Blue-spotted/Jefferson Salamander complex

Ambystoma laterale & jeffersonianum

Federal Listing	N/A
State Listing	SGCN
Global Rank	G4/G5
State Rank	S2
Regional Status	Very High

Photo by Eric Aldrich

Justification (Reason for Concern in NH)

Blue-spotted salamanders and Jefferson salamanders are known to form hybrids. Populations of pure blue-spotted or Jefferson salamander populations are probably very rare; however, a pure male of either species (blue-spotted or Jefferson) is required for the production of viable offspring. Only a handful of individuals have actually been genotyped as pure blue-spotted in New Hampshire, and only one pure Jefferson salamander has ever been identified in New Hampshire. These species and their hybrids may be sensitive to habitat disturbance. Data on this species in New Hampshire is limited. In Massachusetts, a study documented drastic declines in blue-spotted salamander complex breeding populations, having sex ratios consistently skewed towards females (Homan et al. 2007). Often the location of a salamander observation in New Hampshire will indicate the likelihood of either a Jefferson (near the Connecticut River) or blue-spotted salamander (distant from the Connecticut River). However, genetic tests would be required to confirm whether a specimen was truly a blue-spotted or Jefferson salamander versus a blue-spotted/Jefferson hybrid (also referred to as a 'complex'). Reports of a Jefferson or blue-spotted salamander are often documented as 'blue-spotted salamander/Jefferson complex.'

Distribution

Jefferson Salamander
This "species" is limited to the eastern United States and Canada. It ranges from western New England to eastern Illinois, north to Ontario, and south to central Kentucky to Virginia to Maryland (Klemens 1993, DeGraaf and Yamasaki 2001). In New England, it occurs west of the Connecticut River in Vermont, Massachusetts, and Connecticut; and east of the Connecticut River in southwestern New Hampshire and Massachusetts (Klemens 1993, French and Master 1986). Despite the New England range, populations consisting only of pure Jefferson salamanders are known from Pennsylvania southward to Kentucky and West Virginia (NatureServe 2004, Conant and Collins 1998). The Jefferson genotype was found in hybrid individuals (carrying more blue-spotted than Jefferson chromosome sets) in central Maine (Knox 1999).

In New Hampshire, only one pure Jefferson salamander has ever been identified (using DNA analysis). This was a pure male from Winchester in Cheshire County identified in 1984 (French and Master 1986, Bogart and Klemens 1997). It is unknown whether this male represented a pure or mixed pure-hybrid population (Bogart and Klemens 1997). Jefferson salamanders have been reported to the RAARP program for other towns in New Hampshire but it is not known whether these individuals represent pure Jefferson salamanders or hybrids dominated by either Jefferson or blue-spotted

salamander genomes. Recent undocumented reports have come from Merrimack, Cheshire, and Hillsborough counties.

Blue-spotted salamander
This "species" ranges from the maritime provinces of Canada to southeastern Manitoba, southward to northern Illinois, east to New York, then north along the Atlantic coast through New England (Klemens 1993, DeGraaf and Yamasaki 2001). Disjunct populations are located in New Jersey, Long Island (NY), Iowa, and Labrador (Klemens 1993, DeGraaf and Yamasaki 2001). In New England, it occurs widely throughout eastern and central Massachusetts, southeastern New Hampshire, Maine, and the Lake Champlain lowlands in Vermont (Klemens 1993). Scattered populations occur in southwestern New England, but the species does not occur on Cape Cod (Klemens 1993). Only 2 populations of pure (non-hybrid) blue-spotted salamanders are known (one on Prince Edward Island, Canada; the other on Long Island, New York; Knox 1999), though 5 others are suspected in Massachusetts and Connecticut (Bogart and Klemens 1997).

