Activity of Bats (Mammalia: Chiroptera) in Coastal South Carolina: an Acoustic Study

by

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ABSTRACT

Coastal South Carolina has not been the focus of previous studies on distribution of bats, but the proposal of an offshore wind farm has stimulated interest in how bats use coastal areas. Anabat acoustic detectors were used to record echolocation calls of bats over wetlands in Charleston County, South Carolina, during June-October 2014 to determine if salinity of water and presence of vegetation influenced use of habitats by bats. Abundance and diversity of insects as well as environmental conditions were measured to determine if environmental conditions or availability of insects played a prominent role in where bats were active. Bats were significantly less active over wetlands with vegetation than wetlands without vegetation. Freshwater sites generally had the greatest amount of activity. However, salinity of water played a less important role in where bats were active than presence of vegetation. In addition to studying bats over wetlands, echolocation calls were recorded over barrier islands and the mainland both before and during autumnal migration to determine how activity of bats is distributed and whether there is a shift in activity by season. Islands had the greatest activity for almost all species and for overall activity of bats. Activity increased during autumn, but this was not significant for all species or groups. Neither environmental conditions nor abundance and diversity of insects appeared to play a critical role in where or when bats were active. This study implies that maintaining open-water areas devoid of vegetation is critical for managing wetland habitats to promote healthy populations of

bats. Because bats were more active over islands and activity increased during autumn, which is the time when bats experience the greatest mortality due to wind farms, developers and managers of offshore wind farms along coastal South Carolina should mitigate negative impacts on bats.

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CHAPTER 1

BATS AND PESTS:

A REVIEW OF THE IMPORTANCE OF NORTH AMERICAN BATS (MAMMALIA: CHIROPTERA) TO AGRICULTURE

Almost all of the 47 species of bats in North America are insectivorous (Harvey et al. 2011) and provide top-down control of insects, which indirectly reduces herbivory on plants (Kalka et al. 2008, Jung et al. 2012). Many of the large colonies of bats that forage over agricultural landscapes are comprised of pregnant or lactating females (Kunz et al. 1995, Federico et al. 2008). Pregnancy and lactation are two reproductive stages where bats have a greater energy requirement and must consume larger amounts of food to compensate (Racey 1982, Speakman and Thomas 2003). Lactating female Brazilian free-tailed bats (*Tadarida brasiliensis*) can consume up to two-thirds of their body weight in insects each night (Kunz et al. 1995, Lee and McCracken 2002). When this figure was expanded to determine the amount of insects eaten by an entire colony over a season, it was determined that a colony of 20,000,000 Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) in the southwestern United States ate about 13,000 tons of insects each summer (Altringham 1996). Brazilian free-tailed bats are not the only species of bats that consume large quantities of insects. Whitaker (1995) estimated that a colony of 150 big brown bats (*Eptesicus fuscus*) in Indiana consumed about 1,300,000 insects during April-October.

Because bats are feeding on such large quantities of insects, it is likely bats have a significant impact on populations and community dynamics of insects (Altringham 1996, Federico et al. 2008). Many taxa of insects consumed by bats are adults of species where the larval form is a documented agricultural pest (Whitaker 1995). These pests cause extensive damage to crops and it is believed that bats are impacting population cycles of these insects, keeping their populations in check (Boyles et al. 2011). Moths, which have larvae that are among the most destructive of agricultural pests, can constitute about 30% of the diet of an insectivorous bat (Kunz et al. 1995, Whitaker et al. 1996, Lee and McCracken 2002, Cleveland et al. 2006). Leafhoppers (Ciccadellidae), scarab beetles (Scarabiidae), stinkbugs (Pentatomidae), and adults of cotton bollworms (Noctuidae), fall armyworms (Noctuidae), cabbage loopers (Noctuidae), tobacco budworms (Noctuidae), tent caterpillars (Lasiocampidae), cutworms (Noctuidae), and coneworms (Pyralidae) are among the many pests that are consumed by bats (Whitaker 1995, Lee and McCracken 2005, Cleveland et al. 2006, Federico et al. 2008, Clare et al. 2009,).

Bats provide the agricultural and timber industries an ecosystem service due to the avoided costs of having to apply pesticides, boosting profits for farmers (Cleveland et al. 2006, Federico et al. 2008, Boyles et al. 2011). Healthy populations of bats provide services for local farmers, but they also reduce pests on a regional and transcontinental scale (Lee and McCracken 2005, Federico et al. 2008). Many of these pests migrate between Mexico and the United States, so pest management cannot simply be localized (Lee and McCracken 2005). Boyles et al. (2011) calculated the ecosystem service provided by bats for each county in the United States. He determined that bats currently provide a free pesticide service to farmers, allowing farmers to pocket an average annual savings of about $183/hectare. When that figure was extrapolated for the entire United States, bats save the agriculture industry an annual average of $22,900,000,000. This figure only covers the avoided costs of applying pesticides and does not take into account the ecological costs associated with dramatically increasing use of pesticides; this includes increased resistance of pests to pesticides, harmful effects on both vertebrate and invertebrate predators, and downstream effects of larger quantities of pesticides in the landscape (Cleveland et al. 2006, Boyles et al. 2011,).

The economic and ecological importance of bats is clear. Unfortunately, populations of bats are facing many challenges, including wind farms, the spread of white-nose syndrome, and degradation of habitats (Boyles et al. 2011, Kunz et al. 2011). It is in the best interest of land managers and farmers to promote healthy populations of bats through sustainable use of land and by providing appropriate habitats. Research is necessary to determine which characteristics of habitats are optimal for bats so that land managers can make informed decisions regarding managing land for bats. The remainder of this thesis attempts to identify useful habitats for bats in coastal South Carolina, a region that has not had much research. Chapter 2 examines the selection of wetlands by bats based on salinity of water and presence of vegetation to identify which characteristics of wetlands are selected by bats. Chapter 3 attempts to determine if barrier islands are used differentially from the mainland to determine if coastal areas are important habitats for bats.

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Figure 1.1.---Lactating female Brazilian free-tailed bats (*Tadarida brasiliensis*) can consume up to two-thirds of their body weight in insects per night (Kunz et al. 1995, Lee and McCracken 2002). Photo courtesy of J. Scott Altenbach.

CHAPTER 2

SELECTION OF WETLAND HABITATS BY BATS (MAMMALIA: CHIROPTERA) IN COASTAL SOUTH CAROLINA

ABSTRACT

Wetlands provide important habitats for bats. To determine if salinity of water and presence of vegetation influence use of habitats by bats, Anabat acoustic detectors were used to record echolocation calls of bats over wetlands in Charleston County, South Carolina. Abundance and diversity of insects as well as environmental conditions were measured to determine if environmental conditions or availability of insects played a prominent role in where bats were active. It was hypothesized that differences in habitat would affect activity of bats. Bats were significantly less active over wetlands with vegetation compared to open-water habitats. Salinity of water played a less important role than presence of vegetation in where bats were active. Freshwater sites generally had the greatest amount of activity. Maintaining open-water areas devoid of vegetation is critical for managing wetland habitats to promote healthy populations of bats.

INTRODUCTION

Selection of habitats by bats can be affected by many variables, including presence of water, level of vegetative clutter, availability of prey, and structure of echolocation calls (Menzel et al. 2005*b*, Ford et al. 2006, Johnson and Gates 2008, Jung et al. 2012). Landscape-level variables tend to have less influence on how bats select habitats than microhabitat variables (Erickson and West 2003, Ford et al. 2006). An exception is the landscape-level variable of proximity of habitat to water, with bats more likely to be present in habitats that are near a source of water (Ford et al. 2006).

Most habitat-selection studies that have examined microhabitat variables have done so within terrestrial habitats, which have implications for how alteration of habitats by humans would affect activity of bats over land (Erickson and West 2003, Menzel et al. 2005*a*, 2005*b*, Ford et al. 2006). These studies have shown that bats tend to be more numerous around sources of water within terrestrial habitats (Menzel et al. 2005*b*, Ford et al. 2006, Johnson and Gates 2008). For example, Menzel et al. (2005*a*) studied activity of six species of bats at the Savannah River Site in the Upper Coastal Plain of South Carolina. They determined that greatest levels of activity were over riparian areas compared to terrestrial areas for all six species. However, these studies did not focus on microhabitat variables of riparian or wetland areas.

In addition to presence of water, extent of vegetative clutter seems to play a critical role in how bats select habitats. Clutter refers to any structural component that can produce an echo, but is usually a term associated with presence and complexity of vegetation (Fenton 1990). Some bats are better suited to certain habitats based on maneuverability during flight, which is determined by morphology of their wings. Large bats with long, narrow wings are less maneuverable and are adapted to flying high over open, non-cluttered habitats, while smaller bats with short, broad wings are adapted to flying within moderately cluttered habitats (Altringham 1996, Brigham et al. 1997, Carter et al. 2004). Structure of echolocation calls also affects the type of habitat a bat uses, and this is tightly linked to morphology of their wings. Open-adapted bats tend to have low frequency calls and clutter-adapted bats tend to have higher frequency calls (Altringham

1996). This is due to higher frequency sound attenuating more rapidly than low frequency sound, and clutter-adapted bats do not need sound to travel as far as open-adapted bats. Kalko and Schnitzler (1993) found that bats changed the structure of their echolocation call when flying in cluttered habitats, presumably because the bat has to distinguish complex echoes off vegetation from echoes off prey. As a result, selection of habitats is not solely based on abundance and diversity of insects, but is also due to structural components of the habitat. While moderately cluttered habitats are selected by clutter-adapted species, highly cluttered habitats tend to be avoided by both open-adapted and clutter-adapted species regardless of abundance of insects (Brigham et al. 1997, Grindal and Brigham 1999, Carter et al. 2004). Grindal and Brigham (1999) compared activity of bats at moderately cluttered edges of forests and within highly cluttered forests. Availability of insects was equally high in both habitats, yet activity of bats was greatest along edges of forests. Their study indicated that, although abundance of insects is important, level of clutter within the habitat may play a more significant role in selection of habitats by bats.

Most research conducted in South Carolina has focused on how bats select terrestrial habitats at the Savannah River Site in the Upper Coastal Plain, which is one of four ecoregions in the state (Menzel et al. 2001, 2005*a*, 2005*b*, Carter et al. 2004, Ford et al. 2006). These reports reveal that bats selectively forage over water within terrestrial systems and are most abundant in habitats with greater diversity of roosts. The Lower Coastal Plain of South Carolina has the greatest level of structural diversity of roosts within the state, including Spanish moss (*Tillandsia usneoides*), bridges, and many trees with large diameters (Menzel et al. 2003*a*, Johnson and Gates 2008). This fact, combined with the plethora of wetland habitats in this region, suggests that the Lower Coastal Plain is a landscape that provides ample habitats for bats.

When exploring diversity of species in the Lower Coastal Plain, it appears that this region is of prime importance to bats. Of the 14 species that occur in South Carolina, 12 inhabit the Lower Coastal Plain. These include the eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), northern yellow bat (*Lasiurus intermedius*), Seminole bat (*Lasiurus seminolus*), silver-haired bat (*Lasionycteris noctivagans*), evening bat (*Nycticeius humeralis*), tri-colored bat (*Perimyotis subflavus*), little brown myotis (*Myotis lucifugus*), southeastern myotis (*Myotis austroriparius*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), big brown bat (*Eptesicus fuscus*), and Brazilian free-tailed bat (*Tadarida brasiliensis*; Menzel et al. 2003*a*).

The Lower Coastal Plain of South Carolina is riddled with estuaries, rivers, creeks, and wetlands. Considering how important water is for bats, how prevalent water is in coastal South Carolina, and how many species of bats are in the Lower Coastal Plain, it is surprising how few studies have been conducted in this region to evaluate use of wetland habitats by bats. My goal was to determine whether bats were selecting wetland habitats depending on certain characteristics of those habitats. This would help provide an understanding of what management strategies could be employed to promote healthy populations of bats in coastal South Carolina. My objectives were to determine if activity of bats varies with type of wetland habitat, if activity of bats is influenced by abundance and diversity of insects, and if activity of bats is affected by environmental conditions.

MATERIALS AND METHODS

Study sites.---The coastal plain of South Carolina has a variety of terrestrial habitats that consist of loblolly-shortleaf pine (*Pinus taeda-Pinus echinata*; 42%), oak-gum-cypress (*Quercus-Nyssa-Taxodium*; 26%), oak-hickory (*Quercus-Carya*; 12%), oak-pine (*Quercus-Pinus*; 10%), longleaf-slash pine (*Pinus palustris–Pinus elliottii*; 7%), and elm-ash (*Ulmus-Fraxinus*; 3%) communities (Conner and Sheffield 2001). Most terrestrial systems bordering the wetland habitats I studied consisted of mixed pine-hardwood communities. Menzel et al. (2005*b*) determined that type of terrestrial habitat surrounding a source of water had no significant effect on activity of bats over the water.

