SPECIES PROFILE

Jefferson Salamander and Blue-Spotted Salamander

Ambystoma jeffersonianum and Ambystoma laterale

Federal Listing: Not listed
State Listing: Special Concern (Jefferson), Not listed (blue-spotted)
Global Rank: G4 (Jefferson), G5 (blue-spotted)
State Rank: S2S3 (Jefferson), S4 (blue-spotted)
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Element 1: Distribution and Habitat

1.1 Habitat Description

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).

1.2 Justification

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.

1.3 Protection and Regulatory Status

Jefferson salamanders, blue-spotted salamanders, and their hybrids are not specifically protected in New Hampshire, although their habitats receive some protection. See Vernal Pool and Marsh & Shrub Wetlands Profiles.

1.4 Population and Habitat 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.

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 a couple of the reports are from Hillsboro,Cheshire , Coos 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).

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.

1.5 Town Distribution Map

1.6 Habitat Map

N/A

1.7 Sources of Information

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.

1.8 Extent and Quality of Data

No comprehensive survey has been conducted for these species in New Hampshire. 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. 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.

1.9 Distribution Research

Basic distribution data is lacking for Jefferson salamanders. Since this species is listed as imperiled/vulnerable in New Hampshire (i.e., state rank code = S2/S3) it may merit a statewide survey. Pure Jefferson salamanders may be present in southern Vermont and Ontario. Current distribution data are also lacking for blue-spotted salamanders. Blue-spotted salamanders may occur in relatively high densities in southern New Hampshire and have been documented in northern New Hampshire (Taylor 1993). It is present throughout Maine and is reported from southeastern Canada. Statewide surveys should be conducted for both species 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.

Element 2: Species/Habitat Condition

2.1 Scale

There are insufficient data from which to determine species condition.

2.2 Relative Health of Populations

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

2.3 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 (see section 1.4).

2.4 Relative Quality of Habitat Patches

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

2.5 Habitat Patch Protection Status

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

2.6 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.

2.7 Sources of Information

Information was gathered from published literature and New Hampshire laws and administrative codes. Two primary sources of information were DeGraaf and Yamasaki (2001) and Wright and Marchand (2002); the latter source included information from state databases, meetings, and expert reviews.

2.8 Extent and Quality of Data

See Section 1.8 above. Little is known about the extent and locations of Jefferson salamanders or blue-spotted salamanders in New Hampshire.

2.9 Condition Assessment Research

1. New Hampshire needs basic surveys to determine the presence and distribution of pure and hybrid Jefferson/blue-spotted salamanders. 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.

2. If pure populations are discovered, habitat, life history, and dispersal data should be collected. Scientists can then assess the effects of development, forest management, and other activity on local populations.

3. To assist in understanding habitat use and population health, surveys should record or consider the following:

- Stability of the sub-population and/or metapopulation(s)
- Potential for genetic exchange between local populations
- Incidence of physical malformations
- Water quality within the breeding wetlands
- Length and inter-annual variability of breeding wetland hydroperiods
- Real and potential fish presence/absence within the breeding wetlands
- Proximity of the habitat patch to other potential habitat patches
- Proximity of the habitat to roads, development, and other disturbances
- Size and configuration of upland habitat

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Habitat Loss and Conversion)

See Vernal Pool habitat profile, section 3.1.1

3.1.2 Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

See Vernal Pools habitat profile, section 3.1.2

3.1.3 Development (Habitat Loss and Conversion)

See Vernal Pools habitat profile, section 3.1.3

3.1.4 Unsustainable Harvest (Forestry Operations and Management)

See Vernal Pool Habitat Profile, section 3.1.4

3.1.5 Non-Point Source Pollution (Chemical Contaminants, Nutrients (Eutrophication))

(A) Exposure Pathway
Chemical toxins include mercury, pesticides, herbicides, fungicides, gasoline, oil, cleaning products, and many other substances that are not naturally found, or are not naturally found in such high concentrations. These toxins reach wetlands via atmospheric deposition, surface or subsurface runoff, or direct deposition. Fertilizers can leach into soil and ground and surface water and eventually arrive in wetlands where it may cause algal and bacterial blooms.

(B) Evidence
A limited number of studies have explored the effects of toxins on ambystomatids that occur in eastern North America. Generally, studies show that toxins affect hatching success, growth and development, behavior, frequency of deformities, and mortality (Boone and Semlitsch 2001, Bridges 1997, Howard et al. 2002, Hatch and Burton 1998). These effects can vary with species and ecological context (Sparling et al. 2001). Through a variety of mechanisms, toxins and other threats (e.g., UV-B radiation and low pH), may act synergistically to amplify harm to amphibians (Kagan et al. 1984, Hatch and Burton 1998, Zaga et al. 1998, Monson et al. 1999, Blaustein et al. 2001). Toxins may also harm prey resources, which might also affect survival and fecundity.

