Use of artificial wildlife ponds by reptiles in eastern Texas

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ABSTRACT - Reptiles and amphibians can make up a significant part of the biomass in some ecosystems in southeastern North America. Habitat alterations occur on most of the land in the United States and can have both negative and positive effects on the herpetofauna. However, some modifications are intended primarily as wildlife habitat improvement, such as the creation of wildlife ponds. We surveyed 8 artificial wildlife improvement ponds in two National Forests in eastern Texas for the presence of reptiles from 2 May 2001 to 27 December 2006 using aquatic mesh funnel traps. We captured 119 individuals of 11 species in the eight ponds. Snakes accounted for over 78% of the total captures while turtles only accounted for 22%. Reptile captures differed across ponds and across forest and were most common between March and October.

A rich diversity of amphibians and reptiles inhabit the forested lands of the southeastern United States (Peterson, 1998; Harris, 1980). More than half of the herpetofauna native to the United States occurs in the southeast (Russell et al., 2004) and can account for a large portion of the overall biomass in some forest ecosystems (Burton & Likens, 1975; Congdon et al., 1986; Gibbons et al., 2006; Iverson, 1982).

Southern forests cover over 86 million ha and of that, 12 percent is publicly owned (Smith et al., 2003). Much of this public land is managed for timber production, wildlife conservation and recreation. Various forest practices such as clearcutting, thinning and prescribed fire are often used to manage public lands. Concerns about the impacts of these forest practices on wildlife populations have led to a multitude of research. Silvicultural practices such as clearcutting and thinning can positively affect some species of amphibians and reptiles while negatively affecting others (Goldstein et al., 2005; Phelps & Lancia, 1995; Ross et al., 2000). In Pennsylvania, Ross et al. (2000) found that salamander abundance and richness increased with an increase in stand basal area while there was an increase in snake abundance and richness with decreased basal area in forested habitats. They also noted that anuran abundance and richness was not affected by basal area; however, the presence of water did affect amphibian abundance and richness. Semlitsch et al. (2009) found that timber harvest treatments can have different effects on amphibians depending on life stage.

Prescribed burning is another tool used in the management and restoration of forest in the southeastern United States, and can have positive or negative effects on herpetofauna (Floyd et al., 2002; Moseley et al., 2003; Mushinsky, 1985, Mushinsky, 1986; Wilgers & Horne, 2006). Other management practices such as wildlife clearings (openings in the forest canopy that are maintained to retain a herbaceous ground cover), streamside management zones (land adjacent to streams, rivers or lakes that are retained during management practices to protect water quality, wildlife habitat, fish, and other resources), and formation of road rut ponds (holes left in dirt or gravel roads from vehicle traffic that fill with water) can positively affect herpetofauna (Adam & Lacki, 1993; Pais et al., 1988; Rudolph & Dickson, 1990).

In 1930, the United States Congress passed the Knutson-Vandenberg (K-V) Act, which states that some proceeds from the sale of national forest timber will be used for the planting, sowing of tree seeds, and removal of undesirable trees left by the purchaser to improve the future stand of timber within (Knutson-Vandenberg Act, 1930). In 1976,

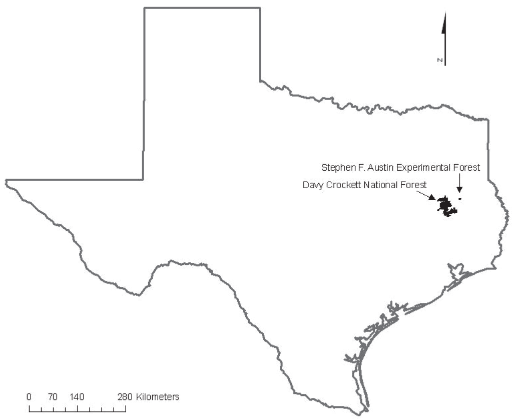

Figure 1. Map of Texas, USA showing the Davy Crockett National Forest and Stephen F. Austin Experimental Forest.

