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Survey and Comparison of Amphibian Assemblages in Two Physiographic Regions of Northeast Tennessee.

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Survey and Comparison of Amphibian Assemblages in Two Physiographic Regions of Northeast Tennessee

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by

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ABSTRACT

Survey and Comparison of Amphibian Assemblages in Two Physiographic Regions of Northeast Tennessee

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Declines in amphibian populations have prompted study of their ecology and distribution. The purpose of this study was to survey two sites located within different physiographic and one herpetofaunal region of Northeast Tennessee, comparing species composition and activity. The first, Henderson Wetland, is in the Appalachian Ridge and Valley physiographic region. The second, John's Bog, is in the Blue Ridge. Survey methods included random walks, aural surveys, and point source collections during a 16-month period (February 1999 to May 2000).

Nine caudate (Plethodontidae) and one anuran species (Ranidae) were found in John's Bog. Seven caudate (Ambystomatidae, Plethodontidae, Salamandridae) and five anuran species (Hylidae, Ranidae) were found in Henderson Wetland. Assemblages were compared using an index of community similarity.

Sites differed regarding amphibians detected. Temporal activity was not compared because of different species compositions. Instead, temporal data were compared to literature. Data will be used in future amphibian studies and site management.

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CHAPTER 1

INTRODUCTION

In recent history there has been great concern over reported declines of amphibian species (Blaustein and Wake 1990, Blaustein et al. 1994, Sarkar 1996, Heyer et al. 1994). Although the causes of decline have been debated and vary by species and region, it is generally agreed that various species of amphibians are experiencing reductions in both range and numbers. This decline has prompted interest in collection of basic distribution and ecological data about amphibians. The first attempt to standardize methods for collection of ecological and biochemical data about amphibians was published in 1994 (Heyer et al.) and many state governments have set up monitoring programs charged with collecting much needed distribution and long-term population data about amphibians.

The collection of data about amphibians in our region is prompted by 2 reasons, the general lack of data about species that occur in Tennessee and the high degree of amphibian diversity in the state. There are 21 species of anurans (frogs and toads) and 45 species of caudates (salamanders) found in Tennessee (Redmond and Scott 1996, Conant and Collins 1998). These numbers represent 33% of anurans and 45% of caudate species reported for central and eastern North America (Conant and Collins 1998). This diversity is, in part, due to the unique environmental setting in Tennessee, which includes 12 distinct physiographic regions and is highly variable in elevation, temperature, soil composition, precipitation, and vegetation.

Redmond (1985) divided Tennessee into 8 areas of faunal similarity based on cluster analyses of amphibian distributions. Frog and toad distributions resulted in 3

areas of similarity and salamander distributions produced 9 areas of similarity (Redmond 1985). The 2 sites in this study, one located in the Appalachian Ridge and Valley and the other in the Blue Ridge Mountain physiographic region, were placed in the same herpetofaunal region using salamander and all amphibian species distributions but in different areas of similarity with regard to anuran distributions (Redmond 1985).

The primary purpose of this study was to compare amphibian assemblages in sites located in 2 different physiographic regions and in the same general herpetofaunal region of Northeast Tennessee to detect similarities in species composition and in temporal occurrence of species common to the sites. Additional goals were to test the effectiveness of 3 survey methods and to collect baseline life history and distribution data on amphibian species in the sites. These data will be of use in both future studies of amphibians in Northeast Tennessee and in creation of management strategies for the sites.

CHAPTER 2

MATERIALS AND METHODS

Study Sites

The first of 2 sites surveyed in this project, Henderson Wetland, is located in the Appalachian Ridge and Valley physiographic region (Fenneman 1938). The following description of the Appalachian Ridge and Valley region was taken from USDA (1981).

> Elevation in the region ranges from 200 m near the southern end (in Alabama and Georgia) to more than 600 m in Central Virginia. Some isolated mountain ridges rise to nearly 1,500 m above sea level. Topography in the region consists of many parallel ridges, narrow intervening valleys, and large bodies of low, irregular hills. The ridges and valleys often have a difference in elevation of 200 m. Average annual precipitation in the region is 925 to 1,400 mm. Maximum precipitation is in midwinter and in midsummer, and the minimum is in autumn. Average annual temperature is 13 to 16 C. Average freeze-free period in the region is 170 to 210 days. Most of the soils are Udults and, to a lesser extent, Ochrepts. They have an udic moisture regime and a thermic or mesic temperature regime. The soils dominantly are well drained, strongly acid, and highly leached and have a clay-enriched subsoil. They range from shallow on the sandstone and shale ridges to very deep in the valleys and on the large limestone formations. This area supports hardwood or mixed hardwood-pine forest vegetation. The deeper soils support good oak-hickory stands. The shallower soils, mostly on southern and western slopes, support pine or oak-pine types. Understory vegetation is also reflected by aspect.

Henderson Wetland is a state-managed wetland located on Crestview Road in Bowmantown, Washington County, TN (Latitude: N 36° 16.48, Longitude: W 82° 35.04). The wetland, elevation approximately 430 m (1410 ft), encompasses an area of about 10.09 ha (25 ac). Approximately 75% (7.57 ha, 18.75 ac) of the site was monitored during this project. Macroenvironmental data for Henderson Wetland includes edaphic and hydrologic data (Table 1). A provisional community classification for Henderson Wetland was proposed by Donaldson (2000) and will be made official in 2001 (Smoot Major, Ecologist and Coordinator, Tennessee Natural Heritage Program, pers. comm.). A description of this classification, along with a list of primary vegetation in the site (Donaldson 2000) is given in the Appendix.

The second site, John's Bog, is located in the Blue Ridge Mountain physiographic region (Fenneman 1938). The USDA (1981) describes the Blue Ridge physiographic region as follows:

> Elevation ranges from 300 m in the lower valleys and on foot slopes to more than 2,000 m in the mountains along the Tennessee-North Carolina boundary, decreasing gradually both north and south from this high point. The rugged mountains have steep slopes, sharp crests, and narrow valleys. Stream dissection is deep and intricate. Major streams and their tributaries flow through gorges and gaps of the mountains. Broad valleys and basins with rolling hills are extensive throughout the area. Local relief is 100 to more than 1,000 m. Average annual precipitation is mainly 1,025 to 1,275 mm but as much as 2,025 mm on the highest peaks in the south. Precipitation is somewhat unevenly distributed. The maximum is in midsummer and in midwinter and the minimum in autumn. Precipitation is 900 to 1,025 mm in the Asheville basin and in similar protected areas. Average annual temperature is 10 to 16 C. Average freeze-free period is 150 to

220 days, decreasing with increasing elevation and from south to north. It is sharply reduced on elevated peaks. The dominant soils are Ochrepts and Udults. They are moderately deep and deep and medium textured. These soils have a mesic temperature regime, an udic moisture regime, and mixed mineralogy. This area supports Appalachian oak forest vegetation. White pine-hemlock, chestnut oak, white oak-red oak-hickory, northern red oak- basswood-white ash, yellow poplar-white oak-northern red oak, and loblolly pine- shortleaf pine are important cover types. Dogwood, hornbeam, pawpaw, sassafras, persimmon, greenbrier, leatherwood, mountain-laurel, rhododendron, and witchhazel are included in the understory vegetation. Red spruce and balsam fir grow at higher elevations.

John's Bog, a cranberry fen, is located in the Cherokee National Forest off Highway 421 on Locust Knob Road (FDR 6079) in Shady Valley, Johnson County, TN (Latitude: N 36° 31.75, Longitude: W 81° 57.77). John's Bog, elevation approximately 1018 m (3339 ft), encompasses 0.61 ha (1.5 ac). A community classification and a list of vegetation for John's Bog (Donaldson 1996) are provided in the Appendix. Macroenvironmental data for the site are shown in Table 1. An additional site, approximately 0.40 km (0.25 mi) east of John's Bog on Locust Knob Road (FDR 6079), was a spring surveyed concurrently with the bog. Data from the spring site (0.20 ha, 0.5 a) are included with data from John's Bog for the purposes of this study.

Table 1. Macroenvironmental Data for Regions Including Study Sites

Environmental Data	**Henderson Wetland**	**John's Bog**
Physiographic Region	Appalachian Ridge and Valley	Blue Ridge Mountain
Climatic Division	East	East
General Soil Area	Ridges and Valleys	Unaka Mountains
Major Drainage	Tennessee River	Tennessee River
Vegetative Features	Appalachian Oak Forest	Appalachian Oak Forest
Elevation	430 m	1018 m

Survey Methods

Henderson Wetland and John's Bog were surveyed during a period of 16 months from February 1999 to May 2000. Three survey methods, random walks, aural surveys, and point source collections, were employed during a total of 19 visits to Henderson Wetland and 17 visits to John's Bog. The temporal distribution of visits to each site is shown monthly in Table 2 and by season in Figure 1. The majority of survey time at each site (62% in Henderson Wetland; 64% in John's Bog) was spent during evening hours, between 6:00 and 11:00 PM, when the majority amphibian species are active. In consideration of diurnal species, a portion of survey time (38% in Henderson Wetland; 36% in John's Bog) was spent during daylight hours (i.e., before 6:00 PM).

