AMPHIBIAN POPULATION DYNAMICS AT SEVEN ISLANDS WILDLIFE REFUGE

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ABSTRACT

Seven Islands Wildlife Refuge (SIWR) is a 360-acre Knox County park about 8.5 miles east of Knoxville, Tennessee. The refuge, on former farmland, includes the Kelly Bend peninsula along the French Broad River. Amphibian sampling on the refuge began in June 2005 and extended to the end of July 2006. Sampling techniques included pitfall traps, mark-recapture methods, and breeding call surveys. In September 2005, a wetland impoundment was constructed and in addition to collecting baseline amphibian population information, data could also be analyzed to make comparisons about density, abundance, and richness prior to and after the construction. Nine anuran species were documented during sampling at SIWR: American bullfrog *(Rana catesbiana)*, American toad *(Bufo americanus)*, Eastern narrow-mouthed toad *(Gastrophryne carolinensis)*, Fowler's toad *(Bufo fowleri)*, green frog *(Rana clamitans)*, pickerel frog *(Rana palustris)*, southeastern chorus frog *(Pseudacris ferarium)*, Cope's gray treefrog *(Hyla chrysoscelis)*, spring peepers *(Pseudacris crucifer)*, and the Southern leopard frog *(Rana sphenocephala)*. The greatest species richness occurred at the wetland after construction. Relative abundance of amphibians was greatest at the pond, and dominated by green frog metamorphs. Green frog metamorphs also were most common at the river, and Fowler's toad was most abundant at the wetland. Peak captures in pitfalls occurred in June and July both years, and corresponded with the emergence of metamorphs. It appeared that levee construction significantly improved the quality of amphibian habitat at the wetland.

Four additional species were documented and total abundance was greater after construction. These preliminary results indicate that important habitats exist at SIWR for amphibians, and wetland construction significantly increased the number of species using the area. If additional suitable sites exist, I recommend construction of similar shallow-water areas to increase the amount and quality of amphibian habitats at Seven Islands Wildlife Refuge.

INTRODUCTION

In the late 1990's the Seven Islands Foundation, a non-profit land conservancy founded by the Pete Claussen family, converted over 400 acres of alluvial bottomland and rolling uplands on Kelly Bend in East Knox County from farmland into a nature and wildlife sanctuary. Their vision was to acquire the property, develop the refuge, and offer it for public enjoyment. That vision became reality in 2002 with an agreement placing the land under jurisdiction of Knox County's Department of Parks and Recreation, with joint management by the Seven Islands Foundation and Knox County. A permanent conservation easement now protects the refuge, and three years of native grassland restoration, habitat diversification and riparian and wetland enhancements are underway. One of these "wetland enhancements" was the construction of a shallow water impoundment with a water control device, which began three months after the onset of sampling (September 2005).

Amphibians are declining globally, and there is a nationwide effort to document species occurrences and their relative abundance. It has been suggested that the decline in amphibians is directly correlated to the loss of wetland habitats. The U.S. Fish and Wildlife Service (USFWS) has shown that we have already lost more than half of the

wetlands that existed at the time of European settlement in what is now the lower 48 continental United States (USFWS 2002). Wetland habitats are essential for amphibians due to their complex life cycle, and water is one of the most essential elements to amphibian reproduction. Water (either permanent or seasonal) is required for reproduction because many (but not all) amphibians perform mating rituals near or in water, lay their eggs in water, and the larval young from these eggs develop in water until metamorphosis (UGA 2005). Without water, reproduction is severely hindered. Establishing baseline data on amphibian communities is essential to documenting population trends (Houlahan et al. 2000, Stewart et al. 2004). Although the Tennessee Wildlife Resources Agency (TWRA) lists 35% of Tennessee amphibian species in concern of decline (TWRA 2005), very little population information exists for most species in our state. At Seven Islands Wildlife Refuge, few amphibian surveys have been performed (W. Schacher, Natural Resource Services, *personal communication*). Therefore, the objectives of this study were:

- Document and compare amphibian populations among four sites (pond, river, constructed wetland, and forested bluff),
- Document and compare amphibian populations before and after wetland construction, and
- Document movement (if any) of individual amphibians among the four sites.

Completion of these objectives will aid the Seven Islands Wildlife Foundation in making management decisions and improvements on the refuge in years to come. By knowing the species already present (and relative population sizes) they will have a better idea of how to manage for those species that present a need for additional conservation.