The Lower Coastal Plain has several salinities of water including freshwater, brackish-water, and saltwater systems. These three salinities of water vary in species and diversity of vegetation. Saltwater marshes tend to have the least species richness and consist largely of smooth cordgrass (*Spartina alterniflora*) and black needle rush (*Juncus romerianus*). Brackish-water marshes can include big cordgrass (*Spartina cynosuroides*), black needle rush, soft-stem bulrush (*Scirpus validus*), leafy three square (*Scirpus robustus*), common reed (*Phragmites australis*), and others. Freshwater marshes in the Lower Coastal Plain have the greatest species richness and can contain soft rush (*Juncus effuses*), giant plumegrass (*Erianthus giganteus*), common buttonbush (*Cephalanthus occidentalis*), swollen bladderwort (*Utricularia inflata*), American lotus (*Nelumbo lutea*), American spongeplant (*Limnobium spongea*), and woolgrass (*Scirpus cypernius*) among others (T. Thornton pers. comm.).

Activity of bats was studied in six types of habitats in Charleston County, South Carolina. Three macrohabitats were identified based on salinity of water and were divided into freshwater, brackish-water, and saltwater habitats. Within each macrohabitat, activity of bats in two microhabitats was evaluated. Each microhabitat was chosen based on level of vegetative clutter. Sites where ≥90% of the wetland lacked vegetation were considered open habitats and sites where ≥90% of the wetland had vegetation were considered cluttered habitats (Figure 2.01). Vegetation in cluttered sites mostly consisted of cord grasses and rushes. There was no canopy cover over any habitat.

There were three study sites for each type of habitat (i.e., open freshwater, cluttered freshwater, open brackish-water, cluttered brackish-water, open saltwater, cluttered saltwater) for a total of 18 sites. These sites were at five locations, including Caw Caw Interpretive Center, Magnolia Plantation, Bear's Bluff National Fish Hatchery, James Island County Park, and Church Creek. Evaluating three study sites per habitat is consistent with previous studies on selection of habitats by bats (Menzel et al. 2005*a*, 2005*b*).

Acoustic monitoring.---Activity of bats was surveyed acoustically using Anabat SD1 bat detectors with zero-crossings-analysis interface modules (ZCAIM; Titley Electronics, Inc., Balina, Australia), which record echolocation calls of bats (Figure 2.02). The detector was placed inside a weatherproof container with the microphone pointing downward. The microphone was inside a 90° PVC elbow, which functioned to protect the microphone from weather and to provide directionality to ensure calls were only being recorded over the habitat studied. The weatherproof container was secured to the top of a 3-m pole, which was placed into a 19-liter bucket filled with concrete for stability. The 3-m pole could be tied to stakes to provide additional stability (Figure

2.03). The detector was placed within 3 m of the habitat studied as described by Menzel et al. (2005*a*) and Brickley (2012).

Surveys were conducted 7 June–24 October 2014. Previous studies have shown low levels of activity with precipitation and high winds, which can trigger the bat detector to record, giving unreliable data. As a result, surveys were not conducted when it was raining or when the wind averaged ≥20 km/hour as was suggested by Johnson and Gates (2008). To reduce potential bias among detectors, three Anabat detectors were rotated among the 18 study sites. Under ideal conditions (i.e., no precipitation and no malfunctions of equipment) three surveys were conducted each night, and all 18 sites were surveyed in 6 consecutive nights. Due to malfunctions with the weather station, 38 surveys were eliminated from analyses. This resulted in a total of 183 survey-nights. Each type of habitat and each study site comprised a relatively equal proportion of surveys (Tables 2.1 and 2.2).

Bats emit search-phase calls when echolocating to both orient themselves and to locate prey. When an insect is detected, the bat then emits an approach-phase call to home in on the insect and then, finally, emits a feeding buzz to capture the insect before returning to emitting search-phase calls (Altringham 1996; Figure 2.04). Because bats are constantly echolocating during flight, a call was recorded each time a bat flew within range of the Anabat bat detector, which is 30 m under optimal environmental conditions (K. Livengood pers. comm.). The detectors were set to passively record calls during 1930-0700 hours. Calls were recorded to a compact flash (CF) card, which was downloaded to a computer each morning. Calls were analyzed using AnalookW software (version 3.9c) and were compared to a call library (K. Livengood and C. Corben pers.

comm.) to determine identity of species. Viewing calls in AnalookW makes it possible to count passes, i.e., the number of times a bat flew past the detector. In Figure 2.05, each vertical line is termed a pulse and a sequence of pulses is termed a pass. As described by Kunz et al (2007), each pass has to be separated from other passes by >1 second to be considered a distinct pass.

Identification of species was only attempted on search-phase calls of ≥3 pulses, as structure of this type of call generally is consistent throughout the sequence of the call (Murray et al. 2001). Using calls of ≥3 pulses for identification of species is consistent with other acoustic studies (Kunz et al. 2007, Johnson and Gates 2008, Johnson et al. 2010). Calls of <3 pulses were counted for overall activity of bats, but were placed in an unidentified category and were not identified to species. Calls can be affected by environmental conditions or vary with age, sex, size, levels of vegetative clutter, and nearness to conspecifics (Kalko and Schnitzler 1993, Hayes 2000, Murray et al. 2001). All of these factors can affect ability to identify a call to species. Any ambiguous calls were placed in the unidentified category and were used to assess overall activity, but were not identified to species. All files were reviewed twice to verify identification of calls. Number of passes per species and total number of passes were compared across all six habitats.

Surveys of insects.---Insects were surveyed at each site where an Anabat bat detector was deployed. Sampling of insects was conducted using a 12-watt, black-light trap powered by a rechargeable, 12-volt battery (Bioquip Inc., Compton, California; Figure 2.06). A photoelectric switch was attached to the trap to prevent the light from turning on during daytime, which reduced the amount of diurnal insects caught in traps.

The trap consisted of a light suspended over a smooth, metal cone that funneled insects into a plastic bag. The bag contained Hot Shot No-Pest Strips (Spectrum Brands, Madison, Wisconsin) that acted as a killing agent. Above the metal funnel were clear vanes held in place by a metal lid and elastic cords. These vanes assisted in stopping insects in flight, causing them to drop into the funnel. The funnel itself was placed inside a 19-liter bucket for stability.

Samples of insects were frozen for transport to the lab, were they were thawed and sorted. Insects were preserved in 70% ethanol to facilitate identification. All insects were identified to order, with Megaloptera being combined with Neuroptera. In addition to tallying total abundance of insects, I also calculated Shannon's diversity index (Molles 2008). Abundance and diversity of insects were compared to activity of bats at each site throughout the sampling period to determine if availability of insects had an effect on activity of bats.

Weather.---Environmental variables can affect activity of bats within a site (Erickson and West 2003). A portable weather station (WS-2080Ambient Weather, Chandler, Arizona; Figure 2.07) was used to measure weather conditions at ~1.5m above the ground. Variables recorded included rainfall (mm), air temperature (°C), daily maximum temperature (°C), daily minimum temperature (°C), mean wind speed (km/h), maximum wind gust (km/h), relative humidity (%), and barometric pressure (kPa). Data points for each variable were taken at 30-minute intervals and were averaged for the night. In addition to the above variables recorded by the weather station, percentage lunar illumination at midnight was obtained from the United States Naval Observatory (http://aa.usno.navy.mil/data/docs/MoonFraction.php).

Statistical analysis.---To determine if type of habitat, weather variables, and abundance and diversity of insects affected activity of bats, I developed 11 a priori regression models. The models were as follows: HABITAT included salinity of water, vegetation, and interaction between water and vegetation; HABITATM included salinity of water and vegetation; WEATHER included temperature, wind speed, humidity, barometric pressure, and lunar illumination; INSECT included total abundance and diversity of insects; HABITAT + WEATHER; HABITATM + WEATHER; HABITAT + INSECT; HABITATM + INSECT; GLOBAL included all variables; GLOBALM included all variables minus interaction between water and vegetation; and NULL included the y-axis intercept and no other parameter. These models were evaluated using Akaike Information Criterion for small samples (AIC_c), differences in models from AIC_{min} (ΔAIC_c), and weights of models (ω). Competing models were ranked according to AIC_c. Only models within <3 units from AIC_{min} were considered as described by Burnham and Anderson (2002).

Before including all continuous weather variables in the models, I tested for autocorrelation using Spearman's correlation test and removed variables if $r^2 > 0.5$ as described by Ford et al. (2006). Maximum wind gust was collinear with mean wind speed ($r^2 = 0.88$), and maximum wind gust was removed as mean wind speed was more representative of the effects of wind during most of the survey period. Average air temperature was collinear with daily maximum temperature ($r^2 = 0.75$) and daily minimum temperature ($r^2 = 0.95$). Average air temperature was more representative of the survey period, so maximum and minimum temperatures were removed from analyses. Once these variables were removed, the pairwise correlation was $r^2 \leq 0.50$.

My dependent variable was data for counts (i.e., number of passes) and I used Poisson regression for analyses. Because I had a repeated-measures design where I surveyed each site multiple times, I used site as a random blocking variable to prevent pseudoreplication as recommended by Crawley (2005). In addition to analyzing passes, species richness of bats was compared across habitats using Poisson regression with site as a blocking variable.

Abundance and diversity of insects was compared across each habitat to determine if insects were distributed equally among habitats, or if certain habitats had a greater abundance or diversity of insects than others. Poisson regression was used to compare abundance of insects and an analysis of variance (ANOVA) was used to compare diversity of insects across habitats. Both analyses included an interaction term between salinity of water and vegetation and also included site as a blocking variable.

RESULTS

When identifying calls to species, two species-groups were established due to certain species being difficult to distinguish from each other. One group included calls from eastern red bats and Seminole bats. The other group included calls from big brown bats and silver-haired bats. It is unlikely that there were many silver-haired bats in coastal South Carolina during summer (Menzel et al. 2003*a*), and it is expected that the majority of calls in the big brown bat/silver-haired bat group from June through August were big brown bats. Rafinesque’s big-eared bats have calls of such low amplitude that they are difficult to record (Kunz et al. 2007). Only 8 passes from Rafinesque’s big-eared bats were recorded and this species was eliminated from analyses. Neither northern yellow bats nor little brown myotis was recorded during this study. This resulted in five species (tri-colored bats, evening bats, southeastern myotis, hoary bats, and Brazilian free-tailed bats) and two groups (eastern red bats/Seminole bats and big brown bats/silver-haired bats) being included in analyses.

Because my dependent variable was data for counts and my dataset had overdispersion (i.e., the variance was greater than the mean), I used negative-binomial regression for analyses instead of Poisson regression, as discussed by Burnham and Anderson (2002). Two species of bats were absent in many surveys, so I used zero-inflated regression for species when applicable. This resulted in using negative-binomial regression for the following species or groups: total number of passes, evening bats, tri-colored bats, eastern red bats/Seminole bats, big brown bats/silver-haired bats, and Brazilian free-tailed bats. Zero-inflated Poisson regression was used for hoary bats and southeastern myotis.

In total, 86,498 echolocation passes were recorded 7 June-24 October 2014. The weather station periodically malfunctioned, causing 38 surveys to be eliminated, which resulted in 76,090 passes being included in statistical analyses (Appendices 1 and 2). About 40% of calls (30,811 passes) were unidentifiable due to ambiguity, poor quality, or calls with <3 pulses. Of the remaining passes, 36% (27,505 passes) were tri-colored bats, 9% (6,566 passes) were evening bats, 7% (5,063 passes) were Brazilian free-tailed bats, 5% (3,697 passes) were eastern red bats or Seminole bats, 3% (2,257 passes) were big brown bats or silver-haired bats, <1% (103 passes) were hoary bats, <1% (80 passes) were southeastern myotis, and <1% (8 passes) were Rafinesque's big-eared bats (Figure 2.08). Light traps captured 247,474 insects, the majority of which were Coleoptera (Appendix 3).

Overall activity of bats, which included number of passes of each species as well as all unidentified passes, was best represented by the HABITATM model with HABITAT as the next-best model (Table 2.3, Appendices 4 and 5). Vegetation and salinity of water were significant parameters in the HABITATM model (Table 2.4). Habitats without vegetation had 3.42 times as many overall passes as habitats with vegetation ($P < 0.001$; 95% CL = 2.04-5.71; Figure 2.09[1]). Freshwater habitats had 2.18 times as many passes as saltwater habitats ($P = 0.018$; 95% CL = 1.14-4.17). There was no significant difference in levels of activity between brackish-water and saltwater or brackish-water and freshwater habitats.

