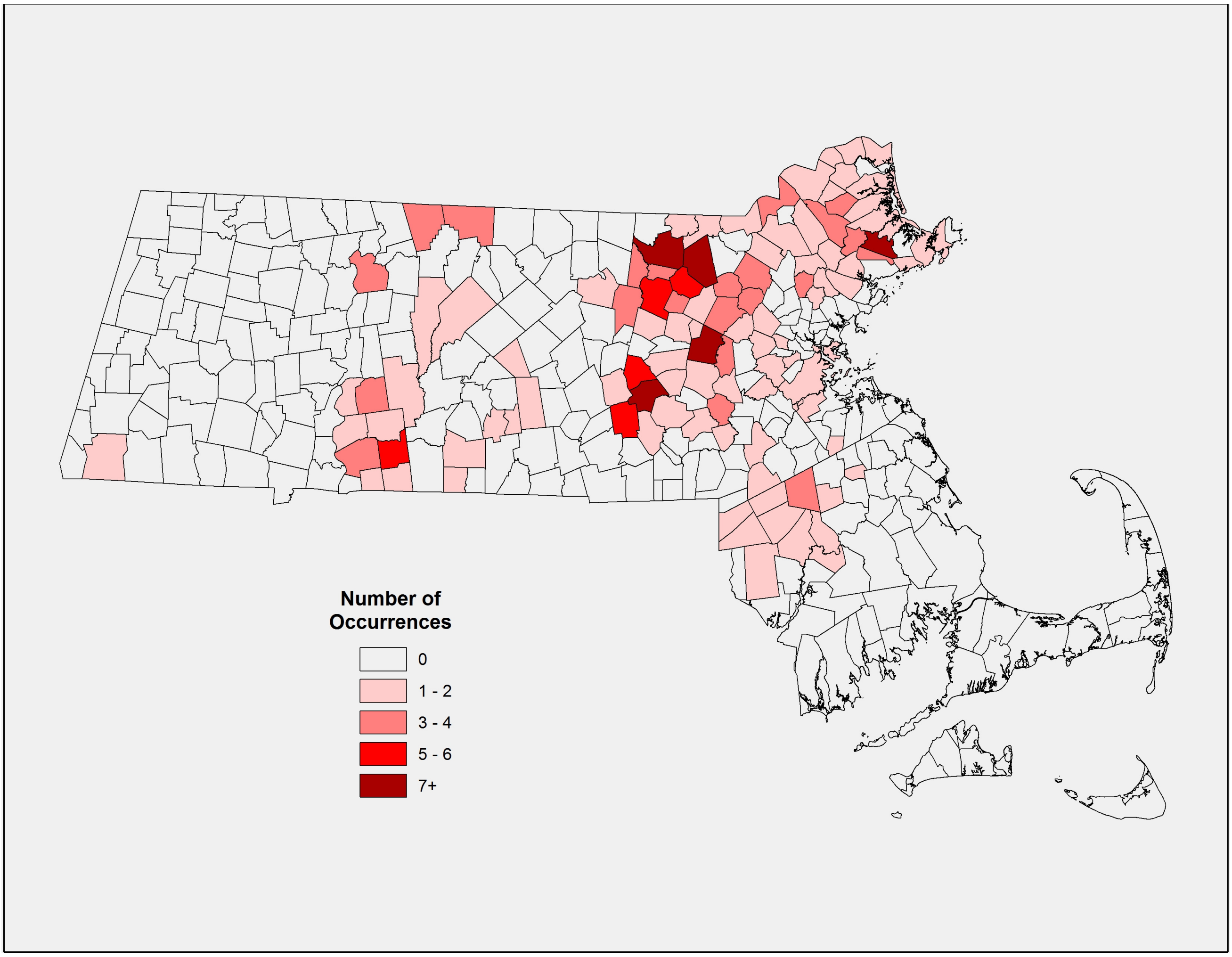


Figure 4. Documented occurrences of **Blue-spotted Salamanders** per town in Massachusetts over the past 25 years. Each occurrence in the Natural Heritage database represents a population.

Jefferson Salamander

Populations of pure Jefferson Salamanders occur to the south of the hybridization zone with Blue-spotted Salamanders. This area extends from southern New York, northern New Jersey, and most of Pennsylvania to Ohio and southern Indiana. The range extends southward only as far as Kentucky, West Virginia and Virginia. The known occurrences of Jefferson Salamanders in Massachusetts are shown in Fig. 5.