MATERIALS AND METHODS

Study Site

Four different habitat locations were chosen at Seven Islands Wildlife Refuge to be the designated sampling sites. The sites were chosen because they either had a permanent water source or could provide a stopover point for amphibians moving between water sources. These sites included a pond site, a wetland site, a site along the French Broad River, and finally a wooded site that didn't have a permanent water source (Figure 1). The pond site includes a 1.5 acre, partially wooded, permanently flooded water source universally referred to as Shumpert's Pond. This pond was constructed in an upland area of SIWR roughly 15 years ago. At one point Shumpert's pond was the primary water source for a domestic cattle herd. Since the land was converted to a refuge, however, it has become a prime location for amphibian populations to flourish. The wetland site began as a drift fence in the middle of unshaded, low elevation grassland that was being managed for warm season grass restoration. There was a small, semi-permanent channel that drained to the French Broad River, bordering one side of the grassland. Once the levee was built and water control structure installed, this site quickly transformed into a shallowly flooded wetland area with a fairly large amount of obligate wetland plants and emergent vegetation. The river site is located along a fork of the French Broad River, downstream from Douglas Reservoir, in a well-shaded riparian zone. Lastly, the forested bluff site was a sampling location in a mixed mesophytic hardwood stand (>50 years) dominated by mast producing trees at a higher elevation. This particular site has no permanent water source but was chosen due to possibility of

documenting movement from the river to the other inland water sources (namely Shumpert's Pond).

Field Sampling

In May 2005, with the assistance of many hard working volunteers, pitfall traps and drift fences were installed at all four sites (Dodd and Scott 1994). Two of these sites (pond-31traps and wetland-25 traps) were partly encircled by the fence for ½ the total circumference of the body of water. The pitfalls and drift fence at the river site (9 traps) were placed in a straight line (~40 m) along the riverbank. We chose a straight line design for this site simply because it is not feasible to "encircle" a river. Finally, at the forested site we created an X-array (6 traps) because there was not a body of water that could be incorporated into the design. This design also provided the maximum amount of fencing and traps that could be placed on a forested bluff site to increase the possibility of capture. Pitfalls were 4.5 gallon buckets and drift fence was 3-ft high silt fencing (Figure 2). To install these pitfall traps, holes were dug using a 12 inch auger, and the buckets were placed down into the resulting hole to the point in which the tops of the buckets were flush with the ground. Once the buckets were in the ground, the remaining soil (from the auger and resulting holes) was used to pack around the edges of the bucket in order to reduce any excess open areas.

For ½ of the distance (or ¼ of the circumference) at the pond and wetland, pitfalls were placed every 10 meters on alternate sides of the fence, and 5 meters for the remaining portion. This was done to determine if pitfall spacing influences amphibian capture rates (an ancillary objective). Alternating buckets from on opposite sides of the fence allows for an increased chance of capturing amphibians both headed to, and away

from, the water source. At the river, pitfalls were spaced every 5 m. The X-array was created by intersecting two 10 m sections of drift fence at their midpoints, resulting in 4 leads equaling 5 m each, and creating 4 capturing quadrants (Corn 1994). We put one bucket at the 4-point intersection in each quadrant, and at the distal end of each lead. The fence bisected the pitfall at the distal end (Figure 2). Approximately 2 cm of water and a 5-cm high sponge were placed in each bucket to help reduce the chance of captured amphibian desiccation and to allow incidentally captured small mammals (or any other species that may run the risk of drowning) to sit elevated above the water, respectively (Dodd and Scott 1994).

All the pitfall traps were opened (by removing the bucket lids) once per week (with the exception of one week in which they were opened twice for teaching purposes) near dusk and rechecked the following morning. If amphibians were captured, the snout-vent length (svl) was measured (to the nearest tenth of a millimeter) with calipers and recorded. Body mass was also determined and recorded (to the nearest tenth of a gram) by using a Pesola® scale (Fellers et al. 1994). Also each captured individual was uniquely toe clipped, following the Hero toe clipping scheme, using sterilized scissors (Donnelly et al. 1994 and Hero 1989). Toe clipping was used as a mark-recapture method to determine if certain individuals were caught more than once, or in a different location, indicating movement. Once data was collected and individuals were uniquely marked, they were released on the opposite side of the fence from which they were captured. Releasing on the opposite side of the fence allows the amphibian to continue in its original direction (either headed to or away from the water source) before it was captured. After each site was inspected for captures, and all captures properly

documented, the lids were placed back on the buckets and the pitfalls were closed until the following week.

