

FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

A STUDY OF THE HERPETOFAUNAL ASSEMBLAGES IN THE  
FLOODPLAIN HABITATS OF THE KISSIMMEE RIVER

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requirements for the degree of

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by

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To: Dean Arthur W. Herriott  
College of Arts and Sciences

This thesis, written by Christopher Jon Farrell, and entitled A STUDY OF THE HERPETOFAUNAL ASSEMBLAGES IN THE FLOODPLAIN HABITATS OF THE KISSIMMEE RIVER, having been approved in respect to style and intellectual content, is referred to you for judgment.

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I dedicate this thesis to my wife, Staci Farrell, and to my family.  
Without their help and support I would not have been able to complete  
this project.

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ABSTRACT OF THE THESIS

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Professor Maureen A. Donnelly, Major Professor

Amphibians and reptiles were sampled using visual encounter surveys in three floodplain habitats (broadleaf marsh, wetland forest, and woody shrub) of the Kissimmee River from August 1996 to July 1997. Twelve species were observed, comprising seven anurans, one salamander, three snakes, and one lizard. *Hyla cinerea* was the most abundant species, and it represented 61.8 % of all observations. *Eurycea quadridigitata* and *Anolis carolinensis* were the second and third most abundant species, respectively, and represented an additional 25.6 % of all observations. The mean abundance of amphibians and reptiles was significantly different among months. Abundance peaked in July, and reached its second highest value in October. *Hyla cinerea* and *A. carolinensis* were observed at all seven study sites among the three habitats. *Eurycea quadridigitata* was observed almost exclusively in the woody shrub habitat. Eleven of the twelve species occurred in the broadleaf marsh habitat at some time during the year.

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## INTRODUCTION

The Kissimmee River, located in south-central Florida, USA, is the subject of one of the largest restoration projects ever attempted (see Restoration Ecology, 1995, vol. 3, no. 3). The goal of the project is to reestablish the historic structure and function of the Kissimmee River ecosystem. Success will be measured by the response of the ecosystem's biotic communities to restoration activities. (Cummins and Dahm, 1995). Baseline data on the current conditions of these communities are necessary to measure changes during and after restoration. The purpose of this study is to describe the pre-restoration condition of the herpetofaunal assemblages in the floodplain habitats of the Kissimmee River.

Since amphibians and reptiles are abundant and integral components of wetland habitats (Gibbons, 1988; Dodd and Charest, 1988), they will serve as good indicators of change for the Kissimmee River restoration. The amphibians that occur in the region have a critical dependence on wetlands because they exhibit complex life cycles. Their eggs are laid in water and later hatch into larvae (salamanders) or tadpoles (anurans). These larval stages are either herbivorous or filter-feeding. Larvae metamorphose into miniature versions of the adult form and begin a terrestrial existence feeding largely on invertebrates. Because amphibians utilize both aquatic and terrestrial components of the ecosystem they offer a unique view on ecosystem function (McDiarmid, 1994). Amphibians and reptiles are often studied together as a herpetofaunal assemblage since both are ectothermic vertebrates associated closely

within a community's structure. They consume small organisms (invertebrates and vertebrates) and are consumed by a variety of large predators.

The description of the herpetofaunal assemblages in the floodplain habitats of the Kissimmee River was accomplished by the completion of several specific objectives. These objectives included creating a species inventory for each site, estimating the monthly abundance of amphibians and reptiles for all sites, describing seasonal aspects of species occurrence and abundances, describing the distribution of individuals among species, computing the species-effort curve for the total number of individuals observed, evaluating habitat use for each species, and determining species-habitat associations.

The results of this study were compared to other studies in peninsular Florida to evaluate patterns in species composition and abundance. These other studies included descriptions of the herpetofauna of Lake Conway (McDiarmid, et al., 1983), Long Pine Key in the Everglades (Dalrymple, 1988) and Jonathan Dickinson State Park (Timmerman, et al., 1994).

## STUDY LOCATION

Prior to 1962, the Kissimmee River meandered for 166 km over a 10.9 m drop in elevation. The river's floodplain ranged from 1.5 to 3 km wide and exhibited seasonal changes in hydrology (Koebel, 1995). Approximately 94% of the floodplain was inundated 50% of the time, with depths usually between 0.3 and 0.7 m (Toth, 1990). The complex nature of the river's structure and hydrology created a variety of habitats. This mosaic of habitats was dominated (approximately 56%) by broadleaf marsh. Other habitat types included wet prairie, wetland shrub, wetland forest, and switchgrass (descriptions are given in Toth et al., 1995). These habitats supported a wide variety of animal species including 39 species of fish (Toth, 1993) and 38 species of waterbirds (Koebel 1995). In 1954, the United States Army Corps of Engineers was authorized specifically to address flood control problems in the Kissimmee River region. In 1962, the Army Corps of Engineers began channelizing the river. Channelization was completed in 1971 and had transformed the river into a 90 km, 9 m deep, 64 to 105 m wide canal, referred to as C-38 (Toth, 1993). The construction of six water control structures converted the river into a series of five impounded reservoirs (hereafter referred to as pools A through E going from north to south; Figure 1). Channelization resulted in the loss of 12,000 to 14,000 ha of wetland habitats, eliminated historic water level fluctuations, and modified flow characteristics (Koebel, 1995).

The alteration of hydrology caused changes in the vegetative community

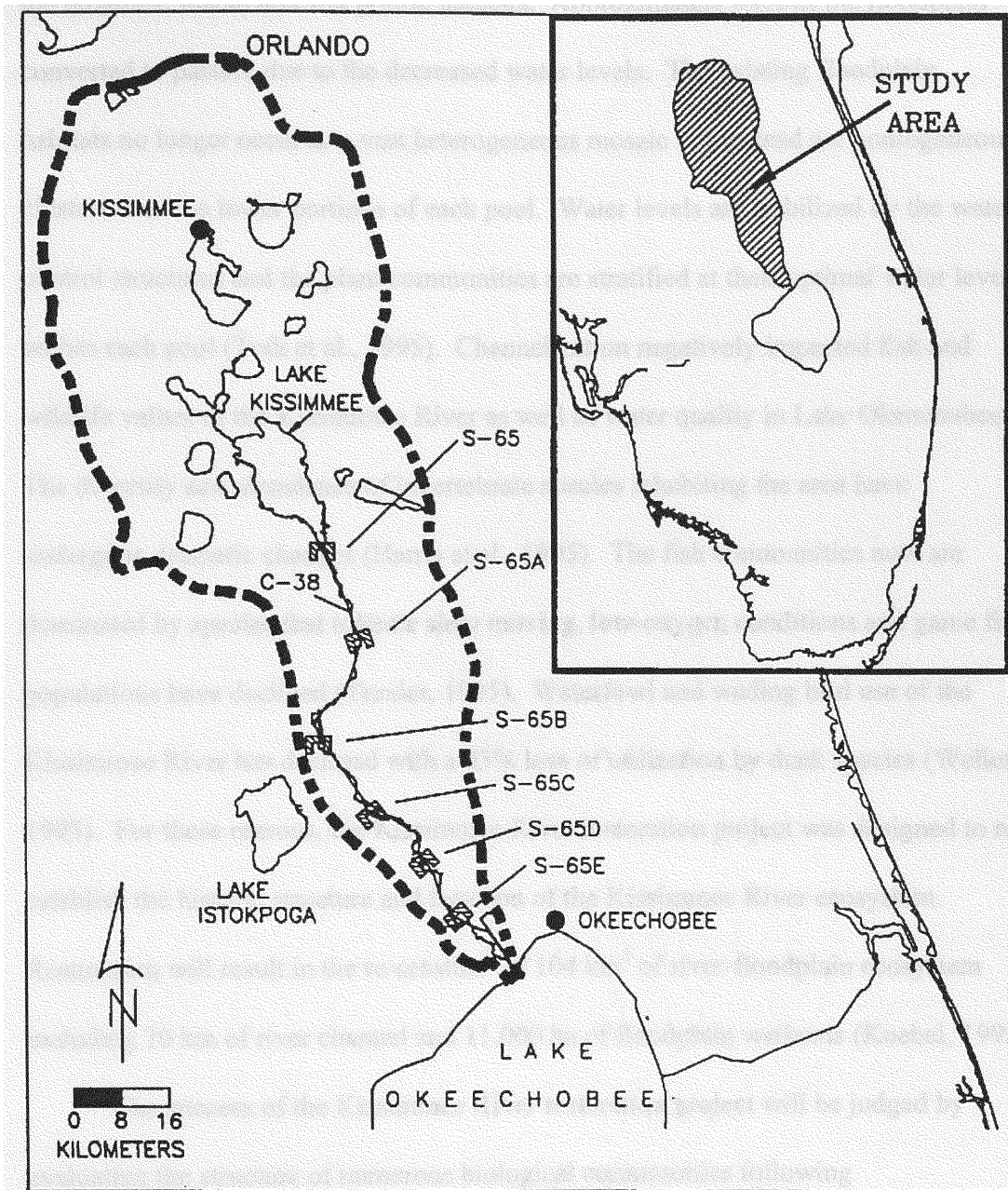


Figure 1. Map of Kissimmee River basin showing headwater lakes and water control structures (modified from Toth 1993).

surrounding the river. Lower water levels in the floodplains have eliminated much of the broadleaf marsh and wet prairie habitats. Approximately 44% of the floodplain converted to pasture due to the decreased water levels. The existing floodplain habitats no longer occur as a vast heterogeneous mosaic but instead are homogeneous clusters near the lower portions of each pool. Water levels are stabilized by the water control structures and the plant communities are stratified at their optimal water levels within each pool (Toth et al., 1995). Channelization negatively impacted fish and wildlife values of the Kissimmee River as well as water quality in Lake Okeechobee. The diversity and abundance of invertebrate species inhabiting the area have undergone dramatic changes (Harris et al., 1995). The fish communities now are dominated by species that tolerate slow moving, low-oxygen conditions and game fish populations have declined (Trexler, 1995). Waterfowl and wading bird use of the Kissimmee River has declined with a 93% loss of utilization by duck species (Weller, 1995). For these reasons, the Kissimmee River restoration project was designed to re-establish the historic structure and function of the Kissimmee River ecosystem. Restoration will result in the re-creation of 104 km<sup>2</sup> of river-floodplain ecosystem including 70 km of river channel and 11,000 ha of floodplain wetlands (Koebel, 1995).

The success of the Kissimmee River restoration project will be judged by evaluating the structure of numerous biological communities following dechannelization. The creation of new habitats and the expansion of existing habitats are fundamental goals of the restoration project. Within the floodplain habitats, the

species composition of many faunal assemblages (invertebrates, fish, amphibians, reptiles, birds, and mammals) will be determined. The post-restoration results will be compared to pre-channelization data when possible and to the results of pre-restoration studies to evaluate the success of the project (U.S. Army Corps of Engineers, 1992).

## METHODS

It is necessary to consider the restoration program when discussing the research design. Therefore, pertinent information will be included when necessary.

The restoration of the river will entail backfilling 70% of the C-38 canal (Kissimmee River) and removal of 2 water control structures. Pools A and E will be left unaltered, pool C will be backfilled first, followed by half of pool B and most of pool D. Broadleaf marsh is expected to be the dominant habitat type upon restoration, and was sampled in pools A, B, and C in this study. The woody shrub sites were located in pools C and D, and the wetland forest sites were in pools B and C. The woody shrub and wetland forest sites were located in the only pools those habitat types occurred in. Vegetation maps (Toth, et al., 1995) and preliminary trips along the river were used to locate the sampling sites. Habitat type, pool location, and method of access for each sampling site are given in Table 1.

### *Line transect sampling with visual encounter surveys*

Three line transects 50 m in length were marked at each site. A site refers to a specific habitat type in a specific pool. For example, the site in broadleaf marsh habitat in pool A is referred to as BLM-A. The first transect was haphazardly located in the habitat and the remaining two transects were located parallel to the first one separated by a distance of 20 m. Transects were marked with 5 cm diameter PVC pipes placed at 5 m intervals. The transects were numbered one through three with the transect closest to the river labeled number one. The design and configuration of the

Table 1. Sampling sites.

Habitat type	Pool location	Access method
Broadleaf marsh	A	Road (vehicle)
	B	River (airboat)
	C	River (airboat)
Wetland forest	B	River (airboat)
	C	River (airboat)
Woody (wetland) shrub	C	River (airboat)
	D	River (airboat)

transects are illustrated in Figure 2.

Before sampling at each site, the weather, time, lunar conditions, and frog species calling in the area were recorded. Transects were sampled by proceeding from the 0 m pipe to the 50 m pipe, using the visual encounter survey method. A visual encounter survey (VES) is one in which field personnel walk through an area or habitat systematically searching for animals (Crump and Scott, 1994). Vegetation was often moved to allow more thorough searching but sampling was not destructive. The following data were recorded for each transect: site, transect number, name of observer, start time, each animal seen and its position on the transect, and end time.

