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The Effect of Auditory Call Playback on Anuran Detection and Capture Rates

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The Effect of Auditory Call Playback on Anuran Detection and Capture Rates

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by

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ABSTRACT

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Derek A. Bozzell

Calls of male anurans during breeding seasons are species-specific identification tools. However, males cease calling after any nearby disturbance, including those of researchers. I proposed a variation on current methods that attempts to reduce this lag in calling after researcher-created disturbance by utilizing the propensity for competition in male frogs. I surveyed 14 breeding sites in Cabell and Wayne counties during the 2010 and 2011 breeding seasons. First, I used traditional visual encounter surveys (VESs). After using automated recording devices to gather site-specific recordings of calls of all species present, I conducted secondary VESs while playing these playlists over a loudspeaker. I expected this would increase anuran detection rates, capture rates, and survey efficiency. Only *Pseudacris c. crucifer* showed a significant increase in detection and capture rates when surveyed using callbacks, which is likely due to aggressive call behavior. Survey efficiency comparison was dropped due to lack of calling activity.

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INTRODUCTION

Order Anura and Amphibian Declines

Order Anura contains frogs and toads, which are collectively known as anurans. Anurans are amphibians and, as such, most species deposit gelatinous eggs in water or moist areas that hatch into aquatic larvae, whereas adults exhibit varying degrees of terrestrial living, depending on the species (Pauley, 2011). Like most amphibians, many anurans use cutaneous respiration; their skin is permeable and used in gas exchange, heat regulation and osmotic regulation (Zug et al., 2001). Unlike other amphibians, most anurans do not possess tails as adults; the word “Anura” is derived from the Latin prefix *an-* (“not”) and the ancient Greek *oura* (“tail”) (Merrem, 1820). Anurans are also especially adapted to saltatory movement, or jumping. Physiological adaptations for this type of motility include a flexible vertebral column; reduced number and size of ribs; a highly ossified appendicular skeleton; large, muscular hind limbs; and extended metatarsals (Zug et al., 2001). One of the most striking adaptations of anurans, and the one that this project relies on, is the auditory calls that males use to attract mates, and defend territory from conspecific males, during the breeding season. The ability of anurans to emit and detect these calls is highly derived and involves several adaptations in the larynx, lungs, vocal sacs, and middle ear (Zug et al., 2001; Vorobyeva and Smirnov, 1987).

Because of their unique skin, and the fact that they are exposed to both terrestrial and aquatic environments during their lifecycle, amphibians are especially sensitive to changes in the environment and to pollution. Amphibian species will be adversely affected by negative impacts to their environment sooner than most organisms, and because of this they are known as bioindicator species (Halliday, 2005a). In the late 1980s, it was discovered that amphibians have been experiencing drastic population declines globally since at least the 1970s (Heyer and Murphy, 2005). Studies have since shown that over one-third of all amphibian species are threatened, and over 120 species are already likely extinct (Stuart et al., 2004). More recently, the extinction rate of amphibians globally has been calculated to be 211 times the normal, background extinction rate, and if all species currently considered threatened go extinct, that rate will increase to 25,000 - 45,000 times greater (McCallum, 2007).

In 1990, several programs were dedicated to understanding and correcting the underlying causes (Heyer and Murphy, 2005). Since these developments, there have been considerable research and funding dedicated to this issue. Currently, there are several different causes for amphibian decline being studied. Among the probable causes are infection diseases, including Chytridiomycosis (Daszak et al., 1999); parasitic infection (Sutherland, 2005); ultraviolet radiation (Blaustein et al., 1994); chemical pollutants (Berrill et al., 1997; Bridges and Semlitsch, 2005); introduced species (Henle, 2005); habitat destruction, fragmentation and degradation (Green, 2005); increased amounts of vehicular traffic (Henle, 2005); unsustainable harvest for the pet trade (Wilson, 2005); and climate change (Reaser and Blaustein, 2005). Many researchers believe a combination of these factors is leading to the continued population declines observed in amphibians (Halliday, 2005b; Green 2005). Research to refine our understanding of these issues, how they interact, and their effects on amphibians is still underway.

Overview of Current Anuran Survey Methods

Traditionally, anuran breeding calls have been used to aid researchers in estimating population parameters (Weir and Mossman, 2005; Weir et al., 2005). The current anuran survey methods include intensive surveys, standardized (manual) call surveys, and the use of automated digital recording devices (Corn et al., 2000). Under ideal conditions in a simple system, as in a laboratory setting, these methods produce similar species richness values (Corn et al., 2000). However, when used in the field, each of these survey types has strengths and weaknesses.

Visual encounter surveys (VESs) are a type of intensive survey wherein the researcher systematically searches the habitat of focus for a known amount of time (Vonesh et al., 2010). This is a well-used and effective method for developing species lists rapidly (Crump and Scott, 1994). Intensive surveys can also be used to gather detailed population abundance or demographic information. However, as the name implies, these methods require a great amount of time; researchers must be on the ground, actively surveying sites in order to gather data. This is exacerbated by the fact that the act of surveying creates disturbances that cause anurans to cease calling (pers. comm. Thomas Pauley).

Standard, or manual, call surveys involve a researcher passively surveying a breeding site by simply listening and recording the calling species. Controlled by the U.S. Geological Survey (USGS), the North American Amphibian Monitoring Program (NAAMP) is the most widespread manual call survey, and the largest anuran research program, with 26 states in the eastern half of the country following the unified protocol (Weir and Mossman, 2005). These surveys can gather data over a wide area, but in order to do so logistically, the surveys must be volunteer-based, as seen in NAAMP. Even though the data are checked by experts, using volunteers potentially reduces the accuracy and credibility of the data. Also, the types of data collected are limited to presence/absence data and categorical abundance numbers. One definite strength of the NAAMP protocol is the standardization of environmental data collected.

Within the last 20 years, automated recording devices, or call monitors, have risen in popularity in anuran surveying. These recording devices can be left in the field and set to automatically record sounds, like the breeding calls of anurans, for a given period of time at given intervals. Song Meter ™ call monitors, a type of automated digital recording device developed by Wildlife Acoustics, have become a common tool in anuran surveys. Automated recording devices, such as the Song Meter SM2, are an established method of monitoring breeding amphibians, especially for presence/absence and basic abundance data (Corn et al., 2000; Acevedo and Villanueva-Rivera, 2006). They are known to produce similar data to manual call surveys (Acevedo and Villanueva-Rivera, 2006). In addition, they are also useful in capturing temporal variation in calling behavior (Bridges and Dorcas, 2000). The main benefit of these devices is that they require much less researcher effort to generate data similar to other methods (Penman et al., 2005). Again, however, the types of data they can be used to generate are limited.

Project Rationale

With so much research remaining, and a decreasing completion window due to the rapid declines and extinction rates of anurans, there is a need to maximize the amount of data collected during anuran surveys. To meet this need, I have attempted to develop a more efficient method of anuran survey than those currently available by combining aspects of current survey methods in order to minimize the weaknesses of each. I have proposed a new method of anuran survey that combines the detailed data gathered from intensive surveys, the environmental data recorded from standardized surveys, and the unique data collected from automated recording devices. In addition, I have incorporated the idea of using auditory callbacks to lure males into calling. In order to understand the reasoning behind including this aspect in my proposed method, one must first understand how the traditional surveys interact when combined, and the calling behavior of anurans.

One of the historical difficulties with surveying anurans is that males cease calling in response to any nearby disturbance, including those created by a surveying researcher (pers. comm. Thomas Pauley). These periods of silence reduce the efficiency of intensive surveys by forcing the researcher to remain inactive until the chorus beings calling again. This reduction of efficiency is a negative impact on VESs, which generate more detailed data than other methods, that other survey types do not encounter.

As mentioned, males use auditory calls to attract mates and ward off competing males. These calls are species specific, and therefore useful identification tools (Weir and Mossman, 2005; Weir et al., 2005). The pressure to attract a mate is so great that males will often engage in call and response contests; when one male calls, a conspecific will respond, in order to lose a potential mate. Hearing the call of a conspecific serves as a stimulus to a male to begin calling (Jones and Brattstrom, 1962). In both laboratory and field settings, it has been shown that males of several species are most likely to call in response to the sound of a conspecific (Schwartz, 2001; Amezquita et al., 2005). It is anecdotally assumed among researchers that using auditory callbacks entices male anurans to call, in order to increase capture numbers (Gibbons, 1983). However, a thorough literature search reveals no actual experiments designed to test this idea.