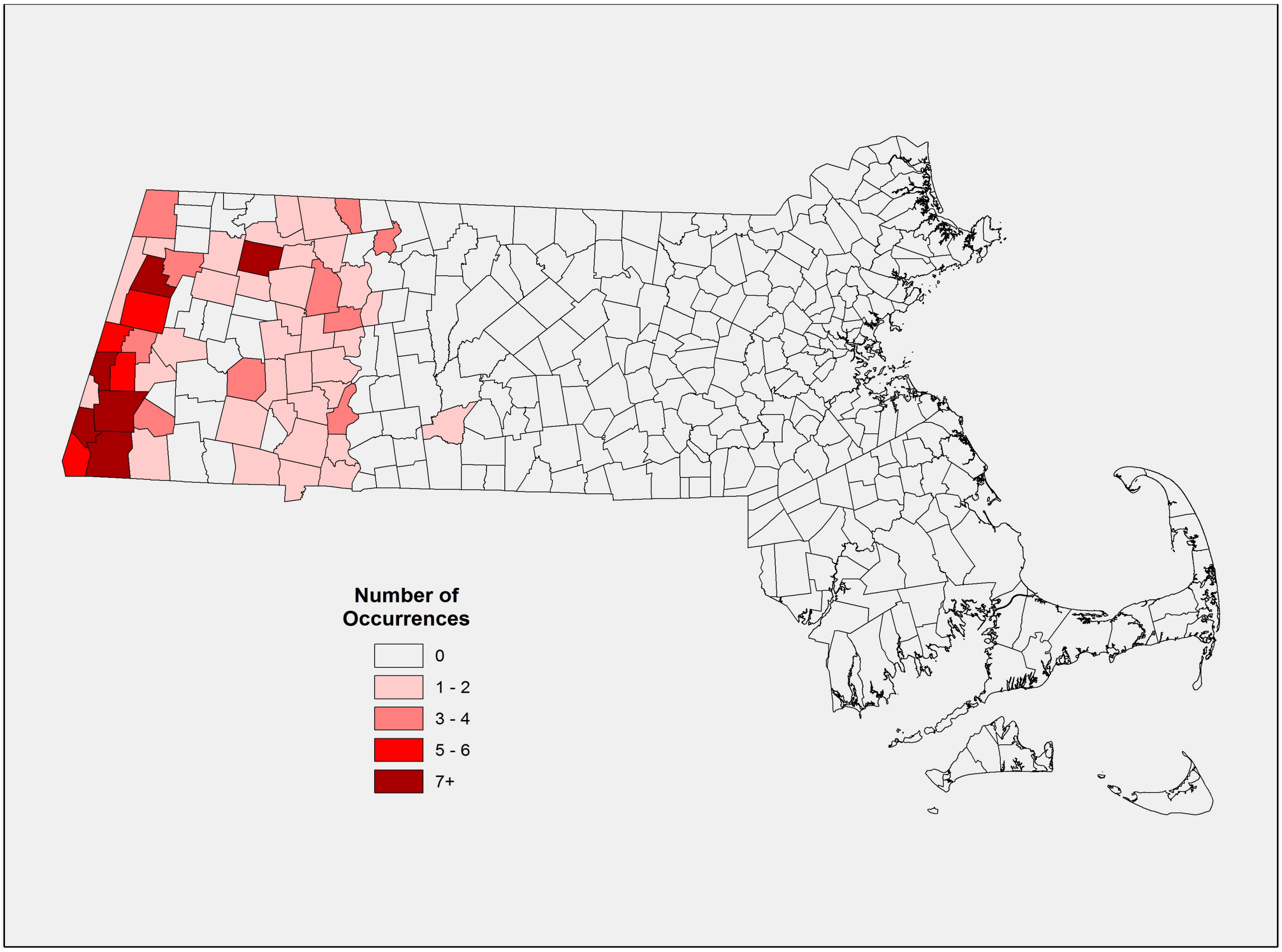


Figure 5. Documented occurrences of **Jefferson Salamanders** per town in Massachusetts over the past 25 years. Each occurrence in the Natural Heritage database represents a population.

Marbled Salamander

The Marbled Salamander is close to the northern limit of its range in Massachusetts. The range begins in southern New England and extends south to the Florida panhandle. It goes as far west as eastern Texas, southeastern Oklahoma, Missouri and southern Illinois. The known occurrences of Marbled Salamanders in Massachusetts are shown in Fig. 6.

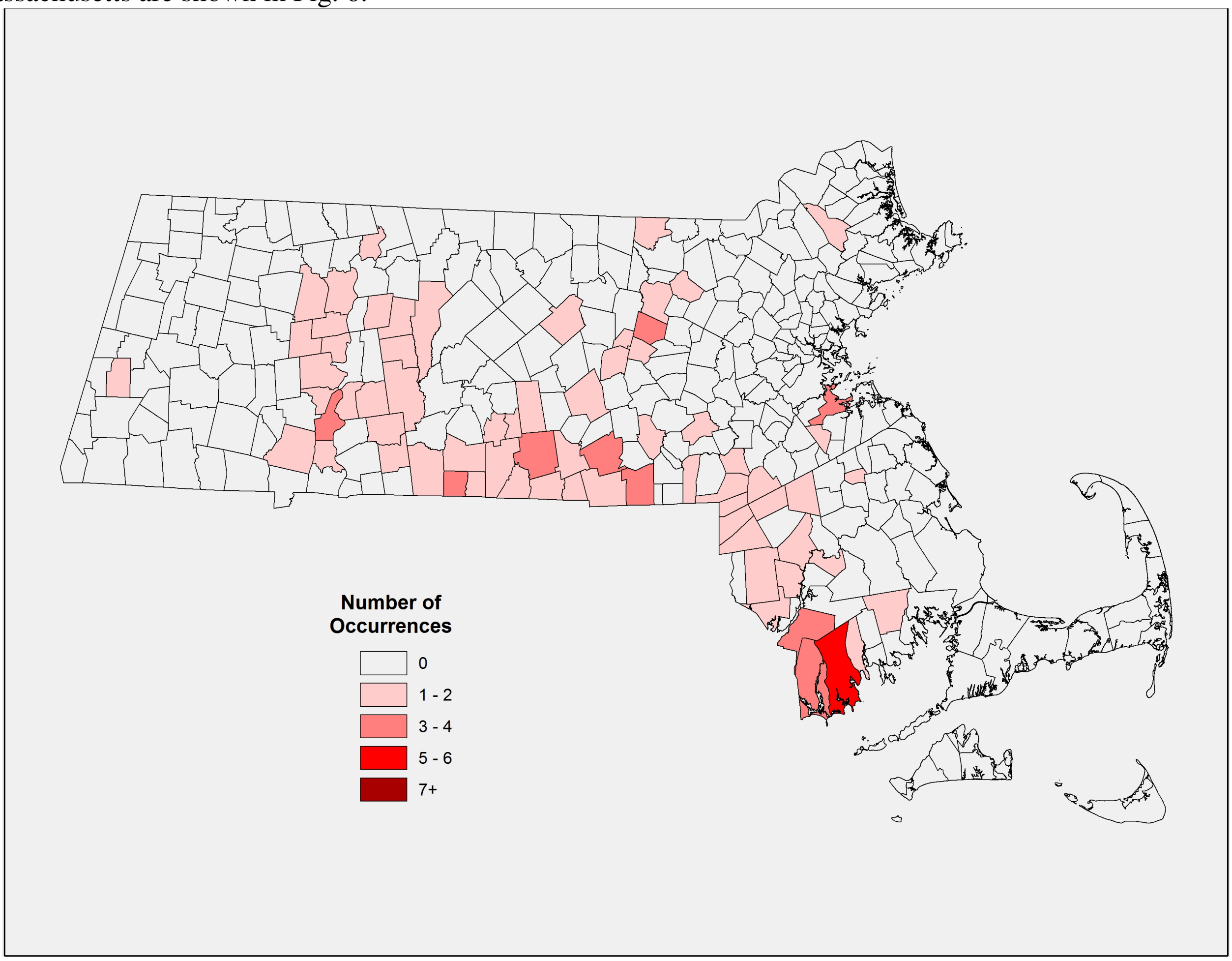


Figure 6. Documented occurrences of **Marbled Salamanders** per town in Massachusetts over the past 25 years. Each occurrence in the Natural Heritage database represents a population.