A random-walk method (Heyer et al. 1994) was employed at the sites. The first step in this method was selection of a random starting point, determined by numbering 10 points throughout each site and selection of a number (1 through 10) from a bag of numbered cards. After the starting point was selected, a series of random compass directions and corresponding series of lengths were chosen from a random numbers table. The first 2 digits of a random number corresponded to direction and the last 2 to length. An area of 1 m on either side of the transect was searched visually for all amphibians. Searches included removal and replacement of all cover objects and dip-net sampling for larvae. Because of time constraints, a minimum transect length of 90 m and a maximum of 130 m were set. Selections were chosen until the transect reached at least 90 m in length. If a selection caused length to exceed 130 m, it was discarded and another made. A schematic drawing of a random walk is shown in Figure 2.

Table 2. Numbers of Survey Visits by Month

Month/Year	Number Visits to John's Bog	Number Visits to Henderson Wetland
2/99	1	1
3/99	2	1
4/99	3	3
5/99	2	2
6/99	1	1
7/99	1	1
8/99	1	1
9/99	1	1
10/99	0	1
11/99	0	0
12/99	1	1
1/00	0	1
2/00	2	2
3/00	1	1
4/00	0	1
5/00	1	1

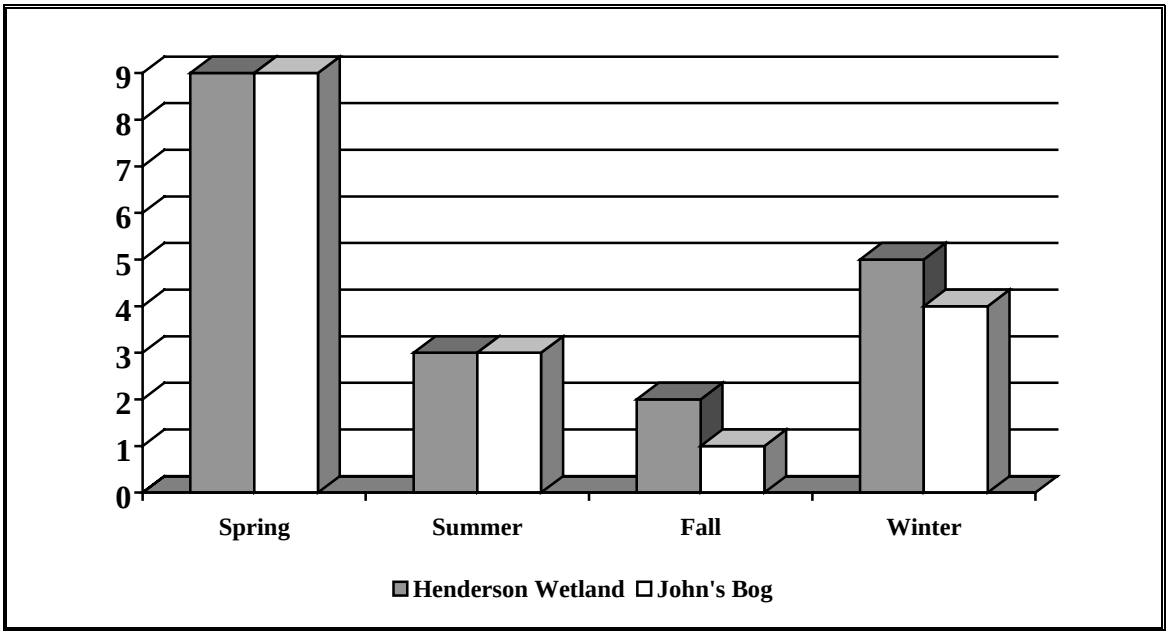

Figure 1. Number of Survey Visits by Season.

(Spring = March-May; Summer = June-Aug.; Fall = Sept.-Nov.; and Winter = Dec.-Feb.)

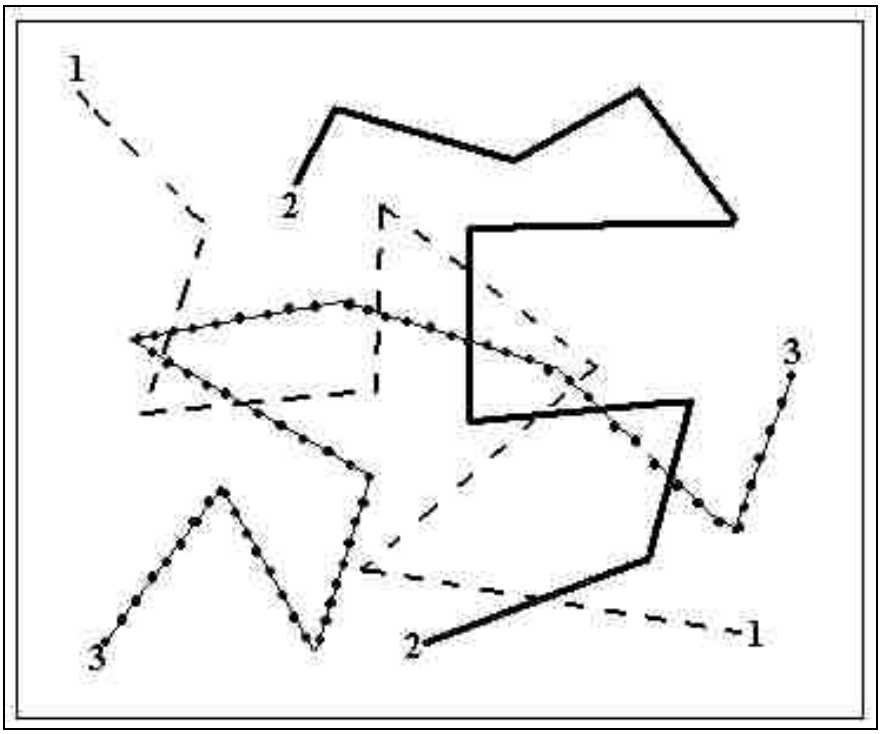

Figure 2. Schematic Drawing of a Typical Random Walk Survey

Note: The lines 1, 2, and 3 represent three separate survey visits to a site.

Taxonomy in this study followed Conant and Collins (1998) and only subspecific designations listed in that publication were used. When possible, individuals were identified in the field and released. However, some individuals were collected and taken to the lab for identification. Specimens taken to the lab were returned within 1 week as close as possible to the site of capture. The only exception to this process was collection of voucher specimens. The 2nd individual of a species was collected and preserved as a voucher. Voucher specimens, maintained in the amphibian collection at East Tennessee State University by Dr. R. A. Pyles, were anesthetized in MS – 222, fixed in formalin, and preserved in 75% ethanol.

Anuran species in the sites were also monitored using an aural survey method, similar to one described by Heyer et al. (1994) and used by many state anuran-monitoring programs. This method began with a 5-minute waiting period after arriving to ensure that frogs disturbed by the arrival of the researcher had time to begin calling again. Following the waiting period, a 10-minute monitoring period began during which all calling anurans were identified. If large numbers of anurans were calling, the number was quantified as either chorus (calls of individuals could not be distinguished) or partial chorus (calls overlapped but individuals could be distinguished). When possible, exact numbers of calling individuals were counted.

Point-source collections were used to supplement random walk and aural methods and served as the major source of voucher specimens. Point-source collections were simply random searches in habitats where amphibians were believed likely to occur. For instance, springs, pond, and stream areas were intensively, visually searched for all amphibians. Specimens were captured, identified, and released as during random walks.

Point-source collections provide reliable information about presence or absence of species, but no information about the densities of those species.

A species list for each site was compiled using data collected by all survey methods. Species lists were compared using an Index of Similarity, 2C/a+b (Krebs 1972 p. 402), where C = number of species common to both sites and "a" and "b" = total numbers of species found in each site, respectively. This equation results in a measure of similarity ranging from 0 (no similarity) to 1 (100% similarity). Relative species abundances were calculated by dividing total numbers of individuals of a species by total numbers of individuals of all species in a site (Brower et al. 1998).