Automated recording devices provide a researcher with sound files of species calls. My proposed method involves using these sound files to create site specific playlists of calling species. I have created a portable, weather-resistant loudspeaker system that can be used to play these calls while surveying. This project compares survey results from traditional VESs with those of surveys with calls playing in the background. The logic behind this approach is that the callbacks playing over the loudspeaker system will entice the males at the site being surveyed to call in spite of nearby researcher-created disturbances. This method would increase the amount of time spent actively surveying, and increase the ability of a researcher to locate individuals during VESs. Combining this with the standardized, detailed environmental data recorded in NAAMP and the unique data gathered by call monitors could potentially result in the most complete, data dense, and efficient anuran survey technique to date.

Project Objective and Hypotheses

The objective of this project is to determine whether the use of auditory callbacks during surveys is preferable to traditional VES methods. To compare the effectiveness of the methods, study sites were surveyed using both techniques and results, in terms of survey efficiency, detectability, and capture probabilities, were compared.

The first hypothesis of this project is that the proposed method will increase survey efficiency. The use of callbacks should lessen time required for males to begin calling after a disturbance. If this is the case, time spent actively surveying during a period of time will increase.

The second hypothesis of this project is that the proposed method will increase detection rates of all species encountered when compared to traditional VES methods. The use of callbacks while surveying may cause male anurans to ignore nearby researcher-created disturbances. This increase in active survey time, combined with the expected overall increase in calling behavior in response to the callbacks, will allow a researcher to locate a higher number of individuals.

The third, and final, hypothesis of this project is that the proposed method will increase capture rates for all species encountered when compared to traditional VESs. If more time is available to actively survey, and more individuals are located during a survey, more opportunities to capture individuals will exist. It should be feasible for a researcher to capture more individuals per unit time.

METHODS

Study Sites

There were 14 study sites across two study areas, Beech Fork State Park in Wayne County, WV, and Green Bottom Wildlife Management Area (WMA) in Cabell County, WV (Figure 1). Sites consisted of a wide range of various habitats that serve as breeding areas, including: wetlands, ponds, lakes, streams, flood plains, man-made water bodies and vernal pools. A brief description of each study site, along with basic location information can be found in Table 1. Sites were grouped into four sets, based on achieving maximum distances between sites in each set, in an attempt to avoid pseudo replication. If sites are in close proximity to one another, the calling behavior during a survey at one site could influence the behavior of individuals at subsequent sites. This could result in the inaccurate inclusion of species heard from a nearby site, not the site currently being surveyed (Eigenbrod et al., 2008). There were two site sets at Beech Fork State Park, each containing four sites, and two at Green Bottom WMA, each containing three sites. Site set divisions can be seen in Figures 2 and 3.

Sites located in Beech Fork State Park were labeled 'BFSP1 - BFSP8' (Figure 4). Site BFSP1 is a shallow alcove along the northern bank of Beech Fork Creek, roughly 65 meters southeast of a large pavilion named Shelter Number 4 (Figure 5). The site consists of mostly denuded, muddy bottom, with a ring of grass hummocks around the three sides that do not lead back to open water. In the spring, the water level is much higher, and covers a large area of grass that is manicured by the park staff. The water quickly recedes, however, and by July the area is mostly thick mud. There is still area to survey, however.

Site BFSP2 is a small, shallow flood plain located along the northern bank Beech Fork Creek that is very ephemeral (Figure 6). During the spring months, this site is shallow and has a grass covered bottom. During both survey years, this site went dry between May and June surveys.

Site BFSP3 is a moderately sized pond on the northern side of Beech Fork Road, east of the intersection with Butler Adkins Branch (Figure 7). This is a permanent body of water that contains fish. The site is characterized by tall grasses and thick vegetation along the southern bank, and a relatively open northern bank.

Site BFSP4 is a small pool located on a small flat area on a roughly east-facing slope (Figure 8). The pool is located immediately beside a power line right-of-way. It is located in an open understory area, but there is some canopy cover caused by surrounding hardwoods. This pool is vernal, and was dry before June surveys began.

Site BFSP5 is a large drainage field downhill from Beech Fork Road (Figure 9). The site is located below the road roughly 100 meters southeast of the power line right of way opening. The area is characterized by heavy canopy cover, but little understory. The water is shallow, never exceeding a half meter in depth during surveys. This site is a vernal water body, and during survey years it was dry by the time June surveys were started.

Site BFSP6 is located in between Beech Fork Creek and the "Road to Nowhere" (Figure 10). The area that floods is near the beginning of a nearby nature trail, just after a bridge. This area has heavier vegetation than the other Beech Fork State Park sites. There is a large amount of coverage by emergent vegetation, which mostly consists of grasses and cattails. There are also several emergent trees. This site is vernal, and was dry by June during both survey years.

Site BFSP7 is a small pond located behind the Blue Goose Picnic Area (Figure 11). It is in an area with an open understory, but a high amount of canopy cover. The western and southern portions of the bank are level, but the northern and eastern portions are steep, the eastern bank especially. The pond is spring fed. This pond is permanent, and during the summer months, it is covered with a thick layer of duckweed.

Site BFSP8 is a flood plain of Beech Fork Lake at the beginning of the Lost Trail, just after a bridge (Figure 12). The area is located just to the south of the first camping area. This breeding location is vernal and characterized by very shallow water during the spring. There is a high degree of emergent grass coverage. This site dried between May and June surveys.

Sites located in Green Bottom Wildlife Management Area (WMA) were designated as 'GRNB 1-6' (Figure 13). Site GRNB1 consists of the shallow area of Hoeft Marsh near the first entrance along Route 2, when driving east. The area is characterized by thickly vegetated banks, and an area of open water. As the water became deeper, thick stands of buttonbush (*Cephalantus occidentalis*) prevented surveys. This site contained the deepest water of all those surveyed. During the spring months of 2011, the water at this site was too deep to survey.   During the summer months, the water level was routinely around 80 cm in depth.

Site GRNB2 is located along the northern, treed boundary of the wetland across the trail from Hoeft Marsh (Figure 14). Like other Green Bottom WMA sites, during the spring months of 2011, the water level was too high to allow for survey by foot. During the summer months, this site is overrun by American Lotus (*Nelumbo lutea).* This drastically reduces possible survey area.

Site GRNB3 is an area of old field habitat located along the northern boundary of the second wetland along the eastern side of the trail at the first entrance of Green Bottom (Figure 15). The area serves as a floodplain for the wetland. It is characterized by a mixture of open soil and emergent grass hummocks. While it also experiences high water during the spring, this site is vernal and went dry between the June and July surveys during both survey years.

Site GRNB4 is an alcove along the northern border of the large wetland accessible from the second entrance to Green Bottom, when driving east on Route 2 (Figure 16). There is a boardwalk trail that follows the boundary of the wetland. This site is roughly eight meters from that boardwalk. It is an area of open, muddy bottom, surrounded by thick grass that reaches roughly one meter in height. It is open on the south side, leading into the wetland with rapidly increasing depth. This site held water during the entirety of both survey periods.

Site GRNB5 is a flooded field to the west of the second entrance of Green Bottom (Figure 17). There is thick grass covering the entire area. This site had shallow water, but the soil was so saturated that walking through the area was difficult. Every step resulted in sinking to nearly the waist. However, this site is vernal and was dry during the summer months of survey.

Site GRNB6 is an inlet at the north western corner of the large wetland accessible from the third entrance of Green Bottom, if driving east along Route 2 (Figure 18). This was the largest survey area, and it contained several different habitat types. There was shallow water with a bare, muddy bottom as well as shallow water with a thickly vegetated bottom. These shallow areas would lose water during the summer months, but they quickly increased in depth. Deeper areas of this site were vegetated, with both underwater and emergent, woody plants. This area contained several small islands; both these and the surrounding banks were covered with thick vegetation.

Field Seasons

The local breeding season of anurans generally takes place from late February or early March until late July or early August (Pauley, 2011). Field season start and end points were based on observations of anuran calling activity. Due to delays in funding and gathering materials, the first field season of the project was limited to June and July of 2010. This served mostly as a trial run to determine sites and address any issues that arose with the experimental design; however, data were collected.