In New Hampshire, pure blue-spotted salamanders have been documented in Hollis (1 female), Rockingham County (2 females and a male), and Strafford County (1 female) (Bogart and Klemens 1997). Additionally, hybrid blue-spotted salamanders (blue-spotted genotype dominant or equal to the Jefferson genotype) were reported in Hollis (4 females), Rockingham County (six females and an unsexed individual), and Strafford County (2 females) (Bogart and Klemens 1997). Taylor (1993) also reported several blue-spotted salamanders (pure or hybrid) observations from Strafford County, Rockingham County, and Hillsborough County, and 1 observation from Coos County. However, Taylor (1993) and Bogart and Klemens (1997) may have been reporting some of the same individuals. Some of these individuals were museum specimens and may actually be historic records. Finally, RAARP has received several reports of blue-spotted salamander observations, but these reports do not distinguish between pure and hybrid salamanders. These reports are primarily from Rockingham and Strafford counties, but some reports have come from Hillsboro, Cheshire, Coos, Grafton, and Merrimack counties.

Hybrids
Most of the individuals across the range of both species are likely hybrids (Klemens 1993). To produce viable offspring, hybrids must mate with a pure male of either parent species. Thus, pure diploid Jefferson salamander and blue-spotted salamander males are likely present throughout parts of New England, but the exact distribution of the pure genotype is unknown (Bogart and Klemens 1997). A recent study documented blue-spotted complex populations in southeast New Hampshire, and Jefferson complexes were documented in southwest New Hampshire (Bogard and Klemens 2008). Local populations of blue-spotted salamanders, Jefferson salamanders, and their associated hybrids, where they exist in New Hampshire, will be clustered in relatively undisturbed forest uplands around temporary and semi-permanent pools and other palustrine wetlands. Such a habitat mosaic, of palustrine wetlands embedded in forested upland, is common throughout New Hampshire but is increasingly fragmented by human development, especially in the southern portion of the state.

Habitat

Jefferson Salamander
Jefferson salamanders breed in palustrine wetlands, but spend most of their lives in nearby forested uplands (Klemens 1993, Faccio 2003). Jefferson salamanders can breed in several types of palustrine

wetlands (i.e. grassy pasture ponds, small impoundments filled by seasonal stream, and vernal shrub swamps), but favor vernal pools (Klemens 1993). High breeding success in vernal pools is attributed to the absence of fish predators. To sustain a viable Jefferson salamander population, these pools must hold standing water until late summer in most years, so that the salamander larvae have sufficient time to develop and metamorphose (Harding 1997). This species attaches its egg masses to vegetation and dead branches within the water column of the vernal pool.

Jefferson salamanders prefer deciduous forest, but also occur in mixed deciduous-hemlock forest (Klemens 1993). This species also seems to prefer steep rocky areas with rotten logs and heavy duff layers (Klemens 1993). It seeks cover and hibernates in small mammal burrows, coarse woody debris, leaf litter, and stones (Faccio 2003, Klemens 1993). Jefferson salamanders have been observed at elevations ranging up to 1,700 feet (Klemens 1993, USFS 2002).

Blue-Spotted Salamander

Blue-spotted salamanders breed in fresh-water wetlands but spend most of their lives in nearby forested uplands (Downs 1989, Klemens 1993, Knox 1999). Blue-spotted salamanders use many wetlands types for breeding, including ephemeral and semi-permanent pools, swamps, ponds, marshes, ditches, and flooded sections of logging roads (Downs 1989, Klemens 1993, Knox 1999). In Connecticut, this species breeds frequently in acidic red maple/sphagnum moss swamps but also occurs in calcareous wetlands (Klemens 1993). Where the ranges of the closely related Jefferson salamanders (*Ambystoma jeffersonianum*) and blue-spotted salamanders overlap, Jefferson salamanders prefer ridge-top vernal pools, whereas blue-spotted salamanders seem to prefer lowland swamps (Klemens 1993). To sustain a viable blue-spotted salamander population, a wetland must hold standing water until late summer in most years so that the salamander larvae have time to develop and metamorphose (Harding 1997). Water depth in breeding wetlands is usually less than 40 cm (Knox 1999). This species sometimes attaches its eggs (singly or in small clusters) to grass and other wetland vegetation (Klemens 1993).