Life History of the State-Listed Mole Salamanders

Life History
Quick Reference Chart

WHAT	WHERE	WHEN
Overwintering	Terrestrial habitat: forested habitat in well-drained soils with small mammal tunnels and burrows	Late fall to early spring: late November to early March
Adult migration to and from breeding sites	Terrestrial and aquatic habitat: overland travel between forested habitat and vernal pools or other aquatic breeding sites	Blue-spotted and Jefferson Salamanders: early spring – March to May Marbled Salamander: late summer and fall – mid-August to mid-October
Courtship, mating and egg deposition	Blue-spotted and Jefferson Salamanders: aquatic habitat – vernal pools, margins of lakes and other wetlands	Blue-spotted and Jefferson Salamanders: early spring – March to May
	Marbled Salamander: terrestrial habitat – dry pond depressions	Marbled Salamander: late summer and fall – mid-August to mid-October
Metamorphosis and emergence of aquatic larvae	Aquatic to terrestrial habitat: vernal pools, margins of lakes and other wetlands with migration into forested habitat	Blue-spotted and Jefferson Salamanders: summer – mid July to August Marbled Salamander: early summer – June to mid-July
Terrestrial habitat use	Terrestrial habitat: deciduous and mixed deciduous/coniferous forests with fallen logs, deep leaf litter, other decaying large woody debris	Year round
Foraging	Terrestrial and aquatic habitat: larvae forage in vernal pools and adults forage in forested habitat	March to November

Overwintering

As their name implies, mole salamanders are fossorial species that spend a lot of their time underground in small mammal burrows and tunnels in forested habitat surrounding vernal pools or similar breeding habitat. During their active season, these salamanders can also be found beneath fallen logs and other decaying large woody debris, but during the winter they retreat to burrows. These salamanders are not known to dig their own burrows, but they will enlarge existing burrows created by shrews, voles and mice. The availability of small mammal burrows is thought to limit the density of mole salamanders surrounding vernal pools, particularly since individuals seem to prefer being alone rather than sharing a tunnel with another salamander (Regosin et al., 2003).

Evidence suggests that mole salamanders will shift their use of mammal tunnels from horizontal ones to vertical ones as the fall arrives (Faccio, 2003). This enables the salamanders to avoid the descending frost line once winter arrives. Burrows in well-drained soils are preferred as wet soils are not as well oxygenated (Windmiller, 1996). Similarly, burrows in south-facing slopes may be preferred since they will freeze later in the fall and thaw earlier in the spring, because of longer exposure to solar insolation.

Mole Salamander Movements

The periods of greatest movements and above-ground activity for mole salamanders are during the adult breeding migration to and from vernal pools or other aquatic breeding sites and during the dispersal away from these sites by newly metamorphosed juveniles. Adults become concentrated at the surface of the forest floor in the area surrounding vernal pools as they travel towards their breeding areas. Although migrations occur at night and often in association with rainfall or high humidity, the salamanders can be found underneath moist, deep leaf litter, fallen logs, and other decaying large woody debris during the day. Outside of this time period, salamanders will occasionally forage above ground, particularly the Blue-spotted Salamander, but their movements are not as extensive and they are more widely distributed around the vernal pool. These species have been found to move an average of 100 to almost 900 feet away from breeding sites (Table 1). A study of vernal pool species in Massachusetts found that at least half of the Blue-spotted Salamanders that were breeding in the studied vernal pool moved more than 300 feet to overwintering sites (Regosin et al,2005). The maximum known movement distance is greater than 4000 feet, traveled by juvenile Marbled Salamanders.

	Straight-line distance moved from breeding site		**#**	
Species and location	**Avg (feet)**	**Max (feet)**	**Salamanders**	**Source**
Jefferson Salamander				
Michigan	128	354	6	Wacasey, 1961
Vermont	302	672	8	Faccio, 2003
Michigan	303	758	45	Wacasey, 1961
Ontario*	676	951	11	Beriault, 2005, pers. comm.
Kentucky	820	-	10	Douglas and Monroe, 1981
Indiana	827	2050	86	Williams, 1973
Blue-spotted Salamander				
Massachusetts**	570	-	-	Homan and Windmiller, 1999
Massachusetts	-	656	-	Windmiller, 1996
Massachusetts	-	820+	-	Regosin et al., in press
Marbled Salamander				
Kentucky	98	-	6	Douglas and Monroe, 1981
Indiana	633	1476	12	Williams, 1973
Massachusetts***	886	4034	284	Gamble, pers. comm.

*95th percentile instead of max. distance
**median value instead of average
***median value instead of average and # represents recaptured salamanders instead of total salamanders

Table 2. Summary of MESA-listed mole salamander movement distances from vernal pools and other aquatic breeding sites.

Adult migration to and from breeding sites

Blue-spotted and Jefferson Salamanders

Mole salamanders require aquatic sites for breeding and will move overland in the spring from their terrestrial hibernation sites to vernal pools or wetland areas, where courtship and mating occur and egg masses are laid. Migration of mole salamanders occurs so early in the spring that the ground may still be frozen, covered in snow, and the vernal pools or fishless ponds where the breeding occurs can still be mostly ice-covered. Migrations begin in mid-March to early April, depending on the weather conditions. When spring rains begin and daytime temperatures reach the mid-40's and overnight temperatures stay near 40 °F, individuals will begin to move. Mole salamanders typically migrate at night. Migrations can occur in bouts or waves particularly if a warm spell is interrupted by colder temperatures. The Jefferson and Blue-spotted Salamanders usually arrive at aquatic sites and begin breeding before the more common Spotted Salamander. Salamanders congregate at higher concentrations at their aquatic breeding areas than in terrestrial habitats during the rest of the year. Mole salamanders leave the aquatic breeding sites to return to terrestrial forested habitat a few days to a few weeks after mating.

Marbled Salamander

Similar to Blue-spotted and Jefferson Salamanders, mass migrations of Marbled Salamanders occur overland to the dried depressions of vernal pools. The primary difference for this species is the timing of these movements. Breeding migrations for Marbled Salamanders do not occur until the late summer or autumn. The other difference is that the migrations occur towards vernal pool depressions that are dry and will not fill with water until fall rains begin.