The second field season occurred from March through July 2011. There were several difficulties during the 2011 survey season that resulted in gaps in data collection. The weather during the spring months, March through May, was extremely wet, resulting in a great deal of flooding at Green Bottom WMA. Some sites were inaccessible, and other sites were too deep to be surveyed by foot. Survey of the Green Bottom WMA sites began in June. During May 2011, personal issues prevented the survey of site set 2. During June of the 2011 season, vehicular issues prevented the survey of all Beech Fork State Park sites.

Survey Methods

The project revolved around a cyclical field season. Each cycle consisted of surveying a set of sites without the use of callbacks, recording calls, creating call playlists for each site, and, finally, surveying with callbacks at that site set. Repeated surveys were necessary to account for the fact that the breeding seasons of different species differ temporally (Bridges and Dorcas, 2000). I was the only researcher to conduct surveys, in an effort to minimize the effects observer bias and the effects of differences in observer skill.

The first day at each site set consisted of surveying sites using traditional visual encounter surveys (VESs). Because the sites surveyed represent a wide range of potential anuran breeding habitats, specific methods were developed for different site types. Two different transect styles were used for sites, depending on the characteristics of the water body that served as the breeding site, but regardless of transect style, the area two meters to either side of the transect line was surveyed. If the site had defined boundaries, such as a pond, then a transect that circumnavigated the shallow area along the bank was used, mainly due to limitations of my ability to survey deep water. If the breeding site was shallow throughout, with no defined boundary, normal transects were used. The distance between transects was decided based on overall habitat size. For sites designated categorically as “small,” consisting of mainly small vernal pools and floodplains, transects were five meters apart. For sites in the “medium” size class, such as larger floodplains, transects were run 10 m apart. For the sites in the “large” size class, such as the wetlands at Green Bottom WMA, transects were 15 m apart. This differentiation of sizes and transect distances was done in an attempt to reduce survey bias in favor of more transects in larger breeding areas. For all classes, transects were run along the shorter axis of the water body. Table 2 contains a list of each site’s designated boundary type, the transect type used and its size class. Figure 19 shows a diagram of survey transect types. All surveys in this project were time-limited to 30 minutes or until the entire area was surveyed. During surveys, if the chorus fell silent, I would turn off my headlamp and wait quietly until the second individual began calling. I chose to wait until the second calling individual in an attempt to counter especially aggressive or brave males.

On the second day, call monitors were placed at each site of the currently surveyed site set and set to record for 10 min on every hour from 20:00 until 08:00 the next morning (Figure 20). This regime was selected in order to capture calling activity of all species in the study areas, as the point at which different species call throughout the night vary (Bridges and Dorcas, 2000). A period of 10 min per recording was selected because that time length represents the point at which diminishing returns in terms of detection begin. The detection of calling individuals of 10 minute recordings does not differ statistically from longer recordings (Pierce and Gutzwiller, 2004).

On the third day, completed recordings were collected and analyzed, i.e., I listened to each recording in order to determine species composition at each site and then used them to create playlists of site-specific calls. I made the decision to manually listen to all recordings due to high inaccuracy and false positive rates found in the use of automatic vocalization recognition software for anuran monitoring (Waddle et al., 2009). These recordings were used to create site-specific playlists of calling species, which would be played during secondary surveys. I altered recordings from the call monitors using the sound editing software Audacity to create clear, one minute files containing only the species of interest for use in the playlists. If it proved impossible to create a clear file for a particular species using the recordings from the previous night, I used files from *The Frogs and Toads of North America* CD by Lang Elliot et al. (2009) with any speech edited out. These two days also act as a buffer between surveys of the site to ensure that the collection/handling from the first survey has no impact on the males' willingness to call during the second.

The fourth day consisted of repeating the surveys of the first day, but while using the generated callbacks during surveying. In order to play calls while surveying, I built a "callbox" using an MP3 player, an amplifier and a loudspeaker (Figure 21). I took a plastic storage container and attached the electrical components to the interior using Velcro strips. I drilled six holes into the side walls of the container and covered them with plastic mesh to allow sound to clearly leave the container but prevent anything from entering. The playlists generated from the call monitors would be loaded onto the MP3 player. The callbox also had a lid that sealed airtight in an effort to keep excess moisture from harming the electronics. In the field, the callbox was placed at a random location in the survey area. I returned to the randomly selected survey start point and allowed the playlist to play twice while I waited quietly, in an effort to minimize the effect of my placing the callbox elsewhere. I would then survey as normal. This four-day process was repeated for each site set. The survey cycle repeated monthly, leaving 30 days between the first surveys of the cycle at each site set.

Data Collection

The types and methods of data collection for this project are based heavily on the North American Amphibian Monitoring Program (NAAMP) procedures (Weir and Mossman, 2005). I began surveying approximately a half hour after true dark, following NAAMP protocol. Site survey order was randomly decided prior to surveying.

Prior to surveying each site, I recorded weather information using a Kestrel 3500 Pocket Weather Meter. Using the Kestrel, I recorded current air temperature in degrees Celsius (ºC), relative humidity (%), barometric pressure in millimeters mercury (mmHg), water temperature in degrees Celsius (ºC), wind speed in miles per hour (mph), wind direction, cloud cover, ambient noise, and percent vegetative cover. All of these variables are known or suggested to affect anuran calling behavior (Granda et al., 2008; Oseen and Wassersug, 2002; Schwartz, 2001). I also recorded wind speed using Beaufort Wind Codes, a categorical measurement used by NAAMP, which is based on mph measurements (Table 3). I recorded Sky Codes according to NAAMP protocol. Sky codes assign numerical values to carrying weather types (Table 4). I recorded ambient noise using the Massachusetts Noise Index, a categorical measurement of the effect of auditory disturbance on surveying, also used by NAAMP (Table 5). As per NAAMP procedures, Sky Codes 3 and 6 were not used (Weir and Mossman, 2005; Weir et al. 2005). Percent vegetative cover was measured using a square meter grid divided into 25 sections equal sections. Lastly, I recorded the NAAMP Calling Index of each species heard at the site. The Calling Index is a measurement of the number of calling males at a breeding site that ranks choruses into categories of 1, if calling individuals are easily counted, 2, if individuals can be distinguished but not counted, and 3, if calls are continuously overlapping (Table 6). This method is known to produce analogous results to mark-recapture studies (Nelson and Graves, 2004).

During surveys, I recorded the species of any individual specifically located as “Seen” and made an attempt to capture it by hand. If successfully captured, it was recorded again as a “Captured” individual. If the anuran escaped, it was not marked as captured. Recording data this way allowed for a percentage of number captured out of total number seen to be easily calculated. Larvae were not considered in this study, as they will not respond to breeding calls of adults. When a full chorus became silent during a survey, I recorded the amount of time that they were silent, until the second individual began calling. I also recorded the survey start and end times, in order to calculate total survey time. In order to calculate different survey efficiencies for the two methods of survey, I did not stop the stop survey time while waiting for the chorus to being calling again.

Data Analysis

I analyzed my data by comparing results from surveys using callbacks and surveys without callbacks for detection and capture rates of each species, as well as of all species combined. I defined survey efficiency as percentage of time spent actively surveying during the survey period, detection probability as the number of individuals seen in a survey per unit time, and capture probability as the number of individuals captured during a survey per unit time. Of the eight species seen during surveys, only four, Northern Green Frog (*Lithobates clamitans melanota*), American Bullfrog (*Lithobates catesbeianus*), Spring Peeper (*Pseudacris crucifer*), and Cope's Gray Treefrog (*Hyla chrysoscelis*), were found in large enough numbers to meet minimum requirements for statistical analyses. The other four species, American Toad (*Anaxyrus americanus*), Pickerel Frog (*Lithobates palustris*), Mountain Chorus Frog (*Pseudacris brachyphona*), and Wood Frog (*Lithobates sylvaticus*), were included in the analyses of the raw, combined data. After completing all surveys, I determined that there were not enough instances of full choruses to analyze survey efficiency data.