Breeding Call Surveys

Once a week, after the pitfall traps were opened and at least 30 minutes after sunset, breeding call surveys were performed at three of the four sites. The forested site was not a part of this particular sampling method due to the fact that the site did not have a water source (usually the location from which breeding males will vocalize) and it was a somewhat hazardous site. This site was deemed "hazardous" because of its location (at the top of a 200-ft bluff), and since only one person conducted this research, it posed a safety risk to hike to this site and back again in the dark, alone. For the surveys performed at the three main sites, all amphibians that were heard calling at some point during a five-minute period were recorded and ranked according to USGS North American Amphibian Monitoring Protocol (English 2002). These surveys provided additional information on species richness of amphibians present, since some species (e.g., treefrogs) are not likely to be captured in pitfalls, but can be readily heard calling at breeding site locations. All of these research methods (pitfall traps, mark-recapture, and breeding call surveys) have been reviewed and approved by the University Of Tennessee Institutional Animal Care and Use Committee (IACUC) (Protocol Number 1458) and the Tennessee Wildlife Resources Agency (Permit Number 1990).

Statistical Analysis

Most of the data that was collected over the consecutive fourteen month sampling period was simply baseline information indicating the species of amphibian present and the relative abundances of those species. Therefore, there was little data that could be

compared or analyzed. However, differences ($\alpha = 0.05$) in relative abundance and species richness among sites were tested using analysis-of-variance (ANOVA) and Ryans-Q Multiple Comparison test when $P < 0.05$.

RESULTS AND DISCUSSION

A total of 633 anurans of 6 species were captured at SIWR between June 2005 and July 2006 (Table 1). Four additional species were heard and documented by breeding call surveys, but not captured. Only one of the species that was captured was not heard calling. Therefore, 10 total anuran species were documented by this fourteen month sampling effort. Only one individual (*Gastrophryne carolinensis*) was captured at the forested bluff site, therefore this site was excluded from all statistical analysis and comparisons. Only one species, *Rana clamitans*, was common (captured and heard) at all three sampling sites. The most abundant species overall was also *R. clamitans*, totaling 84.7% of all captures (Figure 3). The site with the greatest relative abundance and highest mean daily capture was the pond site (Figure 4 and Table 5), which was also dominated by *R. clamitans* metamorphs. The pond is characterized by a permanent hydroperiod with few predatory fish. It is likely that these aquatic conditions favored *R. clamitans* tadpole survival and perhaps metamorph recruitment. Green frog tadpoles also may overwinter in ponds when conditions are favorable and predate eggs of other species, giving them a competitive advantage. By far, the most common age group captured was metamorphs (99.4%). Since adult captures were too low (only 4) to be considered statistically valid, they were excluded from comparisons. *Rana clamitans* metamorphs were also the most common species and demographic captured at the river. However, the most abundant species and age class at the wetland site was *Bufo fowleri.*

We also determined by comparing monthly capture rates that the best sampling period for pitfall trapping and performing breeding call surveys for amphibians at Seven Islands Wildlife Refuge was from mid-April until the end of July (Figure 5). That particular time frame included the highest amount of captures and species heard calling (Figure 6). The other months lacked sufficient captures to validate opening the pitfall traps and the species that were collected during that time were species that were well represented (ie: *R. clamitans & R. catesbiana*) throughout the "ideal" sampling period (Table 3). The relative daily capture rates were also higher during those months.

Richness (total number of species) was greatest overall at the wetland after construction (Figure 7). Furthermore, after the wetland was created, four additional species were documented in the months that overlapped sampling (June & July). After construction, emergent vegetation was shallowly flooded, which may have increased habitat quality for breeding species. Mean relative captures by species and site and relative species richness by site were the only data that proved to be significantly valid. We found that wetland site was significantly (Ryans Q Multiple Comparison Test) different from the other two sites with respect to relative daily capture rates (when $P>0.05$) (Table 4). Also, the greatest overall species richness occurred at the wetland site, which proved to be significantly different (ANOVA) from the river and pond sites ($\alpha=0.05$).