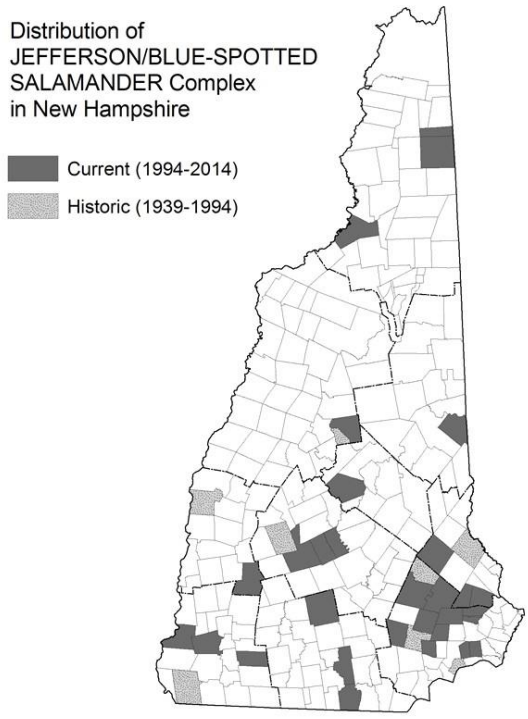
For upland habitat, blue-spotted salamanders prefer damp, deciduous, or mixed woodlands with moderate shade (Downs 1989, Knox 1999). Blue-spotted salamanders are commonly found in water-saturated loamy soil and damp crumbly sand (Downs 1989, Klemens 1993). They seek cover under rocks, rotting stumps and logs, moss, vegetative debris, small mammal burrows, woodpiles, and human debris (Klemens 1993, Knox 1999).

General

The size and configuration of upland habitat needed to sustain Jefferson, blue-spotted, or hybrid populations are unknown. They may require large areas of undisturbed upland forest connected by suitable dispersal corridors to maintain metapopulations (Semlitsch 1998, USFS 2002). Salamanders may migrate several hundred meters from their breeding pools into the adjacent uplands (Williams 1973, Faccio 2003, Carr Research Laboratory and Hyla Ecological Services 2003).

NH Wildlife Action Plan Habitats

- Vernal Pools
- Hemlock Hardwood Pine Forest
- Appalachian Oak Pine Forest
- Floodplain Habitats
- Marsh and Shrub Wetlands
- Northern Hardwood-Conifer Forest
- Northern Swamps
- Peatlands
- Temperate Swamps



Distribution Map

Current Species and Habitat Condition in New Hampshire

There are insufficient data from which to determine the relative health of populations.

Population Management Status

Jefferson salamanders, blue-spotted salamanders, and their hybrids are not specifically protected or managed. No management plan exists for the population from which the only pure Jefferson salamander was collected.

Regulatory Protection (for explanations, see Appendix I)

- NHFG Rule FIS 803.02. tiImportation.
- NHFG Rule FIS 804.02. Possession.
- NHFG Rule FIS 811.01 Sale of tiReptiles.
- NHFG FIS 1400 Nongame special rules
- Fill and Dredge in Wetlands - NHDES
- Clean Water Act-tiSection 404

Quality of Habitat

There are insufficient data from which to determine the relative quality of habitat patches.

Habitat Protection Status

There are insufficient data from which to determine the habitat patch protection status.

Habitat Management Status

Salamander habitat is indirectly managed through wetland and water resource protection, forestry management regulations (i.e., New Hampshire RSA 482-A; New Hampshire Rule Chapters Wt 100-800; Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire), and through land preservation (e.g., conservation restrictions and land acquisitions). These efforts are not specifically designed to manage for salamanders. Population growth and associated development will likely destroy or degrade potential habitat, despite measures aimed at slowing and redirecting development. Additionally, some forest management techniques (e.g., clear cutting) could also contribute to the fragmentation and degradation of potential habitat (deMaynadier and Hunter 1999, Pough and Wilson 1976 cited in DeGraaf and Yamasaki 2001, Faccio 2003).

Basic distribution and habitat use data for the species is needed to develop effective habitat management plans. In the absence of this basic data, habitat management efforts might focus on limiting disturbance in and around vernal pools that are embedded within a relatively large matrix of minimally disturbed forest. The goal of habitat management efforts should be to maintain habitat patches that allow for metapopulation dynamics (i.e., multiple pool/upland patches connected by dispersal habitat). Thus, the usefulness (to salamanders) of pool buffer zones and dispersal corridors between habitat patches needs to be evaluated.