Reproduction

Blue-spotted and Jefferson Salamanders

Most people are more familiar with the breeding rituals of frogs than salamanders. This is because male frogs are much more vocal when attracting females. Courtship between salamanders occurs underwater and is a silent affair. Males hold females from above in a courtship embrace called amplexus. Males deposit spermatophores on the pond substrate. These are small, white, gelatinous structures that have a sperm cap. Males may lay multiple spermatophores and they entice the female to pick up the sperm cap with her cloaca. Fertilization in mole salamanders occurs internally, unlike most frogs which have external fertilization. Salamander females lay eggs 1-2 days after mating. Egg masses are often attached to grasses, twigs or fallen tree branches under the water. This prevents them from sinking to the bottom of the pool where the oxygen supply is low and the temperature is colder. Females lay more than one clump or egg mass, with each containing between 10-50 eggs. After approximately one month, hatchlings emerge from the egg mass in late April or early May. Newly metamorphosed juveniles leave their pool between mid-July and August.

The Jefferson and Blue-spotted Salamanders typically breed in aquatic habitats that do not contain predatory fish. Fish prey on salamander larvae and can severely limit or even eliminate survival, resulting in no metamorphosis of aquatic larvae to terrestrial juveniles. The larvae and tadpoles of some amphibian species contain toxins that discourage fish predation. Both toad tadpoles and newt larvae are unpleasant tasting to fish and discourage predation. Therefore, these species can successfully breed in aquatic sites that contain fish. However, the larvae of mole salamanders are eaten by fish species such as sunfish. Therefore, reproduction of mole salamanders is typically more successful when breeding occurs in fish-less habitats.

The most common type of aquatic habitats associated with Jefferson and Blue-spotted Salamander breeding are woodland vernal or temporary pools. Breeding is also known to occur in flooded areas around the edges of lakes, farm ponds, upland pools along ridges and at the top of stream drainages, pools on the edges of open fields, swamps, abandoned beaver flowages and highway ditches.

Marbled Salamander

Reproduction of Marbled Salamanders differs primarily in its timing and location from that of Blue-spotted and Jefferson Salamanders. Breeding migrations and subsequent mating and egg laying occur in the late summer to early fall instead of in spring. Mating and egg laying occur along the edges of dried pool depressions instead of underwater. Females construct shallow nests under leaf litter, in rodent burrows, and under bark, logs, stones and at the base of grass clumps or in moss mats. Unlike the majority of mole salamander species, females will stay with their eggs until the pool is inundated with water. By guarding their eggs, females can help prevent predation, desiccation, and fungal outbreaks.

Embryos develop to the hatching stage within 15 days but will not hatch until the nest is flooded. This may be within weeks or months of the eggs being laid. Nests range from 50 – 200 eggs. Survival rates of aquatic larvae range are very low, ranging from 0 to 44% (Petranka, 1998). Newly metamorphosed juveniles leave pools between June and mid-July the following summer.

Terrestrial Habitat Use

Although amphibians are often thought of as being associated with various types of wetlands, adult mole salamanders actually spend 90% and juveniles 100% of the year in terrestrial habitat. The MESA-listed mole salamander species in Massachusetts are primarily found in deciduous and mixed deciduous-coniferous forests. Forest characteristics that are important for maintaining salamander populations are the amount of canopy cover, size of the forested area, the depth of leaf litter, size and decay class of large woody debris, adequate soil moisture, and the presence of small mammal tunnels.

A predominantly closed-canopy forest is important for ensuring terrestrial habitat is optimal for MESA-listed mole salamanders. It is also important for maintaining suitable aquatic breeding habitat. In Maine, Blue-spotted Salamander abundance has been positively related with percent canopy cover of both coniferous and deciduous trees greater than 10 feet tall (deMaynadier & Hunter 1998). Blue-Spotted Salamander abundance also significantly increased with increasing proximity to mixed-wood forest interior. A preference for mature, closed-canopy forest (70-90 years old) was found. Capture rates were higher than expected in closed-canopy sites versus sites that had been clearcut 2-11 years previously. The same study found that Blue-Spotted Salamander abundance was negatively related to ambient light levels. In Vermont, sites used by Jefferson Salamanders had a greater average deciduous canopy cover of 74% (trees > 10 ft tall) compared to randomly chosen sites which were not used by Jefferson Salamanders. These unused sites had an average canopy cover of 61% (Faccio 2003). In South Carolina, mole salamander abundance was significantly lower in wetlands located within 46 – 260-foot diameter harvested gaps and along skidder trails, than in control plots with no harvesting (Cromer et al. 2002). The canopy cover was also significantly different between the three types of sites: 18% cover in the gaps, 78% cover along the trails and 93% cover in the control plots.

In addition, the studies in Maine and Vermont found a negative relationship between salamander abundance and mid-story cover. The study in Maine measured mid-story cover of trees 1.6 – 10 feet tall and the Vermont study measured trees 5 – 10 feet tall. The study in Vermont found that sites used by Jefferson Salamanders had a mid-story cover of 23% compared to unused sites, which had a mid-story cover of 44%. The percent of the ground cover consisting of saplings within 10 feet of Jefferson Salamander occurrences was also significantly less than randomly chosen unused sites.

In Maryland, dense tree cover along the margin of aquatic sites was an important determinant of sites used for breeding by Jefferson Salamanders (Thompson et al. 1980). Breeding sites had significantly lower air and water temperatures than comparable unused aquatic sites. The water temperature of breeding sites was consistently cooler than unused sites during the spring and early summer months over the course of a two-year period.

In Maine, Blue-spotted and Spotted Salamander abundances were positively related to the depth of hardwood leaf litter (deMaynadier & Hunter 1998). In Vermont, Jefferson and Spotted Salamanders used sites with a greater percentage of deciduous leaf litter cover compared to random unused sites (Faccio 2003). In South Carolina, salamander abundance, including the Marbled Salamander and two other mole salamander species, was positively correlated with both hardwood leaf litter depth and percent litter cover (Cromer et al. 2002). The same study found that salamander abundance was negatively correlated with the percent of herbaceous cover.

Canopy cover is important in maintaining shaded forest conditions and keeping the forest floor and soil, cool and moist. Deep leaf litter also helps to maintain the soil conditions that are hospitable for mole salamanders. The leaf litter layer is also important for maintaining the invertebrate populations that the salamander feed on. Large woody debris, such as fallen logs, serve as important cover and shelter objects. Large decaying logs and the moist microhabitat beneath them are preferable compared to the smaller branches or drier conditions found under recently fallen or felled trees.