CONCLUSIONS AND CONSERVATION RECOMENDATIONS

Throughout the fourteen-month amphibian-sampling period as Seven Islands Wildlife Refuge, there were many expected and unexpected occurrences. For example, the only species that was captured at the forested ridge site was not a species that we

would not have initially thought to inhabit that particular niche. Some of the predictable results included the strong presence of *R. clamitans* and *R. catesbiana* at the sites that had a permanent water source. This may be accounted for by the fact that the tadpoles of these two ranid species will commonly overwinter in a body of water, which gives them quite a competitive edge as larger and further developed individuals when compared to those tadpoles that have to start and finish larval development in the same season. Also, the species heard calling during the breeding call surveys were typical east Tennessee anuran species that are most often heard calling in similar locations. It was unexpected to have such an extremely low number of adult captures. However, this may be the result of pitfall buckets that were not quite deep enough. Most of the species that were captured exhibit fairly large adults, who may have been able to get out of the buckets, but this is still unclear.

It can be noted that the addition of amphibian habitat significantly increased the diversity and density of amphibians documented. Therefore, I recommend if resources are available that additional shallow-water wetland impoundments be constructed at suitable sites at Seven Islands Wildlife Refuge. In addition, areas along the French Broad River and the pond should be conserved, because they are important amphibian habitats on the refuge. The conservation of river habitats may be accomplished by increasing riparian zones and decreasing or correcting bank erosion.

ACKNOWLEDGEMENTS

I would personally like to thank Seven Islands Foundation and Mr. Pete Claussen for providing the majority funding for this project and for giving me the opportunity to work with such important species at a truly spectacular and beautiful wildlife refuge.

Also, I would like to acknowledge the contributions of Mr. Wayne Schacher, Natural Resource Services, to this project. Wayne provided much appreciated direction and inspiration for this endeavor. I would also like to thank the University of Tennessee College of Agriculture and Natural Resources Honors Research and Creative Achievements Program for providing additional funding and support. And last, but not least, I would like to thank Dr. Matthew J. Gray for providing essential guidance, assistance, and support required to make this undertaking as successful as it possibly could have been.

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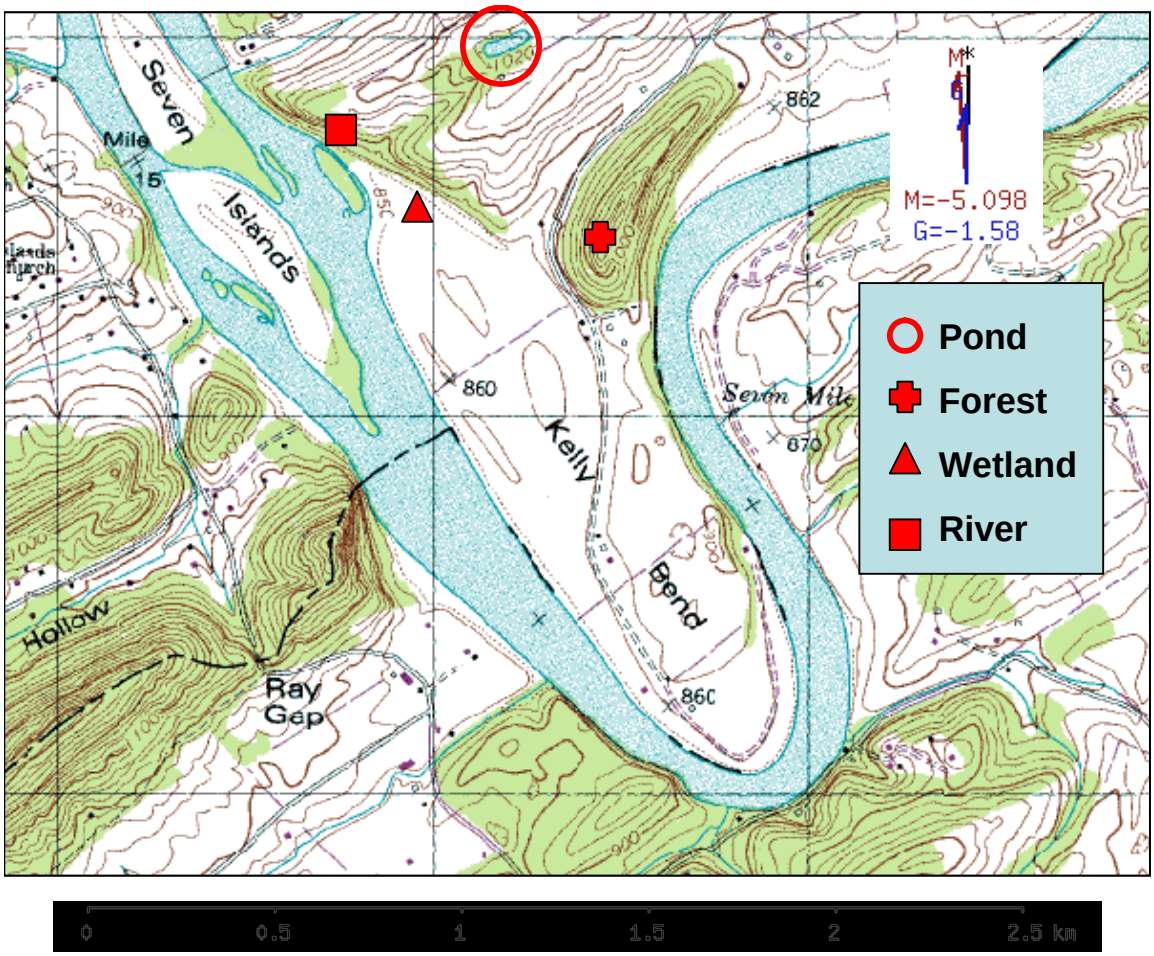