Threats to this Species or Habitat in NH

Threat rankings were calculated by groups of taxonomic or habitat experts using a multistep process (details in Chapter 4). Each threat was ranked for these factors: Spatial Extent, Severity, Immediacy, Certainty, and Reversibility (ability to address the threat). These combined scores produced one overall threat score. Only threats that received a "medium" or "high" score have accompanying text in this profile. Threats that have a low spatial extent, are unlikely to occur in the next ten years, or there is uncertainty in the data will be ranked lower due to these factors.

Habitat conversion due to development of surrounding uplands and associated edge effects (Threat Rank: Medium)

Residential or commercial development may affect breeding habitat (loss and degradation of vernal pools), upland habitat (loss and degradation of forests), and dispersal corridors (by fragmenting landscapes), and may even directly kill amphibians such as salamanders. Opportunistic predators (e.g., raccoons) and invasive plant and animal species are more common near human development. Myriad stressors associated with development collectively reduce local population sizes of amphibians, reduce gene flow between populations, and may ultimately extirpate local populations.

The long-term persistence of salamander populations depends on the exchange of individuals through dispersal and the colonization probability of vernal pools or other wetlands from terrestrial adult populations (Dodd 1997, Semlitsch and Bodie 1998, Skelly et al. 1999). Most amphibians use terrestrial habitat to obtain food and shelter from predation, desiccation, or freezing (Madison 1997, Lamoureaux and Madison 1999, Knutson et al. 1999). Therefore, the suitability of terrestrial habitat surrounding a wetland is likely to have a significant influence on the composition and abundance of amphibians that breed in or otherwise utilize nearby wetlands.

In recent decades, commercial and residential development in New Hampshire have increased

dramatically, in conjunction with accelerated human population growth and immigration (Sundquist and Stevens 1999). Windmiller (1996) noted that increasing urbanization likely reduces mole salamander abundance and excludes salamanders from otherwise suitable habitat. Gibbs (1998a) suggested that ambystomatids are predisposed to local extinction caused by habitat fragmentation.

Habitat conversion from the direct filling of wetlands for development (Threat Rank: Medium)

The direct filling of wetlands for development reduces the availability of breeding habitat for Jefferson and blue-spotted salamanders, through the direct loss and degradation of vernal pools, swamps, ponds, and marshes.

Amphibians, particularly ambystomatid salamanders including marbled salamanders, generally breed in the same wetland every year (Semlitsch et al. 1993, Semlitsch 1998). It is not well known how these species respond when a breeding wetland is no longer available (i.e., filled). Some ambystomatid salamanders will return to breeding wetlands even after those wetlands have been filled, whereas others have been able to disperse to nearby created wetlands (Pechmann et al. 2001). Created mitigation wetlands usually are unsuccessful at replicating the wildlife habitat of the wetlands they are intended to replace (Brown 1999).

Wetland loss in the United States from historic draining and filling is well documented (e.g., Dahl 1990, 2000). Lack of reliable data for vernal pools creates difficulty in accurately determining historic losses. An important aspect of wetland loss is not simply the continued loss of habitat, but the continued under-valuing of vernal pool habitat as well. Size has traditionally been used an important criterion for assessing wetland value. Without increased protection priority for vernal pools, it is certain that vernal pool habitat will decrease in the future.

Mortality of individuals from vehicles on roadways (Threat Rank: Medium)

Vehicle traffic can kill salamander species by hitting and crushing them as they cross roads. This can have a significant impact on some species, and in severe cases could result in local extirpation. Roads may act as partial barriers to overland dispersal or migration, perhaps resulting in decreased gene flow between populations and decreased colonization of unpopulated wetlands or vernal pools. This could disrupt metapopulation dynamics and long-term viability of some species.

Roads also create edge habitat. Along these edges, soil and air moisture may be reduced, leading to increased salamander desiccation. Roads may act as conduits for predators that prey on amphibians (e.g., skunks and raccoons), and dispersal avenues for invasive plants and animals. Runoff from roads can also reduce habitat quality of vernal pools via pollution, increased salt levels, sedimentation, and erosion in pools and adjacent habitats.