Environmental Data Collection

Air temperature and water temperature and pH were measured at both sites during 67% of visits. Air temperature was measured prior to survey. Water temperature was measured at 3 random points, averaged, and recorded. Seven water samples collected from each site in Nalgene containers were taken to the lab where pH measurements were performed. In addition, historical weather data for the regions from nearby NOAA weather stations, including average monthly precipitation and maximum and minimum temperature were collected and compared. Data for Henderson Wetland were taken from a station in Greeneville, TN, approximately 30 km SW of the site [station elevation about 402m (1318 ft.)]. Precipitation data for John's Bog were taken from a station in Mountain City, TN, approximately 15km ESE of the site [station elevation about 765m (2509 ft)]. Temperature data for John's Bog were taken from a station in Banner Elk, NC, approximately 40km SSE of the site [station elevation about 1143 m (3750 ft)].

CHAPTER 3

RESULTS

Habitat Descriptions

Henderson Wetland

Five recognizably different habitat types were defined in Henderson Wetland using hydrologic and vegetative characters (Figure 3). The first and largest habitat in Henderson Wetland was a marsh or pond area, referred to as the wetland. This area was defined by standing water during the majority (>75%) of visits. Primary vegetation in the pond/marsh (Donaldson 2000) was an invasive exotic iris (*Iris pseudoacorus*), cattails (*Typha latifolia*), and grasses. Woody vegetation was mainly Buttonbush (*Cephalanthus occidentalis*) and small number (fewer than 10) of Bald Cypresses (*Taxodium distichum*) planted by Tennessee Wildlife Resources Agency.

The Flooded Forest typically contained standing water (>75%) of visits, but included extensive woody vegetation, in addition to *Iris pseudoacorus* and other herbaceous species. It should be noted that substrate in this area was extremely saturated, and sinkholes as deep as a meter or more were encountered frequently.

Two dry sections of forest (Figure 3) were combined to form the 3rd habitat type, Dry Forest. Standing water was not encountered in these areas on any visit. One section was elevated approximately 10 to 15 m higher than the wetland. Whereas the other section was well drained because of a small stream (possibly constructed) that ran through it.

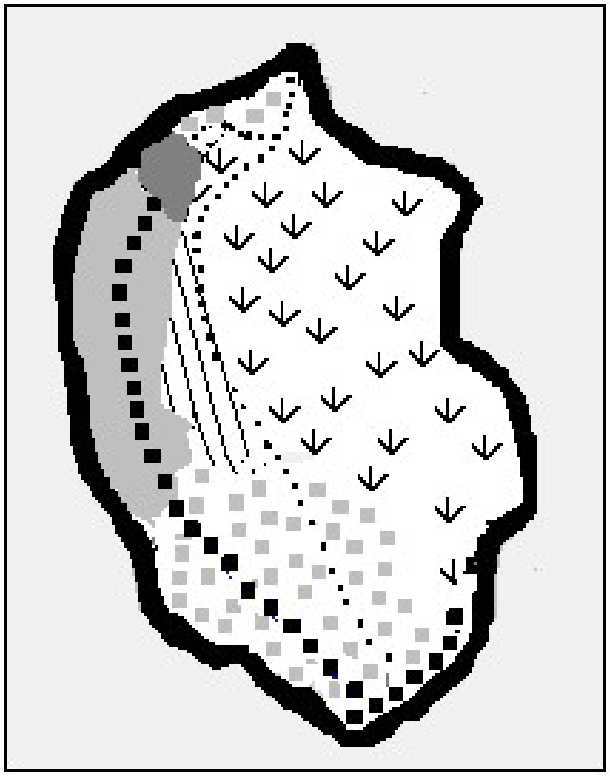

Figure 3. Schematic Drawing of Habitats Described in Henderson Wetland – Not to Scale

= Flooded Forest

= Dry Forest

= Wetland

= Spring

= Stream

= Dry Field

= Road

A large spring, the 4th habitat surveyed, fed the stream that ran through the Dry Forest (Figure 3). The spring was 5/10 m wide, always contained at least 0.5 m of water, and the perimeter was strewn with a few large rocks. Substrate in the spring, a mix of sand and mud, was extremely saturated. Bordering the spring on one side was a dry area where a picnic shelter was constructed during the course of this study.

Two dry fields, assumed to be old pasture fields, were also included in the Henderson Wetland site. One field was excluded from this study because it contained no suitable habitat for amphibians (i.e., it was constantly dry and contained no cover objects). A 2nd, smaller field was surrounded by wet areas and contained cover objects in the form of logs and large clumps of vegetation (Figure 3). This Dry Field was included as the 5th habitat.

John's Bog

John's Bog was divided into 5 habitat types based on hydrologic and vegetative characters (Figure 4). The largest habitat was the Bog itself, which comprised a large area in the center of the site that was dominated by sphagnum moss, sedges, and other herbaceous vegetation. This habitat was moist with substrate saturated on most visits, but standing water was noted only in areas proximal to springs (Figure 4).

Forest habitat in the site included an old road and forest that encircled the bog (Figure 4). The substrate in this habitat was dry on all visits, with the exception of areas near springs, and numerous cover objects were present. A dry ridge opposite to the Forest contained sparse woody vegetation. The difference in vegetation between this and the other Forest habitat facilitated its designation as a 3rd habitat type, Dry Ridge.

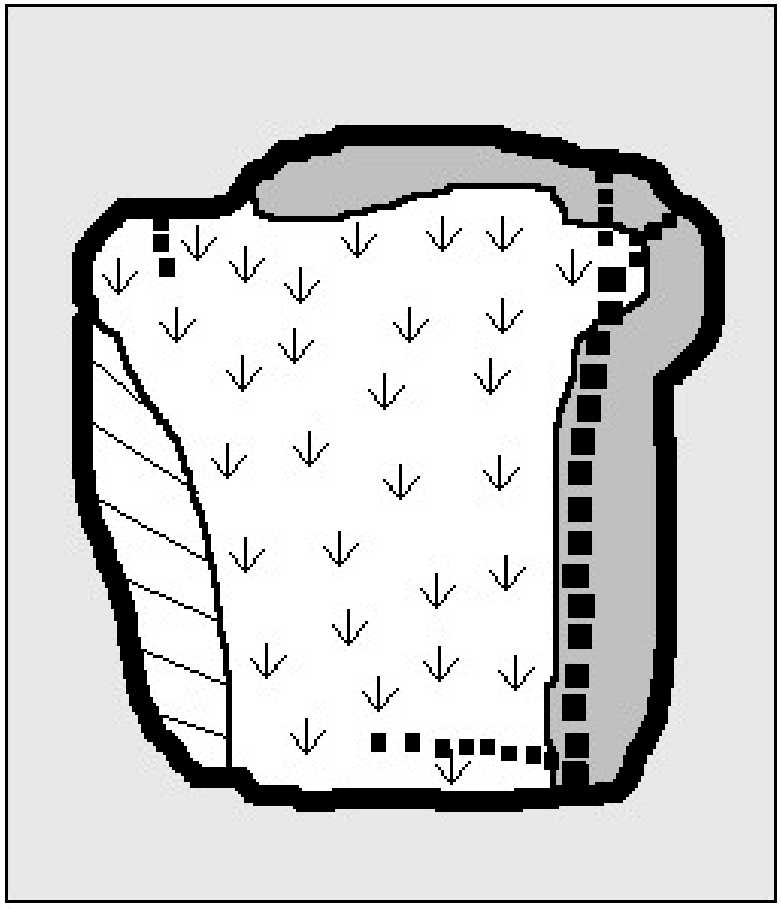

Figure 4. Schematic Drawing of Habitats Described in John's Bog (Not to Scale)

= Bog

= Dry Ridge

= Forest

= Stream

=Springs

Spring habitat in John's Bog included 4 springs adjacent to the bog and an additional site surveyed concurrently with the bog. Two springs were located in the bog itself and ran directly out into vegetation (Figure 4). The other 2 springs were located in the forest around the edge of the bog. Three springs joined to form a small stream that ran along east side of the bog. This stream and an area approximately 2 m on either side comprised the 5th habitat type identified for John's Bog, Stream habitat.

Environmental Data

There were no significant differences in measurements of air and water temperature taken from the sites. Average air temperature (n = 12) was 15.9°C in Henderson Wetland and 16.3°C in John's Bog. Average water temperature (n = 8) was 12.7°C in Henderson Wetland and 12.2°C in John's Bog. However, precipitation and average monthly maximum and minimum temperatures (Hoare 1996) based on data from NOAA Cooperative Weather Stations, when compared for the 2 areas, demonstrated differences in both temperature and precipitation. These data (Tables 3 and 4) established that John's Bog was the cooler of the 2 sites, and that precipitation was greater in the area around the bog.

Measurements of pH revealed significant differences in acidity (Table 5). The pH in Henderson Wetland was consistently between 6 and 7, while measurements in John's Bog were never above 5.2. Average pH for John's Bog was 4.75, but was 6.64 for Henderson Wetland.