Activity of evening bats was best represented by the GLOBALM model with WEATHER+HABITATM and WEATHER also receiving some support (Table 2.3, Appendices 6 and 7). Temperature, barometric pressure, diversity of insects, salinity of water, and vegetation were significant parameters in the GLOBALM model (Table 2.4). For each 1°C increase in temperature, there were 1.09 times as many passes ($P = 0.009$; 95% CL = 1.02–1.16). For each 1-kPa increase in barometric pressure, there were 2.11 times as many passes ($P = 0.028$; 95% CL = 1.09–4.11). Evening bats were more active in areas that had a greater diversity of insects ($P = 0.022$; 95% CL = 1.11–3.60). Habitats without vegetation had 2.17 times as much activity of evening bats as habitats with vegetation ($P = 0.036$; 95% CL = 1.05–4.49; Figure 2.10). Freshwater habitats had 2.64 times as much activity as saltwater habitats ($P = 0.035$; 95% CL = 1.07–6.52). There was

[1] Graphs depicting activity by vegetation and activity by salinity of water reflect average number of passes without considering site as a blocking variable. This may cause the values in the graph to be different than the values reported from regression models.

no significant difference between brackish-water and saltwater or brackish water and freshwater habitats.

Activity of tri-colored bats was best represented by the INSECT + HABITATM model with the HABITATM model also receiving some support (Table 2.3, Appendices 8 and 9). Salinity of water and vegetation were significant parameters in the INSECT + HABITATM model (Table 2.4). Habitats without vegetation had 2.73 times as many passes as habitats with vegetation (P = 0.032; 95% CL = 1.09–6.82; Figure 2.11). Freshwater habitats had 3.54 times as many passes as saltwater habitats (P = 0.027; 95% CL = 1.15 – 10.85). Brackish-water habitats had 3.53 times as many passes as saltwater habitats (P = 0.028; 95% CL = 1.14–10.91). There was no significant difference in activity between brackish-water and freshwater habitats.

Activity of Brazilian free-tailed bats was best represented by the WEATHER + HABITATM model with the GLOBALM, WEATHER+HABITAT, and GLOBAL models also receiving some support (Tables 2.3, Appendices 10 and 11). Temperature, humidity, barometric pressure, lunar illumination, vegetation, and salinity of water were all significant parameters in the WEATHER + HABITATM model (Table 2.4). For each 1°C decrease in temperature and for each 1% decrease in humidity, there were 1.19 and 1.07 times as many passes (P < 0.001 and 0.023; 95% CL = 0.79–0.90 and 0.89-0.99, respectively). For each 1-kPa increase in barometric pressure there were 1.04 times as many passes (P = 0.015; 95% CL = 1.22–6.30). For each 1% increase in lunar illumination, there were 1.01 times as many passes (P = 0.016; 95% CL = 1.00-1.02). Habitats without vegetation had 2.47 times as much activity of Brazilian free-tailed bats as habitats with vegetation (P = 0.042; 95% CL = 1.03–5.91; Figure 2.12). Freshwater habitats had 4.99 times as much activity as brackish-water habitats ($P = 0.016$; 95% CL = 1.60–15.54). Saltwater habitats had 4.20 times as much activity as brackish-water habitats ($P = 0.015$; 95% CL = 1.32–13.38). There was no significant difference between freshwater and saltwater habitats.

Activity of the eastern red bat/Seminole bat group was best represented by the HABITATM model with the WEATHER+HABITATM and HABITAT models also receiving some support (Tables 2.3, Appendices 12 and 13). Presence of vegetation was the only significant parameter in the HABITATM model (Table 2.4). Habitats without vegetation had 5.10 times as many passes as habitats with vegetation ($P < 0.001$; 95% CL = 2.16–12.06; Figure 2.13). Saltwater had more passes than freshwater or brackish-water habitats; however, this was not significant ($P = 0.313$ and 0.083, respectively). There was no significant difference in activity between brackish-water and either saltwater or freshwater habitats.

Activity of big brown bats/silver-haired bats was best represented by the WEATHER + HABITATM model, with the INSECT + HABITATM, GLOBALM, and HABITATM models also receiving some support (Tables 2.3, Appendices 14 and 15). Temperature, humidity, and salinity of water were significant parameters in the WEATHER + HABITATM model (Table 2.4). For each 1°C decrease in temperature and for each 1% decrease in humidity, there were 1.10 and 1.08 times as many passes ($P = 0.002$ and 0.005; 95% CL = 0.85–0.96 and 0.09-0.98, respectively). Freshwater habitats had 4.40 times as much activity as brackish-water habitats ($P < 0.001$; 95% CL = 1.92–10.09; Figure 2.14). There was no significant difference between activity at saltwater and fresh-water or saltwater and brackish-water habitats. Vegetation did not significantly affect activity of big brown bats/silver-haired bats.

Activity of the southeastern myotis was best represented by the INSECT + HABITATM model. The GLOBALM, HABITATM, WEATHER+HABITATM, HABITAT, GLOBAL, INSECT+HABITAT, and WEATHER+HABITAT models also received some support, but not all models received notable support (Tables 2.3, Appendices 16 and 17). Vegetation, salinity of water, and diversity of insects were significant parameters in the INSECT + HABITATM model (Table 2.4). Habitats without vegetation had 3.89 times as many passes as habitats with vegetation ($P = 0.001$; 95% CL = 1.72–8.79; Figure 2.15). Freshwater habitats had 2.82 times as many passes as saltwater habitats ($P = 0.035$; 95% CL = 1.08–7.36). There was no significant difference between brackish-water and saltwater or brackish-water and freshwater habitats. Southeastern myotis were more active in areas that had a greater diversity of insects ($P = 0.050$; 95% CL = 0.15–1.00).

Activity of hoary bats was best represented by the WEATHER+HABITATM model, with the WEATHER+HABITAT and the WEATHER models also receiving some support (Tables 2.3, Appendices 18 and 19). Temperature and vegetation were significant parameters in the WEATHER+HABITATM model (Table 2.4). For each 1°C decrease in temperature, there were 1.17 times as many passes ($P < 0.001$; 95% CL = 0.78–0.94). Habitats that lacked vegetation had 4.22 times as many passes as habitats with vegetation ($P = 0.004$; 95% CL = 1.59–11.16; Figure 2.16). Salinity of water had no significant influence on activity of hoary bats.

Species richness of bats was not significantly affected by the interaction term between vegetation and water, and the interaction term was removed to both simplify and more accurately reflect results as recommended by Crawley (2005). Once the interaction term was removed, species richness was significantly different among habitats with and without vegetation (Table 2.5). Open habitats had 1.24 times as many species as cluttered habitats (*P* = 0.001; 95% CL = 1.09–1.42). Freshwater habitats had 1.17 times as many species as brackish-water habitat; however, these results were barely significant (*P* = 0.053; 95% CL = 0.99–1.38). There was no significant difference in number of species at saltwater and brackish-water or saltwater and freshwater habitats.

There was no significant difference in diversity of insects when the interaction term between water and vegetation was included. Once the interaction term was removed, both saltwater and freshwater habitats had significantly greater diversity of insects than brackish-water habitat (*P* = 0.003 and *P* = 0.007, respectively). Saltwater had a greater diversity of insects than freshwater, but the difference was not significant. There was no significant difference in diversity at open and cluttered habitats.

Abundance of insects varied by both salinity of water and presence of vegetation (Figure 2.17). The interaction term between vegetation and water was significant; thus, the added effect of water on vegetation affected where insects were abundant. Open saltwater habitats had the least amount of insects. Open freshwater habitats had 2.39 times as many insects (*P* = 0.012; 95% CL = 1.21-4.71), open brackish-water habitats had 3.34 times as many insects (*P* <0.001; 95% CL = 1.76-6.34), and cluttered saltwater habitats had 2.66 times as many insects (*P* = 0.005; 95% CL = 1.34-5.30) as open saltwater habitats. Open brackish-water habitats had the most insects, but was only statistically significantly different from open saltwater habitats.

DISCUSSION

Habitat characteristics appear to explain the majority of variation in activity of bats, as evidenced by the HABITATM model being present in the best-approximating model for each species and for overall activity. Analyses determined that patterns exist between habitats and activity of bats. Open habitats tended to have more activity and greater species richness than cluttered habitats. Generally, saltwater habitats had the least amount of activity and freshwater habitats had the most activity, with a few exceptions. The interaction between vegetation and salinity of water was not a significant parameter for overall activity of bats or for activity of any individual species or group of bats. This means that the added effect of salinity of water on type of vegetation did not affect activity of bats. For example, activity did not significantly vary between cluttered brackish-water habitats and any other type of habitat (i.e., open brackish-water, cluttered freshwater, open freshwater, cluttered saltwater, or open saltwater).

Effects of habitats.---It was determined that presence or absence of vegetation was a key factor in whether a bat was active at a site. Overall activity and activity of six of seven species or groups was significantly greater over water without vegetation than over water with vegetation. The seventh species (big brown bats/silver-haired bats) followed the pattern of being more active over open sites, but the difference in activity over open and cluttered sites was not significant. Considering that all groups studied exhibited this pattern, it is apparent that presence or absence of vegetation may play a more important role than salinity of water in where bats are active.

Bats were more active over open sites than cluttered sites, despite there being no significant difference in insects due to vegetation alone. Previous studies have shown that maneuverability within a habitat due to vegetative clutter is a larger factor in selection of habitats than availability of insects (Brigham et al. 1997, Ober and Hayes 2008). Because what was termed clutter in my study referred to vegetation within water and did not impede maneuverability within the habitat, wing morphology should not have affected which habitat was selected. This insinuates there is something about open habitats that is selected by bats.

Siemers et al. (2001) determined that it was easier for several species of European trawling *Myotis* to detect prey if the prey was on a smooth surface (i.e., water) than a textured surface (i.e., vegetation) because the smooth surface was not reflecting as many echoes from clutter. Echoes off of water have a specific type of reflection that is characteristic of smooth surfaces and many bats have been documented trying to drink from smooth surfaces that were not water (Siemers et al. 2001, Hoffman et al. 2015). Species of trawling *Myotis* glean insects off the surface of water and forage 10-50 cm above the surface of water (Siemers et al. 2001), which is much lower than most species in the Lower Coastal Plain of South Carolina. While it is possible that echoes over open water are less beneficial to bats that fly several meters above the surface of the water than trawling bats, it is likely that bats are still exploiting the lack of cluttered echoes when foraging above open water. Schwartz et al. (2007) observed foraging Brazilian free-tailed bats above ponds in Texas and saw that bats flew 5-10 m above the water before diving down toward the water while emitting a feeding buzz. Because bats were diving toward the water, it is possible the bats were using echolocation signals reflected off the smooth surface of the pond to enhance their ability to detect prey. Benefits of foraging over open water due to low-clutter echolocation calls most likely decrease as height of foraging increases.

I detected trends in activity based on salinity of water despite determining there was no significant difference in abundance of insects across salinities of water. Overall activity and activity of five of the seven species or groups was significantly greater at freshwater sites, which also had the greatest species richness. It is possible that activity tended to be greatest at freshwater sites because bats must drink water. It is likely that, due to biases of light traps, abundance of insects collected in light traps did not reflect the insects on which bats forage. Many insectivorous species of bats forage on insects that have an aquatic stage during their life cycle, and because the aquatic stage occurs in freshwater, that species could be more abundant over freshwater. Brackish-water habitats had moderate amounts of activity, the least species richness, and the greatest abundance of insects. Brazilian free-tailed bats were the only species to have significantly less activity at brackish-water habitats. Unfortunately, there is so little research on activity over brackish-water that it is unclear why these results were obtained.

Although saltwater sites tended to have the least activity of bats and the lowest abundance of insects, they did not have the lowest species richness, indicating that saltwater habitats may be important for certain species of bats. Hoary bats and the eastern red bat/Seminole bat group did not have significant differences in activity based on salinity of water. Although it was not statistically significant, the eastern red bat/Seminole bat group was the only group that had more activity over saltwater habitats. There may have been a similar trend for hoary bats if more passes had been recorded.