Roads are a significant source of direct mortality for migrating amphibians (Fahrig et al. 1995, Ashley and Robinson 1996, Mazerolle 2004, Forman 2003), and salamander abundance in roadside habitats may be reduced (deMaynadier and Hunter 2000). Gibbs (1998) found that forest-road edges are less permeable to ambystomatid salamanders than are forest interior and forest-open land edges. Research conducted in southern New Hampshire suggests that roads have a negative impact on wood frogs (*Lithobates sylvatica*) and spotted salamanders (*Ambystoma maculatum*), a similar salamander that also breeds in vernal pools (Mattfeldt 2004). Amphibians can experience delayed development or mortality from runoff contamination from roads, including road salt (Trombulak and Frissell 2000, Turtle 2000).

Species impacts from hybridization (reduced fitness) (Threat Rank: Medium)

Jefferson-blue-spotted salamander hybrids may come to dominate salamander populations where pure Jefferson salamanders are also present (see Distribution). Through competition with hybrids or with pure blue-spotted salamanders, or through local extinction events, pure Jefferson salamanders may be eliminated, and thus, the species as a pure lineage may go extinct.

Jefferson and blue-spotted salamanders hybridize throughout much of their range (Conant and Collins 1998), and other hybrid combinations occur at the western extent of the Jefferson range (Bogart and Klemens 1997). Changes in regional climate, caused by global warming, may facilitate future range overlap. Hybrid populations seem unsustainable without sexual stimulation from pure males, but the pure genome is either not, or only temporarily, incorporated into the lineage (Bogart and Klemens 1997). Hybrids are usually dominant where they are present (Bogart and Klemens 1997). Hybrids may be better adapted to a wider range of habitats and environmental conditions than either parent species.
Hybridization is viewed as a very serious threat by the research and conservation communities (see Wright and Marchand 2002). However, hybridization seems a natural evolutionary step for two species that recently diverged due to temporary geographic isolation (for evolutionary history, see Bogart and Klemens 1997). Were this evolution untouched by human influence, both or either species might still go extinct. Alternatively, they might re-merge into a single species, or survive as two species. The threat is more the potential for human influence to impact this process (i.e., through habitat destruction and fragmentation), than the hybridization itself.

Mortality and species impacts (reduced fitness) from acid deposition (Threat Rank: Medium)

Acid rain and contaminated runoff and discharge may increase soil and water acidity within salamander habitat.

Mole salamanders exhibited a decreased hatching success, larval survival, embryonic developmental rates, and abundance of egg masses at low water pH levels (Pough 1976, Rowe et al. 1992, Rowe and Dunson 1993, Horne and Dunson 1994a, 1994b). Negative effects of low water pH have been observed in amybstomatids (as summarized in Kiesecker 1996). Additionally, metal mobility, and hence toxicity of metals to salamanders, changes with pH (Rowe et al. 1992, Rowe and Dunson 1993, Horne and Dunson 1994b, Horne and Dunson 1995a, 1995b). Research with other amphibians has demonstrated a negative synergistic interaction between low pH and other threats (e.g., UV-B radiation; Long et al. 1995, Hatch and Blaustein 2000). Low soil pH may lead to increased desiccation among terrestrial salamanders, and terrestrial salamanders may avoid habitat that has acidic soil.

List of Lower Ranking Threats:

Mortality and habitat degradation from fertilizer use near wetlands

Mortality and species impacts (reduced fitness) from toxins and contaminants

Mortality and species impacts (decreased fitness) from various diseases (ranavirus, chytrid)

Habitat degradation from introduced or invasive plants

Mortality and degradation from legal and illegal OHRV activity

Mortality and habitat conversion from forestry practices

Mortality and degradation from increased droughts

Actions to benefit this Species or Habitat in NH

Protect habitat

Primary Threat Addressed: Habitat conversion from the direct filling of wetlands for development

Specific Threat (IUCN Threat Levels): Residential & commercial development

Objective:
Maintain and protect habitat for salamanders statewide.