All fieldwork was staged from the Riverwoods Field Laboratory operated by the South Florida Water Management District (SFWMD) and the Center for Environmental Studies. Airboat access was necessary for the sites in pools B, C, and D and was provided by the SFWMD. Each site was sampled monthly for 12 consecutive months. All sampling was performed at night when amphibians are most active. Table 2 shows the sampling dates for each site.

## **Data Analysis**

### **Species diversity**

#### *Species composition*

Species lists for each site were created by listing all species observed at the site during the 12 month study. These lists were compiled to produce a species list for the entire study area.

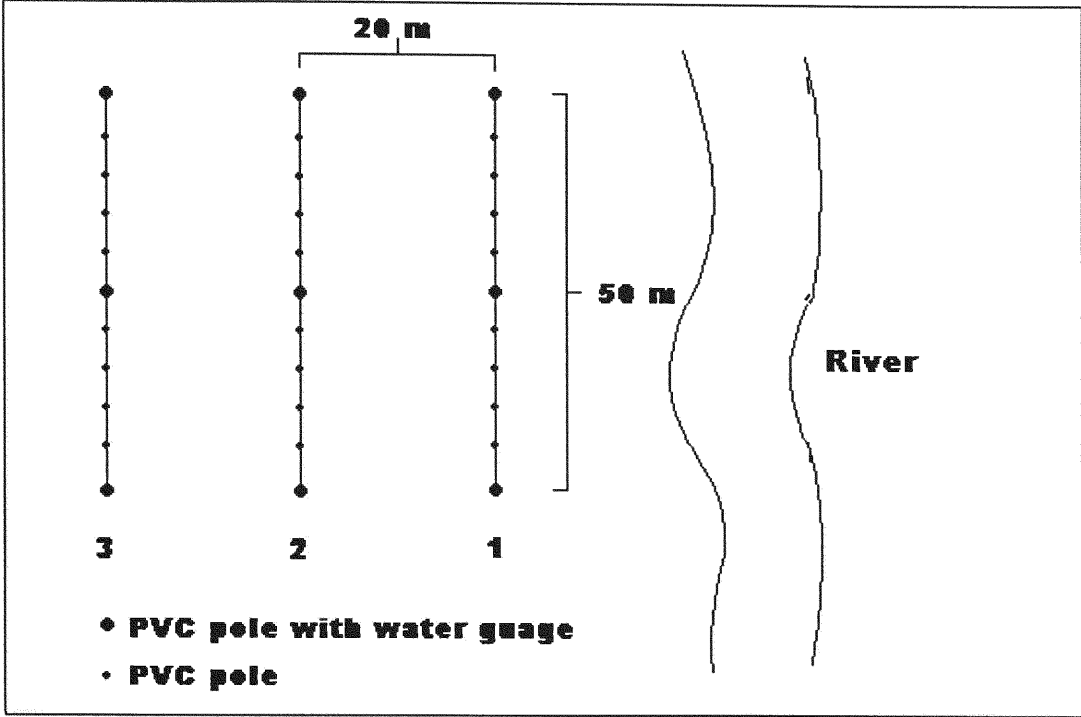


Figure 2. Transect design and configuration.

Table 2. Sampling dates for each site (the day of the month each site was sampled is listed for each month). NS = Not sampled.

Habitat type	Pool	Month/Year											
		Aug-96	Sep-96	Oct-96	Nov-96	Dec-96	Jan-97	Feb-97	Mar-97	Apr-97	May-97	Jun-97	Jul-97
Broadleaf marsh	A	30	13	19	21	16	10	13	1	3	22	26	18
	B	20	20	18	22	6	16	26	20	NS	23	19	10
	C	21	19	17	20	5	17	27	31	29	22	20	11
Wetland forest	B	29	20	18	22	6	16	26	20	29	23	19	11
	C	21	19	17	20	5	17	27	31	NS	22	20	11
Woody shrub	C	21	19	17	20	5	17	26	31	29	22	20	11
	D	29	21	18	22	6	16	26	20	29	22	20	10

### *Abundance and evenness*

The abundance of each species was recorded monthly at each site. Mean abundances were calculated from the three transects at each site. Standard error was calculated to describe dispersion (Hayek and Buzas, 1997). Two separate abundance categories were created for *Hyla cinerea* and *Anolis carolinensis*. These categories (outside PVC and inside PVC) indicate how many of each species were found in the open, and how many were found inside the PVC pipes used to mark the transects. Only the abundance values for *H. cinerea* and *A. carolinensis* found outside the PVC are compared to the those of other species.

Evenness (E) was calculated for each site separately using the equation given by Hayek and Buzas (1997),

$$E = \frac{H}{\ln(S)},$$

where H is Shannon's information function,

$$H = -\sum_i p_i \ln(p_i),$$

and the proportion of each species is calculated as,

$$p_i = \frac{n_i}{N}.$$

The total number of individuals observed is N and  $n_i$  represents the number of individuals from species  $i$ . The abundance values used were the total annual abundances for each species. The value of  $i$  goes from 1 to S for each site. Species richness, S, is the number of different species among the N individuals. Since the

formula for E takes N into account, no further standardization is necessary to compare results among sites. In addition, evenness values were computed for the habitat types described in the habitat use section below.

#### *Comparisons of abundance among sites and among months*

Differences in mean abundances of reptiles and amphibians among sites and among months were analyzed using a two-way ANOVA with repeated measures. Individual differences between sites and between months were evaluated post hoc using Tukey's Honestly Significant Difference (HSD) test (StatSoft, Inc., Statistica 5.1, 1997).

Temperature and rainfall values were plotted to help describe environmental changes in the study area among months. Temperature values were calculated for each month by taking the mean of the mean daily temperatures recorded by the gauge at the S-65C water control structure. Rainfall values were calculated for each month by taking the mean of the total rainfall measured by 4 gauges along the river (S-65A - S-65D). This was done to generate a monthly rainfall value that represented the entire study area.

#### *Species-individual relationship*

A species-effort curve was produced using N, the total number of individuals observed, as the measure of effort. This method is a common way of expressing the relationship between S and N ( $S = fn(N)$ ), and is used to standardize results to allow comparisons among studies (Hayek and Buzas, 1997). The species-individual curve

was created by plotting the cumulative value of S against the cumulative value of N. A linear relationship was achieved using a logarithmic plot, where  $\log(S)$  was plotted against  $\log(N)$ .

## **Habitat analyses**

### *Habitat use and associations*

For all habitat use analyses, the BLM-A site was treated as a separate habitat. The BLM-A site is bordered by wet prairie habitat, and represents more of an ecotone between the two habitat types. Also, this division allows more equivalent comparisons among habitats based on sample size. However, since there is only one site, species richness estimates for this habitat should be viewed as conservative due to the species-area relationship (Simberloff, 1974).

Habitat use was operationally defined as the presence of a species within a habitat. Frequency of habitat use was measured as the number of months a species was present in at least one sample from the habitat. First, occurrence data were grouped by habitat, and the number of months a species was observed in each habitat was counted.

As an operational definition, a species had an association with a habitat if it was found in a significantly larger proportion of samples from that habitat than in samples from the other habitats. Habitat associations were determined by comparing the number of times a species was present in samples from a habitat with the number of times the species was absent in samples from the habitat. These proportions were computed for each habitat type and arranged in a 4 x 2 table. Deviations from

expected values were analyzed using the chi-square test.

### *Comparison of species composition among habitats*

The number of species (S) found in a habitat is a function of the total number of individuals observed (N) (Hayek and Buzas, 1997). Therefore, it was necessary to standardize all habitats to a common value of N in order to compare S, and the resulting species composition, among sites. The N values for the habitats were 118 for the BLM-A habitat, 85 for the BLM (B-C) habitat, 83 for the WF habitat, and 86 for the WS habitat. Values of S and species composition were then determined for each habitat based on the first 83 individuals, the lowest value among all habitat types. After standardization, all possible pairwise comparisons of habitats were performed. For each comparison, the number of species shared, the number of species unique to each habitat, and the combined number of unique species were determined.

### **Anuran calling patterns**

When sampling, all species of anurans heard calling in the vicinity were noted. These data were compiled to create a list of calling species for each site. Species lists from calling data were then compared to the species lists generated from transect data. Calling activity throughout the year was determined by combining the monthly records from all seven sites. These results were compared to information on anuran calling from the literature.

### **The use of PVC pipes by *Hyla cinerea***

The total abundance of *H. cinerea* found inside the PVC pipes was determined

for each month. Monthly average temperature and humidity values were calculated from data recorded by a gauge at the S-65C water control structure. The average rainfall for each month was calculated by averaging data from the S-65A, B, C, and D gauges. Multiple regression was used to analyze the relationships between monthly abundance of *H. cinerea* in PVC pipes and mean monthly values for the three environmental variables.

## RESULTS

### Species diversity

#### *Overall species composition*

Eight amphibian species and four reptile species were found among the seven sites during the course of this study (Table 3). The number of species found at each site ranged from three to seven. Two species, *H. cinerea* and *A. carolinensis*, were found at all seven sites. Species lists for each site are shown in Table 4.

#### *Overall species abundances and evenness*

Three hundred and seventy-two reptiles and amphibians were observed during this study, not including those found in PVC pipes. An additional 584 *H. cinerea* and 29 *A. carolinensis* were found in PVC pipes for an overall total of 985 individuals (Table 5). Throughout this section, animals found in PVC pipes are excluded unless stated otherwise. The most abundant species was *H. cinerea* which made up 61.8 % (n = 230) of the total number of individuals observed. When the animals found in the PVC were included, *H. cinerea* made up 82.6 % (n = 814) of the overall total. The second most abundant species, *E. quadridigitata*, made up 15.1 % (n = 56) of the total number of individuals. *Anolis carolinensis*, the third most abundant species, made up 10.5 % (n = 39) of the total. When the PVC animals were included, *A. carolinensis* was the second most abundant species at 6.9 % (n = 68) of the overall total. The remaining nine species had relatively low abundances: *P.ocularis* at 3 % (n = 11), *R. sphenoccephala* at 2.2 % (n = 8), *A. gryllus* at 1.9 % (n = 7), *T. sauritus* at 1.6 % (n = 6), *H. femoralis* and *G. carolinensis* each at 1.3 % (n = 5), *A. piscivorus* at 0.8 % (n =

Table 3. Species composition for all sites combined.

Taxon	Common Name
<b>Amphibia</b>	
<b>Anura</b>	
<i>Acris gryllus</i>	Florida cricket frog
<i>Gastrophryne carolinensis</i>	Eastern narrowmouth toad
<i>Hyla cinerea</i>	Green treefrog
<i>Hyla femoralis</i>	Pine Woods treefrog
<i>Pseudacris ocularis</i>	Little grass frog
<i>Rana grylio</i>	Pig frog
<i>Rana sphenocephala</i>	Florida leopard frog
<b>Caudata</b>	
<i>Eurycea quadridigitata</i>	Dwarf salamander
<b>Reptilia</b>	
<b>Lacertilia</b>	
<i>Anolis carolinensis</i>	Southern green anole
<b>Serpentes</b>	
<i>Agkistrodon piscivorus</i>	Florida cottonmouth
<i>Nerodia fasciata</i>	Florida water snake
<i>Thamnophis sauritus</i>	Peninsula ribbon snake

Table 4. Species composition of each site.

Habitat Type		
Broadleaf Marsh	Wetland Forest	Woody Shrub
<u>Pool A (6)</u>	<u>Pool B (3)</u>	<u>Pool C (4)*</u>
<i>Anolis carolinensis</i>	<i>Anolis carolinensis</i>	<i>Anolis carolinensis</i>
<i>Acris gryllus</i>	<i>Hyla cinerea</i>	<i>Acris gryllus</i>
<i>Gastrophryne carolinensis</i>	<i>Rana sphenoccephala</i>	<i>Eurycea quadridigitata</i>
<i>Hyla cinerea</i>		<i>Hyla cinerea</i>
<i>Pseudacris ocularis</i>	<u>Pool C (5)</u>	
<i>Thamnophis sauritus</i>	<i>Anolis carolinensis</i>	<u>Pool D (5)</u>
	<i>Gastrophryne carolinensis</i>	<i>Anolis carolinensis</i>
<u>Pool B (7)</u>	<i>Hyla cinerea</i>	<i>Eurycea quadridigitata</i>
<i>Agkistrodon piscivorus</i>	<i>Hyla femoralis</i>	<i>Hyla cinerea</i>
<i>Anolis carolinensis</i>	<i>Rana sphenoccephala</i>	<i>Agkistrodon piscivorus</i>
<i>Eurycea quadridigitata</i>		<i>Rana sphenoccephala</i>
<i>Hyla cinerea</i>		
<i>Nerodia fasciata</i>		
<i>Rana grylio</i>		
<i>Rana sphenoccephala</i>		
<u>Pool C (3)</u>		
<i>Anolis carolinensis</i>		
<i>Acris gryllus</i>		
<i>Hyla cinerea</i>		

\* The presence of *A. carolinensis* at the WS-C site includes data from PVC pipes.