Table 3. Average Maximum and Minimum Temperatures

Month	**Henderson Wetland** [a]		**John's Bog** [b]	
	Maximum	Minimum	Maximum	Minimum
Jan	7.3	-5.1	6.2	-5.1
Feb	9.8	-3.6	7.0	-4.7
Mar	15.4	1.0	11.0	-1.4
Apr	20.3	5.3	16.1	2.6
May	24.8	10.5	20.3	6.9
Jun	28.7	15.2	23.8	11.0
Jul	30.3	17.6	25.2	13.0
Aug	29.8	17.0	24.8	12.4
Sep	26.9	13.4	22.3	9.5
Oct	21.1	6.0	17.5	3.6
Nov	15.5	1.2	11.5	-1.2
Dec	9.8	-3.1	7.1	-4.3
Yearly Average	20.0	6.2	16.1	-3.6

[a] Data (in degrees Celsius) were derived from NCDC TD 9641 Clim 81 1961-1990 Normals from National Climatic Data Center Cooperative Weather Station – Greeneville Exp. Station, Greeneville, TN and are available at ftp://www.ncdc.noaa.gov/pub/data/normals/. Average data are based on 30 years between 1961 and 1990 (Hoare 1996).

[b] Data (in degrees Celsius) were derived from the Global Historical Climatology network, version 2.0 beta (www.ncdc.noaa.gov/cgi-bin/res40.pl) from National Climatic Data Center Cooperative Weather Station – Banner Elk in Banner Elk, North Carolina from 1044 (maximum) and 1045 (minimum) months of data for years between 1907 and 1996.

Table 4. Average Monthly Rainfall

Month	**Henderson Wetland**[a] (mm)	**John's Bog** [b] (mm)
Jan	84.0	91.3
Feb	85.3	104.2
Mar	102.1	122.3
Apr	86.3	105.6
May	100.5	105.0
Jun	95.2	98.3
Jul	123.9	120.6
Aug	88.9	104.9
Sep	82.8	99.6
Oct	67.3	77.0
Nov	77.4	81.4
Dec	78.9	104.9
Yearly Total	1073.1	1215.9

[a] Data (in millimeters) derived from National Climatic Data Center Cooperative Weather Station – Greeneville Exp. Station. Greeneville, TN and are available at www.ncdc.noaa.gov/ol/climate/online/coop-prceip.html. Average data are based on 30 years between 1961 and 1990 (Hoare 1996).

[b] Data (in millimeters) derived from National Climatic Data Center Cooperative Weather Station – Mountain City 2, Johnson County, TN and are available at www.ncdc.noaa.gov/ol/climate/online/coop-prceip.html. Average data are based on 19 complete years from 1956 and 1995 (Hoare 1996).

Table 5. Measurements of pH (n =7)

Site	**pH Minimum**	**pH Maximum**	**pH Mean [a] (± SEM)**
John's Bog	4.38	5.20	4.75(±0.104)
Henderson Wetland	6.12	6.64	6.46(±0.063)

[a] Mean pH was calculated by SUM (pH)/n where n = 7.

Species Occurrences and Community Similarity

An Index of Similarity (Krebs 1972) was used to compare anuran, caudate, and total amphibian assemblages. The sites were different with regard to both anurans and caudates present. Indices of Similarity calculated for various taxonomic assemblages resulted in measures of less than 40% similarity (Table 6). In addition to differences in species composition, large differences in abundance were detected.

Henderson Wetland was the more diverse site with regard to frogs. Five species were documented from Henderson Wetland, while only 1 species was found in John's Bog (Table 7). The most abundant frog in Henderson Wetland based either on the number of visits during which it was encountered or on the percentage of visits including choruses of frogs was *Pseudacris crucifer crucifer*. The least abundant species, detected once by aural survey, was *Rana sylvatica* (Figure 5). Signs of recruitment, defined as eggs or presence of larvae, were found for *Rana sylvatica* and a *Pseudacris* species in Henderson Wetland.

Documentation of *Rana sylvatica*, the only frog found in John's Bog (Table 7), was one occurrence of 2 juvenile frogs (SVL < 3 cm) moving through the site during morning hours (between 10:00 and 11:00 am). It should be noted that 2 anuran species, *Pseudacris c. crucifer* and *Bufo americanus* were detected aurally or visually, respectively, within 1 mile of the site. It was decided that these occurrences were not close enough to be included in the species list. No signs of recruitment (eggs or larval specimens) were found for anurans in John's Bog.

Table 6. Index of Similarity Values for Study Sites [a]

	Number Species in Henderson Wetland (a)	**Number Species in John's Bog (b)**	**Species Common to Both Sites (C)**	**Similarity Value [a]**
Anuran Species	5	1	1	33%
Caudate Species	7	9	3	38%
All Amphibian Species	12	10	4	36%

[a] 2C/(a+b) where C = total species and a and b = species in each site

(Krebs 1972 p. #402)

Table 7. Anuran Species Detected, February 1999 to May 2000

Henderson Wetland	John's Bog
Pseudacris triseriata feriarum **av**	
Pseudacris crucifer crucifer **av**	
Rana sylvatica **avn**	*Rana sylvatica* **vn**
Rana clamitans melanota **an**	
Rana palustris **av**	

a = Species detected aurally

v = Species detected visually

n = No voucher collected

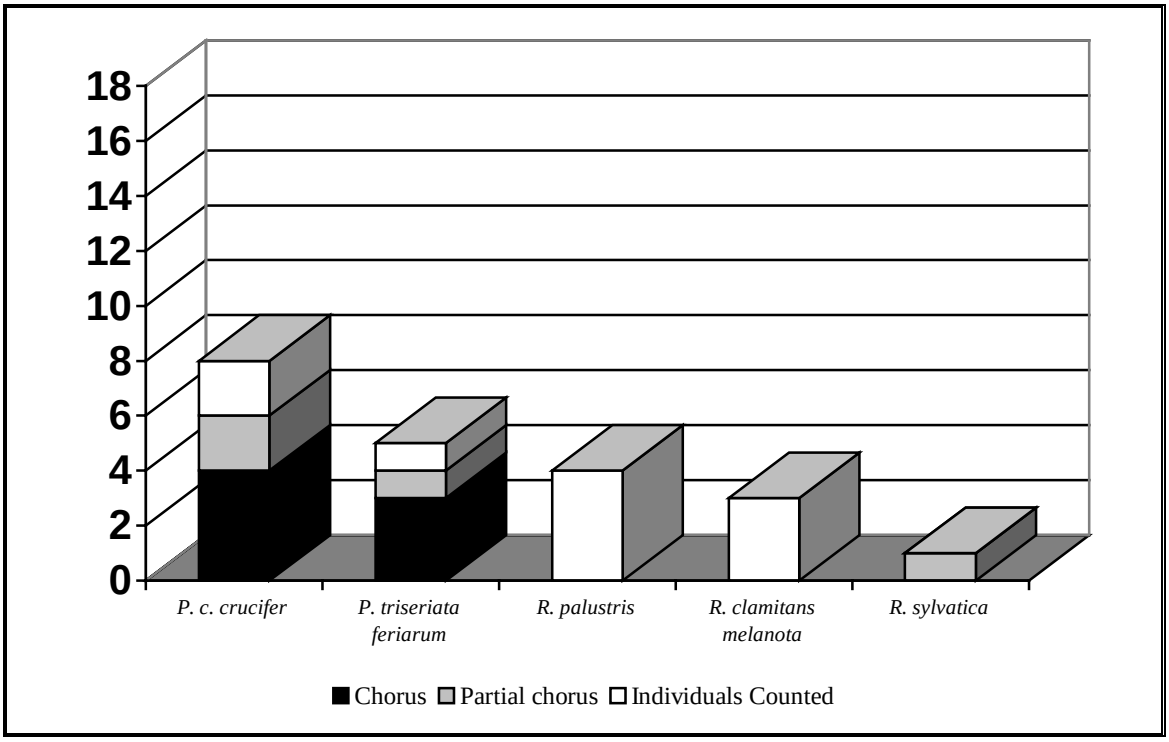

Figure 5. Frequencies of Anurans in Henderson Wetland [a]

[a] Total bar height represents the number of visits (from a total of 19) during which a particular species was calling. Color codes within bars represent the percentage of those samples that included each chorusing behavior.

Henderson Wetland not only supported more frog species, but numbers of individuals of those species greatly exceeded numbers found in John's Bog. Only 2 individual frogs were found in John's Bog. However, frogs were detected during 47% of visits to Henderson Wetland.

Caudate data presented a very different picture than data for anurans. The sites were similar with regard to numbers of species present with 9 in John's Bog and 7 in Henderson Wetland. However, the sites differed in both species composition (Table 8) and numbers of individuals (Tables 9 and 10).