the Act was amended to allow K-V funds, generated from a given sale timber area, to be used to improve the productivity of the renewable resources and for wildlife habitat management within that sale area. Since the passing of the Act, millions of hectares of timber have been harvested on the national forests producing millions of dollars for the improvement of these lands. In the early 1990s, the National Forests and Grasslands of Texas began to use some of these K-V funds to create artificial ponds to improve wildlife habitat. More than 150 ponds have been created across the four national forests in east Texas (Angelina, Davy Crockett, Sabine, and Sam Houston National Forests). These ponds were created by simply excavating holes in the earth or by damming streams. Some ponds have been stocked with fish to create public fishing opportunities while fish were not added to others. The use of these wildlife ponds by reptiles is currently unknown. Snakes and turtles are common in north America, and many of these species prefer aquatic environments (Ernst et al., 1994; Gibbons & Dorcas, 2004; Werler & Dixon, 2000). Thus, it is reasonable to assume that some snakes and turtles would use these wildlife ponds.

The objective of this study was to determine reptile use of these artificially created wildlife ponds in eastern Texas.

METHODS AND MATERIALS

We sampled eight wildlife ponds from 2 May 2001 to 27 December 2006 in eastern Texas. Four ponds (numbered 1-4) are located in the Stephen F. Austin Experimental Forest (SFAEF). The SFAEF, located in Nacogdoches County, Texas, is part of the Angelina National Forest and contains habitats ranging from bottomland hardwoods to upland pine (*Pinus* spp.) (Fig. 1). The four ponds were constructed in April 2000 in secondary growth pine forest. Four additional ponds (numbered 5-8) were located in the Davy Crockett National Forest (DCNF; Fig. 1). The DCNF is located in Houston County, Texas, and consists of various habitat types. The ponds located in the DCNF that were selected for this study were created in 1994 and are also located in areas of second-growth pine stands. All ponds contained water year around and varied in size from 63 m^2 to 1945 m^2.

We placed two 25 x 25 x 46 cm, collapsible mesh funnel traps with 6 cm openings in each pond. The traps were made of flexible mesh material, stretched over a wire frame. We located the traps in the littoral zone of each pond with at least 5 cm of each trap above the water to allow captured animals to breathe. The water level in some of the ponds fluctuated greatly. In these ponds, we placed foam in the traps to act as a float in order to keep the trap from becoming submerged during flood conditions. We opened and monitored the funnel traps one day per week. Reptiles in the traps were removed, identified to species, counted and then released. Traps were not left in situ.

Habitat characteristics were measured at each pond within a 100 m radius. This was accomplished by using 4 x 100 m transects which extended in the four cardinal directions (north, south, east, and west) from the pond. Data were collected every 50 m for a total of 3 plots per transect and twelve plots per pond. Every 50 m we sampled trees using a prism with a basal area factor of 1.0 m^2/ha^{-1}, and we measured percent canopy closure, percent dicot cover, and percent monocot cover using an ocular tube (James & Shugart, 1970). At each pond, we measured overstorey and midstorey height (using a clinometer) and horizontal foliage density (MacArthur & MacArthur, 1961); we also determined stand age by collecting increment cores from two of the dominant trees in the stand. Midstorey density was visually estimated and assigned a categorical score of 1-5, where 1 was the least dense and 5 was most dense.

We used ArcMap™ (Environmental Systems Research Institute, 2006) to determine the distance (km) from each pond to the nearest permanent water source (pond, creek, lake, etc.). We collected GPS locations for each pond, using a Garmin® GPSMAP® 60CSx, and projected the data onto a GIS layer displaying an aerial photograph of the respective stands. We then located the nearest preexisting permanent water source and calculated the straight line distance from the pond to the water source.

We calculated Shannon's diversity index for cumulative reptile captures for each pond and compared the cumulative reptile community among ponds with the Bray-Curtis distance measure (BCI) (McCune and Grace 2002).

RESULTS

We sampled the eight wildlife ponds for reptiles for a total of 16,560 trap days (the cumulative number of days all traps were open). We captured 119 individuals of 11 species in the eight ponds. Of the 119 individuals, 93 were snakes (7 species) and 26 were turtles (4 species). In the SFAEF ponds we captured 107 individuals (11 species) while we captured only 12 individuals (4 species) in the DCNF (Table 1). We captured most reptiles between March and October but one individual was captured in January (Table 2).