Unfortunately, so few passes were recorded from hoary bats that it is difficult to draw strong conclusions for that species. Eastern red bats and hoary bats are migratory and are believed to migrate along the coast of South Carolina during autumn to spend winter in the southeastern United States (Menzel et al. 2003*b*, Johnson et al. 2011). Eastern red bats and hoary bats have been documented migrating 8-41 km off the Atlantic coast (Hatch et al. 2013, Sjollema et al. 2014), so it was not surprising to find that these species more active over saltwater habitats.

It is difficult to ascertain why there are differences in activity over different salinities of water by certain species of bats, and unfortunately, there is a paucity of information on selection of wetland habitats based on salinity. Bats may be engaging in different kinds of behaviors over different salinities of water and certain habitats may provide better foraging areas than others. In a study of activity of Brazilian free-tailed bats and Yuma myotis (*Myotis yumanensis*) over saltwater and brackish-water habitats in California, it was determined that, although saltwater sites were used more frequently, brackish-water was used more often for foraging (Brickley 2012). Future studies that look at types of activity (i.e., commuting or foraging) could help expand our knowledge of how bats are using different habitats.

Effects of insects.---Availability of prey played a smaller role in selection of habitats by bats than characteristics of habitats. Abundance of insects varied significantly based on vegetation and water, but activity of bats was not significantly related to abundance of insects. Open brackish-water habitats had the most insects, yet brackish-water did not have the greatest activity of bats. Similarly, cluttered saltwater habitats had the second-most number of insects, but both saltwater habitats and cluttered habitats generally had the least amount of activity of bats. It is important to note that because I did not conduct fecal or stomach-content analyses to evaluate diet, I cannot confirm that the bats were consuming the insects I collected with light traps. There is inherent bias with using light traps and it is possible that the insects captured do not accurately reflect prey selected for by bats. Kunz (1988) states that detectability of insects by bats varies by species of bat and size of insect. Insects that appear to be abundant in the light trap may not be abundantly available to all bats due to the size of the insect captured. As a result, I can only comment on relative availability of insects at each type of habitat.

Because the interaction term between vegetation and water was significant for abundance of insects, there were significant differences in abundance of insects between the six habitats, although there is no significant difference in abundance of insects between habitats grouped by presence or absence of vegetation or grouped by salinities of water. As a result, open saltwater habitats had the least number of insects and open brackish-water habitats had the most insects relative to other types of habitats. There was no clear pattern in how vegetation affected abundance of insects. Cluttered brackish-water and cluttered freshwater habitats had fewer insects than open brackish-water and open freshwater habitats, but the differences were not significant. This is surprising considering that presence of vegetation tends to coincide with a greater abundance of insects (Kalcounis and Brigham 1995). Cluttered saltwater habitats had significantly more insects than open saltwater habitats, which should not be surprising considering how abundant insects are in saltwater marshes (Davis and Gray 1966).

The abundance of insects seemed to be related to low diversity. As diversity of insects increased, abundance decreased. This is probably due to a few orders, i.e., Coleoptera and Diptera, dominating the total number of insects (Appendix 4). Abundance and diversity of insects did not appear to influence overall activity of bats or activity of any one species of bats. For example, both cluttered freshwater habitats and open freshwater habitats had an intermediate amount of diversity and abundance of insects, yet were used most often by bats.

Abundance and diversity of insects played a smaller role in use of habitat by bats when considering results of previous research. Many studies have been conducted to determine if bats select prey based on taxonomic order (e.g., Carter et al. 1998, 2004, Whitaker 2004). Although these studies elucidated some trends in selection of prey by species of bats, they also showed that bats can forage on many species of prey depending on availability. Because of this ability to have generalist foraging behavior, it is understandable that diversity of insects in the Lower Coastal Plain of South Carolina did not have an effect on activity of bats. Menzel et al. (2005*b*) determined that activity of bats was greatest above the canopy where abundance of insects should have been relatively low. Grindal and Brigham (1999) monitored activity within a highly cluttered forest and at a moderately cluttered edge of a forest. Abundance of insects was equal at both sites, yet activity was focused along the edge. These results insinuate that bats are more likely to forage in habitats best suited to morphology of their wings or because of other desirable characteristics of the habitat, regardless of whether insects are more abundant in less desirable habitats.

Effects of weather.---Environmental conditions could influence activity of bats. However, environmental conditions appear to explain less variation in activity of bats than habitat characteristics because the WEATHER model was not included in the best-approximating model for overall activity and activity of three of the seven species or groups. Despite this, certain parameters in the WEATHER model for overall activity and for activity of the tri-colored bat and southeastern myotis were significant in the GLOBALM model, but did not show up in the best-approximating model for those species.

Previous studies have documented that higher nighttime temperatures and lower wind speeds are associated with both increased abundance of insects and greater activity of bats (e.g., Erickson and West 2002, Ford et al. 2006, Cryan and Brown 2007, Johnson et al. 2011). Only evening bats had significantly greater activity as temperature increased. Both Brazilian free-tailed bats and hoary bats had significantly more activity as temperature decreased. This association for hoary bats could be due to it being migratory and having increased activity during autumn when temperatures are lower than in summer (Johnson et al. 2011). Brazilian free-tailed bats in the Southwest are migratory (Wilkins 1989), but it is believed that southeastern populations are residents instead of migrants (Carter 1962).

Both Brazilian free-tailed bats and the big brown bat/silver-haired bat group had significantly less activity as humidity increased. Evening bats, hoary bats, and eastern red bats/Seminole bats were also less active as humidity increased, but the effects were not statistically significant. Previous studies have shown that activity is negatively associated with increased humidity, which is probably due to sound attenuating more rapidly in conditions with higher humidity (Johnson et al. 2011, Snell-Rood 2012). This more rapid attenuation of sound can make it difficult for bats to echolocate as efficiently.

Barometric pressure significantly affected activity of Brazilian free-tailed bats, evening bats, and overall passes and insignificantly affected activity of tri-colored bats, eastern red bats/Seminole bats, and big brown bats/silver-haired bats, showing an increase in activity of all of these species or groups as barometric pressure increased. Cryan and Brown (2007) determined that low barometric pressure was a good indicator of arrival of bats to Southeast Farallon Island during migration. Hoary bats, a migratory species along the coast of South Carolina, were insignificantly associated with low barometric pressure and may have had a stronger association if more hoary bats had been recorded. It is possible that barometric pressure is a more significant environmental condition during migration in autumn.

The only species of bat to be affected by changes in lunar illumination was the Brazilian free-tailed bat, which increased activity as lunar illumination increased. This is not in agreement with most previous studies, which have shown that activity of bats decreases as lunar illumination increases, presumably to evade predators (Erkert 1982, Cryan and Brown 2007). Other studies have provided evidence that small percentages of lunar illumination are associated with increased activity of bats (Brickley 2012). Areas with good visibility due to lunar illumination are potentially dangerous to foraging and commuting bats and enable predators to detect them with greater ease.

It is important to consider temporal variation within sites when conducting an acoustic study. Hayes (1997) estimated a minimum requirement of 6-8 sampling nights at a site to overcome temporal variability of activity within sites, which is largely due to environmental conditions. Because weather conditions were fairly consistent throughout my sampling period, surveys were standardized by not conducting them on nights with precipitation or high wind speed, and each site was surveyed more than eight times, it is likely that the data recorded on activity of bats represents how activity varies by habitat and not nightly variations in activity due to environmental conditions.

Problems with acoustic detection.---It is important to note that acoustic monitoring has some inherent issues that can affect accurately quantifying activity of bats. In my study, number of passes of each species and total number of passes were compared across habitats. This provided an estimate of how frequently bats were using coastal habitats, keeping in mind that number of passes recorded does not equal number of bats. If 10 passes were recorded, it is impossible to determine if one bat circled the detector 10 times or if 10 bats each circled the detector once. As a result, studies assessing echolocation calls can only provide estimates of presence and activity and not estimates of abundance (Hayes 2000). Some of the largest issues with acoustic detection deal with detectability, including the limited range of detectors and not all bats have the same probability of being detected.

Anabat detectors have a typical range of detection of 30 m, but this can vary depending on environmental conditions (K. Livengood pers. comm.). Changes in humidity can alter absorption of sounds in air, with greater humidity having an increased rate of absorption (Snell-Rood 2012). As humidity increases, sound waves attenuate more rapidly and echolocation calls cannot travel as far before attenuating; thus, the range of detection decreases. In addition to limited range of detection, foraging and commuting height of bats can vary among species. Some species tend to fly closer to the ground and in range of detectors while others fly high and out of range of detectors (Menzel et al. 2005*b*). It is for this reason that acoustic surveys comprised of detectors below the tree canopy may not accurately reflect assemblages of bats because they are less likely to record open-adapted species that fly above the canopy (Menzel et al. 2005*b*). Few hoary bats were recorded during my study, which could have occurred for two reasons. The first is that hoary bats are believed to be uncommon in coastal South Carolina during summer, and the second is because hoary bats were flying out of range of the detectors (Menzel et al. 2003*a*, 2005*b*). Brazilian free-tailed bats have been documented flying 1,118 m above the ground in the Southwest, but it is believed that they do not fly at these heights in the Southeast (McCracken et al. 2008). It is believed that Brazilian free-tailed bats tend to forage 6-10 m above ground (Wilkins 1989), which could explain why many Brazilian free-tailed bats were recorded while hoary bats were not.

Not all species of bats have the same probability of being recorded, which biases acoustic monitoring. Some bats are not detectable when they are 30 m from the Anabat (Kunz et al. 2007). Intensity of the call determines detectability. Rafinesque's big-eared bat has a call so low in intensity they are often referred to as whispering bats and can only be detected if they are 3-5 m from the detector (Ford et al. 2006, Kunz et al. 2007). I recorded 8 passes from Rafinesque's big-eared bats and I was unable to include them in my analysis, despite the fact that one of my study sites had a maternity colony only a few hundred meters away. The frequency range of a call can also determine detectability of the call of a species, even if the call is not of low intensity. The 12 species of bats that have been documented in the Lower Coastal Plain of South Carolina vary in the frequency range of their echolocation calls. High-frequency sounds attenuate more rapidly than low-frequency sounds, resulting in high-frequency calls being more difficult to detect if the bat is far from the microphone. As a result, acoustic detectors are more likely to record bats that emit calls at lower frequencies than higher frequencies (Fenton and Bell 1981, Biscardi et al. 2004, Kunz et al. 2007). Of the species recorded during my study, the southeastern myotis has the call of highest frequency and was not recorded often. It is difficult to separate whether the southeastern myotis simply did not use habitats I studied or if the calls attenuated before they could be detected.

Because hoary bats and southeastern myotis had low rates of detection, models that resulted from statistical analyses were not informative. Hoary bats showed some trends in where they were active, which may have been significant if more passes had been recorded. The model-selection process for southeastern myotis showed that the best-approximating model was not much better than the next-best model. This species had many next-best models that were not different from the best-approximating model. This is one of the issues with biases in acoustic detection; if a species is not recorded adequately because of low rates of detection, then the resulting model and the interpretation of that model are weak.

Implications for conservation.---Bats provide an important ecosystem service to the agriculture and forestry industries through suppression of pests, but populations of bats are negatively affected by loss of habitats, white-nose syndrome, and wind farms (Kunz et al. 2011). These negative impacts are exacerbated by how slowly bats respond to population declines due to constraints of their life-history traits (Altringham 1996, Barclay and Harder 2003, Racey and Entwistle 2003). Many species of bats have low rates of reproduction, and tend to have only one young each year (Barclay and Harder 2003, Racey and Entwistle 2003). Providing good habitat for bats is important in promoting population expansion by giving bats a greater probability of successfully raising young.

Habitat degradation and loss tends to affect foraging habitats more than roosting habitats, and many riparian areas have been converted to croplands or housing developments (Pierson 1998). The Lower Coastal Plain in South Carolina is an area of rapid development and wetlands are frequently destroyed to allow for anthropogenic structures. Considering how important wetlands are for foraging bats, wetlands should not be destroyed and should be maintained as wetlands. However, preventing development of wetlands is not enough to promote use by bats. The distribution of several species of bats can be patchy and it is important to provide connectivity among patches (Pierson 1998, Lookingbill et al. 2010). Providing some wetland areas devoid of vegetation within a forested system is important in maintaining a patchy landscape.

It is increasingly apparent that land managers need to discuss bats when devising conservation-management strategies. Due to the migratory nature of several species of bats, conservation must be conducted on a regional and even transcontinental scale. Many bats migrate along the coast of South Carolina and habitats should be provided for them. Effective conservation dependent on a landscape-level scale that considers all factors that impact a healthy population, including roosting sites, foraging habitats, connectivity among habitats, hibernacula, and migratory patterns (Racey and Entwistle 2003). My study is among those that address the many factors that need to be considered when conserving areas for bats in the Southeast.