For detection and capture rates, I first analyzed the raw data, including all individuals seen of all species, and then each of the four main species individually. I decided to include all species in the raw data calculations to get a more accurate picture of the effectiveness of each method in actual field conditions. I first calculated detection rates. I then ran an F-test using Microsoft Excel 2010 to determine the normality of the data. If the data for that species was normal, I would then use SAS 9.2 (Statistical Analysis System) to run a Student's T-test to determine if there was a significant difference between the detection rates of the two methods. With Student's T-test, SAS automatically uses a two tailed test, and as I was only concerned if my proposed method resulted in higher detection rates, I divided the SAS p-value by two, to create a one-tailed test. If the data for the species was not normal, I would use the Wilcoxon Sum Rank Test due to its smaller margin of error than other Wilcoxon tests. During all tests, I assumed one independent/predictor variable, being the use of callbacks, and used two independent sample groups because there was no way to ensure that the populations of anurans at each site did not change between the two surveys. I used the same process when analyzing capture rates.

RESULTS

Survey Efficiency Analysis

There were not enough surveys containing full choruses on which to run any meaningful analyses. Choruses of NAAMP Call Index 1 or 2 have inherent gaps within calling activity. It proved impossible to determine which gaps were due to researcher-created disturbance, and which were due to a lack of individuals participating in the chorus. As such, I could not run any analysis on survey efficiency data.

Detection Rate Data Analysis

A summary of the detection rate data analysis can be found in Table 3. The F-test of the raw, combined data showed that the data set was normal, so Student's t-test was used to determine differences between the surveys without callbacks and those with. Student's t-test showed no statistically significant differences between the survey methods ($p = 0.166$; $\alpha = 0.05$). The data for the Northern Green Frog (*Lithobates clamitans melanota*) were found to be normally distributed. The two methods resulted in no statistically significant differences in detection of this species ($p = 0.386$; $\alpha = 0.05$). The F-test showed the data for the American Bullfrog (*Lithobates catesbeianus*) to be normal. Student's t-test found no statistically significant difference between the detection rates of the two survey methods for this species ($p = 0.163$; $\alpha = 0.05$). The detection rate data of the Spring Peeper (*Pseudacris crucifer*) was not normally distributed, according to the F-test. As such, Wilcoxon's Sum Rank Test was used to determine if the two methods produced significantly different results, but it found no such differences ($p = 0.22$; $\alpha = 0.05$). Lastly, Cope's Gray Treefrog (*Hyla chrysoscelis*), was found to have normally distributed data. The two survey methodologies produced no statistically significant differences in detection rates for this species ($p = 0.178$; $\alpha = 0.05$).

Capture Rate Data Analysis

A summary of the capture rate data analysis can be found in Table 4. The raw data, with all species combined, was shown to be non-normally distributed by an F-test, so Wilcoxon's Sum Rank Test was used to determine statistical significance in the results of the two methods. No statistically significant differences were found ($p = 0.195$; $\alpha = 0.05$). For the Northern Green Frog, the F-test showed the data to also be non-normal. Wilcoxon's Sum Rank Test did not show any statistically significant differences between the two survey methodologies ($p = 0.278$; $\alpha = 0.05$). The capture rate data for the American Bullfrog was also not normal. There were no statistically significant differences between survey methods, in terms of the capture rates for the species ($p = 0.169$; $\alpha = 0.05$). The capture rate data for the Spring Peeper was normally distributed. Also, there were statistically significant differences between the capture rate results of the two survey types, as found by the Student's t-test ($p = 0.038$; $\alpha = 0.05$). The capture rates for Cope's Gray Treefrog were found to be normally distributed. However, they did now show any statistically significant differences ($p = 0.18$; $\alpha = 0.05$).

DISCUSSION

Interpretation of Results

The first hypothesis, that the proposed method will increase the efficiency of visual encounter surveys (VESs), had to be removed from the study. The protocol of NAAMP uses a categorical Call Index to measure the density or number of calling individuals at a breeding site. In order to effectively measure chorus silences, a Call Index level of 3 is required; levels of 1 or 2 are not dense enough to not innately have gaps in calling. With gaps naturally occurring in a chorus due to lack of calling individuals, it was impossible to determine which periods of silence were due to researcher-created disturbance and which were due to a lack of calling individuals.. During my surveys, I had only 11 instances of species reaching a Calling Index level of 3; the vast majority of choruses I heard were Calling Indices 1 or 2. This was not enough to satisfy the minimum requirements for any meaningful statistical analysis. Due to this lack of calling activity, this portion of the project was dropped.

The second hypothesis of the project, that the proposed method will increase detection rates of all species encountered when compared to traditional VES methods, was rejected. There were no species with higher detection rates using the experimental method of playing callbacks while conducting a VES (Table 7). There were also no differences detected when all species were combined. The third, and final, hypothesis, that the proposed method will increase capture rates for all species encountered when compared to traditional VESs, was also rejected. The only species with higher capture rates when using the proposed method was the Spring Peeper (*Pseudacris crucifer*) (Table 8). There were no differences detected between methods when all species were combined.

No species showed any improvement in detection rates, and only the Spring Peeper showed any increase in capture rates, when comparing the proposed method of using a loudspeaker to play callbacks while conducting a VES to traditional methods. This is likely due to some unique aspects of Spring Peeper calling behavior. It is known that Spring Peepers have a strong call response when presented with the sound of a conspecific call (Jones and Brattstrom, 1962). In addition, peepers exhibit extremely aggressive calling behavior. As the number of stimuli, meaning conspecific calls, increases, individual Spring Peepers actively increase their own calling behavior, in terms of both call duration and number of calls (Schwartz, 1989). They also increase the frequency of aggressive calls and aggressive behavior toward conspecifics (Schwartz, 1989). Compared to other species in the region, such as the Gray Tree Frog, (*Hyla versicolor*), these behaviors result in much more aggressive, dense, and chaotic choruses (Schwartz et al. 2002). This behavior is why the proposed method uniquely increased capture rates in the Spring Peeper; other species do not exhibit such aggressive calling behavior, and as such, they are not affected by the presence of the callbacks.

It is likely that the experimental method did not increase detection rates of Spring Peepers because they were already high using traditional VESs. Anecdotally, eight of the 11 instances of full choruses, those given a Calling Index of 3, were Spring Peepers. Also, Spring Peepers routinely had higher numbers detected and captured than other species. It was likely researcher ability that limited the number of Spring Peepers detected and captured.

It is currently assumed to be possible to entice males into calling using recordings. It has been done with select species in both laboratory and field settings (Schwartz, 1989, 2001, 2002; Amezquita et al., 2005.) The method has been cited anecdotally by eminent herpetologists as a method to increase capture rates (Gibbons, 1983). However, no research has proved this claim. This study suggests that this method only works on a very small proportion of anuran species, specifically those with highly aggressive calling behavior. The limited effectiveness of this approach is not likely a strong enough application to justify developing the use of callbacks as a widely used methodology.

Issues with This Study

There were several difficulties over the course of this study, including several that limited my ability to gather data. A steadier, more complete survey history would increase data and capture a more complete picture of the temporal variations in calling behavior of the species detected. However, these issues could not be avoided. First was the abnormal weather during the 2011 field season. The spring was extremely wet that year, to the point where Green Bottom Wildlife Management Area was largely inaccessible due to flooding, which prevented the survey of those sites until the summer months. Then, the summer was extremely hot and dry, which caused all of the vernal breeding sites to desiccate rapidly. These two factors caused an abbreviated breeding and survey seasons compared to more normal years.

Another difficulty was the issue of a lack of full choruses, which eliminated the possibility of measuring survey efficiency. One of the dangers of behavioral field studies is that it is impossible to force animals to act in a desired fashion. This lack of chorus activity could not be avoided, and the project had to be amended to fit within the parameters the field would allow.

One concern is an increase in observer skill over the course of the field season. Using only one researcher was an attempt to keep this steady, but with repetition, it is possible there was an increase in the efficiency in detecting or capturing individuals. The two day buffer period in between the traditional and experimental surveys at each site served not only to reduce the impact of repetitive capture on anurans, but also to prevent a great increase in observer skill. Also, there was roughly a two week period in between the end of one monthly survey cycle and the beginning of the next. This gap also likely reduced the increase in detection and capture abilities of the observer.