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Figure 1. Pond, forest, wetland and river sampling sites at Seven Islands Wildlife Refuge, Knox County, Tennessee. Map created at www.topozone.com.

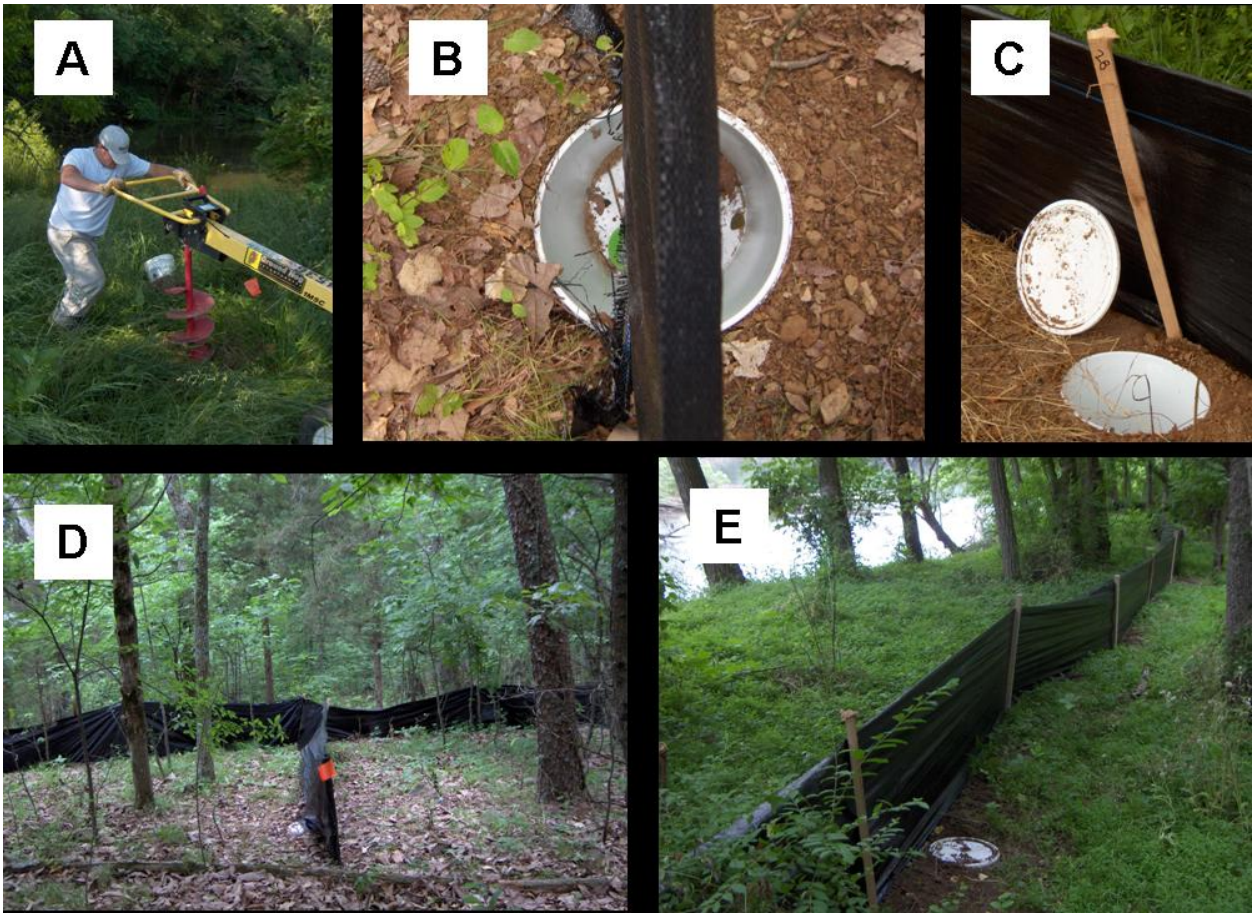

Figure 2. Pitfall installation (A), array pitfalls (B), straight-line drift fence pitfalls (C), X-array at forested site (D), and straight-line drift fence at river site (E), Seven Islands Wildlife Refuge, Knox County, Tennessee.

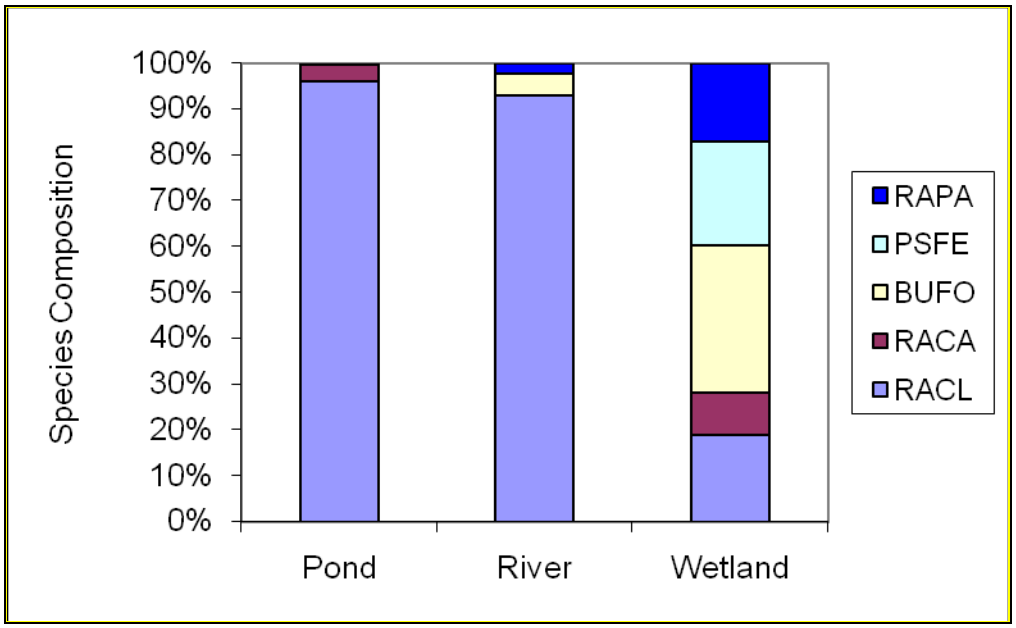

Figure 3. Total Species Composition of anurans caputured per site at Seven Islands Wildlife Refuge over a fourteen month sampling period (June 2005-July 2006).