Shannon's diversity index for reptiles ranged from 1.509 to 1.743 in the SFAEF and 0 to 1.011 in the DCNF (Table 1). Ponds 7 and 8 in the DCNF had only one individual capture and thus a diversity index could not be calculated. Ponds 5 and 6 had 3 species and thus low indices of 0.637 and 1.011, respectively. The cumulative reptile communities were more similar within the SFAEF (avg. BCI = 0.4693) than within the DCNF (avg. BCI = 0.7103) (Table 3). Pond 3 was the most dissimilar within the SFAEF (BCI = 0.6228) and pond 8 (BCI = 0.9048) was the most dissimilar among the DCNF ponds.

Nerodia erythrogaster was the most common reptile captured in traps, occurring in seven of eight ponds (n = 44); in contrast, we only captured one *Regina rigida* and one *Deirochelys reticularia*. The traps in pond 4 captured the most individuals (n = 42) and pond 4 had the highest species richness (n = 8) while the traps in ponds 7 and 8 only captured one individual (Table 1).

We captured the most individuals in 2003 (n = 35) followed by 2004 (n = 25) (Table 4). The fewest individuals were captured in 2002 (n = 7), which was the first full calendar year of trapping.

Habitat characteristics varied across pond and forest (Table 5). Average basal area ranged from 0.9 m^2/ha to 22.6 m^2/ha across the eight ponds. The average basal area was typically lower around the ponds in the SFAEF when compared to the ponds in the DCNF. The average foliage density measurement (0-1 m) ranged from 2.5 m to 20.1 m with most of the ponds in the DCNF having a higher measurement (less foliage) compared to the ponds in the SFAEF (Table 5). The average percent canopy closure ranged from 15.8% to 90.1%. The habitat surrounding the ponds in the DCNF typically had a more closed canopy compared to the habitat surrounding the ponds in the SFAEF (Table 5). The average distance to a permanent water source for the ponds in the SFAEF was 0.67 kilometers while the average distance for the DCNF was 1.23 kilometers. Also, it is important to note that the permanent water source nearest the ponds in the SFAEF was a creek; conversely the nearest water source for the DCNF ponds were all ponds with the exception of pond 8 which was closest to Ratcliff Lake.

DISCUSSION

We captured more than 100 individual reptiles across eight artificial wildlife improvement ponds. Snakes accounted for most of the individuals captured and most of the species. Turtles were much less commonly trapped and only accounted for 26 individuals and four species. This difference could be due, in part, to the type of traps we used. All of the turtle species that occur in eastern Texas can grow to a size that is too large to fit in the openings in the traps we used (Ernst et al., 1994). Thus our sampling might have been biased towards sampling smaller immature turtles while excluding adults.

Species	SFAEF ponds 1	2	3	4	DCNF ponds 5	6	7	8	Total
Squamata									
Nerodia erythrogaster	9	11	5	14	2	2	1	0	44
Nerodia fasciata	2	4	0	6	0	1	0	1	14
Nerodia rhombifer	1	5	6	6	0	0	0	0	18
Thamnophis proximus	3	1	0	4	0	0	0	0	8
Farancia abacura	3	2	0	1	0	0	0	0	6
Regina rigida	0	0	1	0	0	0	0	0	1
Agkistrodon piscivorus	0	0	0	1	1	0	0	0	2
Testudines									
Trachemys scripta	2	2	0	9	0	0	0	0	13
Kinosternon subrubrum	0	0	5	1	1	3	0	0	10
Sternotherus odoratus	0	0	2	0	0	0	0	0	2
Deirochelys reticularia	0	0	1	0	0	0	0	0	1
Total	20	25	20	42	4	6	1	1	119
Shannon's diversity index	1.539	1.509	1.584	1.743	0.637	1.011	0.00	0.00	

Table 1. Number of individuals and species captured in each wildlife pond in the Stephen F. Austin Experimental Forest (SFAEF) and Davy Crockett National Forest (DCNF), Texas, U.S.A., from 2 May 2001 to 27 December 2006.