Table 5. Monthly and total abundances for each species for all sites combined.

Taxon	Month												Total
	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	
<b>Amphibia</b>													
<b>Anura</b>													
<i>Acris gryllus</i>	0	0	6	1	0	0	0	0	0	0	0	0	7
<i>Hyla cinerea</i>	34	21	14	16	20	3	23	15	10	6	10	58	230
<i>Hyla cinerea</i> (in PVC)	0	1	24	70	88	177	75	70	71	3	4	1	584
<i>Hyla femoralis</i>	0	1	1	1	0	0	1	1	0	0	0	0	5
<i>Gastrophryne carolinensis</i>	2	0	0	0	0	0	0	0	0	0	0	3	5
<i>Pseudacris ocularis</i>	0	0	1	0	0	0	2	1	2	0	0	5	11
<i>Rana grylio</i>	0	0	0	0	1	0	0	0	0	0	0	0	1
<i>Rana sphenoccephala</i>	1	1	0	2	0	0	0	0	0	0	0	4	8
<b>Caudata</b>													
<i>Eurycea quadridigitata</i>	1	2	29	3	6	6	1	4	0	3	0	1	56
<b>Reptilia</b>													
<b>Lacertilia</b>													
<i>Anolis carolinensis</i>	2	2	4	2	4	1	5	6	1	6	0	6	39
<i>Anolis carolinensis</i> (in PVC)	0	1	1	4	2	16	2	2	0	0	0	1	29
<b>Serpentes</b>													
<i>Agkistrodon piscivorus</i>	0	0	0	0	0	0	0	0	0	0	2	1	3
<i>Nerodia fasciata</i>	0	0	1	0	0	0	0	0	0	0	0	0	1
<i>Thamnophis sauritus</i>	0	5	1	0	0	0	0	0	0	0	0	0	6
<b>Total</b>	40	34	82	99	121	203	109	99	84	18	16	80	985

3), and *N. fasciata* and *R. gryllo* each at 0.3 % (n = 1). The overall evenness value for all sites combined was 0.54.

#### *Comparisons of abundance among sites and among months*

Due to missing data from two sites (see Table 2), the remaining data from April were excluded from the ANOVA calculations. Analysis of the reptile and amphibian abundance data showed significant differences among the sites ( $F_{6,14} = 13.03$ ;  $P < 0.01$ ). Mean monthly abundance and 95 % confidence intervals for each site are shown in Figure 3. Post hoc comparisons using Tukey's HSD test were used to determine which sites were different from the others. Table 6 ranks the sites according to their mean abundance values and shows which sites differed significantly from others.

Significant differences in the abundances of reptiles and amphibians existed among months ( $F_{10,140} = 6.36$ ;  $P < 0.01$ ). Mean monthly abundance and 95 % confidence intervals for each month are shown in Figure 4. Post hoc comparisons using Tukey's HSD test showed that July, the month with the greatest abundance of reptiles and amphibians, was significantly greater than all other months except October. October had the second highest abundance of reptiles and amphibians, and was significantly different from January, May, and June. No other months had significant differences in their abundances of reptiles and amphibians. These data are summarized in Table 7.

Variation in rainfall and temperature at the study area is shown in Figure 5. The cooler months were generally dry, except for April 1997.

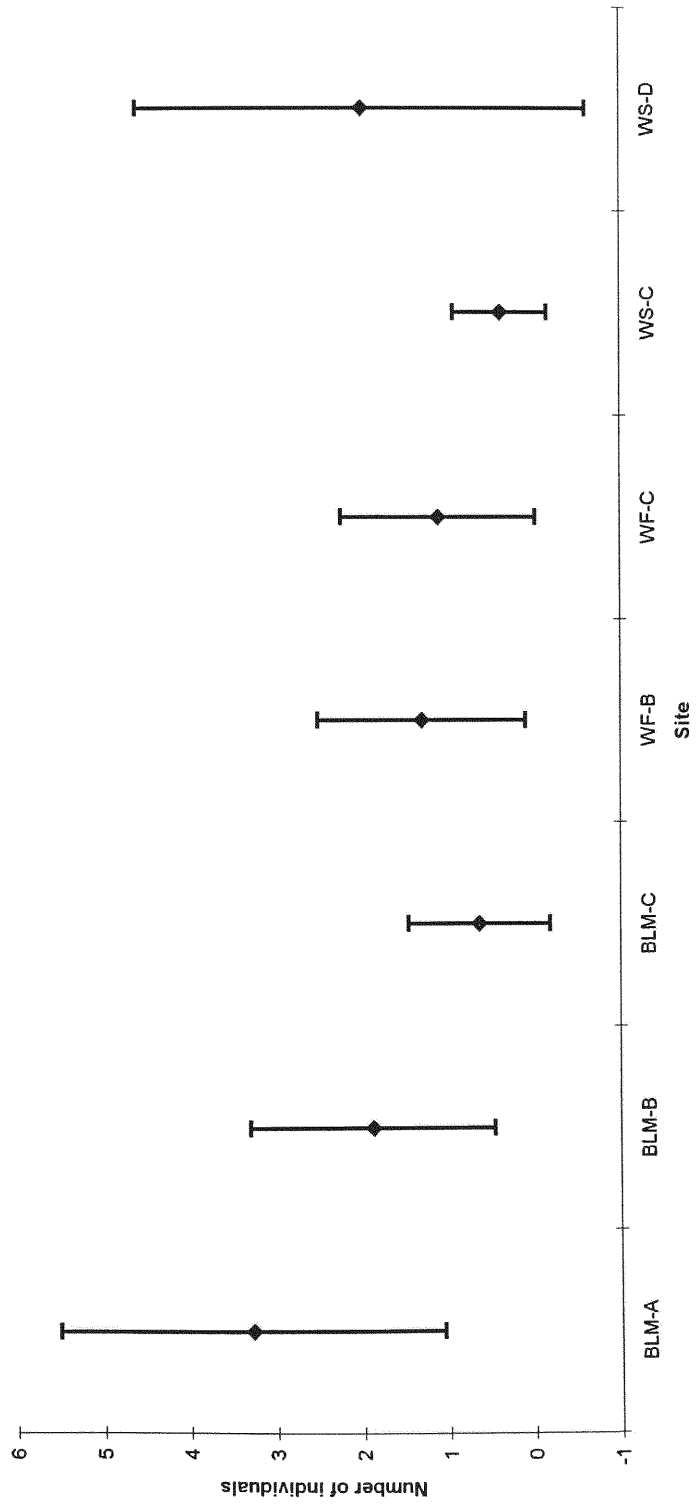


Figure 3. Mean transect abundance and 95 % confidence intervals for each site.

Table 6. Mean abundance of amphibians and reptiles per site. Results of post hoc comparisons using Tukey's HSD shown on right (SD = significant difference, n = not a significant difference).

Rank	Site	Mean abundance	Comparison with site												
			BLM-A	WS-D	BLM-B	WF-B	SD	WF-C	BLM-C	WS-C	SD	SD			
1	BLM-A	3.39	-	n	SD	n	n	n	n	n	n	n	n	n	n
2	WS-D	2.12	n	-	n	n	n	n	n	n	n	n	n	n	n
3	BLM-B	1.88	SD	n	-	n	n	n	n	n	n	n	n	n	n
4	WF-B	1.30	SD	n	n	-	n	n	n	n	n	n	n	n	n
5	WF-C	1.12	SD	n	n	n	n	-	n	n	n	n	n	n	n
6	BLM-C	0.67	SD	SD	n	n	n	n	n	-	n	n	n	n	n
7	WS-C	0.39	SD	SD	SD	n	n	n	n	n	n	n	n	n	-

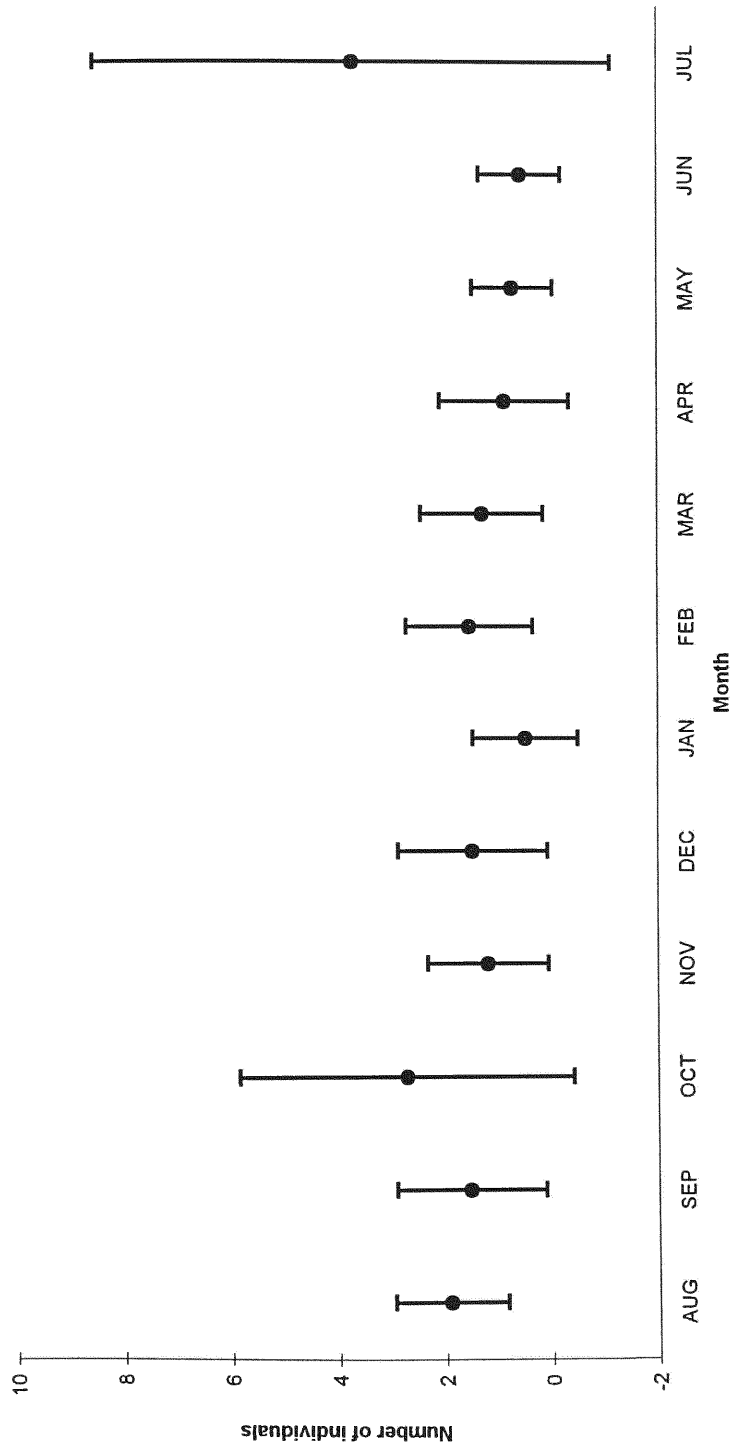


Figure 4. Mean transect abundance and 95 % confidence intervals for each month.

Table 7. Mean abundance of amphibians and reptiles per month. Results of post hoc comparisons using Tukey's HSD are summarized on right (SD = significant difference, n = not a significant difference).