Algal and bacterial blooms (as well as the fertilizers themselves) may be toxic to salamanders or cause anoxia, which affects salamanders or prey resources. Larvae often exhibit decreased feeding and swimming activity, and increased disequilibrium, paralysis, incidence of abnormalities and edemas, and mortality (Marco et al. 1999, Baker and Waights 1994). Terrestrial phases of these species may alter feeding behavior in the presence of nitrogenous fertilizers (e.g., Hatch et al. 2001). Fertilizers may have a synergistic effect with other threats, such as low pH (Hatch and Blaustein 2000). Farm fertilizer use, lawn-care fertilizer use, and human septic/farm animal manure disposal may affect salamanders differently based on the ratios of their component nutrients and their application rates.

3.1.6 Acid Deposition

(A) Exposure Pathway
Acid rain and contaminated runoff and discharge may increase soil and water acidity within salamander habitat.

(B) Evidence
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). Swimming activity of blue-spotted salamanders decreased with decreasing pH (Kutka 1994). Similarly negative effects of low water pH have been observed in other amybstomatids and amphibian species (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. Jefferson salamanders experienced reduced whole body water and Na^+ concentrations at increased soil acidity, and preferentially chose substrates with higher pH (Horne and Dunson 1994a). In the same study, pH of pond water and adjacent soil were highly correlated (Horne and Dunson 1994a). Wyman (1988) also found that spotted salamander distribution was significantly influenced by soil pH.

3.1.7 Scarcity (Hybridization)

(A) Exposure Pathway
Jefferson-blue-spotted salamander hybrids may come to dominate salamander populations where pure Jefferson salamanders are also present (see section 1.4). 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.

(B) Evidence
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.

3.2 Sources of Information

Information about threats was compiled from an extensive literature review and from personal communications and observations.

3.3 Extent and Quality of Data

The genetic and reproductive mechanisms of hybridization and the effects of low pH on ambystomatid salamanders are well documented. The impacts of other threats are less well documented. However, some threats (e.g., road effects, logging) have been well documented for other similar species.

3.4 Threat Assessment Research

Additional research is needed to establish and thoroughly detail the specific effects of most of these threats (except effects of low pH). Yet foremost, New Hampshire needs a systematic survey to determine the distribution of blue-spotted and Jefferson salamanders.

Element 4: Conservation Actions

Refer to the Vernal Pools habitat profile for a complete list of conservation actions that are intended to protect vernal pools and vernal pool wildlife.

4.1.1 Amphibian Migration Facilitation, Restoration and Management/Education and Outreach

(A) Direct Threats
Transportation Infrastructure (Mortality, Fragmentation, Dispersal Barriers)

(B) Justification
Roads may often cut across major amphibian migration routes, although often in small, spatially discrete areas. In this context, “amphibian” refers to species such as spotted salamanders, Jefferson salamanders, blue-spotted salamanders, marbled salamanders, wood frogs, and spring peepers that migrate en masse from upland landscapes to vernal pools in the spring. Roads threats to amphibian populations are increasing in New Hampshire, as development in the state accelerates (Sundquist and Stevens 1999). Installing tunnels beneath roads that intersect amphibian migration routes will facilitate dispersal. Road signs may alert drivers to the possibility of migrating am-

phibians and lessen amphibian mortality caused by traffic. 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).

(C) Conservation Performance Objective:
The objective is to reduce the impacts of roads on amphibian population and metapopulation dynamics, and thus maintain viable populations of breeding amphibians.

(D) Performance Monitoring:
Potential indicators that can be easily monitored include:

- Number of road-killed salamanders where roads cross migration routes, before and after tunnels have been installed
- Nightly counts of migrating animals during peak migration (warm rainy nights during March-May)
- Number of salamanders and other amphibians observed crawling through installed tunnels
- Egg mass abundance before and after tunnels have been installed

Overall, road kills are expected to be negatively correlated with egg mass abundance, despite normal annual fluctuations in salamander breeding population size and egg production. Tunnels should increase migration success, leading to an increase in successful breeding.

(E) Ecological Response Objective
The short-term objective of installing tunnels and facilitating migration is to increase migration success and thus the breeding pool of amphibians. If new roads and tunnels are installed simultaneously, then the objective is to have no effect on breeding populations.

(F) Response Monitoring
If feasible, baseline population growth rates of target species could be established prior to migration facilitation, and then changes in population growth rates following migration facilitation could be used as a response indicator. However, amphibian populations fluctuate naturally from year to year, so monitoring efforts should continue for several years (five or more) to try to differentiate actual response from natural variation. Comparison of growth rates, counts of road mortality, nightly migration surveys, and use of tunnels should elucidate the effect of the conservation action.

(G) Implementation
- Locate intersections between roads and amphibian migration routes
- Determine pre-facilitation road kill frequencies and growth rates (i.e., conduct road kill and egg mass surveys)
- Implement migration facilitation program (i.e., migration tunnels, road signs, volunteer observers).
- After facilitation implementation, determine annual road kill frequencies and growth rates
- Monitoring growth rates and road kill frequencies until they have stabilized or are consistently positive
- Continue migration facilitation unless it is deemed unnecessary ineffective

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.