Future Work

Certain aspects of this study may benefit from further research. Given the results of the study, it is unlikely that additional field seasons would see drastic differences in the comparison of the traditional and experimental methodologies. However, given the abnormality and abbreviated nature of the field season of this project, further research may provide insight into calling behavior of the species detected. In addition, controlled, laboratory experiments to determine the calling behavior, specifically the aggression, of local populations may shed light onto the underlying reasons the proposed methodology was unsuccessful in increase VES detection and capture rates. The calling behavior of many species is undocumented, and it is possible that there is variation across the species range. These differences could lead to regionally unique interactions within and between species during the breeding season. As such, it may be useful to replicate this experiment in other areas. Other assemblages of anuran species, with potentially different calling behaviors, may lead to different results.

APPENDIX

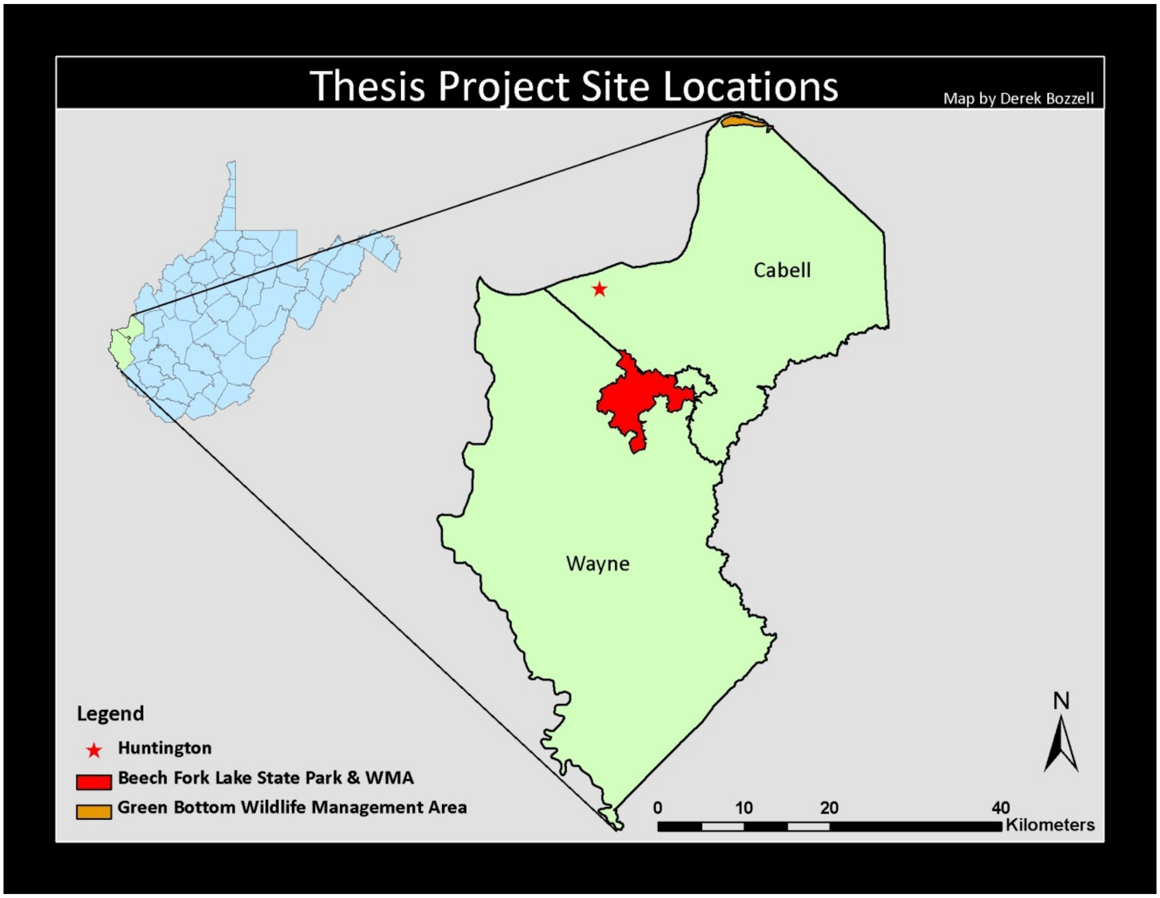

Figure 1: A map of the study areas of this project, Beech Fork State Park and Green Bottom Wildlife Management Area. Created in ArcMap 9.3.

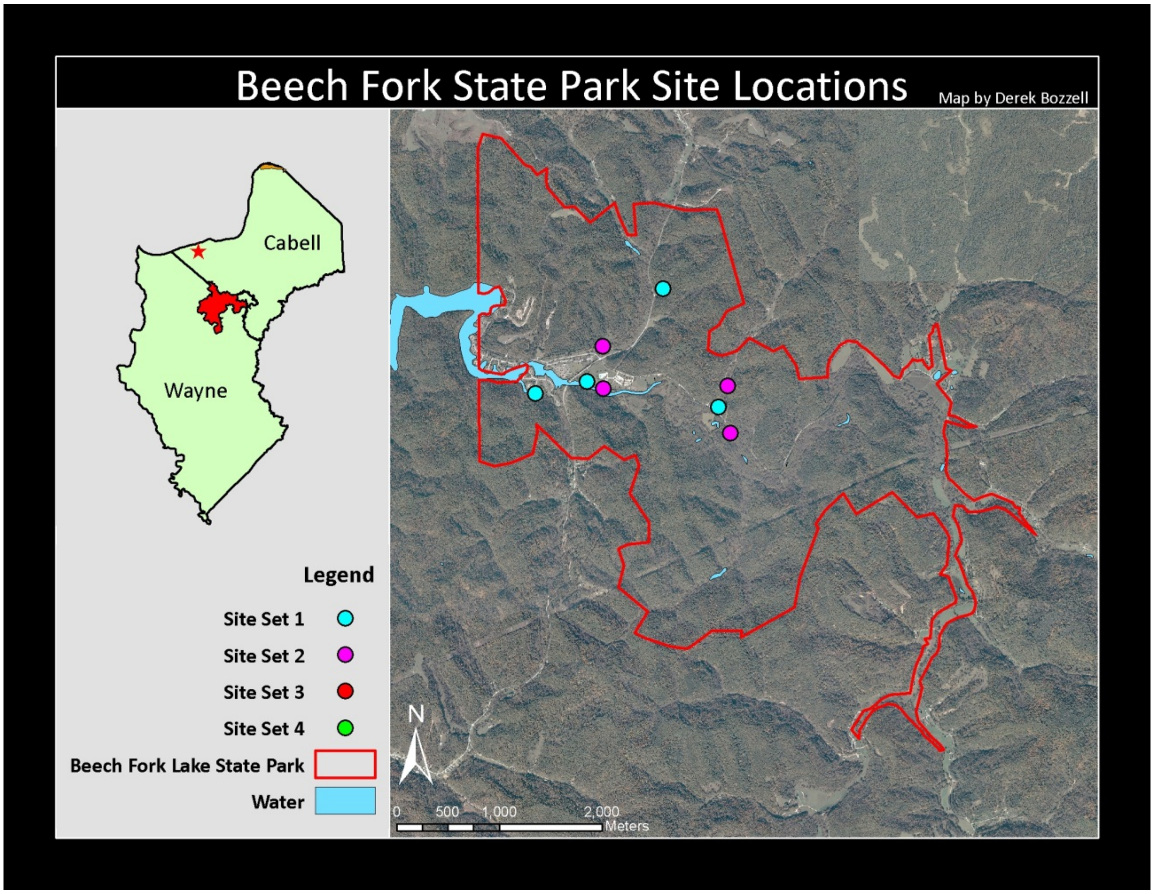

Figure 2: A map of the study site locations in Beech Fork State Park. Created in ArcMap 9.3.