John's Bog was the most diverse site based on the number of salamander species. Nine species were found in the bog (Table 8). The most abundant species (based on adult specimens found) was *Desmognathus ochrophaeus*. Two species, *Eurycea wilderae* and *Plethodon yonahlossee,* were least abundant, represented by 1 individual. Relative species abundances for caudates in John's Bog are shown in Table 9. Larval specimens of *Gyrinophilus porphyriticus porphyriticus* and *Pseudotriton ruber ruber* were found in the site. Gravid specimens of *Eurycea wilderae* and *Desmognathus quadramaculatus* (defined by large, yolked ova) were also found. John's Bog was also richer with regard to numbers of individual caudates. The rate of collection of caudates, expressed as individuals per hour, in John's Bog was over 7 times greater than in Henderson Wetland (Table 11).

Table 8. Caudate Species Detected, February 1999 to May 2000.

Henderson Wetland Site	John's Bog Site
Ambystoma maculatum [aen]	
Desmognathus fuscus fuscus [an]	*Desmognathus fuscus fuscus* [aj]
Desmognathus ochrophaeus [an]	*Desmognathus ochrophaeus* [aj]
Desmognathus monticola [an]	
	Desmognathus quadramaculatus [agn]
Eurycea wilderae [al]	*Eurycea wilderae* [agn]
	Gyrinophilus porphyriticus porphyriticus [al]
Notophthalmus viridescens viridescens [an]	
Plethodon hoffmani [an]	
	Plethodon cinereus [a]
	Plethodon cylindraceus [a]
	Plethodon yonahlossee [an]
	Pseudotriton ruber ruber [al]

[a] 1 or more adults
[e] Egg mass
[g] Gravid female
[j] Juvenile
[l] Larvae
[n] No voucher collected

Table 9. Relative Species Abundance of Caudates in John's Bog [a]

Species	Number Individuals	Relative Abundance
Desmognathus fuscus fuscus	25	0.294
Desmognathus ochrophaeus	34	0.400
Desmognathus quadramaculatus	5	0.059
Eurycea wilderae	1	0.012
Gyrinophilus porphyriticus porphyriticus	1	0.012
Plethodon cinereus	12	0.141
Plethodon cylindraceus	3	0.035
Plethodon yonahlossee	1	0.012
Pseudotriton ruber ruber	3	0.035
Total	85	1.000

[a] Based on occurrence of adult specimens

Table 10. Relative Species Abundance of Caudates in Henderson Wetland [a]

Species	Number of Individuals	Relative Abundance
Ambystoma maculatum	1	0.125
Desmognathus fuscus fuscus	1	0.125
Desmognathus ochrophaeus	1	0.125
Desmognathus monticola	1	0.125
Eurycea wilderae	1	0.125
Notophthalmus viridescens viridescens	2	0.250
Plethodon hoffmani	1	0.125
Total	8	1.000

[a] Based on occurrences of adult specimens

Table 11. Collection Rates for Caudates Using Visual Searches [a]

Study Site	Hours Spent in Visual Searches	Number of Individuals Collected	Collection Rate (Specimens per Hour)
Henderson Wetland	23.80	11	0.46
John's Bog	27.98	97	3.47

[a] Occurrences of groups of larval specimens or egg masses were counted as one specimen

According to this study, Henderson Wetland supports a poorer salamander assemblage, composed of 7 species. The most abundant species (based on adult specimens) was *Notophthalmus v. viridescens*, represented by 2 individuals. All other caudate species in the wetland were represented by 1 adult specimen each. Relative species abundances for salamanders in Henderson Wetland are shown in Table 10. Signs of recruitment, larval specimens or eggs, for *Eurycea wilderae* and *Ambystoma maculatum*, were detected in the site.

Occurrences of amphibians were grouped by season (Figures 6 and 7). It was not practical to compare temporal distribution of species common to both sites because of differences in numbers and types of species found. However, occurrences were compared to published data to detect similarities.

Species	**Spring (March-May)**		**Summer (June-Aug.)**		**Fall (Sept.-Nov.)**		**Winter (Dec.-Feb.)**	
Pseudacris crucifer crucifer	●		●				●	
Pseudacris triseriata feriarum	●						●	
Rana clamitans melanota	●		●					
Rana palustris	●							
Rana sylvatica				■			●	

Figure 6. Seasonal Occurrence of Anurans (● = Henderson Wetland, ■ = John's Bog)

Species	**Spring (March-May)**		**Summer (June-Aug.)**		**Fall (Sept.-Nov.)**		**Winter (Dec.-Feb.)**	
Ambystoma maculatum	●							
Desmognathus fuscus fuscus	●	■		■		■		■
Desmognathus monticola							●	
Desmognathus ochrophaeus	●	■		■		■		■
Desmognathus quadramaculatus		■						
Eurycea wilderae	●	■	●					
Gyrinophilus porphyriticus porphyriticus		■		■		■		■
Notophthalmus viridescens viridescens	●							
Plethodon cinereus		■		■				
Plethodon cylindraceus		■						
Plethodon hoffmani	●							
Plethodon yonahlossee				■				
Pseudotriton ruber ruber		■		■		■		

Figure 7. Seasonal Occurrence of Caudates (● = Henderson Wetland, ■ = John's Bog)

CHAPTER 4

DISCUSSION

Community Similarity and Temporal Comparisons

Distribution of species is controlled by a multitude of large-scale environmental and ecological factors. “Geologic, climatic, and evolutionary events of the past have played an important role in the development of the present-day distributions of amphibians in Tennessee” (Redmond 1985). However, smaller scale environmental variables including elevation, pH of water and soil, habitat structure, temperature, and amount and timing of rainfall influence both distribution and activity patterns of amphibian species within their ranges (Heyer et al. 1994, Conant and Collins 1998, Pough et al. 1998).

The variety of environmental settings in Tennessee promotes a diverse amphibian population. On a large scale, parts of the state may be clumped into areas of herpetofaunal similarity using species occurrences, as shown by Redmond (1985). However, distribution and temporal occurrence of species within those areas is not homogenous. The purpose of this study was to survey and compare 2 sites within different physiographic regions and the same general herpetofaunal area in Northeast Tennessee. Additional purposes were to collect baseline data about amphibians to be used in both future studies of amphibians and in formation of management strategies for the sites and to determine the effectiveness of 3 survey methods.

The sites in this study, Henderson Wetland and John’s Bog, supported very

different amphibian assemblages, with a Similarity Index of less than 40%. Several frogs were found in Henderson Wetland while only 1 species was found in John's Bog. Both sites supported a diverse assemblage of caudates, but species composition and richness of salamanders varied greatly between the 2. Differences in species assemblages did not allow comparisons about the activity of species common to the sites to be made with confidence. Therefore, data collected about activity of species were compared to published information.

Differences in species composition in the sites could be attributed to differences in multiple environmental factors. Average temperatures, elevation, rainfall, and pH in the 2 sites were different. In addition, overall habitat structure and placement within species' ranges were different.

Significantly more anurans were found in Henderson Wetland than in John's Bog. The sites are in different herpetofaunal regions based on anuran distributions with the notable difference being the absence of *Acris crepitans* from the area near John's Bog (Redmond 1985). However, absence of anuran species from John's Bog is probably attributed to small-scale factors including pH and/or habitat structure.

The acidity of water in Henderson Wetland and John's Bog was very different (Table 5). Naturally acidic conditions are found in peat bogs, *Sphagnum* sp. dominated ponds, and blackwater streams and ponds (Gorham et al. 1985). Low pH in John's Bog may be due to natural processes including, but not limited to, the presence of *Sphagnum* moss. Presence of *Sphagnum* sp. lowers pH in bogs because of the release of hydrogen ions into the water. In addition to lowering the pH in the entire site, areas near dense growths of *Sphagnum* sp. may have an additionally lowered pH (Gorham et al. 1985).

Low pH has been shown by numerous studies to increase mortality in amphibian larvae (Gosner and Black 1957, Pough 1976, Ling et al. 1986, Freda et al. 1991). Sublethal pH has been shown to produce detrimental effects such as growth inhibition in tadpoles (Freda and Dunson 1985, Ling et al. 1986). Tolerance limits of amphibians for pH vary both by species and genetically (Gosner and Black 1957, Pierce and Wooten 1992). It was shown by Freda and Taylor (1992) that amphibian larvae may actively avoid areas of low pH. While pH may play a role in limiting anuran diversity in John's Bog, habitat structure probably plays a greater role.