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Table 2.1.---Number of acoustic surveys of bats in each habitat examined in Charleston County, South Carolina, June- October 2014.

	Number of surveys
Habitat	
Open freshwater	31
Cluttered freshwater	29
Open brackish-water	31
Cluttered brackish-water	31
Open saltwater	32
Cluttered saltwater	31
Water	
Freshwater	60
Brackish-water	62
Saltwater	61
Vegetation	
Open	92
Cluttered	91

Table 2.2.---Number of acoustic surveys of bats at each study site in Charleston County, South Carolina, June-October 2014.

Study site	Number of surveys
Bear’s Bluff National Fish Hatchery	
Cluttered saltwater 3	11
Open saltwater 3	11
Church Creek	
Open saltwater 1	10
Caw Caw Interpretive Center	
Cluttered brackish-water 2	11
Open brackish-water 2	10
Cluttered brackish-water 3	9
Open brackish-water 3	12
Cluttered saltwater 1	11
Cluttered freshwater 1	9
James Island County Park	
Open freshwater 1	10
Open saltwater 2	9
Cluttered saltwater 2	9
Magnolia Plantation	
Cluttered brackish-water 1	11
Open brackish-water 1	9
Cluttered freshwater2	10
Open freshwater 2	9
Cluttered freshwater 3	10
Open freshwater 3	12

Table 2.3.---Negative binomial and zero-inflated regression models within 3 units of AIC_{min}. These are best approximating models for determining which parameters are providing the most influence on activity of bats over the wetlands under study in Charleston County, South Carolina, June-October 2014. Models were ranked based on AIC_c.[a]

Model	K	AIC_c	ΔAIC_c	ω
Overall activity[b]				
HABITATM	4	2,449.93	0.00	0.58
HABITAT	6	2,452.67	2.75	0.15
Evening bat[b]				
GLOBALM	11	1,603.94	0.00	0.37
WEATHER + HABITATM	9	1,604.64	0.70	0.26
WEATHER	6	1,605.48	1.53	0.17
Tri-colored bat[b]				
INSECT + HABITATM	6	1,963.88	0.00	0.34
HABITATM	4	1,964.03	0.15	0.32
Brazilian free-tailed bat[b]				
WEATHER + HABITATM	9	1,277.34	0.00	0.43
GLOBALM	11	1,278.94	1.60	0.19
WEATHER + HABITAT	11	1,279.14	1.80	0.17
GLOBAL	13	1,280.05	2.71	0.11
Eastern red bat/Seminole bat[b]				
HABITATM	4	1,200.73	0.00	0.39
WEATHER + HABITATM	9	1,201.54	0.82	0.26
HABITAT	6	1,203.58	2.85	0.09
Big brown bat/silver-haired bat[b]				
WEATHER + HABITATM	9	1,127.74	0.00	0.31
INSECT + HABITATM	6	1,128.28	0.54	0.24
GLOBALM	11	1,128.54	0.80	0.21
HABITATM	4	1,130.73	2.98	0.07
Southeastern myotis[c]				
INSECT + HABITATM	6	306.88	0.00	0.21
GLOBALM	11	307.24	0.37	0.18
HABITATM	4	307.42	0.55	0.16
WEATHER + HABITATM	9	307.84	0.96	0.13
HABITAT	6	308.78	1.90	0.08
GLOBAL	13	308.95	2.08	0.08
INSECT + HABITAT	8	308.13	2.25	0.07
WEATHER + HABITAT	11	309.34	2.47	0.06

Table 2.3.---Continued.

Hoary bat[c]				
WEATHER + HABITATM	9	336.34	0.00	0.42
WEATHER + HABITAT	11	337.34	1.00	0.25
WEATHER	6	337.88	1.54	0.20

[a] See text for parameters that comprise each model. K is the number of parameters in the model, including the intercept. ΔAIC_c is the difference in the AIC_c of the current model and the best approximating model, or AIC_{min}. ω is the Akaike weight, or the probability that the current model is the best representative model among the a priori models considered.

[b] Species or groups analyzed with negative-binomial regression.

[c] Species analyzed with zero-inflated regression.

Table 2.4.---Description of parameters in the best approximating model for each species or group of bats recorded in Charleston County, South Carolina, June-October 2014[a].

Parameter	Coefficient estimate	*SE*	*P*-value	95% CL
Overall activity[b] (HABITATM)				
Intercept	110.31	1.31	**<0.001**	65.39-186.09
Freshwater	2.18	1.39	**0.018**	1.14-4.17
Brackish-water	1.30	1.39	0.432	0.68-2.48
Open	3.42	1.30	**<0.001**	2.04-5.71
Evening bat[b] (GLOBALM)				
Intercept	1.47E-33	6.45E+14	**0.027**	1.36e-62-0.00
Temperature	1.09	1.03	**0.009**	1.02-1.16
Humidity	0.99	1.02	0.652	9.51-1.03
Wind speed	1.02	1.06	0.772	0.908-1.14
Barometric pressure	2.11	1.40	**0.028**	1.09-4.11
Lunar illumination	1.00	1.00	0.627	0.994-1.00
Freshwater	2.64	1.59	**0.035**	1.07-6.52
Brackish-water	1.98	1.60	0.146	0.789-4.95
Open	2.17	1.45	**0.036**	1.05-4.49
Insect abundance	1.00	1.00	0.239	0.999-1.00
Insect diversity	2.00	1.35	0.239	1.11-3.60
Tri-colored bat[b] (INSECT+HABITATM)				
Intercept	10.78	1.71	**<0.001**	3.79-30.67
Freshwater	3.54	1.77	**0.027**	1.15-10.85
Brackish-water	3.53	1.78	**0.028**	1.14-10.91
Open	2.73	1.60	**0.032**	1.09-6.82
Insect abundance	1.00	1.00	0.090	0.99-1.00
Insect diversity	1.48	1.26	0.091	0.94-2.33
Brazilian free-tailed bat[c] (WEATHER+HABITATM)				
Intercept	3.45E-41	1.03E+18	**0.025**	1.70e-76-6.99e-06
Temperature	0.84	1.03	**<0.001**	0.79-0.896
Humidity	0.94	1.03	**0.023**	0.89-0.99
Wind speed	0.104	1.07	0.592	0.91-1.19
Barometric pressure	1.04	1.52	**0.015**	1.22-6.3
Lunar illumination	1.01	1.00	**0.016**	1.00-1.02
Freshwater	4.99	1.79	**0.016**	1.60-15.54
Saltwater	4.20	1.81	**0.015**	1.32-13.38
Open	2.47	1.56	**0.042**	1.03-5.91

Table 2.4.---Continued.

Eastern red bat/Seminole bat[b] (HABITATM)				
Intercept	5.69	1.55	**<0.001**	2.41-13.46
Freshwater	0.58	1.71	0.313	0.20-1.67
Brackish-water	0.39	1.71	0.083	0.14-1.13
Open	5.10	1.55	**<0.001**	2.16-12.06
Big brown bat/silver-haired bat[c] (WEATHER+HABITATM)				
Intercept	1.73E-23	1.44E18	0.21	4.43E-59-6.72E12
Temperature	0.91	1.03	**0.002**	0.85-0.96
Humidity	0.93	1.03	**0.005**	0.09-0.98
Wind speed	1.07	1.07	0.319	0.93-1.23
Barometric pressure	1.84	1.53	0.149	0.80-4.22
Lunar illumination	1.00	1.00	0.431	1.00-1.01
Freshwater	4.40	1.53	**<0.001**	1.92-10.09
Saltwater	2.03	1.55	0.103	0.87-4.77
Open	1.61	1.41	0.164	0.82-3.17
Southeastern myotis[b] (INSECT+HABITATM)				
Intercept	0.22	1.93	**0.02**	0.06-0.79
Freshwater	2.82	1.63	**0.035**	1.08-7.36
Brackish-water	1.39	1.66	0.517	0.51-3.75
Open	3.89	1.51	**0.001**	1.72-8.79
Insect abundance	1.00	1.00	0.741	0.99-1.00
Insect diversity	0.39	1.61	**0.050**	0.15-1.00
Hoary bat[b] (WEATHER+HABITATM)				
Intercept	3.11E60	3.99E32	0.06	0.00-2.45E124
Temperature	0.86	1.05	**<0.001**	0.78-0.94
Humidity	0.99	1.04	0.78	0.91-1.07
Wind speed	1.00	1.12	0.97	0.80-1.24
Barometric pressure	0.26	2.12	0.07	0.06-1.14
Lunar illumination	1.00	1.00	0.64	0.99-1.01
Freshwater	1.06	1.77	0.91	0.35-3.25
Brackish-water	0.75	1.83	0.64	0.23-2.44
Open	4.22	1.64	**0.004**	1.59-11.16

[a]Coefficient estimates reported for continuous variables reflect number of passes for each 1 unit increase in the continuous variable. For ease of interpretation this may have been reworded in the results for a 1 unit decrease in the continuous variable.
[b]Saltwater and cluttered vegetation are the references for water and vegetation variables.
[c]Brackish-water and cluttered vegetation are the references for water and vegetation variables.

Table 2.5.---Results of Poisson regression on species richness of bats documented in Charleston County, South Carolina, June-October 2014.

Parameter	Coefficient estimate	*SE*	95% Confidence limit	*P*-value
Freshwater[a]	1.17	1.09	0.99 – 1.38	**0.053**
Saltwater	1.08	1.09	0.91 – 1.27	0.376
Open[b]	1.24	1.07	1.09 – 1.42	**0.001**

[a] Brackish-water is the reference group.
[b] Cluttered vegetation is the reference group.

Figure 2.01.---Habitats used by bats in Charleston County, South Carolina, June-October 2014.

Figure 2.02.---Anabat SD1 bat detectors were used to record echolocation calls in Charleston County, South Carolina, June-October 2014.

Figure 2.03.---Design of the Anabat detector support used to record bats in Charleston County, South Carolina, June-October 2014.

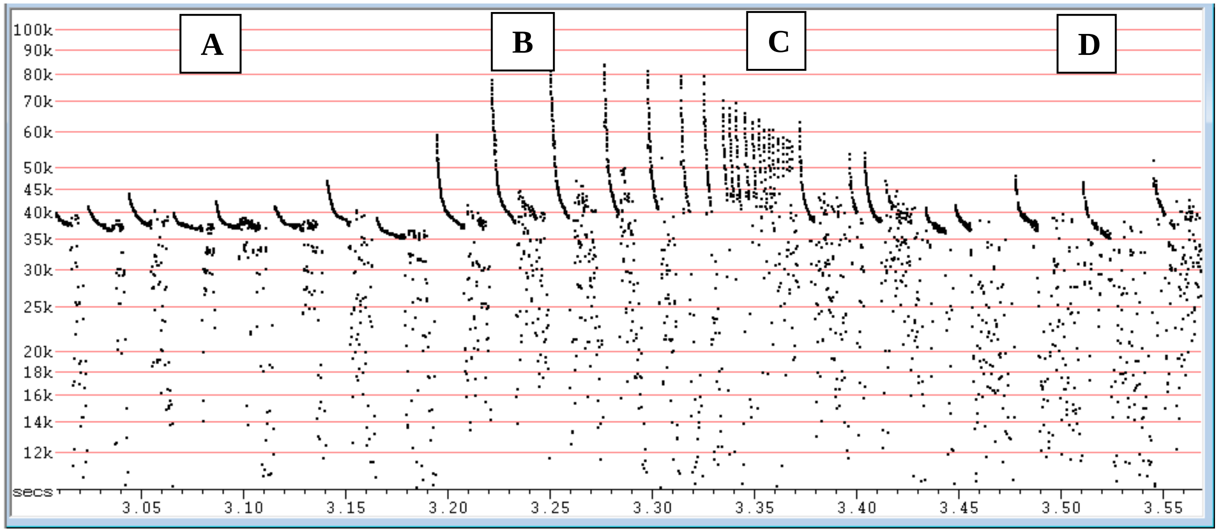

Figure 2.04.---Types of calls emitted by bats while commuting and foraging. Bats emit search-phase calls when echolocating to both orient themselves and to locate prey (A). When an insect is detected, the bat then emits approach-phase calls (B) when homing in on the insect and then, finally, emits a feeding buzz (C) to capture the insect before returning to emitting search-phase calls (D). This sequence was recorded at Caw Caw Interpretive Center in Charleston County, South Carolina on May 10, 2014.