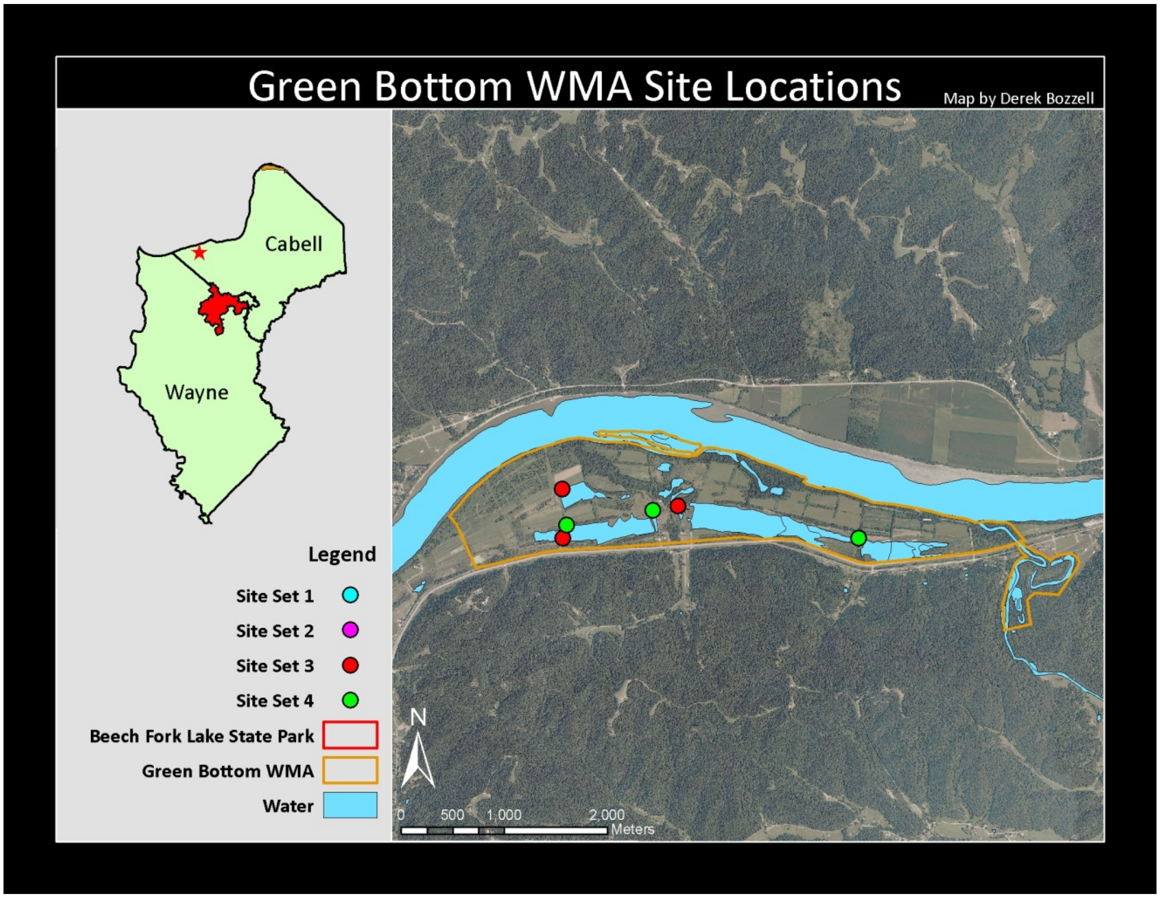

Figure 3: A map of the study site locations in Green Bottom Wildlife Management Area. Created in ArcMap 9.3.

Site	Site Set	UTME	UTMN	Basic Site Location Description
BFSP1	1	382302.9	4240630.6	Shallow alcove off of Beech Fork Creek. Roughly 110 meters SSE of walking trail underpass of Long Branch Road. Vernal
BFSP2	2	382459.9	4240563.5	Flood plain of Beech Fork Creek. Roughly 85 meters south of pool parking lot. Vernal
BFSP3	1	383579.6	4240383.9	Pond along Beech Fork Road. Near Butler Adkins Branch. Permanent
BFSP4	2	383673.5	4240589.0	Small pool located upslope along power line right of way near Butler Adkins Branch. Vernal.
BFSP5	2	383697.5	4240129.1	Large drainage field down slope Beech Fork Road. Site below road roughly 100 meters southeast of power line clearing that leads to site BFSP5. Vernal.
BFSP6	2	382453.7	4240973.7	Flood plain located near beginning of Nature Trail. Between it and the Road to Nowhere. Vernal
BFSP7	1	383044.5	4241535.9	Pond just behind the Blue Goose Picnic area. Permanent
BFSP8	1	381799.2	4240515.2	Flood plain of Beech Fork Lake at the beginning of the Lost Trail, just after bridge. Vernal
GRNB1	3	390066.1	4271603.8	Shallow area of Hoeft Marsh along trail at first entrance. Permanent
GRNB2	4	390101.7	4271731.2	Northern boundary of large wetland across from Hoeft Marsh. Permanent
GRNB3	3	390060.6	4272081.8	Second wetland on right of the trail at the first entrance. Old field habitat serves as flood plain. Vernal.
GRNB4	3	391182.2	4271919.9	Alcove of large wetland at second entrance. Along boardwalk trail. Permanent
GRNB5	4	390938.5	4271875.6	Flooded field along left side of second entrance road. Vernal
GRNB6	4	392933.6	4271608.1	Inlet in the northwestern corner of large wetland at the third entrance. After second bridge, on right. Permanent

Table 1: Location information of study sites. Includes UTM (Universal Transverse Mercator) coordinates and a brief description of site location.

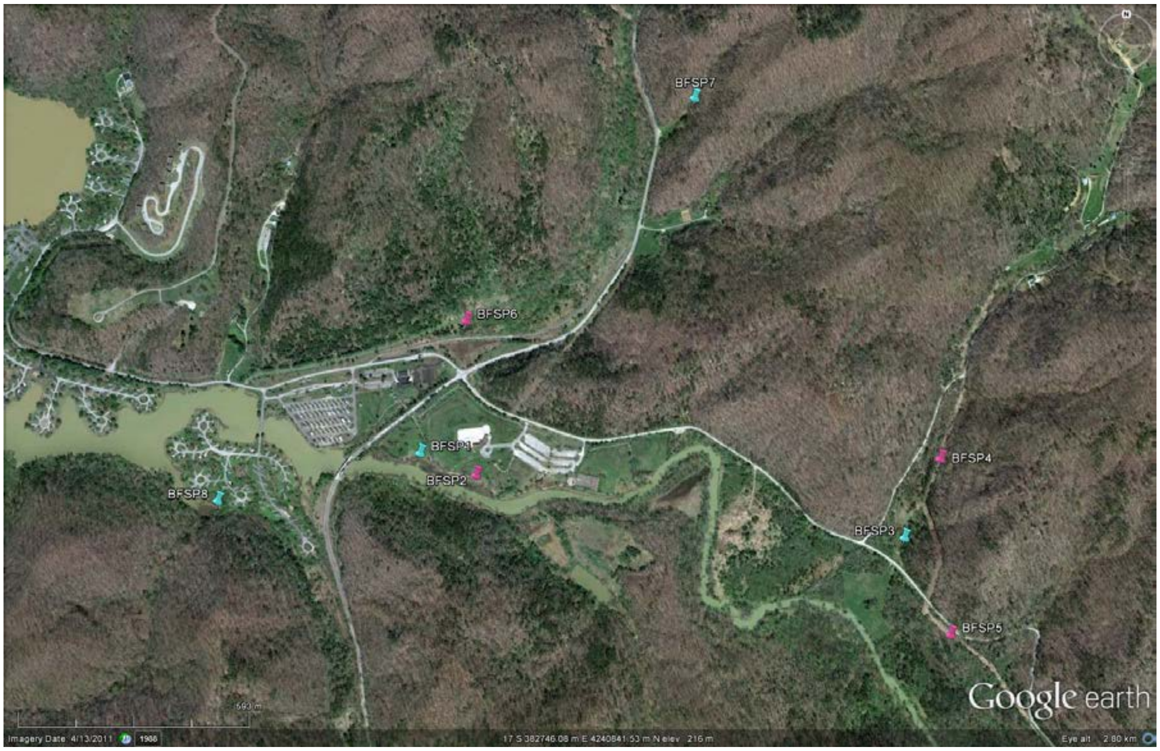

Figure 4: A Google Earth aerial photo of Beech Fork State Park, contain labeled points for BFSP1-BFSP8. Sites of set 1 are labeled using a red pin, and sites of set 2 are represented using a yellow pin.

Figure 5: A Google Earth aerial photo of site BFSP1, represented by the red pin on the left. Note the proximity to site BFSP2.

Figure 6: A Google Earth aerial photo of site BFSP2.

Figure 7: A Google Earth aerial photo of site BFSP3.

Figure 8: A Google Earth aerial photo of site BFSP4.

Figure 9: A Google Earth aerial photo of site BFSP5.

Figure 10: A Google Earth aerial photo of site BFSP6.