Species	Month: Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Squamata												
Nerodia erythrogaster	0	0	2	6	10	8	5	5	5	3	0	0
Nerodia fasciata	1	0	1	3	3	2	1	2	1	0	0	0
Nerodia rhombifer	0	0	0	1	7	2	2	2	3	1	0	0
Thamnophis proximus	0	0	0	2	4	0	0	0	1	1	0	0
Farancia abacura	0	0	0	0	2	1	2	0	1	0	0	0
Regina rigida	0	0	0	0	0	1	0	0	0	0	0	0
Agkistrodon piscivorus	0	0	0	0	2	0	0	0	0	0	0	0
Testudines												
Trachemys scripta	0	0	0	1	7	5	0	0	0	0	0	0
Kinosternon subrubrum	0	0	1	1	2	2	2	0	0	2	0	0
Sternotherus odoratus	0	0	0	0	1	0	1	0	0	0	0	0
Deirochelys reticularia	0	0	0	0	1	0	0	0	0	0	0	0
Total	1	0	4	14	39	21	13	9	11	7	0	0

Table 2. Number of individuals and species captured in traps by month from 2 May 2001 to 27 December 2006 in the Stephen F. Austin Experimental Forest (SFAEF) and Davy Crockett National Forest (DCNF), Texas, U.S.A. All ponds combined.

Pond	1	2	3	4	5	6	7	8
1	0.0000	0.2444	0.7000	0.4194	0.8261	0.7692	0.9048	0.9048
2	0.2444	0.0000	0.5556	0.2836	0.8571	0.8065	0.9231	0.9231
3	0.7000	0.5556	0.0000	0.6129	0.7391	0.6154	0.9048	1.0000
4	0.4194	0.2836	0.6129	0.0000	0.8667	0.8333	0.9535	0.9535
5	0.8261	0.8571	0.7391	0.8667	0.0000	0.3333	0.5000	1.0000
6	0.7692	0.8065	0.6154	0.8333	0.3333	0.0000	0.7143	0.7143
7	0.9048	0.9231	0.9048	0.9535	0.5000	0.7143	0.0000	1.0000
8	0.9048	0.9231	1.0000	0.9535	1.0000	0.7143	1.0000	0.0000
SFAEF mean	0.4546	0.3612	0.6228	0.4386				
DCNF mean					0.6111	0.5873	0.7381	0.9048
Overall mean	0.6812	0.6562	0.7325	0.7033	0.7318	0.6838	0.8429	0.9280
N standard deviations	-0.68	-0.95	-0.13	-0.45	-0.14	-0.66	1.05	1.96

Table 3. Sorensen (Bray-Curtis) distance measures comparing the cumulative reptile community among wildlife ponds in the Stephen F. Austin Experimental Forest (ponds 1-4) and Davy Crockett National Forest (ponds 5-8), Texas, U.S.A., 2 May 2001 to 27 December 2006.

Species	2001	2002	2003	2004	2005	2006	Total
Serpentes							
Nerodia erythrogaster	6	3	17	3	8	7	44
Nerodia fasciata	1	0	7	1	3	2	14
Nerodia rhombifer	8	0	3	3	0	4	18
Thamnophis proximus	0	3	1	1	2	1	8
Farancia abacura	0	0	5	1	0	0	6
Regina rigida	0	0	0	1	0	0	1
Agkistrodon piscivorus	0	0	0	1	0	1	2
Testudines							
Trachemys scripta	0	0	2	9	0	2	13
Kinosternon subrubrum	0	0	0	5	4	1	10
Sternotherus odoratus	1	1	0	0	0	0	2
Deirochelys reticularia	0	0	0	0	0	1	1
Total	16	7	35	25	17	19	119

Table 4. Number of individuals and species captured each year in the Stephen F. Austin Experimental Forest (SFAEF) and Davy Crockett National Forest (DCNF), Texas, U.S.A., from 2 May 2001 to 27 December 2006. All ponds combined.

	SFAEF ponds				DCNF ponds			
Vegetation Characteristics	1	2	3	4	5	6	7	8
Basal area (m^2/ha)	0.9	17.6	10.1	15.4	22.6	19.3	15.9	15.1
Canopy closure (%)	15.8	61.8	57.7	82.3	90.1	67.9	75.3	76.3
Dicot/fern ground cover (%)	7.1	14.3	21.0	4.2	0.8	20.0	23.9	31.8
Monocot ground cover (%)	5.0	17.8	30.5	0.1	9.9	9.3	9.5	21.8
Foliage density 0-1 m (m)	2.5	7.3	2.6	6.2	20.1	6.5	6.8	4.0
Foliage density 1-2 m (m)	2.8	13.0	7.6	16.0	50.0	10.4	12.6	15.6
Midstorey density (1-5)	5.0	2.0	2.0	3.0	3.0	2.0	4.0	2.0
Overstorey height (m)	27.4	27.4	21.3	29.0	27.4	25.9	27.4	25.9
Midstorey height (m)	6.1	9.1	9.1	10.7	7.6	9.1	12.2	7.6
Stand age (year)	84.0	86.0	35.0	63.5	98.0	73.5	80.0	78.5
Distance to permanent water (km)	0.37	0.80	0.50	0.99	1.14	0.67	1.50	1.61