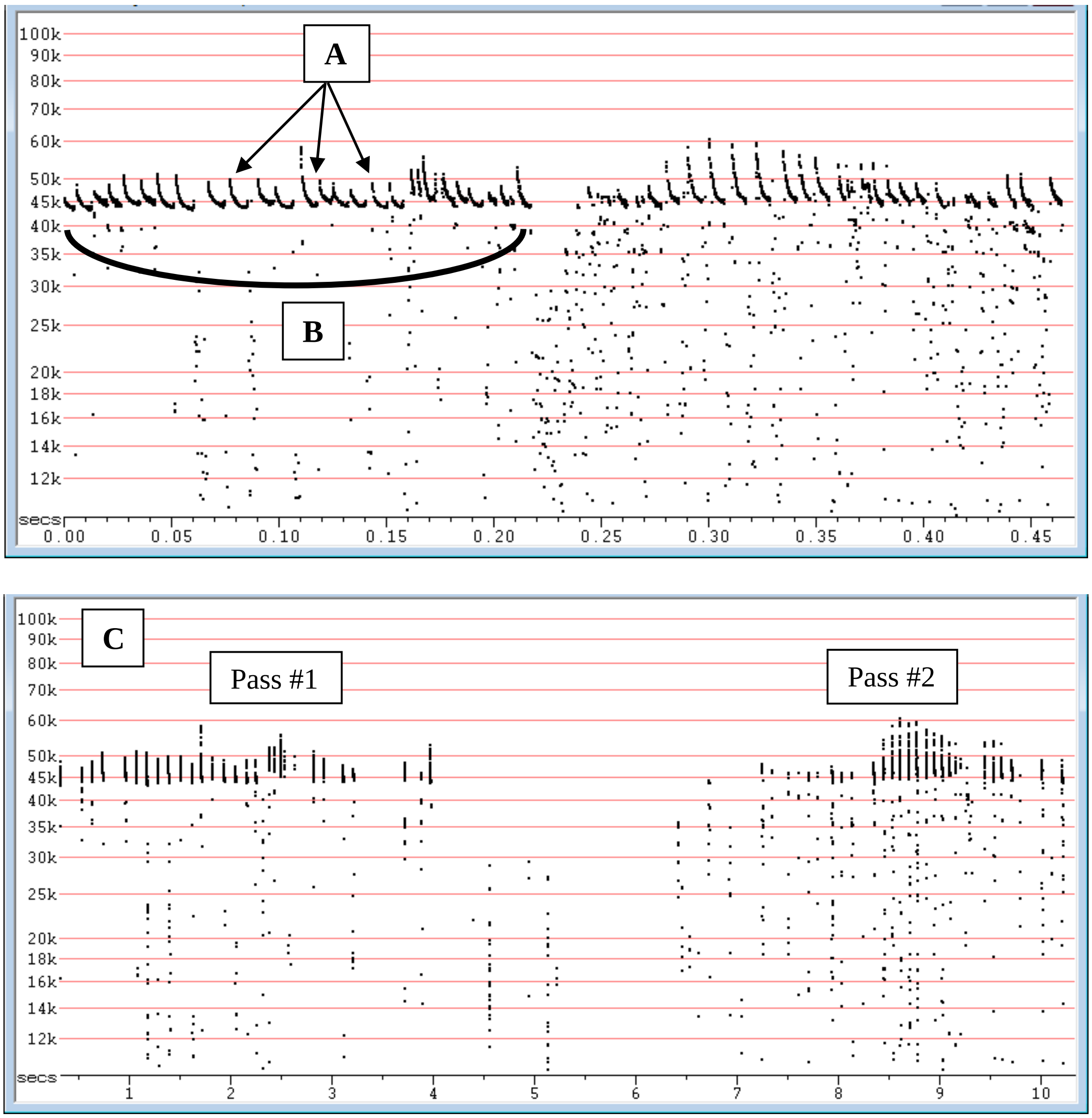

Figure 2.05.---Description of terms used in sonograms. Each vertical line is termed a "pulse" (A) and a sequence of pulses is termed a "pass" (B). Each pass has to be separated from other passes by >1 second when viewed in real time (C) to be considered a distinct pass (Kunz et al. 2007). These two passes were recorded in Charleston County, South Carolina on July 18, 2014.

Figure 2.06.---Black-light trap used to sample insects in Charleston County, South Carolina, June-October 2014.

Figure 2.07.---Portable weather station used to document environmental variables in Charleston County, South Carolina, June-October 2014.

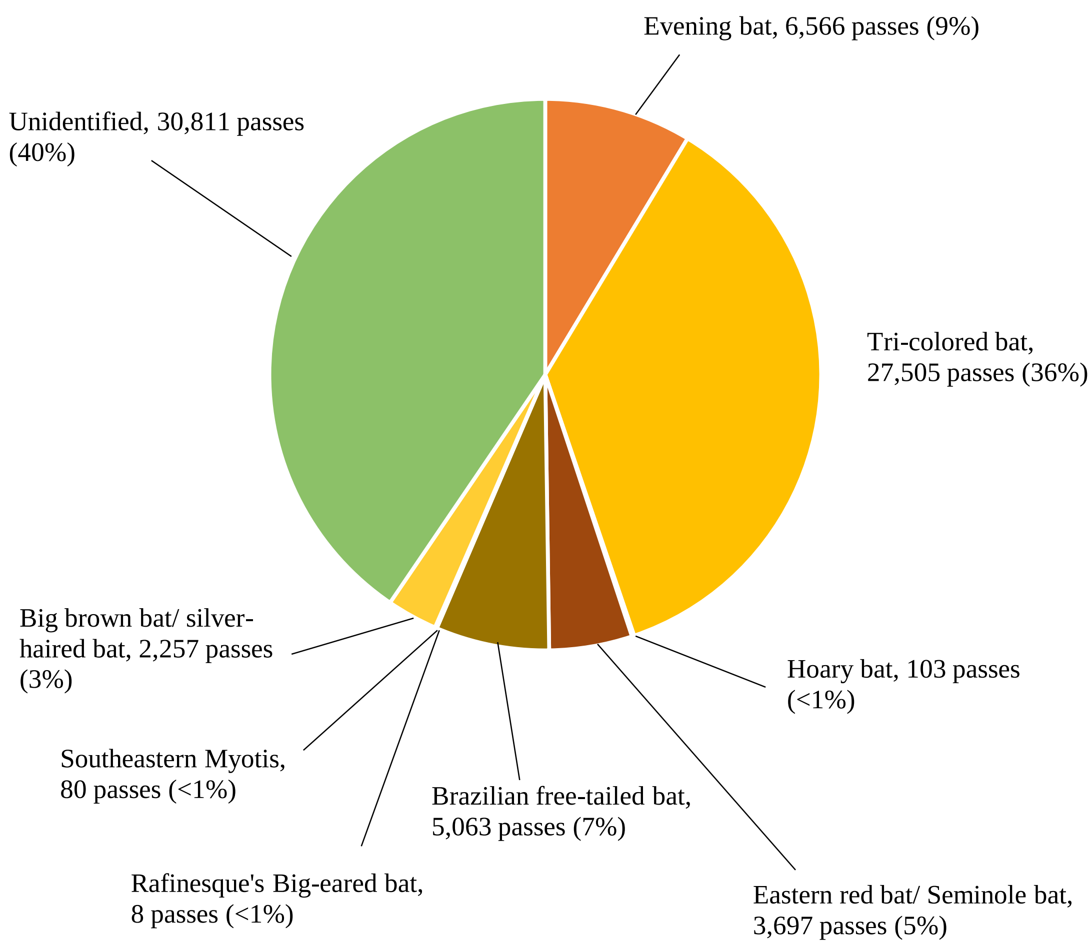

Figure 2.08.---Passes by species or groups of bats recorded during 183 surveys conducted in Charleston County, South Carolina, June-October 2014.

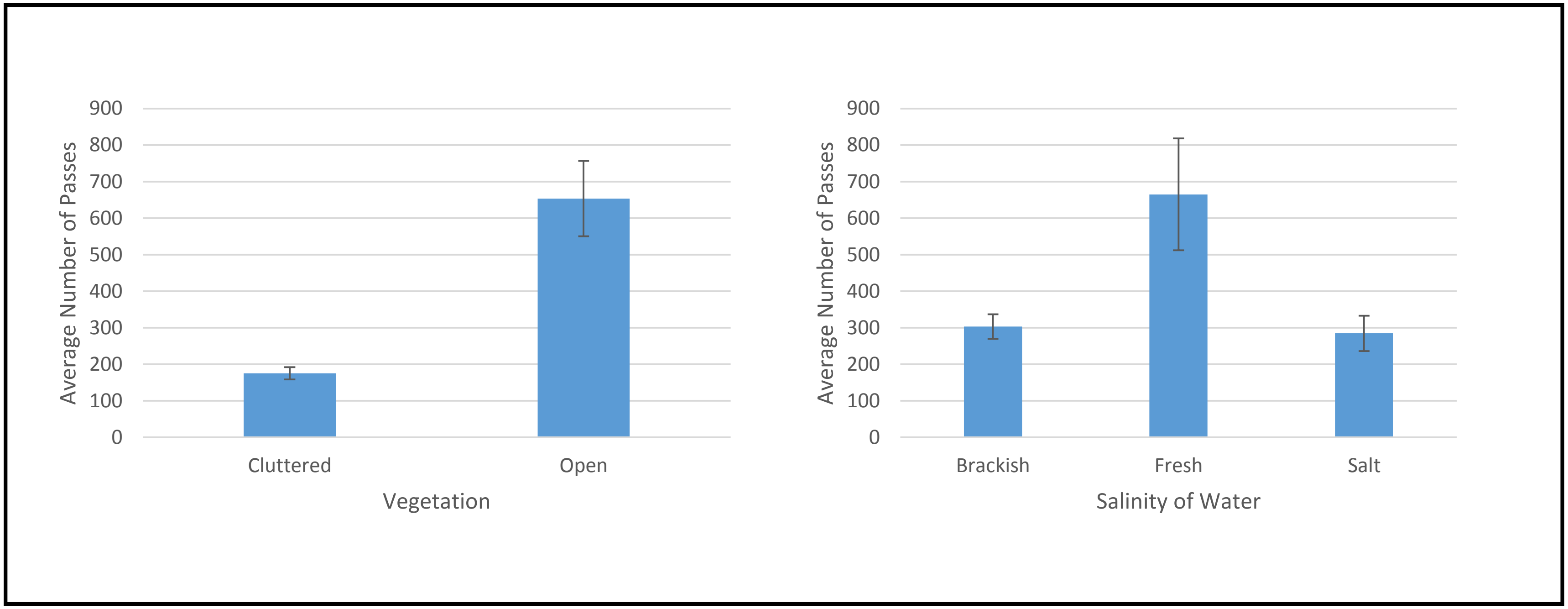

Figure 2.09.---Overall activity of bats in Charleston County, South Carolina, as a function of vegetation and salinity of water.

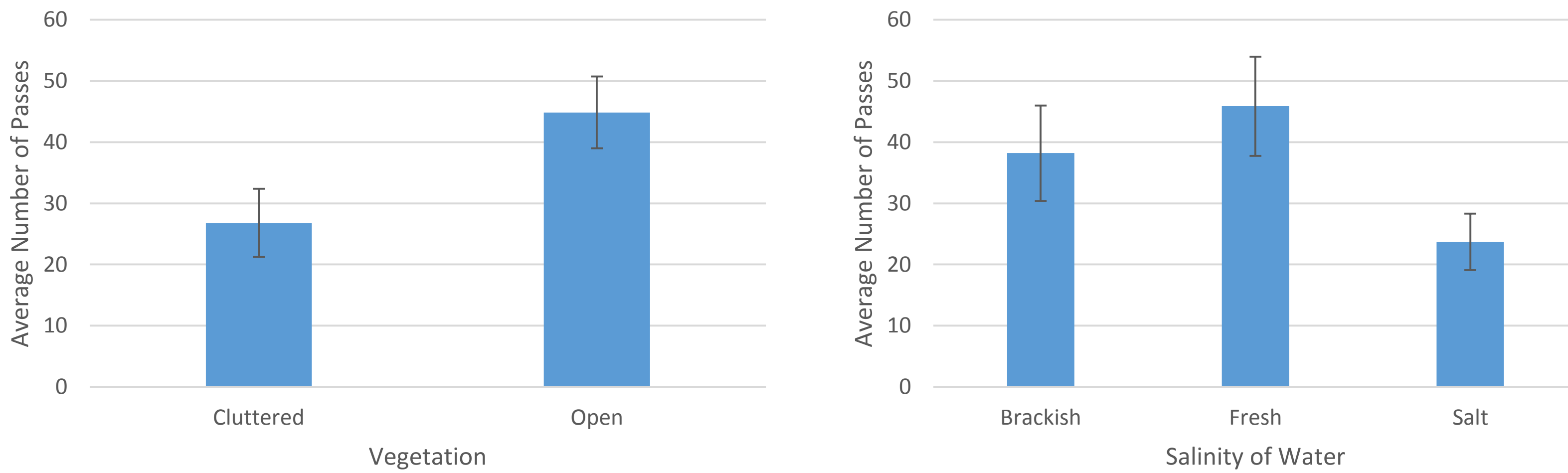

Figure 2.10.---Activity of evening bats (*Nycticeius humeralis*) in Charleston County, South Carolina, as a function of vegetation and salinity of water.