Rank	Month	Mean abundance	Comparison with month														
			JUL	OCT	AUG	SEP	FEB	SD	DEC	MAR	NOV	MAY	JUN	JAN			
1	July	3.71	-	n	SD	n	n	n	n	n	n	n	n	n	n	n	n
2	October	2.71	n	-	n	n	n	n	n	n	n	n	n	n	n	n	n
3	August	1.90	SD	n	-	n	n	n	n	n	n	n	n	n	n	n	n
4	September	1.52	SD	n	n	-	n	n	n	n	n	n	n	n	n	n	n
5	February	1.52	SD	n	n	n	-	n	n	n	n	n	n	n	n	n	n
6	December	1.48	SD	n	n	n	n	-	n	n	n	n	n	n	n	n	n
7	March	1.29	SD	n	n	n	n	n	-	n	n	n	n	n	n	n	n
8	November	1.19	SD	n	n	n	n	n	n	-	n	n	n	n	n	n	n
9	May	0.71	SD	SD	n	n	n	n	n	n	n	-	n	n	n	n	n
10	June	0.57	SD	SD	n	n	n	n	n	n	n	n	n	-	n	n	n
11	January	0.48	SD	SD	n	n	n	n	n	n	n	n	n	n	n	-	n

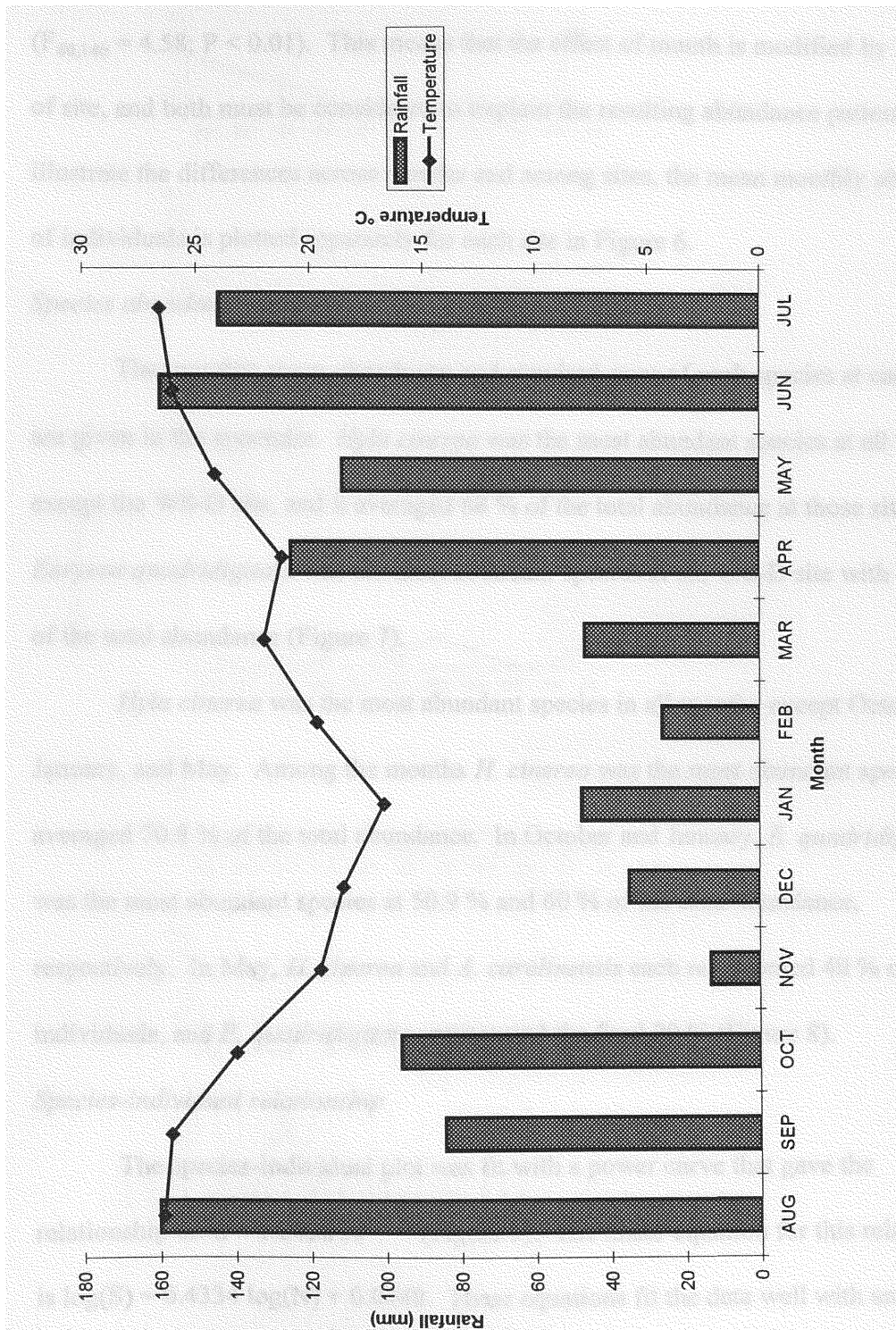


Figure 5. Rainfall and temperature variation at the study area (see text for details).

The interaction between the main effects of site and month was significant also ( $F_{60,140} = 4.58$ ;  $P < 0.01$ ). This means that the effect of month is modified by the effect of site, and both must be considered to explain the resulting abundance patterns. To illustrate the differences across months and among sites, the mean monthly abundance of individuals is plotted separately for each site in Figure 6.

#### *Species abundances and evenness*

The monthly mean abundance and standard error of each species at each site are given in the appendix. *Hyla cinerea* was the most abundant species at all sites except the WS-D site, and it averaged 68 % of the total abundance at those sites. *Eurycea quadridigitata* was the most abundant species at the WS-D site with 69.4 % of the total abundance (Figure 7).

*Hyla cinerea* was the most abundant species in all months except October, January, and May. Among the months *H. cinerea* was the most abundant species, it averaged 70.8 % of the total abundance. In October and January, *E. quadridigitata* was the most abundant species at 50.9 % and 60 % of the total abundance, respectively. In May, *H. cinerea* and *A. carolinensis* each represented 40 % of all individuals, and *E. quadridigitata* represented the final 20 % (Figure 8).

#### *Species-individual relationship*

The species-individual plot was fit with a power curve that gave the relationship of  $S = 1.0458 N^{0.4334}$  (Figure 9). The linear equation for this relationship is  $\log(S) = 0.4334 \log(N) + 0.0448$ . These equations fit the data well with an  $R^2$  value of 0.986 ( $F_{1,11} = 772$ ;  $P < 0.01$ ). The maximum value of N was 372 individuals that

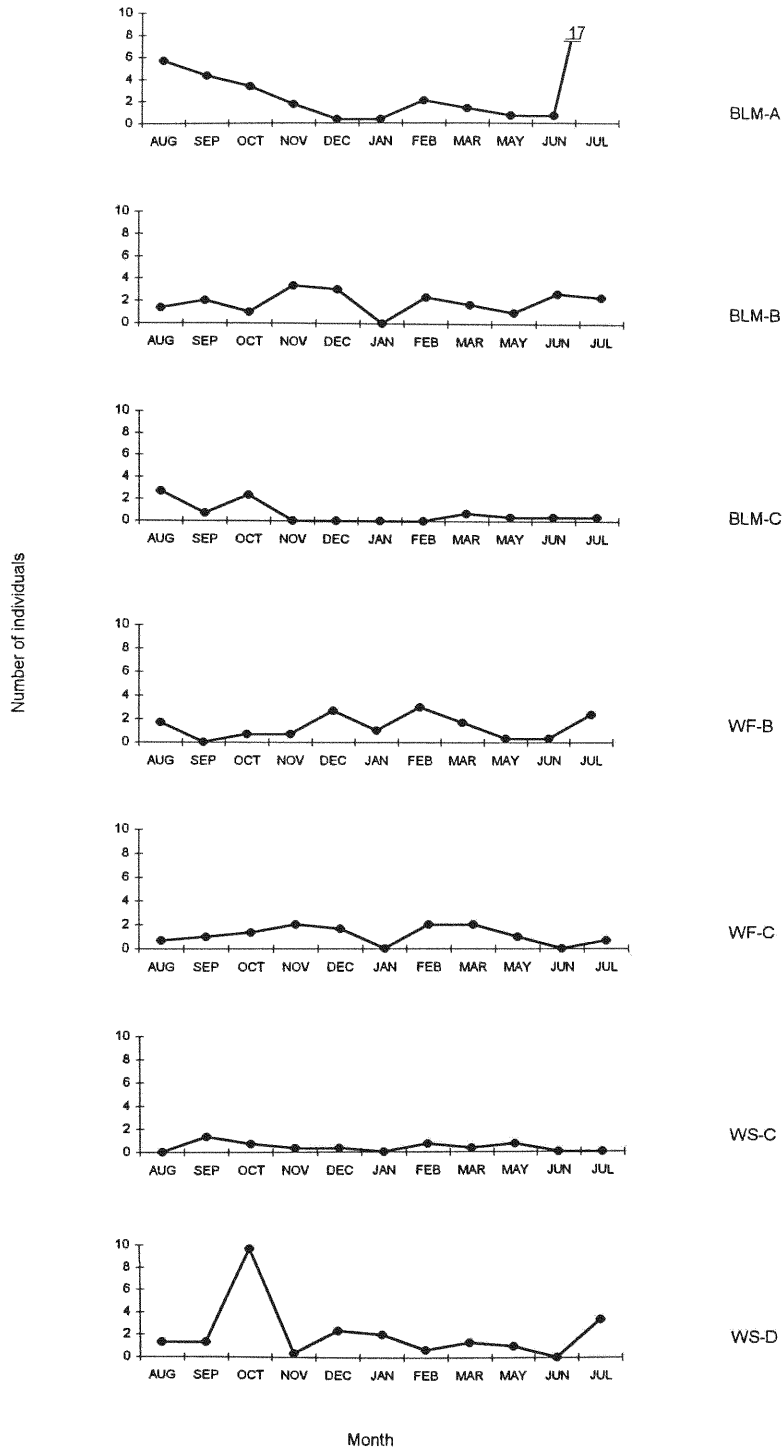


Figure 6. Monthly mean number of individuals at each of the seven sites.

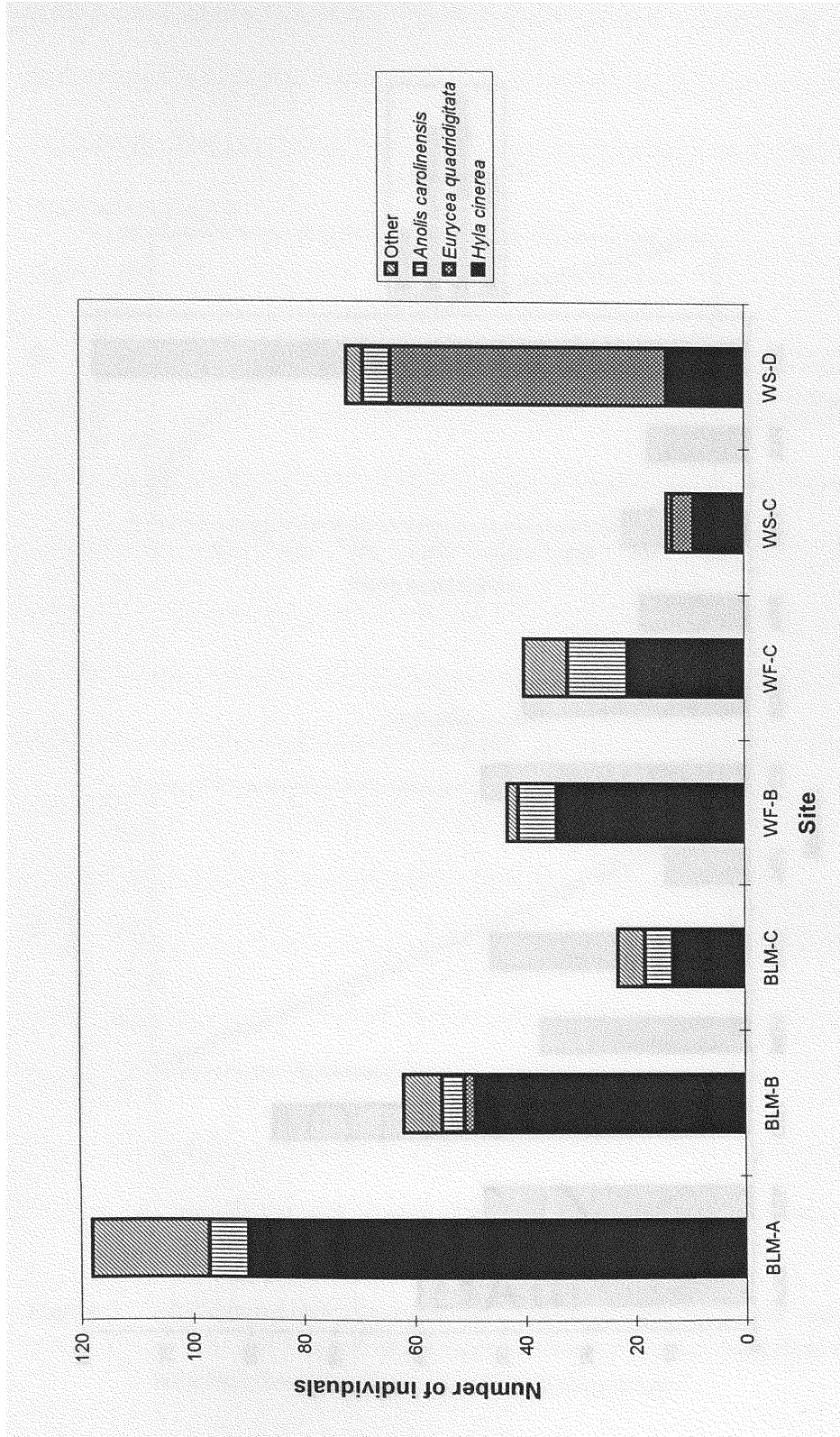


Figure 7. Number of individuals per site and their distribution among species.