Foraging

Mole salamander larvae feed on a myriad of small aquatic organisms as well as invertebrates that might fall into their aquatic environment. They eat zooplankton, small aquatic crustaceans, water mites, water fleas, midge larvae, snails, aquatic insects, pill bugs, aquatic worms, springtails, mosquito larvae, and flies. They have been observed to eat caterpillars that drop into the water from overhanging trees. As larvae grow larger, they sometimes become cannibalistic or feed on the larvae of other mole salamander species.

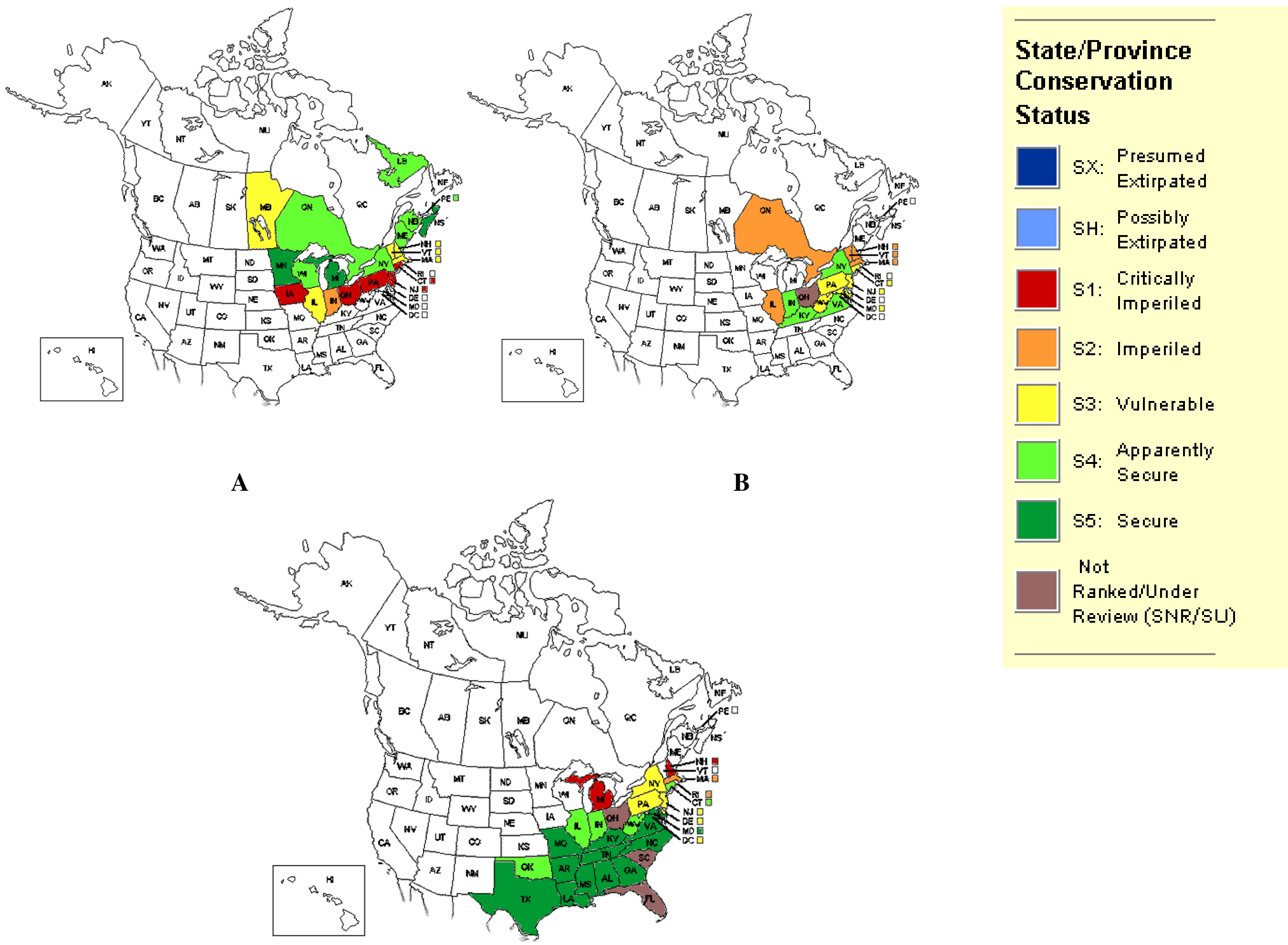
The diets of the terrestrial juveniles and adults are similar and are composed of snails, earthworms, pill bugs, centipedes, spiders, beetles, centipedes, roaches, beetle larvae, springtails, mayfly nymphs, caddisfly and midge larvae, slugs, moth larvae, and miscellaneous plant debris.

The difference in the timing of reproduction between Marbled Salamanders and Blue-spotted and Jefferson Salamanders allows Marbled Salamanders to take advantage of the presence of other amphibian eggs and larvae present in vernal pools as a food source. Marbled salamanders lay their eggs in the fall and are the first larvae present in pools in the spring. They will eat Wood Frog embryos, eggs and embryos of Jefferson Salamanders affected by freezing, and Spotted Salamander hatchlings, and they will even chew on the legs, gills and tails of fellow larvae. Repeated attacks of larger larvae on smaller larvae can eventually lead to death for the larvae that are injured.

MOLE SALAMANDER CONSERVATION CONCERNS

Status Across Range

The Marbled Salamander is a threatened species in Massachusetts and the Blue-spotted and Jefferson Salamanders are species of special concern. The status of the salamanders in the other states and provinces of their ranges is shown in Fig. 7.



C

Figure 7. The status of the Blue-spotted Salamander (A), Jefferson Salamander (B) and Marbled Salamander (C) across their ranges (NatureServe, 2015).

Population Biology of Vernal Pool Breeding Species

The reproductive success of many vernal pool breeding species is dependent in large part on the length of time that the pool holds water (its hydroperiod). The population dynamics of many vernal pool breeding species have been described as “boom or bust” because during years when the pool dries prematurely, reproductive success can be 0%, while in favorable years when the pool holds water long enough, the number of metamorphosing juveniles can greatly outnumber that of breeding adults. The resulting trend in the size of the adult population size is one of fluctuation, as the influx of new individuals into the population can be sporadic (Alford & Richards, 1999; Berven & Grudzien 1990; Semlitsch 1983; Semlitsch et al. 1996; Stenhouse 1987).