All frogs and toads in Northeast Tennessee require pools or ponds for egg deposition. While the size of the pool required may vary by species, from small puddles sometimes used by *Rana sylvatica* to larger ponds and lakes required by *Rana catesbeiana* (Martof et al. 1980), open water is a requirement. This type of habitat did not exist in John's Bog. The majority of open water in the site was in the Stream habitat. The Bog habitat, where pools may have been possible, was choked with vegetation and offered no pools or pond-like areas. In contrast, Henderson Wetland offered many areas of open water for breeding. Three habitats, the Wetland, Flooded forest, and Spring all offered areas of open, still water. The presence of open water in Henderson Wetland may also explain the presence of 2 caudate species, *A. maculatum* and *N. v. viridescens,* which both use pool habitats for egg deposition.

The sites were placed in the same herpetofaunal region based on salamander distributions (Redmond 1985). However, salamander species composition and richness were very different in the 2. Henderson Wetland did not support large populations of caudates with only 11 individuals found during this study. Again, several explanations

exist for this fact. It is possible that 1 species, *Desmognathus ochrophaeus*, may reach the western limit of its range in Washington County. It is also possible that the wetland, which contains very few cover objects and is surrounded by mainly agricultural land, is marginal habitat that does not support rich caudate populations. Other explanations might also include lowered water quality and/or disturbance. However, this study did not adequately test for these variables, and, thus, they are only as possible causes.

Caudate data from this study were compared to data from Morgan (1998) for Buffalo Mountain, Washington County, Tennessee. Buffalo Mountain is an outlier of the Blue Ridge physiographic region (Fenneman 1938). Morgan's site, intermediate in elevation (616 to 665m) between John's Bog (1018 m) and Henderson Wetland (430 m), was in a forested area. Physical structure consisted mainly of stream and seep habitat (Morgan 1998). Thus, it resembled areas of John's Bog more closely than habitats found in Henderson Wetland. Indices of similarity calculated for the 3 sites are shown in Table 12. Buffalo Mountain and John's Bog are more similar (74%) than either compared to Henderson Wetland. This would seem to suggest that while differences in presence or absence of a few species in Henderson Wetland and John's Bog are because of large-scale differences, the majority of variation in species composition is facilitated by smaller scale differences, perhaps habitat structure and/or elevation.

It was hypothesized that differences in environmental factors including temperature and precipitation could produce differences in activity of species found in both Henderson Wetland and John's Bog. However, species assemblages in the 2 were so different that temporal comparisons were deemed inappropriate. Instead, occurrences were compared to literature to determine if observations made in this study were typical.

Table 12. Indices of Similarity for Caudate Species in Henderson Wetland, John's Bog, and Buffalo Mountain [a]

Sites Compared	Similarity Index[b]
Henderson Wetland vs. John's Bog	38%
Henderson Wetland vs. Buffalo Mountain	47%
John's Bog vs. Buffalo Mountain	74%

[a] Data for Buffalo Mountain were taken from Morgan (1998).

[b] 2C/(a+b) where C = total species and a and b = species in each site (Krebs 1972 p. 402)

All frogs found in this study with the exception of 2 observations were found in Henderson Wetland. Occurrences of anurans recorded in Henderson Wetland are temporally consistent with published data for anurans in Northeast Tennessee. *Pseudacris c. crucifer* (Northern Spring Peeper) breeds from February to May in our region (Martof et al. 1980) and may be heard from December through April (Lamb 1996). However, individuals may be found at other times wandering through the woods in damp and rainy weather (Conant and Collins 1998). *Pseudacris c. crucifer* was found by aural survey in Henderson Wetland beginning in February, and choruses or partial choruses continued throughout spring and summer with the latest in August, which concurs with published data for this species.

Another *Pseudacris* species, *Pseudacris triseriata feriarum* (Upland Chorus Frog), was also found in Henderson Wetland. Upland Chorus Frogs breed in semipermanent pools from February to May in the northern part of their range (Martof et al. 1980). These frogs were found in full chorus in February 1999 in Henderson Wetland. Choruses and partial choruses continued throughout spring with the latest during the first week of May. A full chorus of *P. triseriata feriarum* was observed again in February 2000. The data collected for this species seem to concur with published information.

Rana sylvatica (Wood Frog) is the earliest breeding frog in our region. This species breeds from January to late February (Wilson 1995) and breeding is concentrated into a few days (Meeks 1972). In February 1999, Wood Frogs were in partial chorus in Henderson Wetland and an egg mass was found, indicating that breeding occurred in the site and timing was consistent with published information. Only 1 occurrence (2 juvenile Wood Frogs in early June 1999) indicated that *Rana sylvatica* was present near John's

Bog. However, there was no evidence that Wood Frogs used the fen as a breeding site.

Another ranid, *Rana clamitans melanota* (Green Frog), breeds fairly late in the season, mainly in May and June (Martof et al. 1980) but may be heard from late April to August (Wilson 1995). Occurrences of Green Frogs in Henderson Wetland were fairly scarce, with a total of 3 observations. Two occurrences in May of 1999 and 2000 were single frogs and 3 frogs were heard in July, 1999. No evidence of breeding (eggs or larvae) was found for Green Frogs, but timing of calling behavior seemed consistent with published information about breeding.

Pickerel Frogs (*Rana palustris*) breed from late winter to early spring with the advent of heavy rains (Martof et al. 1980). While no evidence of breeding by Pickerel Frogs was found in Henderson Wetland, a few calling males were detected using aural survey. All Pickerel Frogs in the site were found in April and May, as would be expected from published information. No more than 3 frogs were detected during any visit.

Three species of caudates were found in both sites. *Desmognathus ochrophaeus* was found only in the spring months in Henderson Wetland but was found throughout the course of study in John's Bog. Morgan (1998) also reported occurrence of this species throughout the year in Northeast Tennessee. Another dusky salamander, *Desmognathus f. fuscus*, was found in Henderson Wetland in the spring months but was found in all seasons in John's Bog. A period of surface inactivity in winter has been reported for *D. f. fuscus* (Ashton 1975), and it should be noted that winter dates of discovery for *D. f. fuscus* in John's Bog were in late February. Morgan (1998) did not find *D. f. fuscus* during summer months on Buffalo Mountain. *Eurycea wilderae* was also found in both sites. An adult specimen was found in Henderson Wetland in August 1999 and larvae

were present in both spring of 1999 and of 2000. A gravid female was found in the spring/seep site (surveyed concurrently with John's Bog) in spring of 1999. Courtship in this species occurs in fall and eggs are laid in winter and spring in streams or seeps (Martof et al. 1980). Adults then return to the forest for summer months (Bruce 1988). Data collected for *E. wilderae* in this study seem consistent with those reported in the literature.

Three species of caudates, *Notophthalmus v. viridescens*, *Plethodon hoffmani*, and *Desmognathus monticola*, were represented in this study by only 1 occurrence in Henderson Wetland. The occurrence of *N. v. viridescens* in late spring is consistent with breeding behavior reported by Martof et al. (1980). *Desmognathus monticola* was found in late February in Henderson Wetland and *Plethodon hoffmani* was found in late March. Both these occurrences are consistent with published data. One caudate, *Ambystoma maculatum*, was represented by 2 observations in Henderson Wetland. Eggs of an ambystomid species were found in late February and an adult *A. maculatum* was collected in March 1999. This is consistent with breeding behavior, egg deposition in late winter or early spring, reported by Martof et al. (1980).

Two species of caudates were found on only 1 visit to John's Bog. Slimy salamanders (members of *Plethodon glutinosis* complex) are active from spring through fall except during periods of drought when they burrow underground (Martof et al. 1980). Thus the occurrence of *Plethodon cylindraceus* (White- Spotted Slimy) in John's Bog in spring, 2000 was not unusual. Little is known about the breeding biology of another caudate, *Plethodon yonahlossee*, (Martof et al. 1980) found during 1 visit to John's Bog in early summer.

Three salamander species were found in John's Bog but were never found in Henderson Wetland. Adult *Pseudotriton r. ruber* were present in John's Bog in March, April, and August 1999 and larvae were found in April 2000. Martof et al. (1980) reports that courtship for this species occurs in summer, spawning in fall, and eggs hatch in winter, which is consistent with data from this study. *Plethodon cinereus* were found in John's Bog in spring and late summer (August), consistent with Morgan's (1998) reports for Buffalo Mountain in Washington County, TN. This occurrence is also consistent with a report by Nagel (1977) that suggests egg deposition in June followed by a retreat into soil to avoid the heat of summer (Taub 1961). Larvae of another caudate, *Gyrinophilus p. porphyriticus*, were found throughout the year in John's Bog. Bruce (1978) suggested a prolonged larval period for *Gyrinophilus porphyriticus* in North Carolina but states the extent of the period is not known. Presence of larval *G. p. porphyriticus* in John's Bog throughout this study seems to support the hypothesis of a prolonged larval period.