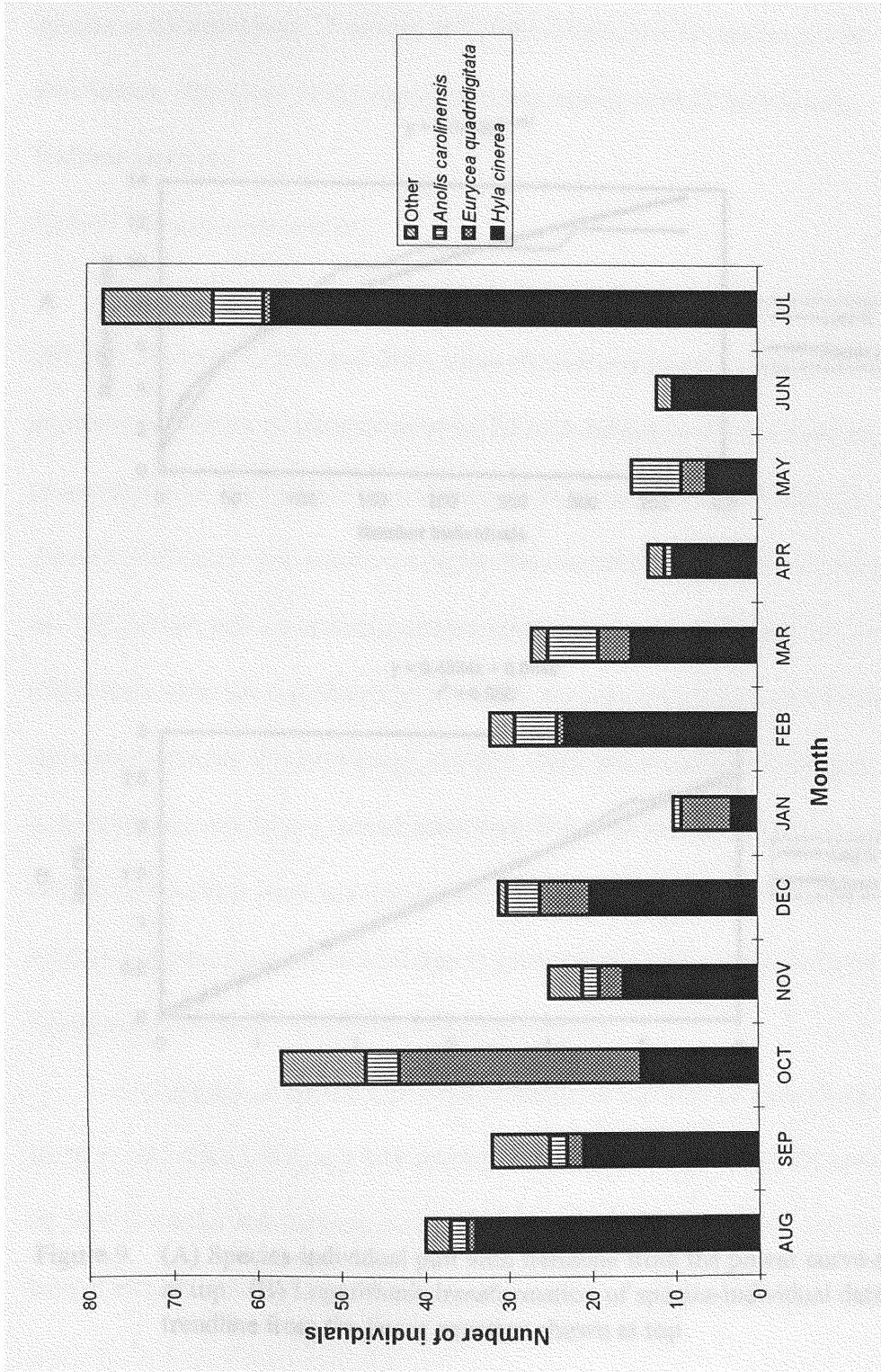


Figure 8. Number of individuals per month and their distribution among species.

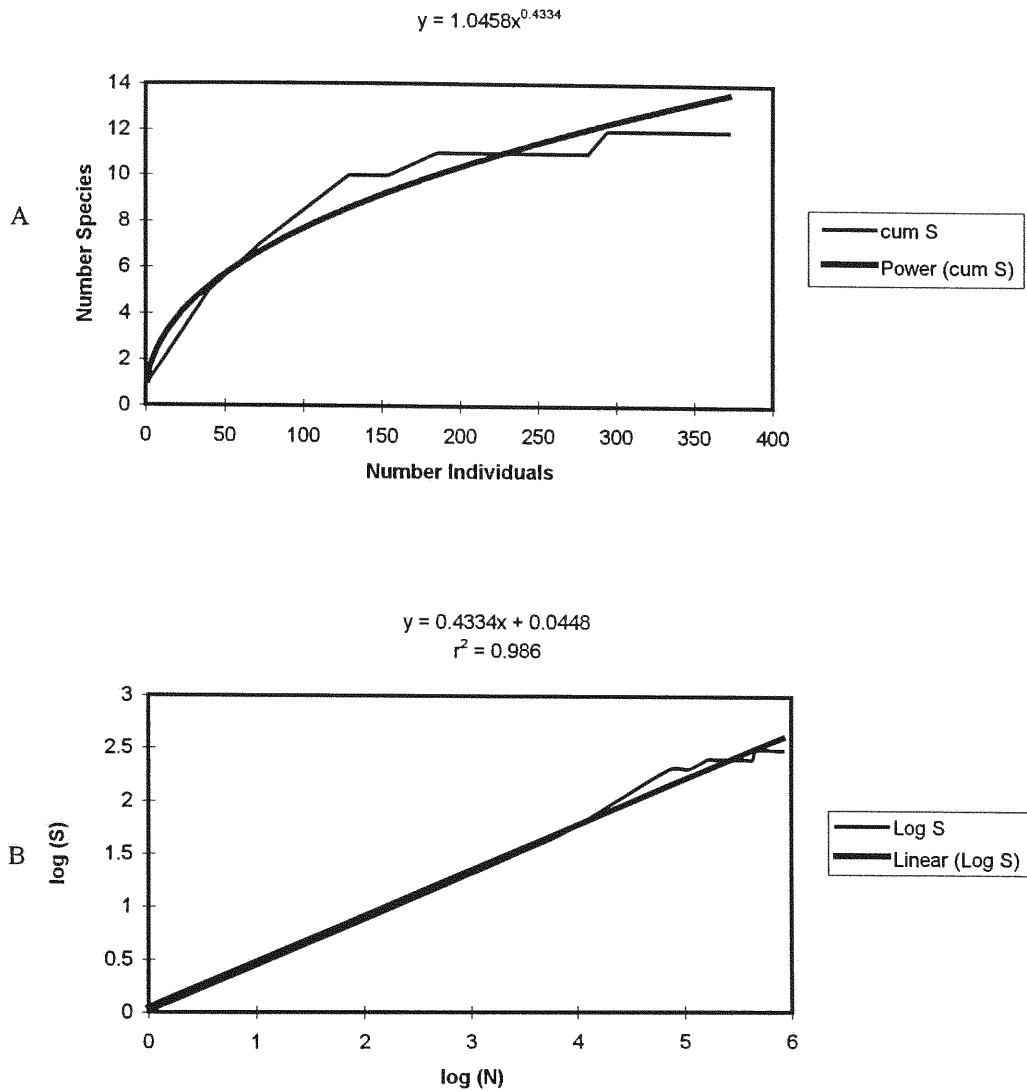


Figure 9. (A) Species-individual plot with trendline from the power curve shown at top. (B) Logarithmic transformation of species-individual data with trendline from the linear equation shown at top.

were divided among 12 species. The cumulative value of S rose quickly, reaching 5 species at 40 individuals, 7 species at 72 individuals, and 10 species at 129 individuals. The slope of the curve decreases rapidly after 50 individuals.

## **Habitat analyses**

### *Habitat use and associations*

Two species, *H. cinerea* and *A. carolinensis*, occurred in all four habitats (BLM A, BLM B-C, WF, and WS). *Hyla cinerea* was found in a greater than expected proportion of samples from the BLM A habitat, and a less than expected proportion from the WS habitat, and these differences were significant ( $\chi^2_3 < 0.01$ ). *Anolis carolinensis* was found in a higher than expected proportion of samples from the WF habitat, and a less than expected proportion from the WS habitat, but these differences were not significant ( $\chi^2_3 = 0.13$ ). *Eurycea quadridigitata* was significantly associated with the WS habitat ( $\chi^2_3 < 0.01$ ). Only one sample containing *E. quadridigitata* was from a habitat other than WS. The remaining species were rare and chi-square tests were not appropriate. Habitat use, shown as the number of months a species occurred in a habitat, is presented for each species in Table 8.

### *Comparison of species composition among habitats*

The number of species (S) was calculated for the first 83 individuals from the BLM A, BLM B-C, WF, and WS habitats. The BLM A habitat had six species, the BLM B-C habitat had eight species, the WF habitat had five species, and the WS habitat had six species.

Table 8. Habitat use by amphibians and reptiles of the Kissimmee River floodplain. The numbers represent how many months of the year each species occurred in each habitat. A dash indicates the species did not occur in that habitat.

	Habitat			
	Broadleaf Marsh (A)	Broadleaf Marsh (B - C)	Wetland Forest	Woody Shrub
<b>Amphibia</b>				
<b>Anura</b>				
<i>Acris gryllus</i>	1	1	-	1
<i>Hyla cinerea</i>	11	11	12	8
<i>Hyla femoralis</i>	-	-	5	-
<i>Gastrophryne carolinensis</i>	1	-	1	-
<i>Pseudacris ocularis</i>	5	-	-	-
<i>Rana grylio</i>	-	1	-	-
<i>Rana sphenoccephala</i>	-	2	3	1
<b>Caudata</b>				
<i>Eurycea quadridigitata</i>	-	1	-	10
<b>Reptilia</b>				
<b>Lacertilia</b>				
<i>Anolis carolinensis</i>	5	5	8	5
<b>Serpentes</b>				
<i>Agkistrodon piscivorus</i>	-	1	-	1
<i>Nerodia fasciata</i>	-	1	-	-
<i>Thamnophis sauritis</i>	2	-	-	-

All possible pairs of habitats were compared to assess their similarities. All pairs except the BLM B-C and WS pair shared three species, *H. cinerea*, *A. carolinensis*, and a third species which varied among comparisons. The BLM A and BLM B-C habitats combined for the largest number of species with eleven of the twelve species found during the study. All other pairs of habitats gave combined species lists of eight to ten species. The species composition of the WS habitat was a subset of the species found in the BLM B-C habitat. Table 9 shows the number of shared species, number of species unique to each habitat, and total number of species for all habitat comparisons.

### **Anuran calling patterns**

Six species, *A. gryllus*, *G. carolinensis*, *H. cinerea*, *P. ocularis*, *R. grylio*, and *R. sphenoccephala*, were heard calling near the seven sites sampled during this study. The most species heard calling in a given month was five during both May and July. Two species, *H. cinerea* and *R. grylio*, were heard calling throughout most of the year. *Hyla cinerea* called in all months except September and October. *Rana grylio* called during seven months scattered throughout the year. All other species were heard calling in fewer than six months of the year. Calling patterns for each of the six species are shown in Figure 10.

Three species, *H. cinerea*, *R. grylio*, and *R. sphenoccephala*, were heard calling near all seven sites. *Acris gryllus dorsalis* was heard calling at the BLM-A, BLM-C, and both WS sites, but never at the WF sites. *Pseudacris ocularis* called from the BLM-A and BLM-C sites. *Gastrophryne carolinensis* called from the

Table 9. Comparisons of species composition among habitats. AC = *Anolis carolinensis*, AG = *Acris gryllus*, AP = *Agkistrodon piscivorus*, EQ = *Eurycea quadridigitata*, GC = *Gastrophryne carolinensis*, HC = *Hyla cinerea*, HF = *Hyla femoralis*, NF = *Nerodia fasciata*, PO = *Pseudacris ocularis*, RG = *Rana grylio*, RS = *Rana sphenoccephala*, TS = *Thamnophis sauritus*.