General Strategy:
Maintaining vernal pool habitat, upland habitat, and dispersal corridors will be the most effective way to protect this species. To assist in understanding habitat use and population health, surveys should consider the following: the size and configuration of upland habitat needed to sustain Jefferson, blue-spotted, or hybrid populations; proximity of occupied habitat to roads, development, and other disturbances, the exact distribution of the pure Jefferson genotype; density of species at various sites and the potential for genetic exchange between local populations; habitat use; the degree of isolation and regional persistence mechanism of local populations in New Hamp-shire and neighboring states and the usefulness to salamanders of pool buffer zones and dispersal corridors between habitat patches.

Political Location:
Statewide

Watershed Location:
Statewide

Conduct a survey for the presence of blue-spotted salamanders and Jefferson salamanders and complete a threat assessment for the species and its hybrids

Objective:
To better understand the distribution, status, and habitat use of Jefferson and blue-spotted salamanders. If pure populations are discovered, habitat, life history, and dispersal data should be collected.

General Strategy:
New Hampshire needs a statewide systematic survey to determine the distribution of blue-spotted and Jefferson salamanders and their hybrids. Much of the existing distributional data for New Hampshire is unreliable because it does not distinguish between pure Jefferson salamanders, blue spotted salamanders, and their hybrids. This survey should distinguish (genetically) between pure and hybrid blue-spotted salamanders so that distribution maps can be drawn for pure populations, populations where pure forms and hybrids coexist, and hybrid populations that lack pure genotypes.
It may help to first delineate its potential habitat. A GIS habitat layer could be produced using remote sensing (e.g., aerial photography) and ground truthing. Potential habitat should be determined by comparing a vernal pool data layer to a forest cover data layer. Additional research is needed to establish and thoroughly detail the specific effects of various threats to Jefferson and blue-spotted salamanders. Data for the species is needed to develop effective habitat management plans. In the

absence of this basic data, habitat management efforts might focus on limiting disturbance in and around vernal pools that are embedded within a relatively large matrix of minimally disturbed forest. The goal of habitat management efforts should be to maintain habitat patches that allow for metapopulation dynamics (i.e., multiple pool/upland patches connected by dispersal habitat). Thus, needs to be evaluated.

Political Location:
Statewide

Watershed Location:
Statewide

Location Description:
Surveys should start with known occupied sites, and historic occurrences.

Education and outreach to facilitate amphibian migration across roads

Primary Threat Addressed: Mortality of individuals from vehicles on roadways

Specific Threat (IUCN Threat Levels): Transportation & service corridors

Objective:
Reduce the impacts of roads on amphibian population and metapopulation dynamics, and thus maintain viable populations of breeding amphibians.

General Strategy:
Facilitation activities could be coordinated at the state level by a government, non-profit, or consulting group. Facilitation could alternatively be implemented and monitored at the municipal level. Volunteers should be trained and utilized to perform much of this conservation action. Installing tunnels beneath roads that intersect amphibian migration routes will facilitate dispersal. Community education may further decrease the threat of road traffic to migrating amphibians. Community members can help salamanders cross roads and witness the migrations at these locations (see Jackson 1996, 2003, Jackson and Tyning 1989).

Political Location:
Statewide

Watershed Location:
Statewide

References, Data Sources and Authors

Data Sources
Information relating to the distribution of this species was gathered during a literature review. Two primary sources of information and references were DeGraaf and Yamasaki (2001) and the "Species Data Collection Form" completed by the USFS (Wright and Marchand 2002); the latter included information from state databases, meetings, and expert reviews.
Threat assessments were conducted by a group of NHFG biologists (Michael Marchand, Brendan Clifford, Loren Valliere, Josh Megysey).

Data Quality
No comprehensive survey has been conducted for these species in New Hampshire. Much of the

existing distributional data for New Hampshire is unreliable to the species level because it does not distinguish between pure Jefferson salamanders, blue spotted salamanders, and their hybrids. The work of Bogart and Klemens (1997), which genetically identified 18 pure/hybrid blue-spotted salamanders from New Hampshire, is highly accurate, but of limited quantity. Regional distribution maps suggest that the species may be present throughout the state.

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