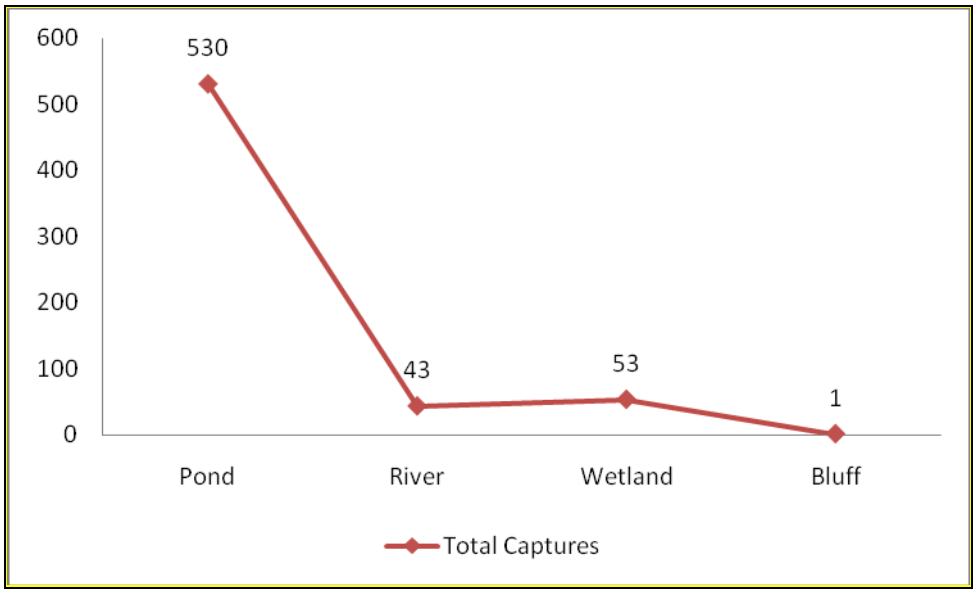

Figure 4. Total number of individuals captured at Seven Islands Wildlife Refuge by site from June 2005-July 2006.

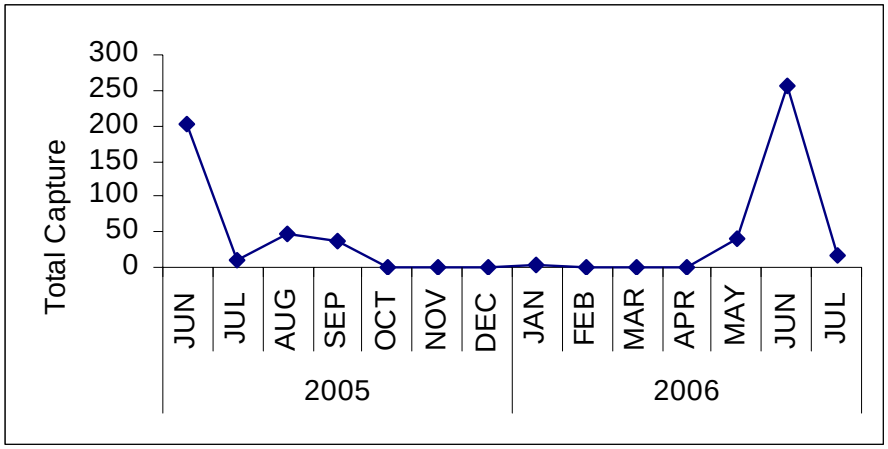

Figure 5. Total Number of Captures at Seven Islands Wildlife Refuge during fourteen month sampling period.

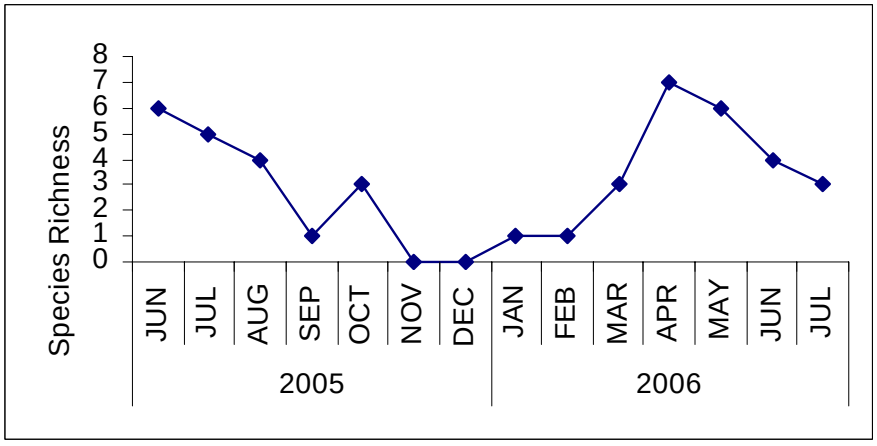

Figure 6. Total Richness (Number of Species heard calling) at Seven Islands Wildlife Refuge during fourteen moth sampling period.