Mole salamanders are relatively long-lived compared to other amphibian species and will reproduce a number of times over the course of their life span. Not all adults breed every year and the number of adults that actually breed in a given year is sometimes reduced if the environmental conditions are not favorable. Due to their long life spans, population recovery from successive years of poor reproductive success is more probable than for shorter lived amphibian species experiencing declines in abundance. Minimizing any activities that may cause mortality of adult mole salamanders, protecting the forested habitat where they reside, and maintaining breeding habitat quality in order to promote successful reproduction are all essential for the long-term viability of mole salamander populations.

Vernal Pool Protection and Mole Salamander Life Zones (Buffers)

Increasing recognition of the importance of vernal pool habitats, particularly for amphibian species, has resulted in Best Management Practices (BMP) for forestry activities conducted near these particular wetlands. A USDA Forest Service publication, *Forested Wetlands: Functions, Benefits and the Use of BMPs*, includes in their recommendations a buffer zone of 132 feet in width surrounding vernal pools with a minimum of 50% crown cover retention (Welsch et al., 1995). On state forest land in Pennsylvania, a 200-foot buffer is retained around vernal pools with no disturbance within the first 100 feet and retention of 50% of the canopy closure or a minimum basal area of 60 square feet of live trees from 100 to 200 feet (www.dcnr.state.pa.us/forestry/sfrmp/water.htm#protecting). Additionally, cutting operations within the buffer are restricted to November through January. Forestry Habitat Management Guidelines for Vernal Pool Wildlife that were developed in Maine suggest maintaining a minimum average of 75% canopy cover of trees a minimum of 20 - 30 feet tall within the first 100 feet around the vernal pool and a minimum average of >50% canopy cover for areas 100 - 400 feet from the pool (Calhoun & deMaynadier, 2004).

Two publications that have specifically addressed the size of vernal pool buffers needed for mole salamander conservation have recommended a "life zone" of critical habitat extending 534 and 574 feet from the breeding pool (Facccio, 2003; Semlitsch, 1998). Management recommendations for the federally threatened Flatwoods Salamander (*Ambystoma cingulatum*), which is a mole salamander, include a 1,476-foot buffer zone (www.fws.gov/endangered/wildlife.html#Species). This area includes a 538-foot zone where a basal area of 45 - 50 square feet per acre is maintained and a secondary zone in which 75% of the area has to be maintained with a basal area of 45 – 50 square feet per acre.

Activities that Impact Mole Salamander Populations

Habitat Loss, Degradation, and Fragmentation

Mole salamander populations are at risk from the loss, degradation, and fragmentation of both the aquatic breeding pool habitat required for reproduction and the terrestrial habitat needed for foraging, overwintering, growth and development. Although protection is increasing for mole salamanders' aquatic habitat, a sufficient percentage of the surrounding terrestrial habitat is not usually included in this protection.

Permanent loss of the terrestrial habitat can occur because of commercial and/or residential development. Loss of the breeding habitat can occur because of draining or filling. Vernal breeding pool habitats can also be lost as successful reproductive sites if the hydrology of the habitat is altered. If changes to the local land use result in less water reaching the vernal pool, then it may not retain water long enough for the mole salamanders to develop to metamorphosis. For example, construction blasting near vernal pools in order to build foundations has resulted in the significant reduction of hydroperiod and, therefore, in the loss of vernal pool habitat. Alternatively, if the amount of impermeable surfaces, such as paved roads and parking lots, increases nearby such that there is increased run-off into the pool, this can also have negative effects. If the pool becomes permanent and fish are introduced, this can eliminate successful reproduction altogether. Increased runoff can also decrease the water quality if erosion and subsequent sedimentation occurs or if contaminants reach the pool.

Temporary loss of suitable salamander habitat can occur after clear-cutting forested habitat (Petranka et al. 1993). Habitat degradation and the ultimate loss of hospitable terrestrial habitat for mole salamanders can occur if heavy equipment causes rutting and extensive soil compaction, leading to the loss of underground tunnels and burrows. While upland forested habitat can be temporarily lost after clear-cutting or other even aged forest management techniques salamanders can, under certain environmental and weather conditions, successfully migrate across these areas (Veysey et al. 2009). Removal of coarse woody debris and other cover objects such as rocks can lead to the loss of suitable microhabitats within the forest, and disturbance to the leaf litter on the forest floor can be detrimental.

Fragmentation of habitats and protection of single populations without consideration of connections between populations at a landscape scale threaten the long-term viability of species populations and interferes with biological processes. Fragmentation because of roads, curbs, impermeable fencing or other impassable surfaces can hinder migration to breeding pools within local populations. Additionally, forestry operations may result in a reduced ability of juvenile salamanders to disperse across the landscape to other suitable breeding pools when areas of heavy timber removal are located between two or more breeding habitats (Patrick et al. 2008). At a landscape scale, it can isolate populations genetically and prevent immigration from populations acting as a source of new individuals to populations that are decreasing in abundance.

Water Pollution

The initial growth and development of mole salamanders occur in pools of water. Blue-spotted and Jefferson Salamanders inhabit vernal pools for at least 4 months and Marbled Salamanders spend up to 10 months as aquatic larvae, prior to their metamorphosis to a terrestrial juvenile. The quality of the larval habitat is important, not only to reach metamorphosis successfully, but it can also have implications for the health of the adult population. Evidence suggests that amphibians that are a larger size at metamorphosis due to ideal growing conditions develop into larger adults and have an associated increase in their reproductive potential. Larger female amphibians produce more eggs than smaller individuals and larger males may have greater success when competing with smaller males for breeding females.

Even when habitat is protected for vernal pool breeding amphibians, impacts from the surrounding land use can have negative effects (Brooks et al. 2002). Run-off from pesticides used on lawns, oil leaking onto roads from cars, and agricultural contaminants in the form of chemicals and animal wastes will all affect the water quality of breeding habitat. Decreased water quality has been correlated with reduced embryo hatching success and reduced larval survival. Not all sources of pollution occur locally since distant sulphur and nitrogen pollution contributes to acid precipitation which also affects water quality negatively. Acidic conditions can be lethal to amphibian embryos directly, or can reduce hatching success, slow larval development, and have been associated with embryo abnormalities.

Roadkill

For mole salamander populations whose habitat has already been fragmented by roads separating the breeding habitat from the terrestrial habitat, significant adult mortality due to vehicles can occur during mass breeding migrations. Public awareness of the importance of vernal pool habitats is fairly high in Massachusetts and volunteers often participate in spring "big nights" when the majority of the adult amphibians are moving to their local breeding site. Volunteers place amphibian crossing signs, aid in slowing traffic flow, and move individual amphibians off the road. Culverts specifically installed to aid salamander movement underneath a road have been installed in some locations. However, for other populations that are not assisted by volunteers or culverts, repeated vehicular mortality year after year can ultimately lead to the loss of a local population.