Habitats	S	Unique to habitat	Present in both	Total unique
BLM A	6	3: GC, PO, TS	3: AC, AG, HC	11
BLM B-C	8	5: AP, EQ, NF, RG, RS		
BLM A	6	3: AG, PO, TS	3: AC, GC, HC	8
WF	5	2: HF, RS		
BLM A	6	3: GC, PO, TS	3: AC, AG, HC	9
WS	6	3: AP, EQ, RS		
BLM B-C	8	5: AG, AP, EQ, NF, RG	3: AC, HC, RS	10
WF	5	2: GC, HF		
BLM B-C	8	2: NF, RG	6: AC, AG, AP	8
WS	6	0	EQ, HC, RS	
WF	5	2: GC, HF	3: AC, HC, RS	8
WS	6	3: AG, AP, EQ		

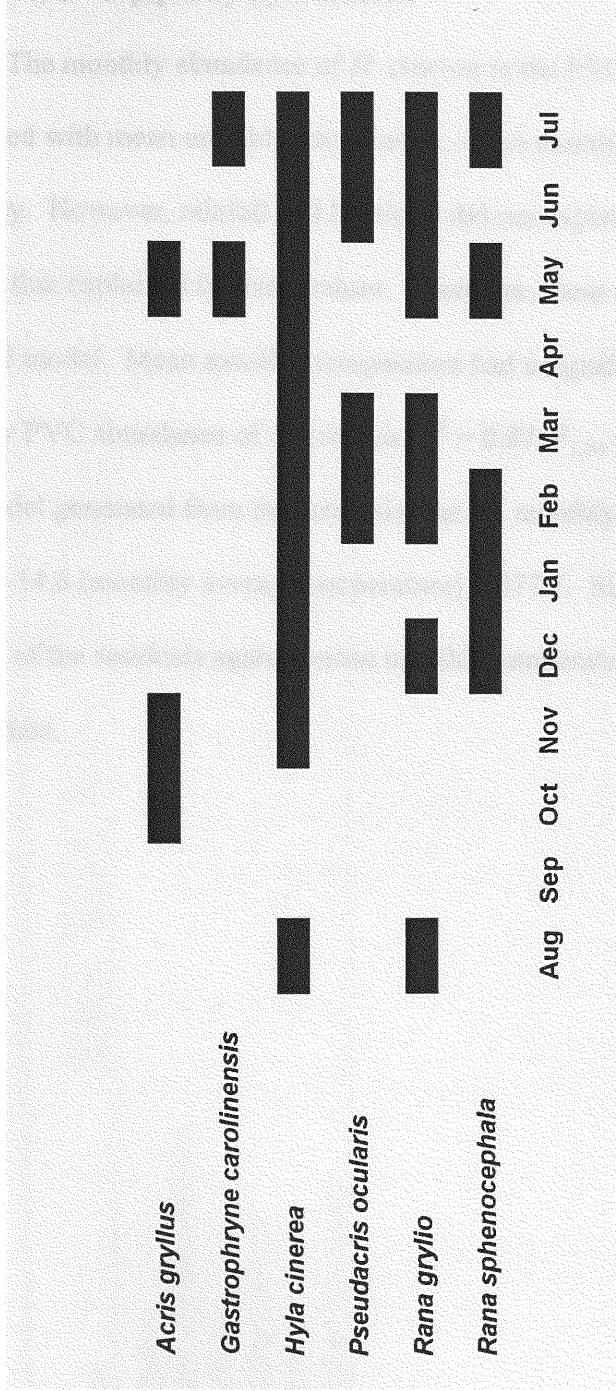


Figure 10. Calling patterns for the six anurans species heard calling during the study.

BLM-A and WS-C sites. Calling data for all seven sites are given in Table 10.

### **The use of PVC pipes by *Hyla cinerea***

The monthly abundance of *H. cinerea* in the PVC pipes was significantly correlated with mean monthly temperature, mean monthly rainfall, and mean monthly humidity. However, rainfall and humidity did not explain any additional variation beyond that explained by temperature. Therefore, these factors were not included in the final model. Mean monthly temperature had a significant negative correlation with monthly PVC abundance of *H. cinerea* ( $R^2 = 0.87$ ;  $F_{1,10} = 67.22$ ;  $p < 0.01$ ; Figure 11). The model generated from this analysis was the monthly abundance of *H. cinerea* in PVC =  $-14.6$  (monthly average temperature) +  $377.7$ . Since no pattern was evident in the plot of the residuals against mean monthly temperature, the model used appears appropriate.

Table 10. Anuran calling data for all study sites.

Species	Site							
	BLM-A	BLM-B	BLM-C	WF-B	WF-C	WS-C	WS-D	
<i>Acris gryllus</i>	✓		✓			✓		✓
<i>Gastrophryne carolinensis</i>	✓					✓		✓
<i>Hyla cinerea</i>	✓	✓	✓	✓	✓	✓		✓
<i>Pseudacris ocularis</i>	✓		✓					✓
<i>Rana grylio</i>	✓	✓	✓	✓	✓	✓		✓
<i>Rana sphenoccephala</i>	✓	✓	✓	✓	✓	✓		✓

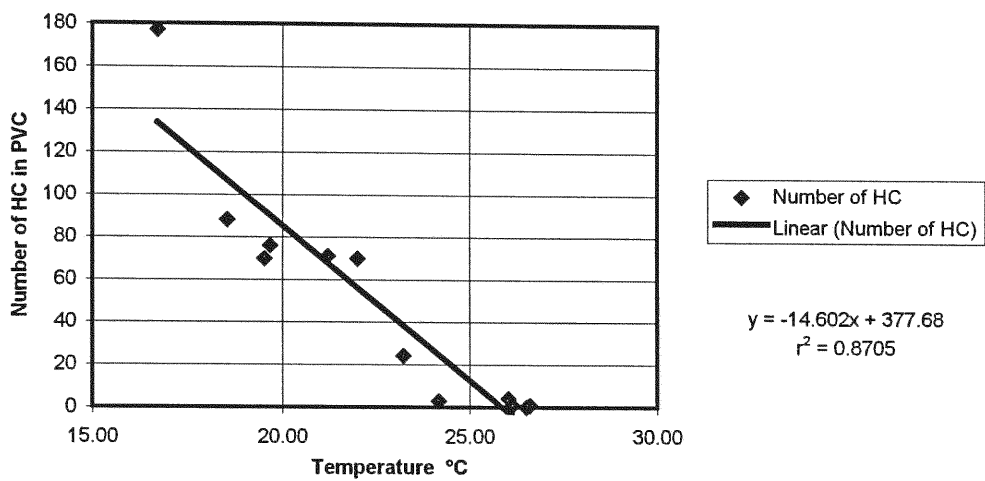


Figure 11. Correlation between monthly abundance of *Hyla cinerea* in PVC poles and temperature. Linear equation for the trendline and the coefficient of determination are given on the right.

## DISCUSSION

### Species diversity

#### *Overall species composition*

A total of 49 species of amphibians and reptiles were predicted to occur in the floodplain habitats of the Kissimmee River (Table 11). This list was compiled based on the regional distribution and habitat use data presented in field guides (Conant and Collins, 1991; Ashton and Ashton, 1985; Ashton and Ashton, 1988a; Ashton and Ashton, 1988b; Tennant, 1997), published papers (Dalrymple, 1988; Duellman and Schwartz, 1958), and historical collection data (Bachman, 1996). Only 12 of these species were encountered on the transects used by this study. However, five additional species were seen near the study sites or in similar habitats along the river. These species included three amphibians, *Notophthalmus viridescens*, *Amphiuma means*, and *Siren lacertina*, one snake, *Nerodia taxispilota*, and one crocodylian, *Alligator mississippiensis*. *Alligator mississippiensis* is commonly found along all waterways of the Kissimmee and is the dominant predator in the Kissimmee aquatic system (Karr et al., 1992).

It is difficult to tell whether or not the remaining species are actually absent from the study area due to biases inherent in the sampling methods. Only active animals, or those resting in the open, are observed during visual encounter surveys. Animals with cryptic coloration or those that remain hidden within the substrate are difficult to observe. Since many of the sites had standing water and mats of aquatic vegetation, amphibians

Table 11. Species predicted to occur in the Kissimmee River floodplain habitats.

<b>Family</b>	<b>Genus</b>	<b>Species</b>
Crocodylidae	<i>Alligator</i>	<i>mississippiensis</i>
Chelydridae	<i>Chelydra</i>	<i>serpentina</i>
Kinosternidae	<i>Sternotherus</i>	<i>odoratus</i>
Kinosternidae	<i>Kinosternon</i>	<i>baurii</i>
Kinosternidae	<i>Kinosternon</i>	<i>subrubrum</i>
Emydidae	<i>Deirochelys</i>	<i>reticularia</i>
Emydidae	<i>Pseudemys</i>	<i>floridana</i>
Emydidae	<i>Pseudemys</i>	<i>nelsoni</i>
Emydidae	<i>Terrapene</i>	<i>carolina</i>
Polychrotidae	<i>Anolis</i>	<i>carolinensis</i>
Scincidae	<i>Scincella</i>	<i>lateralis</i>
Scincidae	<i>Eumeces</i>	<i>laticeps</i>
Scincidae	<i>Eumeces</i>	<i>inexpectatus</i>
Colubridae	<i>Nerodia</i>	<i>fasciata</i>
Colubridae	<i>Nerodia</i>	<i>taxispilota</i>
Colubridae	<i>Nerodia</i>	<i>cyclopion</i>
Colubridae	<i>Regina</i>	<i>alleni</i>
Colubridae	<i>Regina</i>	<i>rigida</i>
Colubridae	<i>Seminatrix</i>	<i>pygaea</i>
Colubridae	<i>Thamnophis</i>	<i>sirtalis</i>
Colubridae	<i>Thamnophis</i>	<i>sauritus</i>
Colubridae	<i>Storeria</i>	<i>dekayi</i>
Colubridae	<i>Diadophis</i>	<i>punctatus</i>
Colubridae	<i>Opheodrys</i>	<i>aestivus</i>
Colubridae	<i>Farancia</i>	<i>abacura</i>
Colubridae	<i>Elaphe</i>	<i>obsoleta</i>
Colubridae	<i>Elaphe</i>	<i>guttata</i>
Colubridae	<i>Lampropeltis</i>	<i>triangulum</i>
Colubridae	<i>Lampropeltis</i>	<i>getula</i>
Micruridae	<i>Micrurus</i>	<i>fulvius</i>
Viperidae	<i>Agkistrodon</i>	<i>piscivorus</i>
Sirenidae	<i>Siren</i>	<i>lacertina</i>
Sirenidae	<i>Siren</i>	<i>intermedia</i>
Sirenidae	<i>Pseudobranchius</i>	<i>striatus</i>
Amphiumidae	<i>Amphiuma</i>	<i>means</i>
Salamandridae	<i>Notophthalmus</i>	<i>viridescens</i>
Plethodontidae	<i>Desmognathus</i>	<i>auriculatus</i>
Plethodontidae	<i>Eurycea</i>	<i>quadridigitata</i>
Microhylidae	<i>Gastrophryne</i>	<i>carolinensis</i>
Hylidae	<i>Hyla</i>	<i>cinerea</i>
Hylidae	<i>Hyla</i>	<i>femoralis</i>
Hylidae	<i>Hyla</i>	<i>squirella</i>
Hylidae	<i>Pseudacris</i>	<i>nigrita</i>
Hylidae	<i>Pseudacris</i>	<i>ocularis</i>
Hylidae	<i>Acris</i>	<i>gryllus</i>
Ranidae	<i>Rana</i>	<i>gryllo</i>
Ranidae	<i>Rana</i>	<i>catesbeiana</i>
Ranidae	<i>Rana</i>	<i>sphenocephala</i>

and reptiles that make extensive use of this portion of the habitat may be underrepresented or missing in the data.

#### *Overall abundance and evenness*

*Hyla cinerea* was the most prevalent species in the floodplain habitats sampled during this study. However, nocturnal hylid frogs were the most conspicuous animals encountered. Also, anurans often call and this increased their chance of being observed. Therefore, even though *H. cinerea* is an ubiquitous and abundant species, its numerical dominance may be overestimated by these methods.

Animals with cryptic coloration or those that stay hidden in the substrate may be underrepresented by this sampling method. *Rana sphenoccephala*, *R. grylio*, *G. carolinensis*, and all of the aquatic snakes fall into this category. Alternative sampling methods, including drift fences and funnel trapping, are necessary to more accurately measure the abundance of these species in the targeted habitats. However, *R. sphenoccephala*, *R. grylio*, and *G. carolinensis* seem to prefer habitats that were not sampled during this study, and truly appear to be uncommon in the sampled habitats. The two ranid species were commonly heard and seen around the banks of the canal (C-38) and near smaller canals (e.g., near the broadleaf marsh in pool A) and *G. carolinensis* is a fossorial species usually encountered in more mesic habitats. The rarity of aquatic snake observations, though, may reflect method bias rather than actual rarity.

Great variation existed in the distribution of individuals among the 12 species.

This variation resulted in an evenness value of 0.54 for the entire study area.