Table 5. Habitat characteristics measured at each wildlife pond in the Stephen F. Austin Experimental Forest (SFAEF) and Davy Crockett National Forest (DCNF), Texas, U.S.A. Values for basal area, canopy closure, dicot cover, and monocot cover represent means. Values for foliage density represent the mean distance (m) to 50% obscurity of a density board. Midstorey density values range from 1 to 5, with 1 being the least dense and 5 the most dense.

The traps in the ponds in the SFAEF captured more individuals than the traps in the ponds in the DCNF, with the SFAEF accounting for 90.6% of the total captures. Reptile diversity was also higher in the SFAEF ponds than in the DCNF ponds. Several factors could have played a role in the differences in the species and numbers of individuals captured. The ponds in the SFAEF were created 1 year prior to sampling, while the DCNF ponds were created 7 years prior to sampling. The distance to the nearest permanent water source from each pond could also play a key role in the colonisation rates of these wildlife ponds by reptiles. The ponds in the SFAEF were closer to a pre-existing permanent water source than those located in the DCNF. Also, since the permanent water sources were different (creek versus ponds/lake) this could have had an effect on the species and numbers of reptiles dispersing to the ponds. The differences between the SFAEF ponds and DCNF ponds likely explain why the reptile communities within the SFAEF ponds were more similar to one another than those within the DCNF. All eight ponds surveyed were created in similar age stands; however, there were some differences in the management of these stands as is evident in the basal area, canopy closure, and foliage density measurements (Table 5). These three variables are highly correlated and could explain some of the variability found across ponds. Our trends followed Ross et al. (2000) who found an increase in snake abundance and richness with a decrease in basal area. However, we had too few replicates to make any definitive inferences regarding the effect these habitat variables may have on the distribution of the reptiles in our study area.

We captured the most individuals in 2003 followed by 3 years in which we captured fewer individuals (Table 4). Since the traps in the ponds in the SFAEF accounted for most of the individuals captured, and these ponds were relatively new, it is possible that the number of individuals moving into these ponds peaked in 2003. However, we do not have enough data to determine if we observed ecological succession or merely yearly variation.

All of the species that were captured in funnel traps were aquatic to semi-aquatic reptiles; these species are known to prey heavily on other organisms that inhabit aquatic habitats (Gibbons

& Dorcas, 2004; Werler & Dixon, 2000). For example, the genus *Nerodia* is a common group of watersnakes in eastern Texas. The three species of *Nerodia* that we captured accounted for more than 63% of our captures and primarily prey on fish and amphibians. The four turtle species that we captured are also classified as aquatic species and feed on a variety of aquatic algae, invertebrates and vertebrates (Ernst et al., 1994).

In eastern Texas, the mean annual air temperature falls between 15.5°C and 21°C and the growing season (time between last and first frost) in eastern Texas exceeds 200 days in most years; the last frost can occur from February to April but most often occurs in March, while the first frost can occur from October to December but typically occurs in November (Chang et al., 1996). As expected, most reptiles were captured from March to October, which coincides with the warm months in eastern Texas.

Our study suggests that creating artificial wildlife ponds is an effective wildlife management practice for improving habitat for aquatic and semi-aquatic reptiles in eastern Texas. A larger sample size is needed in order to truly understand the effect pond age and forest structure have on reptile use of wildlife ponds. Our study also did not control for recaptures since we did not mark any of the captured animals; as a result, our capture numbers could be inflated. Future studies should use multiple-sized funnel traps, mark captured individuals and take pond size into account when determining number of traps per pond. There are many aspects that we still do not know about these wildlife ponds (colonisation rates, successional stage, predation rates, etc) that would help us understand differential use of ponds by reptiles.

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