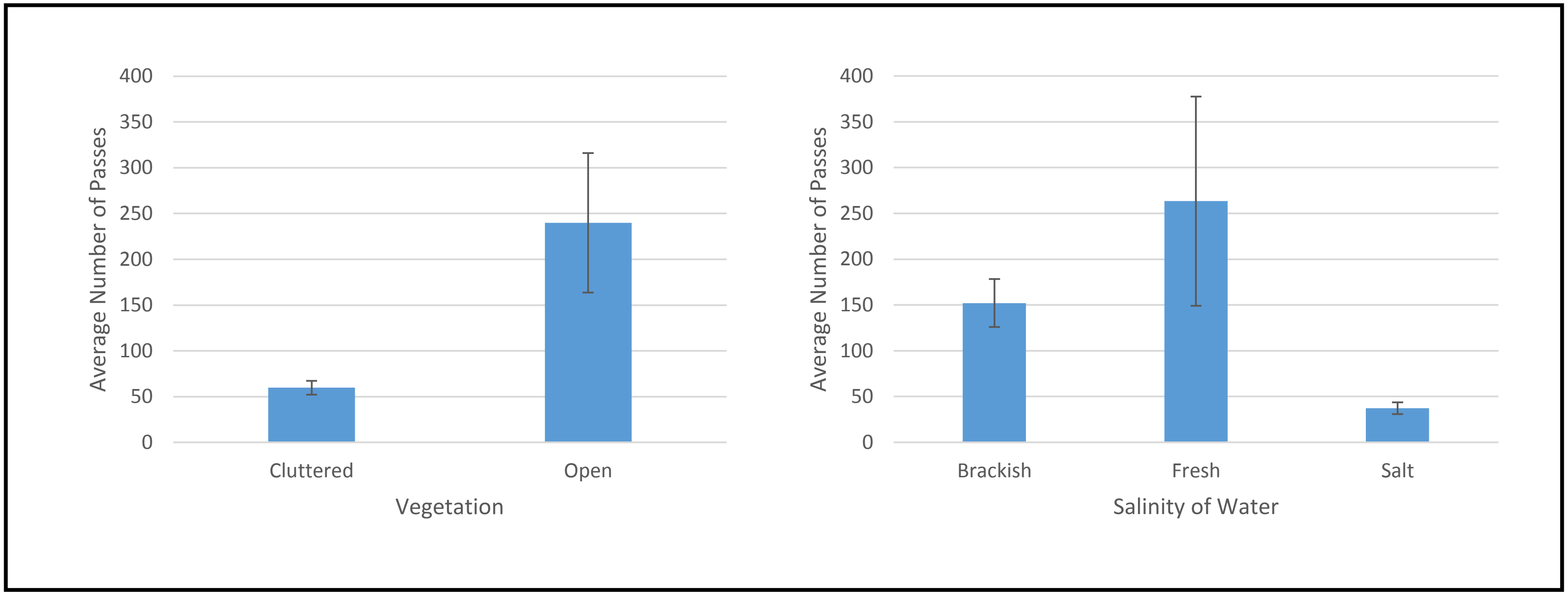

Figure 2.11.---Activity of tri-colored bats (*Perimyotis subflavus*) in Charleston County, South Carolina, as a function of vegetation and salinity of water.

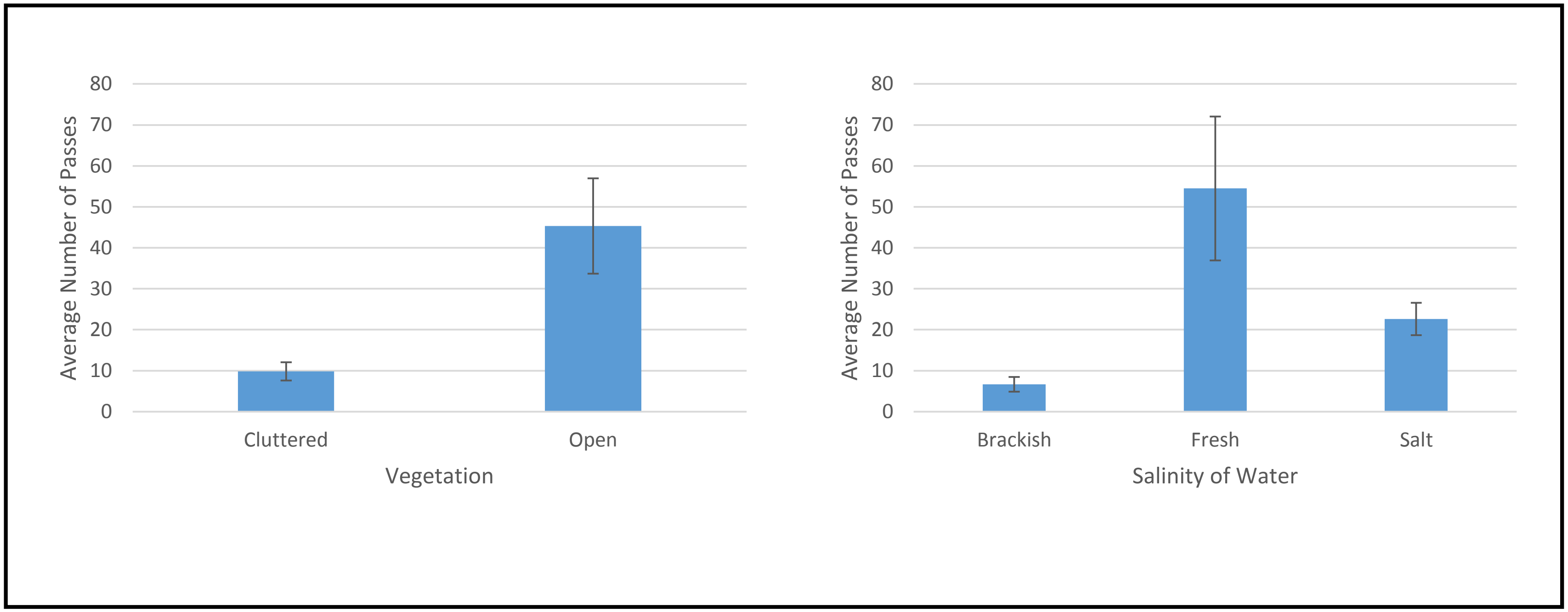

Figure 2.12.---Activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) in Charleston County, South Carolina, as a function of vegetation and salinity of water.

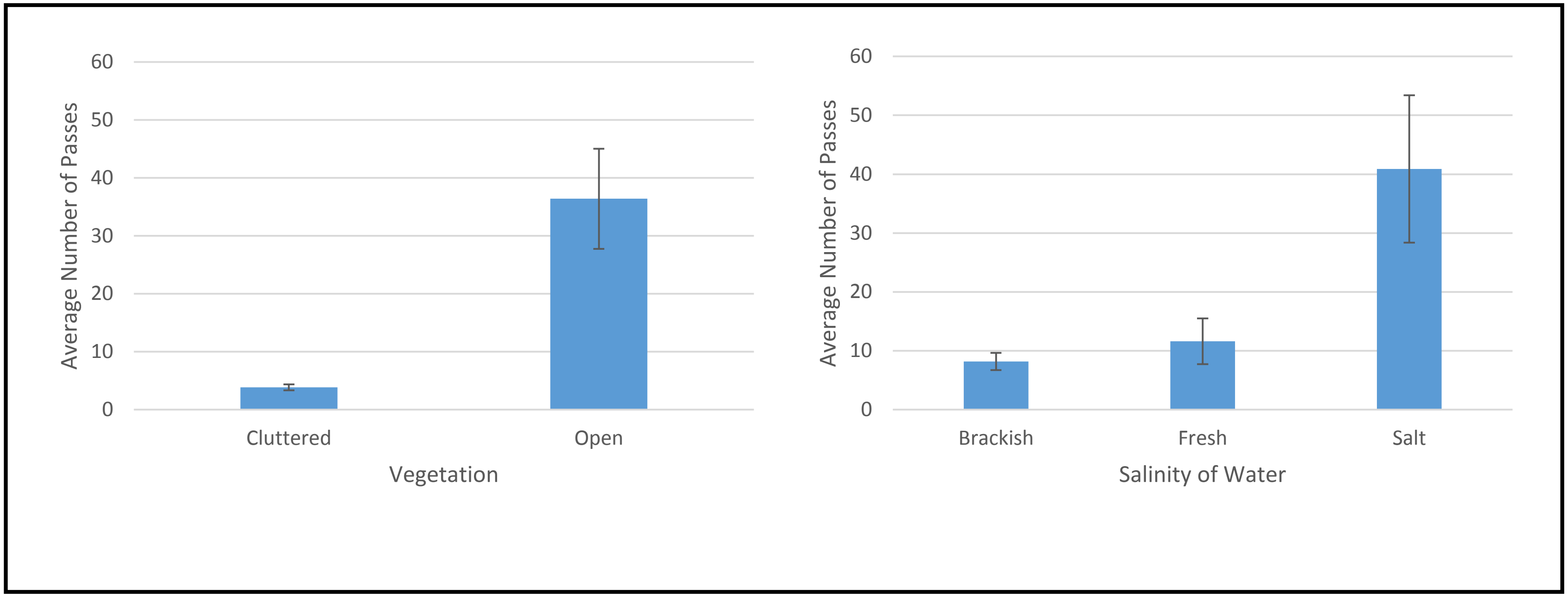

Figure 2.13.---Activity of eastern red bats (*Lasiurus borealis*)/Seminole bats (*Lasiurus seminolus*) in Charleston County, South Carolina, as a function of vegetation and salinity of water.

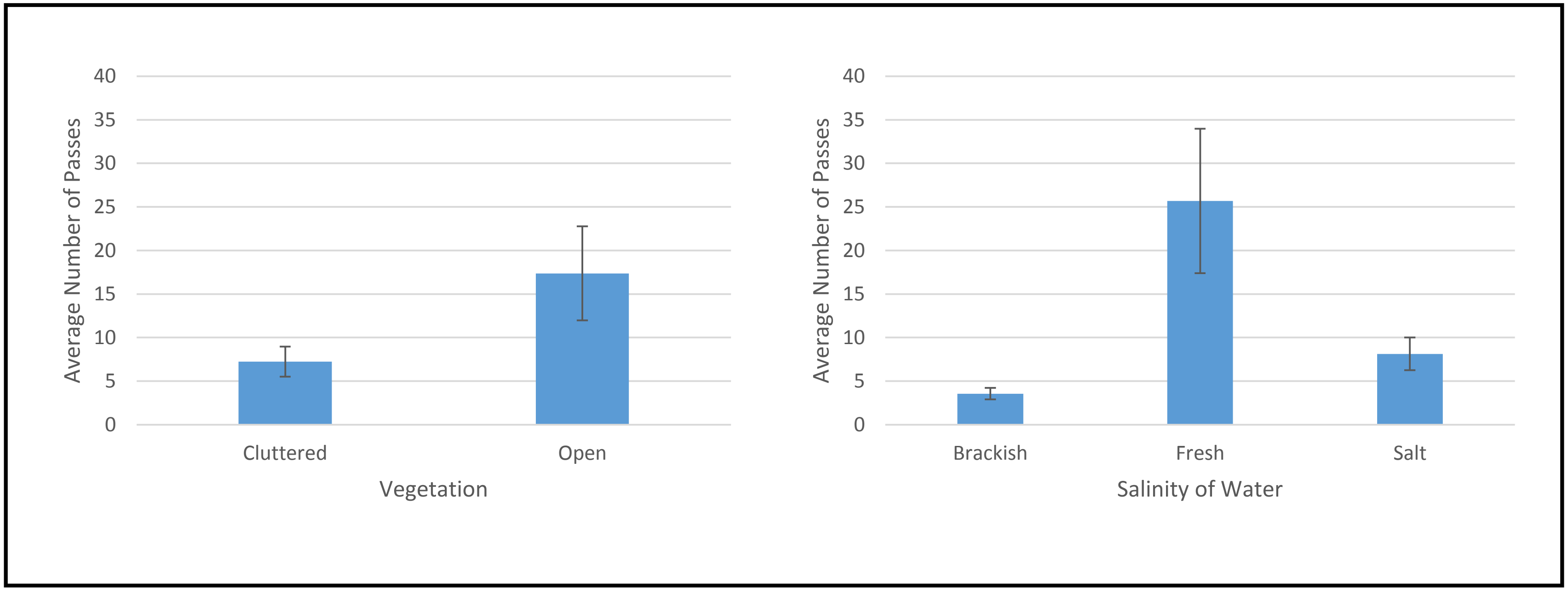

Figure 2.14.---Activity of big brown bats (*Eptesicus fuscus*)/silver-haired bats (*Lasionycteris noctivagans*) in Charleston County, South Carolina, as a function of vegetation and salinity of water.