Originally it was believed that temperate-zone faunas had low evenness values and that tropical faunas were more evenly distributed. Further research has shown that almost all habitats worldwide have uneven abundances of their component species wherein there are a few abundant species and many that are relatively uncommon (Donnelly and Guyer, 1994).

#### *Comparisons of total abundance among sites and among months*

The differences found among sites may reflect environmental variation among sampling dates. The high mean monthly abundance values for the BLM-A site and the WS-D site were heavily influenced by one sampling period at each site. The mean abundance of individuals for July at the BLM-A site was approximately 17 individuals per transect, almost three times greater than any other mean value at that site. These data were collected while it was raining and many *H. cinerea* were active and calling. Likewise, the mean abundance for October at the WS-D site was approximately 10 individuals per transect, around 2.5 times greater than any other mean value at that site. Additional data from these sites are necessary to determine if the differences among sites are accurate. Long-term sampling can help remove environmental variation as noise and allow the true signal in the data to be detected (Gibbs, 1996; Morrison, 1988).

The differences found among months show that mean monthly abundances are greater during months in the wet season than during months in the dry season.

Environmental variation among sampling periods is less of a problem for the comparison among months because the differences in activity among months are driven by these environmental changes. Also, the environmental variation within a month is smaller than the variation among months, so changes among months should be easier to detect.

The significant interaction between months and sites suggests different activity patterns exist at the different sites. This could be caused by the differences in species composition among sites. Since *E. quadridigitata* are most abundant in woody shrub sites, and *H. cinerea* are most abundant in the other sites, differences in the activity patterns of these species would be observed as different patterns among the sites. Temporal differences in habitat use could also explain the different patterns observed among sites. Both of the wetland forest sites show relatively large numbers of *H. cinerea* in the winter months. This suggests *H. cinerea* use this habitat more during the dry, winter season, possibly due to the greater presence of refuge sites.

#### *Species abundances and evenness*

##### Broadleaf Marsh

The BLM-A site was very different from the other two broadleaf marsh sites. The sites in pools B and C were situated in relatively large portions of broadleaf marsh habitat. The pool A site, however, was located in a small patch of habitat adjacent to wet prairie habitat. This proximity to a more terrestrial habitat explains the presence of four particular species found at the BLM-A site. *Gastrophryne carolinensis* is a

fossorial toad that spends most of its time in damp soils (Ashton and Ashton, 1988b). Duellman and Schwartz (1958) noted that *P.ocularis* and *A. gryllus* are residents of prairies and flats, but are not found in essentially aquatic habits. *Thamnophis sauritus* uses the terrestrial margins of wetlands and is often found in prairies, hammocks, and on canal banks (Tennant, 1997). The evenness value of 0.49 expresses the dominance of *H. cinerea* over all other species at the site.

The BLM-B site has data for only 11 months because it could not be sampled in April 1997. Still, the BLM-B site was the most diverse site in the study. Seven of the 12 species found during the study occurred at this site (3 anurans, 2 snakes, 1 salamander, and 1 lizard). The BLM-B site was the most inundated site in the study. The lowest water depth recorded at a gauge was 18 cm, and many gauge readings were greater than 100 cm. This probably contributes to the presence of species like *A. piscivorus*, *N. fasciata*, and *R. grylio*, which are most abundant in primarily aquatic habitats (Duellman and Schwartz, 1958). The evenness value for this site was 0.44, the lowest among all seven sites. This seems contrary to the fact that this site was the most taxonomically diverse and had the highest number of species.

Only 23 individuals were found at the BLM-C site, the least among the BLM habitats. This site was dry most of the year, with standing water in only a few months. The high evenness value for this site, 0.90, is due to the small number of individuals sampled and would probably decrease if more individuals were sampled.

### Wetland Forest

Forty-three individuals from 3 species occurred at the WF-B site. However, the data represent only 11 months because this site was not sampled in April, 1997. The evenness for this site was relatively low at 0.57. This resulted from the dominance of *H. cinerea* which accounted for 79.1 % (n = 34) of the observations.

Though only 40 individuals were observed at the WF-C site, they were spread among 5 species and resulted in a relatively high evenness value of 0.74. This site is the only one where *H. femoralis* was observed. The total abundance for *H. femoralis* was 5, but all records were probably for the same individual that displayed a high degree of site fidelity. This is assumed because the data recorded the presence of *H. femoralis* at the same position on the same transect for 5 months between September, 1996, and March, 1997. Two *G. carolinensis* were encountered at this site when some debris was disturbed along a transect. Their abundance was probably much greater, but VES methods probably underestimate the abundance of these cryptic toads.

### Woody Shrub

The WS-C total of 14 individuals was the lowest number of individuals among all 7 sites. As with the BLM-C site, the high evenness value for the WS-C site, 0.76, is probably a result of the low number of individuals observed and would probably decrease if more individuals were sampled.

The WS-D site was the only site where *H. cinerea* was not the most abundant species. The most abundant species was *E. quadridigitata* which accounted for

69.4 % (n = 50) of all observations. *Eurycea quadridigitata* was found at both WS sites, but the abundance was much greater at this site. The evenness for this site was 0.57, a relatively low value due to the dominance of *E. quadridigitata*.

### **The use of evenness values**

Two problems are apparent in evaluating sites based on evenness. First, the number of individuals used to calculate E can greatly affect its value. The use of proportions eliminates one problem of sample size, but the fact that S is a function of N also creates a problem. Values of S increase sharply as N begins to increase. At these low values of N, differences of just a few individuals can result in changes of S. This, of course, affects the value of E, and the problem is confounded by the fact that changes in S affect E the most at low values of N. This problem would minimize as S stabilizes, and changes in N would then only affect the species proportions. A species-individual curve could be used to determine if S has stabilized by looking for an asymptote in the curve. Unfortunately, the individual counts for these study sites were low and their evenness values may not be accurate. Another problem with using evenness values to analyze species diversity is that they do not give any indication of the diversity above species level. For instance, both the WF-C and WS-D sites had 5 species. The WF-C site had an evenness of 0.74 (n = 40), and the WS-D site had an evenness of 0.57 (n = 72). The species observed at the WF-C site were 4 anurans and 1 lizard. The WS-D site had 2 anurans, 1 salamander, 1 lizard, and 1 snake. Diversity is a difficult concept to define and cannot be aptly described by indices that condense

and eliminate so much important information. Therefore, it is important to consider S, species composition, and N when comparing diversity among sites or among studies.

## **Habitat analyses**

### *Habitat use and associations*

*Hyla cinerea* and *A. carolinensis* were found in all 4 habitats, and at all 7 sites when the PVC data are included. This is not surprising since *H. cinerea* is found in almost all habitats throughout Florida, and *A. carolinensis* is widespread reaching its highest abundances in mesic habitats (Duellman and Schwartz, 1958). *Hyla cinerea* had significant differences in habitat use, with its highest frequency of occurrence at the BLM-A site. *Anolis carolinensis* was found more frequently at WF sites, though the association was not significant. However, *A. carolinensis* will range high into the crowns of trees, and they often sleep on the branches. This makes observation by nocturnal VES difficult and could underestimate their abundance in the wetland forest sites. *Eurycea quadridigitata* was associated with the WS habitat, where all but one of its occurrences were from. It was usually found on mats of *Azolla caroliniana*, *Lemna* sp., and *Salvinia rotundifolia*. Occasionally it was seen on emergent vegetation including *Sagittaria lancifolia*. The remaining species were not encountered enough to accurately examine their use of the habitats targeted during this study.

### *Comparison of species composition among habitats*

A majority (11/12) of the species found in this study used broadleaf marsh habitat at some time during the year. Yet, there were important differences in species

composition among the broadleaf marsh sites. Five of the species from broadleaf marsh habitat were found only in the highly inundated marsh in pool B. Three of the species from broadleaf marsh habitat were found only in the pool A marsh, most likely due to the proximity of wet prairie habitat. This suggests that hydroperiod and adjacent habitat types can produce differences in the assemblage structure among sites, even those with very similar floral composition. Habitats are often defined in terms of their plant associations, even though the composition of both flora and fauna appear dependent on the significant physical characteristics of an area (Campbell and Christman, 1982). Determining which factors affect the distribution of a species would be necessary to explain its presence or absence in a particular area. Though many species make use of the broadleaf marsh habitat, the species composition for any given broadleaf marsh site may depend heavily on adjacent habitats and abiotic factors.

*Hyla femoralis* was the only species that did not occur in the broadleaf marsh; it was found exclusively in the wetland forest. This species is particularly arboreal, and spends much of its time high in the forest canopy (Wright and Wright, 1995). Therefore, it is almost certainly dependent on the presence of forest habitat to persist in the floodplain.

The species found in the woody shrub were a subset of those found in the BLM B-C habitat. The woody shrub habitat is considered to be a degraded remnant of broadleaf marsh habitat resulting from channelization (L. Toth, pers. comm. to M. A.

Donnelly). One major difference between the two habitats was in the abundance of *E. quadridigitata*. *Eurycea quadridigitata* was found only once at a broadleaf marsh site, while it was found numerous times at both woody shrub sites.

### **Species-individual curve**

The power curve  $S = 1.0458 N^{0.4334}$  provides a good fit to the data ( $R^2 = 0.986$ ; Figure 3). At 372 individuals the curve is not yet asymptotic, which suggests the presence of additional species. However, making predictions beyond the range of the data should be done with caution (Draper and Smith, 1981). Species-individual curves from studies in the temperate zone usually reach an asymptote between 200 and 500 individuals. Curves from studies in the tropics often reach high numbers of individuals without reaching an asymptote (Hayek and Buzas, 1997). The species-individual curve from this study of a subtropical fauna most closely resembles the temperate zone pattern with 10 species from the first 129 individuals sampled, and only 2 species from the last 243 individuals sampled.

### **Anuran calling patterns**

Six of the 7 anurans encountered in this study were also heard calling at some point in time. *Hyla femoralis*, which was only found at the WF-B site, was never heard calling. Ashton and Ashton (1988b) states that *H. cinerea* calls from April to October, but during this study *H. cinerea* was heard calling throughout the year with the exception of September and October. The second most often heard species, *R. grylio*, is known to call continuously throughout the year (Carr, 1940). The majority

of the observations occurred in May, June, and July, which coincided with the beginning of the wet season. All six species were heard calling during this time period. The least amount of rain fell from November to March, during which time all species except *G. carolinensis* were heard calling. These cooler, drier months represent the activity peak for *R. sphenoccephala* and the beginning of the breeding season for *P. ocellularis* (Ashton and Ashton, 1988b).

*Hyla cinerea*, *R. gryllio*, and *R. sphenoccephala* were heard calling at all 7 sites. *Hyla cinerea* was the only species of the three that also was encountered on transects at all 7 sites. The fact that *R. gryllio* and *R. sphenoccephala* were heard calling at all 7 sites attests to their abundance in the region even though they were rarely encountered on transects. These species were probably calling from nearby river channel or canal banks and were not using the sampled habitat. For the three remaining species, some of their calling data did not coincide with their occurrence data from this study.

*Pseudacris ocellularis* was heard calling at the BLM-C site, *G. carolinensis* was heard calling at the WS-C site, and *A. gryllus* was heard calling at the WS-D site.

#### **The use of PVC pipes by *Hyla cinerea***

Beginning in October, it was apparent that *H. cinerea* were using the PVC pipes that marked the transects as refuges. The analysis of *H. cinerea* abundance in the PVC shows a strong negative correlation with temperature ( $R^2 = 0.87$ ;  $F_{1,10} = 67.22$ ;  $p < 0.01$ ). While the major factor causing *H. cinerea* to seek refuge appeared to be temperature, the prevention of water loss may have been important. A study that

used PVC pipes to trap hylid frogs recorded 55 % of their captures from the 20 % of their traps that were sealed on one end and held water (Moulton et al., 1996). Since the PVC pipes marking the Kissimmee floodplain transects were driven into the ground, the bottom was sealed and retained water. Therefore, the use of the PVC pipes to mark the transects unintentionally created an attractive refuge for *H. cinerea*.

### **Comparisons with other studies in Florida**

Few quantitative studies of herpetofaunal assemblages have been performed in central or southern Florida. McDiarmid et al. (1983) studied the herpetofauna of Lake Conway in central Florida. Dalrymple (1988) examined the herpetofauna of Long Pine Key (LPK) in Everglades National Park. Most recently, Timmerman et al. (1994) described the herpetofauna of Jonathan Dickinson State Park (JDSP). Other studies have been performed in central or southern Florida but they were mainly qualitative and did not record patterns of abundance (Duellman and Schwartz, 1958; Campbell and Christman, 1982; Meshaka, 1997).