(H) Feasibility
It is possible to implement this conservation action wherever volunteers are willing to help amphibians cross roads. Installation of tunnels and signs will require funding. This action is likely to improve the success of amphibian road crossings.

4.2 Conservation Action Research

Critical holes exist in knowledge of blue-spotted and Jefferson salamanders in New Hampshire. This general lack of knowledge bars the confident prescription of conservation actions. The first step is to conduct a statewide survey. Survey sites can be selected using aerial photographs and GIS data layers (as has been done in Massachusetts; contact the Massachusetts Natural Heritage Program at: natural.heritage@state

.ma.us), as well as local knowledge. Surveys should target adults, eggs, or larvae. Genotypes must be analyzed to confirm the genetic identity of individuals; thus, surveyors must clip toes of captured animals or gather eggs for DNA analysis.

Maintaining vernal pool habitat, upland habitat, and dispersal corridors will be the most effective way to protect Jefferson salamanders, if populations exist in New Hampshire. Research should address:

- Dispersal capability in both undisturbed and variously disturbed (e.g., suburbia, forest clearcuts) habitats
- Degree of isolation and regional persistence mechanism of local populations in New Hampshire and neighboring states
- Threats to the species

Research should be used to develop specific conservation actions and best management practices for this species. Such a conservation management plan should be developed in cooperation with those neighboring states and provinces that also contain the species.

Element 5: References

5.1 Literature

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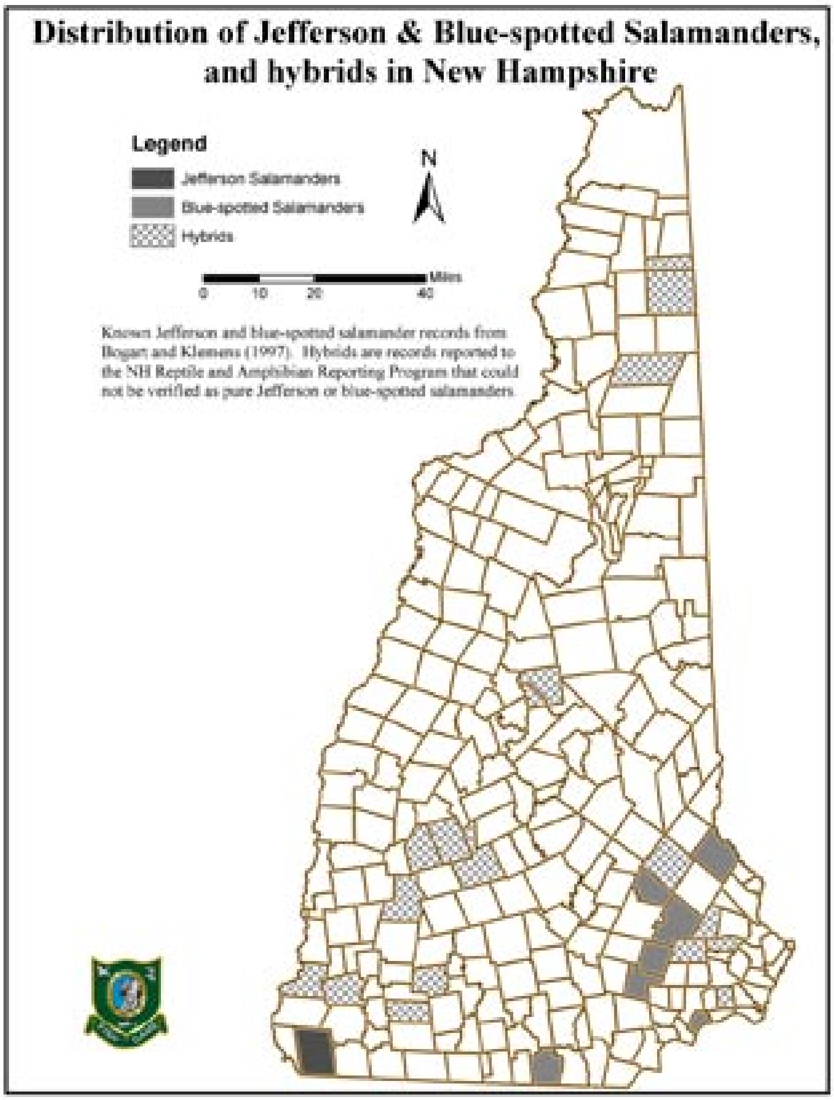
Distribution of Jefferson & Blue-spotted Salamanders, and hybrids in New Hampshire
Legend
Jefferson Salamanders
Blue-spotted Salamanders
Hybrids
N
Miles
0
10
20
40
Known Jefferson and blue-spotted salamander records from Bogart and Klemens (1997). Hybrids are records reported to the NH Reptile and Amphibian Reporting Program that could not be verified as pure Jefferson or blue-spotted salamanders.