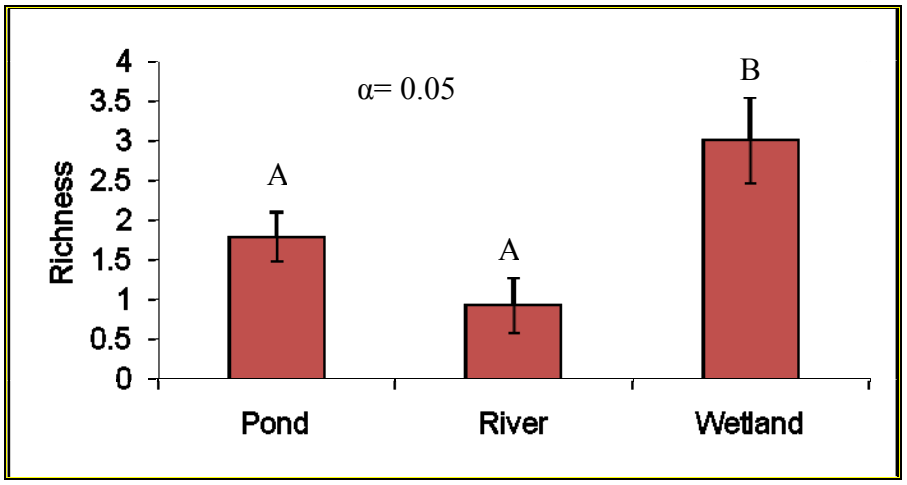

Figure 7. Total overall species richness (including captures and breeding call surveys) by site at Seven Islands Wildlife Refuge. (ANOVA analysis)

Species Heard	Species Captured
RACL	RACL
RACA	RACA
PSFE	PSFE
BUFO	BUFO
RAPA	RAPA
RASP	GACA
HYCH	
PSCR	
BUAM	

RACL = *Rana clamitans* = green frog
RACA = *Rana catesbiana* = American bullfrog
PSFE = *Pseudacris feriarum* = Southeastern chorus frog
BUFO = *Bufo fowleri* = Fowler's toad
RAPA = *Rana palustris* = pickerel frog
RASP = *Rana spehenocephela* = Southern leopard frog
HYCH = *Hyla chrysoscelis* = Cope's gray tree frog
PSCR = *Pseudacris crucifer* = spring peeper
BUAM = *Bufo americanus* = American toad
GACA = *Gastrophryne carolinensis* = Eastern narrow-mouthed toad

Table 1. Species (and species acronyms) documented at Seven Islands Wildlife Refuge from June 2005-July 2006.

Variable	Species	Age-Class	Mean	SE
SVL	Green	AM*	71.05	4.05
		Meta*	29.03	0.24
	Bull	Meta	39.48	1.045
	NMTD	AF*	33.25	1.35
	Chorus	Meta	11.62	0.234
	Ftoad	AF	72.9	-
		Meta	14.78	1.079
	Atoad	Meta	12.9	-
	Pickerel	Meta	31.18	0.583
Mass	Green	AM	32.25	8.25
		Meta	2.805	0.067
	Bull	Meta	6.702	0.469
	NMTD	AF	3.25	0.25
	Chorus	Meta	0.5	0
	Ftoad	AF	62	-
		Meta	0.59	0.07
	Atoad	Meta	0.5	-
	Pickerel	Meta	3.188	0.193

Table 2. Size Information By Species and Demographic By Site at Seven Islands Wildlife Refuge. (SE=Standard Error)
*AF= Adult female, AF= Adult Male, and Meta= Metamorph

	2005						2006			
	JUN	JUL	AUG	SEP	OCT	DEC	JAN	MAY	JUN	JUL
RACL	199	8	45	34	0	1	0	15	234	12
RACA	2	1	3	2	1	0	3	0	9	3
BUFO	0	0	0	0	0	0	0	15	2	2
PSFE	1	0	0	0	0	0	0	9	2	0
RAPA	0	0	0	0	0	0	0	0	10	0
Totals:	202	9	48	36	1	1	3	39	257	17

Table 3. Monthly Species Composition of species captured at Seven Islands Wildlife Refuge from June 2005-July 2006. (Months with zero captures were omitted.)

Species	Pond Mean	SE	Wetland Mean	SE	River Mean	SE	
Green	0.263 A	0.118	0.0065 B	0.0026	0.059 B	0.031	P= 0.026
Bull	0.0099 A	0.0045	0.0032 A	0.0017	0	0	P= 0.167
Chorus	0	0	0.0077	0.0043	0	0	
Ftoad	0	0	0.011 A	0.0085	0.0036 A	0.0036	P= 0.43
Atoad	0	0	0.0006	0.0006	0	0	
Pickerel	0	0	0.0058 A	0.0046	0.0018 A	0.0018	P= 0.42

Table 4. Mean Daily Relative Capture Rate by species and site at Seven Islands Wildlife Refuge from June 2005- July 2006.

*****Ryans-Q Multiple Comparison Test (P>0.05), where A and B are significantly different