Discussion of Survey Methods

The distribution of salamanders within the sites in this study presented a unique opportunity to test the effectiveness of the random walk method. The proposed purpose of the method is to randomly sample large sites and collect data about species occurring in all habitats (Heyer et al. 1994). Because the basis of the method is a transect design, species densities can also be determined. This method was more appealing than pre-determined transects because those would have only sampled distinct areas and may not have given accurate information about the entire site. However, all caudates found

during this study with the exception of *Notophthalmus v. viridescens* were concentrated in the periphery of the sites near springs or streams. The randomization of starting points and directions during random walks resulted in a majority of survey time being spent in the large Wetland or Bog habitats in the middle of sites instead of vigorously sampling habitats such as springs and streams where caudates were believed likely to occur.

Several solutions would holistically sample sites and avoid large samples of unsuitable habitat. Random transects stratified by habitat would both avoid sampling habitats disproportionately and collect information about an entire site. Other methods such as pre-determined transects in each habitat would also avoid disproportionate sampling but could miss species that occurred specific microhabitats.

Aural survey, a widely used method of surveying anurans, was employed at both sites. One inherent problem with aural survey is the method does not count all anurans present because females and juveniles do not vocalize (Heyer et al. 1994). Shirose et al. (1997) found a positive, linear correlation between numbers of individuals reported by call counts and actual numbers of individuals present. However, further research is needed before a method of estimating total individuals from call counts can be established (Shirose et al. 1997).

A problem encountered using aural survey in this study is that the calls of several species (*P. triseriata feriarum, P. c. crucifer*) carry much farther than calls of other species (*R. sylvatica, R. palustris*) and may mask their presence at a site. On several occasions, during approach to Henderson Wetland, both *Pseudacris* species could be heard from 2 or 3 times the distance than other species including *Rana sylvatica* or *Rana palustris* could be heard. Inclusion of multiple points from which to perform aural

surveys could be used in order to identify all species in a large site.

Point source collections were employed as a supplemental method in this study. This type of collection is suitable when the goal of a study is a species list rather than density estimates (Heyer et al. 1994). It should be noted, however, that it might be possible to use presence/absence data to detect species declines when a species is absent from sites where it previously occurred (Strayer 1999).

Occurrences of Note and Site Management Implications

Redmond and Scott (1996) wrote the most comprehensive publication about amphibian distributions in Tennessee. This publication lists species occurrence by county. Using Redmond and Scott (1996) as a reference, this study has documented 4 new species occurrences for Washington County and 2 new occurrences for Johnson County (Table 13).

Two salamanders found in John's Bog are watch – listed by the state of Tennessee. The Tennessee Department of Environment and Conservation (TDEC), Division of Natural Heritage lists *Desmognathus quadramaculatus* as an S4, G4 species, meaning that the species is widespread, abundant, and apparently secure both within the state and range-wide, but with cause for long-term concern (McCoy et al. 2001). *Plethodon yonahlossee* has a state rank of S3 (the species is rare and uncommon in the state with 21-100 occurrences) and a global rank of G4 (the species is widespread, abundant, and apparently secure range-wide, but with cause for long-term concern) (McCoy et al. 2001).

The occurrence of *Plethodon hoffmani* in Henderson Wetland would constitute a large range extension. However, the identification of this species was made on 1 individual, no other specimens were found, and no voucher collected. This occurrence would need to be confirmed by subsequent survey before it can be noted with confidence that the species does occur in the wetland.

Both John's Bog and Henderson Wetland are managed sites. John's Bog is considered an extremely rare (G1) community and is managed by the USDA Forest Service. Management strategy includes controlled burns with the proposed purpose of controlling encroachment of woody vegetation into the bog, which contains several rare plant species (Appendix -Table A2) including Large Cranberry, *Vaccinium macrocarpon*. Henderson Wetland is managed by Tennessee Wildlife Resources Agency (TWRA). Management of the site includes construction of a picnic shelter and a boardwalk through the site and planting of warm season grasses and native tree species (Pete Wyatt, TWRA, pers. comm.). A controlled burn in spring 2000 was implemented in dry fields in the site (pers. obs.).

The effects of fire on amphibian populations have not been well studied. Some studies suggest only temporary effects on amphibian populations (Kirkland et al. 1996, McLeod and Gates 1998). While data from before and after burns in this study suggest only temporary effects on amphibians, it should be noted that data were not adequate to fully investigate this problem.

Table 13. New Reports of Amphibian Species in Johnson and Washington Counties

Johnson County (John's Bog)	**Washington County (Henderson Wetland)**
Desmognathus fuscus fuscus	*Pseudacris triseriata*
Gyrinophilus porphyriticus	*Rana clamitans*
	Rana sylvatica
	Notophthalmus viridescens
	Plethodon hoffmani[a]

[a] The occurrence of this species is questionable and, therefore, it will not be reported as an addition to the Atlas of Amphibians in Tennessee (Redmond and Scott, 1996)

The fire in Henderson Wetland was contained in dry fields where, according to this study, amphibians were at extremely low density or did not occur. Thus, no detrimental effects were observed. However, if burns were prescribed for other habitats, the results might have been different.

The fire in John's Bog (spring 1999) may have had temporary effects on amphibians. It not only burned the bog but also some of the surrounding forest and dry ridge habitats where 4 species (*P. yonahlossee*, *P. cinereus*, *P. cylindraceus*, and *D. ochrophaeus*) were found. No amphibians were found 2 days after the fire (April 9). However, 3 species were found in the spring site, which was not burned, on the same day. On the next visit (April 18) caudates were found in the bog, and numbers were no less than before the fire. One might speculate that confining burns to the bog habitat and burning at a time when amphibians are not active would avoid potential detrimental effects of fire.

Accounts of amphibians in Henderson Wetland and John's Bog will be reported to the Tennessee Wildlife Resources Agency and USDA Forest Service, respectively. These data will serve as baseline information about amphibians in the sites. Amphibian species present should be taken into account when developing management strategies for the sites. In addition, lists of other organisms including fish, reptiles, and some invertebrates encountered during this study will be reported to the respective agencies.

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APPENDIX

VEGETATION DATA FOR HENDERSON WETLAND AND JOHN'S BOG

Henderson Wetland

Donaldson, (2000) proposed a community classification for Henderson Wetland. This provisional classification which will be approved in 2001 (Smoot Major, TDEC, pers. comm.) describes the site as a *Cephalanthus occidentalis* – (*Fraxinus pennsylvanica – Acer rubrum – Salix nigra*) / *Typha latifolia – Leersia orysoides – Peltandra virginica* Semipermanently Flooded Shrubland. [button bush - (green ash - red maple - black willow)/ cattail - rice cut grass - green arrow arum Semipermanently Flooded Shrubland]. This classification (rewritten from Donaldson, 2000) is as follows:

> Groundwater (and rainwater) supplied shrub and forb dominant wetland with deepwater areas dominated by *Cephalanthus occidentalis*. Areas of shrubs intermixed with forbs (*Typha latifolia, Peltandra virginica, Iris pseudoacorus* dominant); other common forbs include *Sium suave, Impatiens capensis, Lemna* sp.); grasses (*Leersia oryzoides* dominant, but also *Glyceria striata* among others), sedges (*Carex lupulina, C. lousianica, C.* spp., *Scirpus atrovirens, Schoenoplectus tabernaemontani, Dulichium arundinaceum*), and rushes (*Juncus effusus, J.* spp.). Wetland typically with standing water throughout the year, but a summer dry season possible. *Fraxinus pennsylvanica, Acer rubrum, Salix nigra*, and *Lindera benzoin* are locally abundant along the margins and at the outlet of the wetland. Adjacent areas may grade into *Acer rubrum - Fraxinus pennsylvanica* Seasonally Flooded Forest Alliance [CEGL 4420 *Acer rubrum* v. *trilobum - Fraxinus pennsylvanica* / *Carex crinita - Peltandra virginica* Forest] (found at the outlet of Bowmantown).

Vegetation in the site was surveyed by Donaldson (2000) (Table A1). Vouchers for plant species are archived in the John C. Warden Herbarium at East Tennessee State University, Johnson City, TN.