Figure 11: A Google Earth aerial photo of site BFSP7.

Figure 12: A Google Earth aerial photo of site BFSP8.

Figure 13: A Google Earth aerial photo of Green Bottom Wildlife Management Area, contain labeled points for GRNB1-GRNB6. Sites of set 3 are labeled using a blue pin, and sites of set 2 are represented using a green pin.

Figure 14: A Google Earth aerial photo of site GRNB1, marked by the lower blue pin. Note the proximity to site GRNB2.

Figure 15: A Google Earth aerial photo of site GRNB2.

Figure 16: A Google Earth aerial photo of site GRNB3.

Figure 17: A Google Earth aerial photo of site GRNB4.

Figure 18: A Google Earth aerial photo of site GRNB5.

Figure 19: A Google Earth aerial photo of site GRNB6.

Site	Site Set	Boundary Type	Transect Type	Size Class
BFSP1	1	Undefined	Traditional	Small
BFSP2	2	Undefined	Traditional	Small
BFSP3	1	Defined	Boundary	N/A
BFSP4	2	Undefined	Traditional	Small
BFSP5	2	Undefined	Traditional	Medium
BFSP6	2	Undefined	Traditional	Medium
BFSP7	1	Defined	Boundary	N/A
BFSP8	1	Undefined	Traditional	Medium
GRNB1	3	Defined	Boundary	N/A
GRNB2	4	Undefined	Traditional	Large
GRNB3	3	Undefined	Traditional	Large
GRNB4	3	Defined	Boundary	N/A
GRNB5	4	Undefined	Traditional	Large
GRNB6	4	Undefined	Traditional	Large

Table 2: Site boundary types and the transect style used to survey each site.

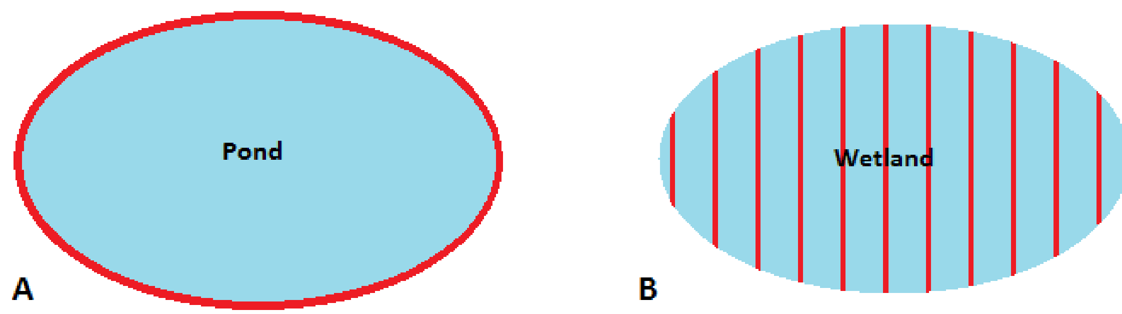

Figure 20: A diagram of the two types of transects used in this experiment. Red lines mark the path that would be followed in a transect. Diagram A represents the boundary type transects, used when the water bodies at sites have a clear, defined boundary, pond banks, for example. Diagram B represents the traditional type of transect, used when the breeding site has no clear boundary.

Figure 21: A Song Meter SM2™ automated digital recording device, designed by Wildlife Acoustics, attached to a tree. The left image has the cover on, and the right image is with the cover removed, revealing the controls. Photo courtesy of Wildlife Acoustics.

Figure 22: The ‘callbox’ used to play breeding calls during experimental surveys. In the top left of the plastic storage bin is the MP3 player, which is attached to the amplifier on the top right. That is wired to the loudspeaker in the bottom of the box. The holes covered with plastic meshing on the sides allow sound to clearly escape the box. In the field, it would also have an airtight lid covering it.

Beaufort Wind Codes	
0	Calm (<1mph) Smoke rises vertically
1	Light Air (1-3 mph) smoke drifts, weather vane inactive
2	Light Breeze (4-7 mph) leaves rustle, can feel wind on face
3	Gentle Breeze (8-12 mph) leaves and twigs move around, small flags extend
4*	Moderate Breeze (13-18 mph) moves thin branches, raises loose papers * Do not conduct survey at Level 4, unless in Great Plains
5**	Fresh Breeze (19 mph or greater) small trees begin to sway ** Do not conduct survey at Level 5 in ALL REGIONS

Table 3: The Beaufort Wind Code scale used in NAAMP protocol to note categorical wind speed during survey

Sky Codes (numbers 3 and 6 are not used)	
0	Few clouds
1	Partly cloudy (scattered) or variable sky
2	Cloudy or overcast
4	Fog or smoke
5	Drizzle or light rain (not affecting hearing ability)
7	Snow
8*	Showers (is affecting hearing ability). *Do not conduct survey.

Table 4: The Sky Code scale used in NAAMP protocol to note sky cover and weather during survey.

Massachusetts Noise Index	Definition
0	No appreciable effect (e.g. owl calling)
1	Slightly affecting sampling (e.g. distant traffic, dog barking, one car passing)
2	Moderately affecting sampling (e.g. nearby traffic, 2-5 cars passing)
3	Seriously affecting sampling (e.g. continuous traffic nearby, 6-10 cars passing)
4	Profoundly affecting sampling (e.g. continuous traffic passing, construction noise)

Table 5: The Massachusetts Noise Index, used by NAAMP to measure ambient noise categorically.

Amphibian Calling Index	
1	Individuals can be counted; there is space between calls
2	Calls of individuals can be distinguished but there is some overlapping of calls
3	Full chorus, calls are constant, continuous and overlapping

Table 6: The Calling Index used by NAAMP to provide a categorical abundance measurement of calling individuals during survey

Species	F-test	P-value	Result
Raw Data	Normal	p= 0.166	Not Significant
Northern Green Frog	Normal	p= 0.386	Not Significant
American Bullfrog	Normal	p= 0.163	Not Significant
Spring Peeper	Not Normal	p= 0.22	Not Significant
Cope's Gray Tree Frog	Normal	p= 0.178	Not Significant

Table 7: Results of the detection rate data analysis. Normal data was analyzed using Student's T-test and non-normal data was analyzed using the Wilcoxon Sum Rank Test. The alpha value for all tests was 0.05. According to these analyses, the two survey methods did not differ statistically for any species, or all species combined.

Species	F-test	P-value	Result
Raw Data	Not Normal	p= 0.195	Not Significant
Northern Green Frog	Not Normal	p= 0.278	Not Significant
American Bullfrog	Not Normal	p= 0.169	Not Significant
Spring Peeper	Normal	p= 0.038	Significant
Cope's Gray Tree Frog	Normal	p= 0.18	Not Significant

Table 8: Results of the capture rate data analysis. Normal data was analyzed using Student's T-test and non-normal data was analyzed using the Wilcoxon Sum Rank Test. The alpha value for all tests was 0.05. According to these analyses, the two survey methods differed statistically for only the spring peeper.

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CURRICULUM VITAE

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Research Experience

May 2010 to Present: Thesis Project titled "The Effect of Auditory Call Playback on Anuran Detectability, Catch Probability and Survey Efficiency"
Marshall University, Huntington, West Virginia

May 2010 to November 2010: Field Technician for a graduate thesis titled "Eastern Box Turtle Nest Site Selection and Hatchling Behavior"
Marshall University, Huntington, West Virginia

May 2010 to August 2010: Environmental consultant monitoring an Eastern Spadefoot Toad population for potential management strategies
The Point Industrial Park, South Point, Ohio

January 2010 to January 2011: Monitoring of West Virginia State Endangered Streamside Salamander Population Breeding Behavior
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May 2009 to August 2009: Field Technician for the North East Amphibian Research and Monitoring Initiative
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February 2008 to August 2008: Herpetology Collection Assistant
Frostburg State University Biology Department, Frostburg, Maryland

October 2009 to November 2009: Northern Saw Whet Owl Banding
Garrett County Maryland Banding Station, Bittinger, Maryland
Position held during additional periods:
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October 2007 to November 2007

Teaching Experience

Spring 2012: Herpetology - Lab Instructor
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Fall 2011 to Spring 2012: Human Physiology – Lab Teaching Assistant
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Spring 2011: Principles of Biology for Majors II - Lab Teaching Assistant
Marshall University, Huntington, West Virginia