Forestry

Maintaining forested habitat adjacent to vernal pools and other potential wetland breeding sites is essential for the conservation of mole salamanders. The primary concern posed by forestry practices within MESA-listed mole salamander habitat is alteration of upland forested habitat surrounding breeding sites. Some of the specific features within a forest that have been identified as important for mole salamanders are a predominantly closed-canopy, a deep layer of deciduous leaf litter, availability of large and decaying coarse woody debris, the presence of small mammal tunnels, and moist and cool forest floor conditions. Alteration of these features through even-aged management techniques (clear-cuts and seed tree harvests) could result in salamander mortality, reduced or failed reproduction, and subsequent population decline and loss (Semlitsch et al. 2009). However, lighter harvests that promote uneven-aged management techniques may have a positive effect on the vital rates (birth, death, immigration, emigration) of amphibian populations (Semlitsch et al. 2009). Direct mortality of salamanders due to crushing by motorized equipment is a concern particularly during mass breeding migrations when adult salamanders are most active. Similarly, the loss of underground burrows or tunnels to soil compaction by machinery can lead to decreased survival rates of adult and juvenile salamanders.

MESA-LISTED MOLE SALAMANDER FORESTRY CONSERVATION MANAGEMENT PRACTICES

The following management practices apply to forested areas surrounding vernal pools, isolated swamps, and marshes that function as breeding habitat within Blue-spotted, Jefferson, and Marbled Salamander Priority Habitats identified in the MA Natural Heritage Atlas. NHESP recognizes that impacts to MESA-listed mole salamander habitat from forestry operations are temporary. Different standards for MESA-listed mole salamander conservation will be applied to other projects and activities that impact MESA-listed mole salamander Priority Habitat.

R – required management practice **G** – guideline or recommended management practice

Maintenance of breeding site habitat integrity and forest floor conditions

Conservation management objectives

Protect the hydrology, water quality, and physical integrity of breeding pools. Maintain shaded, moist, and cool conditions in the forested habitat surrounding vernal pool and isolated marsh and swamp breeding sites that are used by MESA-listed mole salamanders. Reduce soil compaction and destruction of underground burrows and tunnels, and minimize rutting and disturbance to leaf litter.

Rationale

Vernal pools and the surrounding forest provide essential habitat for mole salamanders to complete their life cycle. Providing shaded, moist, and cool conditions, including deep forest floor litter and coarse woody debris, are necessary for maintaining upland and breeding pool habitats.

General management recommendations

Maintain land surrounding aquatic breeding sites used by MESA-listed mole salamanders in a predominantly forested condition.

Specific management practices

The following stand treatments must be followed within 450 feet of specified vernal pools or isolated shrub swamp and marsh breeding habitat within mole salamander Priority Habitat. NHESP will indicate the relevant areas on a map included with the review letter sent to the DCR service forester.

R No harvesting can occur in Certified and uncertified vernal pools in MESA-listed mole salamander Priority Habitat.

R *0 - 50 feet from breeding pool high water mark:* Retain a no-cut filter strip

R *50 – 450 feet from breeding pool high water mark:* (Mole Salamander life zone) Retain ≥70% of the area with ≥65% canopy cover, or equivalent basal area, of trees ≥ 30 feet in height (see Appendix for residual basal area requirements). Any portion of this area that is cut to <65% canopy cover shall retain ≥10 square feet of basal area per acre of dominant or co-dominant live trees at least 10 inches dbh.*

Management Zone	20-foot diameter vernal pool (Acres)	100-foot diameter vernal pool (Acres)
vernal pool depression	0.01	0.2
50-foot no-cut filter strip	0.25	0.5
450-foot mole salamander life zone	15	17
70% with 65% or greater canopy cover	10.5	12
30% with less than 65% canopy cover	4.5	5

Table 3. Sample acreage within 50 and 450-foot management zones surrounding hypothetical vernal pools 20 and 100 feet in diameter.

* If the land surrounding a vernal pool has multiple owners then these percentages will be applied in proportion to the amount of land owned within the 450-foot mole salamander life zone. For example, if the area is divided equally between two landowners then each landowner could harvest 15% of the 450-foot management zone to conditions with ≥65% canopy cover. These percentages apply only when the land cover surrounding the aquatic breeding site is entirely forested. A higher percentage of the area may need to be maintained at 65% canopy cover if the area within 450 feet of the breeding pool is not entirely forested.

R Within the 450-foot mole salamander life zone, the areas with <65% canopy cover shall not be concentrated disproportionately close to the vernal pool (Fig. 8).

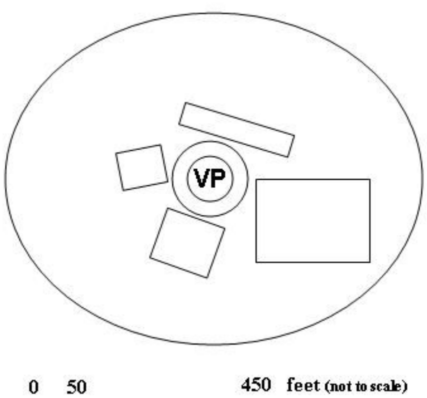


Figure 8A. Example of **a**reas with <65% canopy cover concentrated too close to vernal pool. Boxes represent areas of canopy below 65% retention.

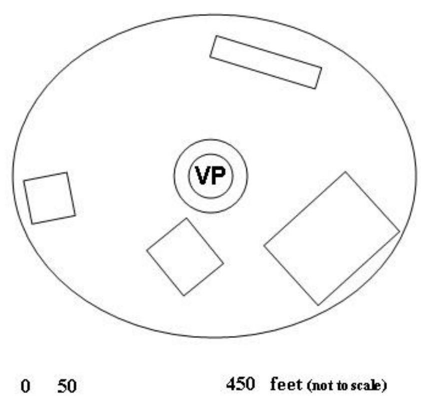


Figure 8B. Example of areas with <65% canopy cover with acceptable distribution around vernal pool. Boxes represent areas of canopy below 65% retention.