Table 14. List of Plant Species in Henderson Wetland
(Rewritten from Donaldson 2000 - Unpublished)
* D = Dominant, A = Abundant, ~A = Common, # is voucher specimen collected

Scientific Name	Common Name	Status	Voucher	Comment
BRYOPHYTES (No Sphagnum observed)				
Mnium sp.	moss		4727	
FORBS				
Alisma subcordatum	southern water plantain			
Arisaema triphyllum	jack-in-the-pulpit			
Aster puniceus	rough red-stemmed aster			
Bidens sp.	beggar's tick			
Boehmaria cylindrica	false nettle	˜A		
Chelone glabra	white turtlehead			
Eupatorium perfoliatum	boneset			
Galium tinctorium?	bedstraw			
Galium triflorum	bedstraw			
Gentiana clausa	a gentian			
Impatiens capensis	spotted jewelweed	A		
Iris pseudoacorus	yellow iris	D		Invasive exotic
Lemna sp.	duckweed	A	4725	
Lysimachia nummularia	money wort			Invasive exotic

Table 14 (cont'd)

Scientific Name	**Common Name**	**Status**	**Voucher**	**Comment**
Peltandra virginica	green arrow arum	A-D	4729	
Polygonum punctatum v. *p.*	smart weed		4734	
Polygonum sagittatum	tear thumb			
Ranunculus sp.	buttercup	˜A		
Rudbeckia laciniata	green coneflower			
Sagittaria latifolia	common arrow head			
Sium suave	water parsnip	˜A	4730	
Solidago canadensis	canada goldenrod			
Typha latifolia	cattails	D-A		
Vernonia noveboracensis	iron weed			
GRAMINOIDS				
?*Dulichium arundinaceum*	three-way sedge	˜A	4737	
Carex louisianica	louisiana sedge		4733	
Carex lupulina	a sedge	˜A	4732	
Carex spp.	sedges	A		
Cinna arundinacea	wood reed		4736	
Glyceria striata	fowl manna grass			
Juncus effusus	soft rush			
Juncus sp.	rush			

Table 14 (cont'd)

Scientific Name	Common Name	Status	Voucher	Comment
Leersia orysoides	rice cut grass	D-A		
Microstegium vimineum	Japanese stilt grass			Invasive exotic
Schoenoplectus tabernaemontani (= *Scripus validus*)	bulrush	˜A	4735	
VINES				
Apios americana	ground nut			
Fabaceae, Unknown	"a pea vine"	˜A	4726	
Lonicera japonica	Japanese honeysuckle	A		Invasive exotic
Toxicodendron radicans	poison ivy			
WOODY PLANTS (TREES AND SHRUBS)				
?*Celtis* sp.	?hackberry			
Acer negundo	box elder			
Acer rubrum	red maple	A		
Cephalanthus occidentalis	buttonbush	D-A	4728	
Fraxinus pennsylvanica	green ash	A		
Juniperus virginiana	eastern red cedar			
Ligustrum sp.	privet			Invasive exotic
Lindera benzoin	spicebush	˜A		
Rosa multiflora	multiflora rose			Invasive exotic
Rosa palustris	swamp rose			

Table 14 (cont'd)

Scientific Name	Common Name	Status	Voucher	Comment
Salix nigra	black willow	A		
Staphylea trifoliata	bladdernut			
Taxodium distichum	bald cypress			Presumed planted
Ulmus rubra	slippery elm			
Unknown, opposite leaved shrub, similar to *Spiraea*			4738	

John's Bog

John's Bog was previously classified as a *Carex atlantica – Rhynchospora alba – Parnassia asarifolia* / *Sphagnum warnstorfii* Herbaceous Vegetation (CEGL004157) [Southern Appalachian Herb Bog (Long Hope Valley Type), G1 (rarest global ranking) community However, Donaldson (1996) suggests that a more accurate classification would be as a *Glyceria* species (*G. laxa, G. melicaria*) – *Carex* species (*C. scoparia, C. crinita, C. lurida*) – *Hypericum ellipticum* / *Sphagnum* species community, John's Bog subtype. Donaldson's classification will be accepted in 2001 (Smoot Major, Ecologist and Coordinator, Tennessee Natural Heritage Program, pers. comm.).

There are 2 communities found in John's Bog (as surveyed by Donaldson 1996). Data from the first of these, the cranberry bog, are relevant to this study. Vegetation data in this community were taken from Donaldson (1996). A list of rare plants found in John's Bog is shown in Table A2.

> The open bog is dominated by members of the sedge family: *Carex lurida, C. intumescens, C. stipata, C. swanii, C. crinata* (very extensive), *C. scoparia, C. spp*., three-way sedge (*Dulichium arundinaceum*), spike rush (*Eleocharis tenuis*), and bulrushes (*Scirpus polyphyllus, S. purshianus*). Grasses are also important in the bog, along with mats of *Sphagnum* mosses. *Gylceria laxa* has been reported in the site.
>
> Herbaceous vegetation other than sedges extensive in the bog inlcudes pale St. John's-wort (*Hypericum ellipticum*), rushes (*Juncus effuses, J. spp.*), cinnamon fern, and smartweed (*Polygonum saggitatum*). Other herbaceous species found in and along the bog margin are violet (*Viola cucullata*), may apple, false lily-of-the-valley (*Maianthemum canadense*), bluets (*Houstonia serpyllifolia*), bulbous buttercup (*Ranunculus bulbosus* – exotic), golden groundsel (*Senecio aureus*), skullcaps

(*Scutellaria elliptica* v. *hirsuta*, *S. laterfolia*), New York fern, hay-scented fern, southern lady fern, clearweed (*Pilea pumila*), eastern willow –herb (*Epilobium coloratum*), nodding ladies-tresses (*Spiranthes cernua*), swamp milkweed (*Asclepias incarnata* subsp. *pulchra*), monkey flower (*Mimulus ringens*), arrowhead (*Sagittaria* sp.), red-stemmed aster (*Aster puniceus*), mint (*Mentha* sp.), sneezeweed (*Helenium autumnale*), St. John's-wort (*Hypericum mutilum*), mountain mint (*Pycnanthemum virginianum*), and cardinal flower (*Lobelia cardinalis*). An exotic mint (peppermint or spearmint) is present in part of the bog below the old housesite.

Woody vegetation in the bog and along it borders are black chokecherry (*Aronia melanocarpa*), swamp rose (*Rosa palustris*), large cranberry, and apple trees. Swamp rose was very extensive in the bog until a controlled burn in spring 1995. The burn killed about 70% of above ground stems of the rose.

The forest community located north of the bog at lower elevations was logged 69 years ago. On drier slopes above the bog the secondary forest includes sassafras, Fraser's magnolia, flame azalea, rhododendron, squaw huckleberry (*Vaccinium stamineum*), staghorn sumac, apple trees, blackberries (*Rubus occidentalis*, *R. hispidus*, *R.* sp.), black locust, white pine, wild black cherry, poplar, and common elderberry (*Sambucus canadensis*). Further up the slope in the secondary forest, red maple is dominant along with other species such as eastern red cedar (*Juniperus virginiana*), poplar, blackberry, multiflora rose, and wild black cherry.

It should be noted that another controlled burn was implemented in spring 1999 to control encroachment of *Rosa palustris* (pers. obs.). Donaldson (pers. com) states that the rose regrew strongly after burning stopped and has become a uniform height stand. It should also be noted that since Donaldson published in 1996, 5 years should be added to the time since logging of the forest community above the bog.

Table 15. List and State Ranks of Rare Plants in John's Bog [a]

Scientific Name	**Common Name**	**Rank or Status of Species [b]** **1. Global Rarity Rank** **2. State Rarity Rank** **3. State Status**
Cypripedium acaule	pink ladyslipper	1. **G5** (Demonstrably secure globally, though it maybe quite rare in parts of its range, especially at the periphery. Thus, the plant is of long-term concern.)
		2. **S4** (Widespread, abundant, and apparently secure within the state, though it may be quite rare in parts of its range especially at the periphery and is of long-term concern.)
		3. **E-CE** (Endangered due to commercial exploitation)
Dryopteris cristata	crested shield-fern	1. **G5** (See Above Definition)
		2. **S2** (Very rare and imperiled with the state, 6 to 20 occurrences and less than 3000 individuals, or few remaining individuals, or because of some factor(s) making it vulnerable to extirpation from Tennessee.)
		3. **S** (Special Concern Species – Any species or subspecies of plant that is uncommon in Tennessee, or has unique or highly specific habitat requirements, or scientific value and therefore requires careful monitoring of its status.)
Glyceria laxa	northern mannagrass	1. **G5** (See above definition)
		2. **S1** (Extremely rare and critically imperiled in the state with 5 or fewer occurrences, or very few remaining individuals, or because of some special condition where the species is particularly vulnerable to extirpation from Tennessee.)
		3. **S** (See above definition)
Hypericum ellipticum	pale St. John's-wort	1. **G5** (See above definition)
		2. **S1** (See above definition)
		3. **E** (Endangered in the state.)
Vaccinium macrocarpon	large cranberry	1. **G4** (Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery. Thus, the plant is of long-term concern.)
		2. **S2** (See above definition)
		3. **T** (Threatened in the state.)

[a] List of rare plants was taken from Donaldson (1996).

[b] Definitions of species' ranks were taken from the Introduction to Tennessee's Rare Plants (TDECa 2001) and species' ranks were taken from the Rare and Endangered Vascular Plant List in Tennessee (TDECb 2001).

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