Fall 2010: Principles of Biology for Majors I - Lab Teaching Assistant
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Spring 2010: Principles of Biology for Majors II - Lab Teaching Assistant
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Other Work Experience

July 2011: Laboratory Preparation Assistant for the Health Sciences and Technology Academy
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Marshall University, Huntington, West Virginia

April 2010 to Present: West Virginia State Coordinator for the North American Amphibian Monitoring Program (NAAMP)
US Geological Survey, Huntington, West Virginia

May 2004 to January 2008: Kennel Assistant, Sunchaser Kennels
Libertytown, Maryland
Position held during only during summer and winter seasons

May 2004 to August 2004: Cashier/Stock Personnel, High's Dairy Store
Mount Airy, Maryland

Grants and Scholarships Received

May 2011: Marshall University Summer Thesis Award
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June 2009: Roscoe Bartlett Scholarship Recipient
Frostburg State University, Frostburg, Maryland

May 2009: Rocky Mountain Elk Foundation Wildlife Leadership Award 2009 Recipient
Frostburg State University, Frostburg, Maryland

2006 and 2007: Loats Scholarship Recipient
University of Maryland, College Park, Maryland

2005-2007: Senatorial Scholarship recipient
University of Maryland, College Park, Maryland

Grants and Scholarships Applied

November 2010: NSF Graduate Research Fellowship
Marshall University, Huntington, West Virginia

Invited Speaker and Community Presentations

April 2012: "The Effect of Auditory Call Playback on Anuran Detection and Capture Rates"
Association of Southeastern Biologists 73rd Annual Meeting
Athens, Georgia

April 2011: Poster titled "The Effect of Auditory Call Playback on Anuran Detectability, Catch Probability and Visual Encounter Survey Efficiency"
Association of Southeastern Biologists 72nd Annual Meeting
Huntsville, Alabama

April 2010: "West Virginia Amphibians"
Canaan Valley Master Naturalists Chapter Meeting
Davis, West Virginia

April 2010: "Vernal Pools"
Canaan Valley Master Naturalists Chapter Meeting
Davis, West Virginia

April 2010: "Local Amphibians - Field Work" Guest Lecturer
Kanawha Valley Master Naturalists Chapter Meeting
Kanawha State Forest, Charleston, West Virginia

March 2009: "FIPG Risk Management Policies"
Phi Mu Delta- Mu Omicron Chapter General Body Meeting
Frostburg State University, Frostburg, Maryland

November 2008: "Arkansas Listed Herps - Reptiles"
Student Chapter of the Wildlife Society Meeting
Frostburg State University, Frostburg, Maryland

November 2008: "Arkansas Listed Herps - Amphibians"
Student Chapter of the Wildlife Society Meeting
Frostburg State University, Frostburg, Maryland

October 2008: "A Comparative Survey of Herpetofauna in Regions of the C&O Canal that Exhibit Varying Amounts of Disturbance"
Student Chapter of the Wildlife Society Meeting
Frostburg State University, Frostburg, Maryland

September 2008: "Wildlife of Appalachia"
2008 Appalachian Festival
Frostburg State University, Frostburg, Maryland

January 2008: "Effects of Global Warming Stream Table"
Focus the Nation 2008
Frostburg State University, Frostburg, Maryland

Honors and Awards

March 2010: Southeastern Chapter of The Wildlife Society's Conclave Quizbowl Judge
Frostburg State University, Frostburg, Maryland

December 2009: Magna cum Laude Honors
Frostburg State University, Frostburg, Maryland

April 2009: Greek Life Awards: Risk Management Award
Frostburg State University, Frostburg, Maryland

March 2009: Southeast Wildlife Conclave Essay Competition, 4th Place
University of Arkansas - Monticello, Little Rock, Arkansas

Fall 2007 to Fall 2009: Dean's List
Frostburg State University, Frostburg, Maryland

Spring 2006: Dean's List
University of Maryland, College Park, Maryland

Memberships and Positions Held

March 2010 to Present: Member of the Association of Southeastern Biologists

January 2010 to Present: Member of Partners in Amphibian and Reptile Conservation

December 2009 to Present: Alumnus member of The National Fraternity of Phi Mu Delta

May 2009 to May 2010: Member of the Rocky Mountain Elk Foundation

May 2008 to Present: Student Member of the National Wildlife Society

November 2008 to December 2009: Active member of The National Fraternity of Phi Mu Delta, Mu Omicron Chapter
Frostburg State University, Frostburg, Maryland
FIPG Risk Management Chair (Spring 2009 to December 2009)
Sanctions Committee Chair (Spring 2009 to December 2009)
Mentor (Fall 2009)

Fall 2007 to December 2009: Student Chapter of the Wildlife Society
Frostburg State University, Frostburg, Maryland
Vice President (Spring 2009 to Fall 2009)
Secretary (Spring 2008 to Spring 2009)

Conferences and Workshops Attended

April 2011: Association of Southeastern Biologists 72nd Annual Meeting
Huntsville, Alabama

November 2010: North Carolina Herpetological Society Fall Meeting
Raleigh, North Carolina

April 2010: Association of Southeastern Biologists 71st Annual Meeting
Asheville, North Carolina

March 2010: Southeastern Chapter of The Wildlife Society's Conclave
Frostburg State University, Frostburg, Maryland

April 2009: Northeastern Chapter of The Wildlife Society's Conclave
University of Maine, Acadia National Park, Maine

March 2009: Southeastern Chapter of The Wildlife Society's Conclave
University of Arkansas - Monticello, Little Rock, Arkansas

April 2008: Northeastern Chapter of The Wildlife Society's Conclave
Pennsylvania State University, State College, Pennsylvania

March 2008: Southeastern Chapter of The Wildlife Society's Conclave
University of Tennessee- Knoxville, Knoxville, Tennessee

November 2007: Conservation Leaders for Tomorrow
Julian, Pennsylvania

Community Service

Fall 2009 to Spring 2009: "Arboretum Cleanup Days" Crew Member
Frostburg State University, Frostburg, Maryland

Fall 2008: "Frostburg Community Haunted House" Event Planner, Coordinator and Laborer
Frostburg, Maryland

Fall 2008: "Fall Fest" Event Setup Crew Member
Frostburg State University, Frostburg, Maryland

Fall 2007 to Spring 2008: "Arboretum Cleanup Days" Crew Member
Frostburg State University, Frostburg, Maryland

Training Certifications

August 2010: Collaborative Institutional Training Initiative (CITI): Responsible Conduct of Research, Basic Course
Marshall University, Huntington, West Virginia

February 2009: Training for Intervention Procedures (TIPS) Certification
Frostburg State University, Frostburg, Maryland

Research Interests

Herpetology
Amphibian Natural History
Amphibian Behavior
Ecology
Conservation Biology
Wildlife Management Techniques
Forestry Management Practices
Plant Ecology
Community Ecology

Special Skills

Field Techniques:

- Reptile and amphibian capturing, handling and care
  - Northeastern US herpetofauna visual identification
  - Northeastern US amphibian larval identification
  - Northeastern US frog call identification
  - Conducting visual encounter surveys
  - Dipnetting
  - Stream surveying
  - Toe clipping
  - Visual implant elastomer marking

- Chytrid fungus detection swabbing
- Pitfall trapping
- Drift fences
- Radio telemetry

Avian capture, handling and care
- Mist netting
- Bird banding

Mammal capture and handling
- Mammal trapping (Sherman traps, body holding traps, leg hold traps, snares, tomahawk traps, etc.)
- Radio telemetry

Forestry Techniques:
- Timber cruising
- Performing cuts
- Northeastern US tree identification
- Northeastern US shrub identification
- Northeastern US herb identification

Equipment:
- Basic field equipment associated with herpetological, ecological and wildlife management surveys and techniques
- Compasses
- GPS units
- Handheld weather meters
- Digital cameras
- Automated recording devices
- Trail cameras
- Radio telemetry equipment

Museum Curation Techniques:
- Skeletonizing
- Skeleton preparation
- Alcohol preparation
- Creating study skins
- Mounting specimens
- Molding and Casting

Software:
- Familiar with Windows, Macintosh and several Linux operating systems
- Microsoft Office: PowerPoint, Word, Excel, Access
- ArcGIS 9.3
- SAS 9.2