Since the studies from LPK and JDSP involve numerous habitat types and several sampling techniques, comparisons of species composition are not meaningful. However, abundance patterns can be compared among studies. In both the LPK and the JDSP studies, abundance was greater in the wet season (May - October) than in the dry season (November - April). This pattern was true for the Kissimmee River floodplain herpetofauna, with the 4 greatest monthly abundances occurring in the wet season. The JDSP study also compared abundances among 4 seasons, winter (January

- March), spring (April - June), summer (July - September), and fall (October - December). The abundance of reptiles and amphibians was greater in the summer for both this study and the JDSP study. Also, the fall had a greater abundance than the winter in both studies. The major difference occurred in the spring months, where the JDSP study has its second greatest abundance of reptiles and amphibians, yet in this study abundance was at its lowest levels. Differences in spring activity patterns could be due to differences in the composition of the respective faunas. Unlike the floodplain habitats targeted by this study, the JDSP fauna had many reptiles, including 22 species of snakes. Dalrymple et al. (1991) showed that snakes in southern Florida reach their peak abundances in the spring and in the fall. This may account for the large difference in abundances during the spring months for the two studies.

The Lake Conway study allows more meaningful comparison with this study for several reasons. Lake Conway is relatively close to the study area, approximately 75 km north of the Kissimmee River. Both this study and the Lake Conway study targeted habitats that are transitions between aquatic and terrestrial areas (the shoreline is where a majority of the species occurred at Lake Conway). Also, enough data are presented in the Lake Conway study to allow comparison of standardized samples. The herpetofauna of Lake Conway was sampled using several methods from June, 1977, to September, 1980. A total of 11,928 individuals from 12 species of amphibians and 17 species of reptiles was recorded during the study. After the first 372 individuals observed, the total number found in this study, the Lake Conway study

had found 11 species. Though this study has a greater number of species at 372 individuals, the species accumulation curves look very different. The species accumulation curve for the Lake Conway study was still increasing rapidly at 372 individuals, while the curve was flattening for this study. Unfortunately, it is not possible to tell which 11 species were observed first at Lake Conway, or what methods were used to observe them. Thus, the entire species list is used to compare the two studies. Of the 12 amphibians found at Lake Conway, 7 were also found by this study. Three more of these species were found opportunistically in habitats along the Kissimmee River similar to those targeted by this study and may eventually be found at the study sites. Only *Bufo terrestris* and *Pseudobranchius striatus* were found at Lake Conway and have not been seen in the floodplain habitats of the Kissimmee River. One species, *P. ocularis*, was found in this study but was absent from the Lake Conway herpetofauna. Seventeen species of reptiles were found at Lake Conway that were not found in this study. These species include 9 turtles, 7 snakes, and *A. mississippiensis*. Turtles were only seen in river channel habitats along the Kissimmee and none were found in the floodplain habitats. Two snakes were found by both studies. The Lake Conway study also included *Coluber constrictor*, *Farancia abacura*, *Regina alleni*, *Nerodia cyclopion*, and *Thamnophis sirtalis*. The first three of these snakes were represented by only a few individuals even in their sample of 11,928 individuals. One snake, *A. piscivorus*, was found by this study but was absent from the Lake Conway study. McDiarmid et al. (1983) believe the lack of swampy or

riverine habitat explains the absence of *A. piscivorus* at Lake Conway. One lizard, *A. carolinensis*, was very abundant and was found at all study sites in the Kissimmee floodplain habitats. However, no lizards were found at Lake Conway.

## CONCLUSIONS

Twelve species of reptiles and amphibians were found in the floodplain habitats targeted by this study. Five additional species were found opportunistically either at the study sites or in similar habitats along the river. It is expected that future sampling will increase the species richness for these habitats to somewhere between 15 and 20 species. This list was generated for 3 specifically targeted habitats and should not be viewed as a complete list for the entire floodplain.

Using only one method to sample multiple taxa provides limited success (McDiarmid et al., 1983; Pearman et al., 1995). However, the habitats in this study are often inundated and many traditional methods used to sample reptiles and amphibians cannot be employed without great difficulty. The use of VES to sample these habitats allows long-term data collection at a minimal cost. For a more complete description of the herpetofauna of the Kissimmee River floodplain, including an exhaustive species list, additional data from alternative sampling methods is necessary.

Environmental variation among sampling periods can make interpreting results difficult. This problem can be minimized by decreasing the time between samples or by sampling over long periods of time. Sampling over several years can eliminate environmental variation as noise and increase the chance of detecting patterns in the data (Gibbs, 1996). Therefore, continued sampling of these floodplain sites until restoration is necessary to give the most accurate description of pre-restoration conditions.

The presence of *H. cinerea* and *A. carolinensis* at all seven study sites indicates that they are habitat generalists within the Kissimmee River system. Their ubiquitous distribution suggests that they play an important role in energy flow through the floodplain ecosystem. Many of the remaining species, however, occurred in or were associated with only one habitat. These differences in habitat use indicate the importance of having multiple habitat types present in the floodplain to maintain diversity. Also, species composition varied greatly among sites within a habitat type. These differences among sites probably resulted from differences in the surrounding habitat types and differences in abiotic factors. Therefore, the presence of multiple habitat types, the numerous combinations of ecotones they produce, and the variation of abiotic factors among areas all seem to play an important role in structuring the herpetofaunal assemblages in the floodplain.

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Appendix. Mean abundance and standard error of individuals per transect shown monthly for the broadleaf marsh (SE = Standard error).

	Month																										
	AUG		SEP		OCT		NOV		DEC		JAN		FEB		MAR		APR		MAY		JUN		JUL				
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE			
<b>BLM-A</b>																											
<i>A. carolinensis</i>	0.00	0.00	0.33	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.33	1	1	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	
<i>A. carolinensis</i> in PVC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.67	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>A. gryllus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>G. carolinensis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>H. cinerea</i>	5.67	2.40	2.33	0.88	2.33	0.33	1.33	0.67	0.33	0.33	0.00	0.00	0.33	0.33	1.00	0.00	1.33	0.88	0.33	0.33	0.67	0.33	14.33	3.33	0.00	0.00	
<i>H. cinerea</i> in PVC	0.00	0.00	0.00	0.00	7.00	3.51	5.00	1.15	16.00	7.02	17.33	6.33	3.00	0.58	7.33	2.33	20.33	5.24	0.67	0.67	1.33	0.33	0.00	0.00	0.00	0.00	
<i>P. ocularis</i>	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67	0.33	0.33	0.67	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>T. sauritus</i>	0.00	0.00	1.67	0.67	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>Total</b>	5.67	1.39	4.33	0.69	10.33	1.71	6.67	1.07	16.33	3.98	18.00	3.76	5.67	0.51	9.00	1.15	22.33	3.89	1.33	0.38	2.00	0.58	17.00	1.45	0.00	0.00	
<b>BLM-B</b>																											
<i>A. carolinensis</i>	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67	Not Sampled	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00
<i>A. carolinensis</i> in PVC	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Not Sampled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>A. piscivorus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67	
<i>E. quadridigitata</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>H. cinerea</i>	1.33	0.33	1.67	1.20	0.67	0.67	2.00	1.00	2.67	0.67	0.00	0.00	2.33	1.33	1.00	0.58	1.00	0.58	1.00	0.58	2.00	1.00	1.67	1.67	0.00	0.00	
<i>H. cinerea</i> in PVC	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67	0.00	0.00	4.67	1.86	3.67	1.76	3.33	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>N. fasciata</i>	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>R. gryllo</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>R. sphenocephala</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>Total</b>	1.33	0.19	2.00	0.88	1.00	0.33	4.33	0.38	3.00	0.58	4.67	1.07	6.00	1.15	5.00	1.00	Not Sampled	1.00	0.33	2.67	0.19	2.33	0.33	2.33	1.35	0.00	0.00
<b>BLM-C</b>																											
<i>A. carolinensis</i>	0.00	0.00	0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.33	0.00	0.00	
<i>A. carolinensis</i> in PVC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>A. gryllus</i>	0.00	0.00	0.00	0.00	1.67	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<i>H. cinerea</i>	2.67	0.67	0.67	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.33	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.33	
<i>H. cinerea</i> in PVC	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	1.00	0.58	1.00	1.00	1.33	0.33	1.00	0.58	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>Total</b>	2.67	0.38	0.67	0.38	2.33	0.19	0.33	0.19	1.33	0.38	1.00	0.58	1.33	0.19	1.67	0.69	0.67	0.33	0.33	0.19	0.33	0.19	0.33	0.19	0.67	0.33	

Appendix. Mean abundance and standard error of individuals per transect shown monthly for the wetland forest (SE = Standard error).

	Month																									
	AUG		SEP		OCT		NOV		DEC		JAN		FEB		MAR		APR		MAY		JUN		JUL			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE		
<b>WF-B</b>																										
<i>A. carolinensis</i>	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.33	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.33
<i>A. carolinensis</i> in PVC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>H. cinerea</i>	1.00	0.58	0.00	0.00	0.67	0.67	0.33	0.33	1.67	0.88	1.00	1.00	3.00	0.58	1.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	1.67	1.20
<i>H. cinerea</i> in PVC	0.00	0.00	0.00	0.00	0.67	0.33	12.00	1.00	5.67	0.88	16.33	1.76	7.33	1.20	1.00	0.58	0.33	0.33	0.33	0.33	0.33	0.33	0.00	0.00	0.00	0.00
<i>R. sphenocephala</i>	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33
<b>Total</b>	1.67	0.51	0.00	0.00	1.33	0.19	12.67	0.69	8.33	1.35	17.67	1.86	10.33	0.51	2.67	0.51	0.67	0.38	0.67	0.38	0.33	0.19	2.33	0.33	2.33	0.84
<b>WF-C</b>																										
<i>A. carolinensis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.33	0.00	0.00	0.67	0.67	0.33	0.33	0.33	0.33	1.00	0.58	0.00	0.00	0.67	0.33	0.67	0.33
<i>A. carolinensis</i> in PVC	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>G. carolinensis</i>	0.67	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>H. cinerea</i>	0.00	0.00	0.33	0.33	1.00	0.58	1.33	0.88	1.33	0.88	0.00	0.00	1.00	0.00	1.33	1.33	0.67	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>H. cinerea</i> in PVC	0.00	0.00	0.00	0.00	0.33	0.33	3.00	1.53	5.00	1.15	12.67	3.93	5.00	1.53	9.00	1.53	2.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>H. femoralis</i>	0.00	0.00	0.33	0.33	0.33	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>R. sphenocephala</i>	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	0.67	0.38	1.00	0.33	2.00	0.33	5.00	0.58	6.67	1.86	12.67	2.27	7.00	0.33	11.00	0.88	3.00	0.33	1.00	0.33	0.00	0.00	1.00	0.00	1.00	0.00

Appendix. Mean abundance and standard error of individuals per transect shown monthly for the woody shrub (SE = Standard error).

	Month																									
	AUG		SEP		OCT		NOV		DEC		JAN		FEB		MAR		APR		MAY		JUN		JUL			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE		
<b>WS-C</b>																										
<i>A. carolinensis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>A. carolinensis</i> in PVC	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>A. gryllus</i>	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>E. quadrifidata</i>	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.67	0.67	0.00	0.00	0.00	0.00
<i>H. cinerea</i>	0.00	0.00	1.33	0.33	0.00	0.00	0.33	0.33	0.33	0.33	0.00	0.00	0.67	0.67	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>H. cinerea</i> in PVC	0.00	0.00	0.33	0.33	0.00	0.00	0.67	0.33	0.33	0.33	3.67	0.88	1.67	0.88	1.33	0.67	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	0.00	0.00	2.00	0.33	0.67	0.38	1.00	0.33	1.00	0.33	5.67	1.17	2.33	0.19	1.67	0.51	1.33	0.19	0.67	0.38	0.00	0.00	0.00	0.00	0.00	0.00
<b>WS-D</b>																										
<i>A. carolinensis</i>	0.33	0.33	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.33
<i>A. carolinensis</i> in PVC	0	0	0	0	0	0	1	1	0	0	2.67	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>A. piscivorus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>E. quadrifidata</i>	0.33	0.33	0.67	0.67	9.33	4.06	0.33	0.33	2.00	1.53	2.00	1.53	0.33	0.33	1.00	0.58	0.00	0.00	0.33	0.33	0.33	0.33	0.00	0.00	0.33	0.33
<i>H. cinerea</i>	0.67	0.33	0.67	0.33	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.33	0.00	0.00	0.67	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00
<i>H. cinerea</i> in PVC	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.33	1.33	0.33	3.33	0.88	3.00	1.53	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>R. sphenoccephala</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	1.33	0.19	1.33	0.19	9.67	4.33	3.00	0.33	3.67	0.69	8.00	0.33	3.67	0.96	2.00	0.00	0.67	0.19	1.00	0.58	0.00	0.00	0.00	0.00	3.33	0.77