R If harvesting is to be done within 450 feet of specified vernal pools or isolated shrub swamp and marsh breeding habitat within mole salamander Priority Habitat then a forester licensed to practice forestry in

Massachusetts under M.G. L. Ch 132 s 47-50 shall prepare the cutting plan. The cutting plan shall include:

- a narrative explaining the existing forest conditions and the silvicultural prescription
- a description of how the condition of the residual stand meets MESA-listed mole salamander habitat requirements such as presence of course woody debris, moist soils, abundant leaf litter
- a map indicating the areas within 450 feet of the breeding pool that will fall below the 65% canopy cover threshold

Within the harvesting area, the boundary of the 50 and 450-foot management zones from the vernal pool shall be clearly identified by flagging or marking paint prior to cutting plan approval and harvesting. The trees that will be harvested within these management areas shall also be marked prior to cutting plan approval and harvesting.

R If the entire area within 450 feet of specified vernal pools or isolated shrub swamp and marsh breeding habitat within mole salamander Priority Habitat is left uncut then a licensed forester is not required to prepare the forest cutting plan and no additional narrative or map is required.

R New landings and skid roads must be located at least 100 feet and farther away if possible, from MESA-listed Mole Salamander breeding pools, including both Certified and uncertified vernal pools.

G Where feasible, extending the management zone beyond 450 feet to 600 feet or even greater would be beneficial for the conservation of mole salamanders.

G Where feasible, retaining more than 70% of the 450-foot management zone with ≥75% canopy cover would be beneficial for the conservation of mole salamanders.

G Patch cuts, new landings, and new skid or woods roads, should not be located between vernal pools when vernal pools are grouped in a cluster (Fig. 9). The forested areas between vernal pools are important dispersal and migration corridors for mole salamanders.

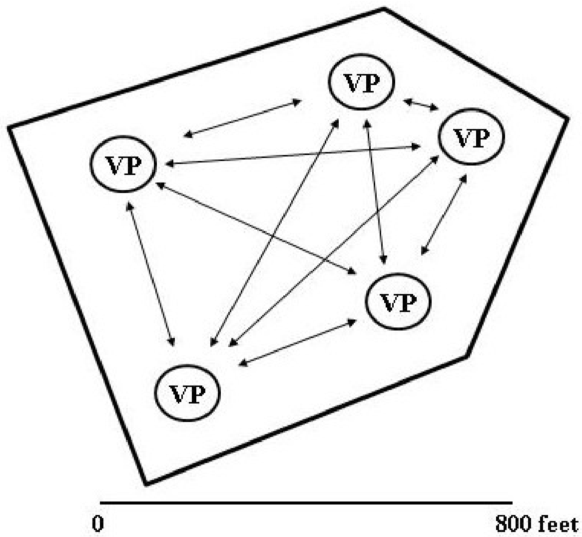


Figure 9. Diagram showing a group of vernal pools and potential MESA-listed mole salamander migration and dispersal corridors (arrows). Minimizing disturbance and habitat alteration from patch cuts, landings, and roads within the outlined area is important for MESA-listed mole salamander conservation.

G Where feasible and in accordance with other regulations, leave two snags/acre or older/dying trees uncut in order to provide a future source of large woody debris that will provide shelter and cover. Small patches of uncut trees around snags would avoid possible safety issues.

G Leave sections of downed wood 12 inches and larger in diameter and 15 inches long or larger to provide microhabitat areas of shelter and cover.

G Avoid disturbing fallen logs as they are important microhabitat features that provide shelter and cover.

G Leave limbs and tops in the forest, consistent with other laws, regulations and forestry best management practices, in order to provide a source of woody debris that can be used as cover and shelter objects.

G Harvesting during the winter when the ground is frozen or snow-covered is preferred in order to reduce soil compaction, rutting, and disturbance to the forest floor habitat.

Preventing Salamander Mortality

Conservation management objective

Reduce direct mortality of mole salamanders from any forestry-associated activity involving motorized equipment.

Rationale

Mole salamanders are the most active and the most concentrated above ground during their breeding migrations. By accessing forested areas outside of the period when breeding migrations occur, direct mortality will be reduced.

General management recommendations

Adjust the timing of mechanized forestry activities so that the mole salamander is less likely to be active above ground.

Specific management practices

Blue-spotted and Jefferson Salamanders

R Motorized vehicle use, consistent with the Massachusetts Forestry Best Management Practices, may occur between 50 and 450 feet of the high water mark from a breeding pool or other potential wetland breeding habitat between May 15th and February 28th. All motorized vehicles shall be excluded from this area between March 1st and May 14th.

Marbled Salamander

R Motorized vehicle use, consistent with the Massachusetts Forestry Best Management Practices, may occur between 50 and 450 feet of the high water mark from a breeding pool or other potential wetland breeding habitat between October 15th and August 15th. All motorized vehicles shall be excluded from this area between August 16th and October 14th.

Species	Distance from breeding Habitat (feet)	Time period when harvesting can occur
Blue-spotted and Jefferson Salamander	50 - 450	May 15 – February 28
Marbled Salamander	50 - 450	October 15 – August 15

Table 3. Recommendations for motorized vehicle use for forestry activities according to straight-line distance from mole salamander breeding habitat.

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APPENDIX

Table 1. Draft residual basal area levels of trees >4 inch dbh sampled with a BAF-10 prism for 65% canopy cover within the Mole Salamander life zone. Residual trees should be greater than or equal to 30 feet in height*.

Average Stand	Forest Type**					
dbh (inches)	WP,WK,RP,SR,PP, HK, TK, CD, SF	WH, HH	BW, RM, BC, BB, SM, BM, BE	W0, PO	OH	OR, OM
4	50	40	25	20	15	10
5	50	50	35	30	15	10
6	60	55	35	30	25	20
7	70	55	40	35	20	15
8	75	60	45	30	25	20
9	80	60	45	40	25	20
10	85	65	50	35	30	25
11	85	65	50	45	30	25
12	90	70	55	40	35	30
13	95	75	55	50	35	30
14	100	80	60	45	40	35
15	100	80	60	55	40	35
16	105	85	55	50	45	40
17	110	85	65	60	45	40
18	110	90	60	55	50	45
19	110	90	60	65	50	45
20	115	95	65	60	55	50
21	115	95	65	70	55	50
22	115	100	70	65	60	55
23	115	100	70	65	60	55
24	120	105	70	75	70	65
25	120	105	75	70	65	60
26	120	110	80	75	70	65

*Residual basal area required for 70% of the life zone (remaining 30% of life zone has 10 square feet/acre residual basal area requirement).
**Refer to Ch. 132 Forest Cutting Plan form for definition of forest types.