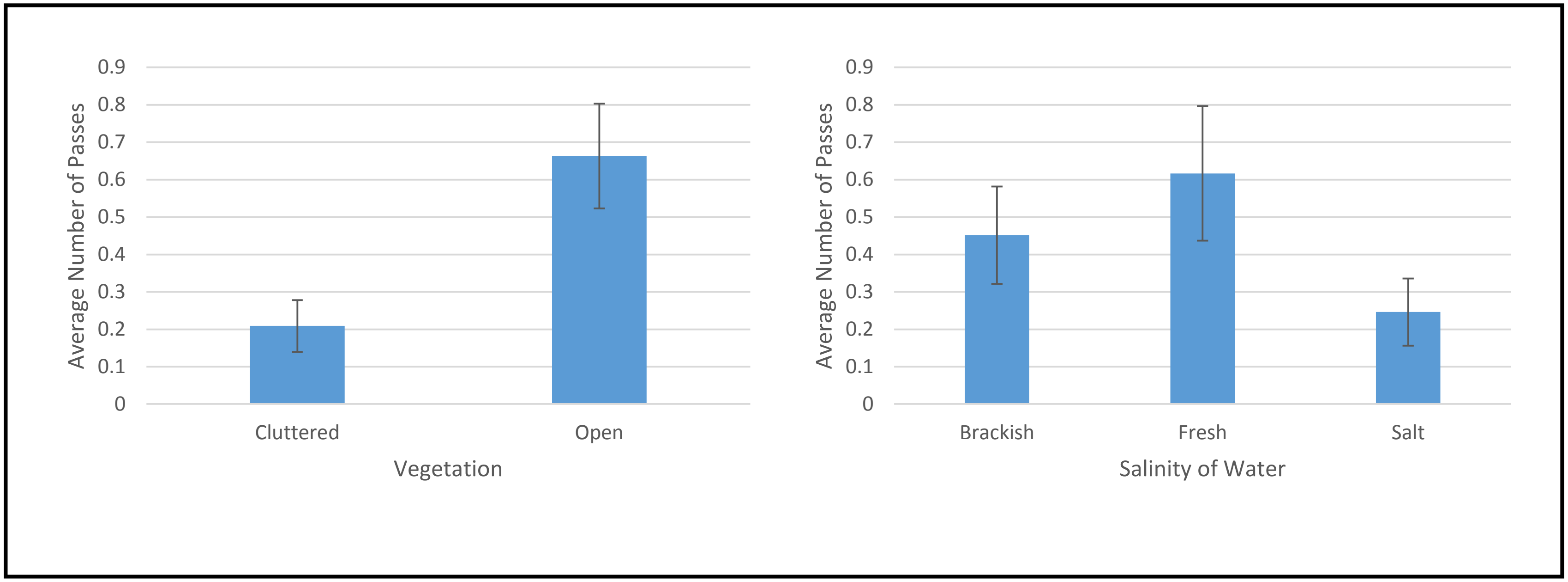

Figure 2.15.---Activity of southeastern myotis (*Myotis austroriparius*) in Charleston County, South Carolina, as a function of vegetation and salinity of water.

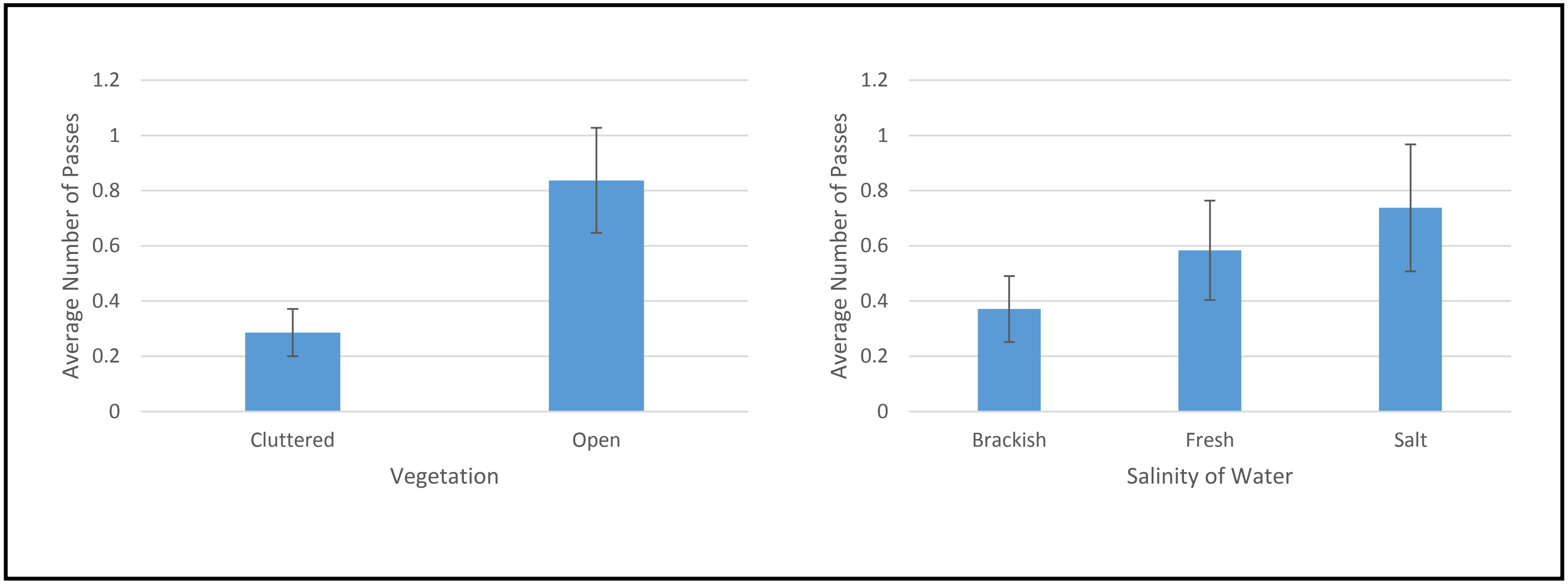

Figure 2.16.---Activity of hoary bats (*Lasiurus cinereus*) in Charleston County, South Carolina, as a function of vegetation and salinity of water.

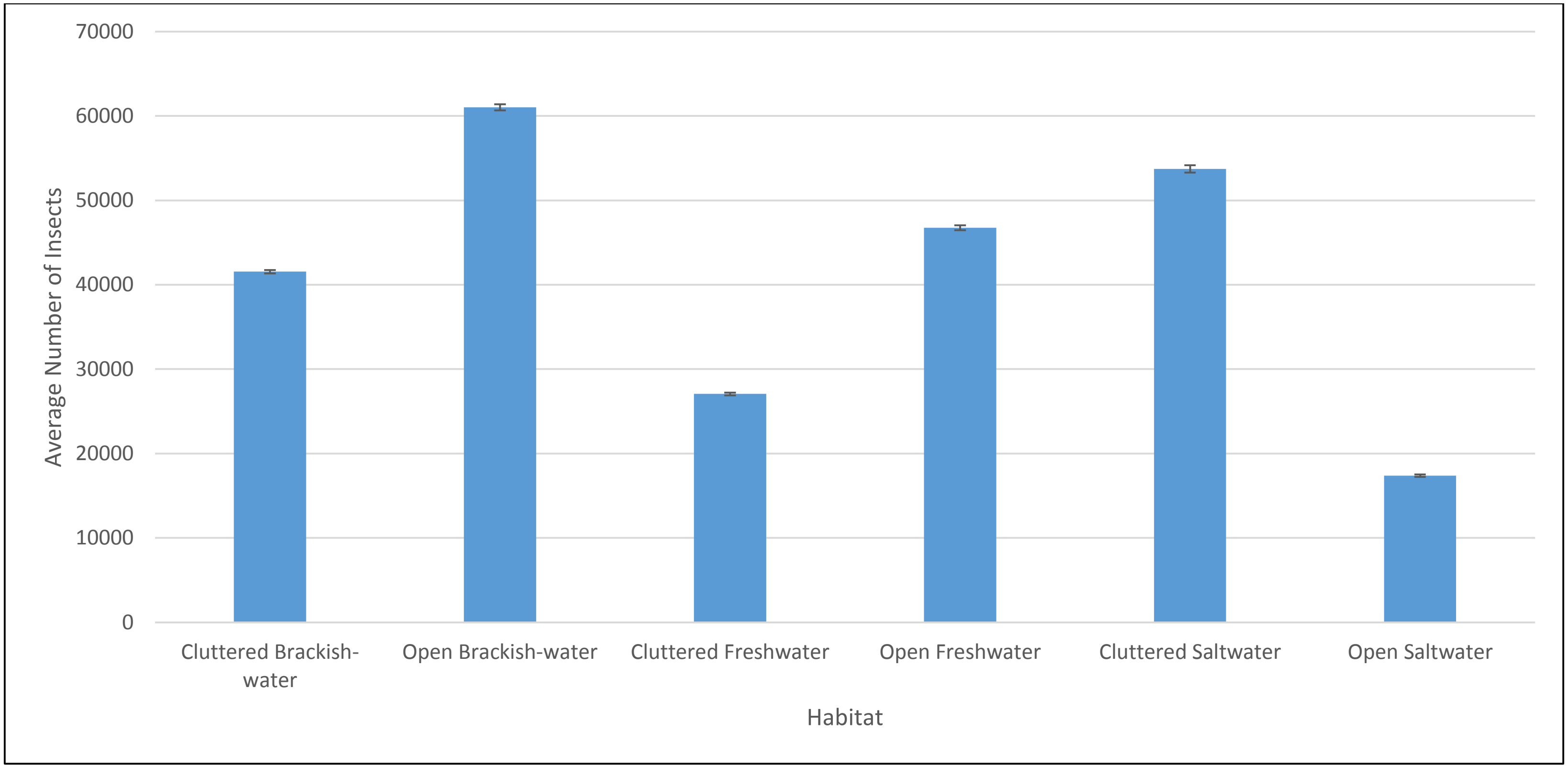

Figure 2.17.---Abundance of insects captured in Charleston County, South Carolina, as a function of habitat.

CHAPTER 3

VARIATION IN ACTIVITY OF BATS (MAMMALIA: CHIROPTERA) ON ISLANDS VERSUS MAINLAND OF THE LOWER COASTAL PLAIN, SOUTH CAROLINA

ABSTRACT

A proposal has been made to place a wind farm off the coast of South Carolina, yet little is known about bats along the coast. Activity of bats was studied using Anabat acoustic detectors on barrier islands and the mainland of Charleston County, South Carolina, during June-October 2014 to determine if islands are important habitats for bats. The study was divided into two time frames to determine if there was a difference in activity before and during migration in autumn. Abundance and diversity of insects as well as environmental conditions were measured to determine if these parameters played a prominent role in where and when bats were active. Islands had the greatest amount of activity for almost all species and for overall activity of bats. Activity increased during autumn, but this difference in timing was not significant for all species or groups. Neither abundance and diversity of insects nor environmental conditions appeared to play a critical role in where or when bats were active. Placement and management of wind turbines off the coast of South Carolina should consider that bats had more activity over islands than the mainland and that activity increased at a time when there would be greatest mortality due to wind turbines.

INTRODUCTION

Although harnessing wind appears to be a beneficial source of alternative energy, it has the potential to decimate populations of bats and throw ecosystems out of balance (Cryan and Brown 2007, Boyles et al. 2011, Johnson et al. 2011). Several studies have been conducted that attempt to quantify the number of bats killed by turbines each year, and estimated rates of mortality show considerable variation among studies, which is largely due to difficulty in quantifying mortality (Kunz et al 2007*b*, Hayes 2013, Smallwood 2013). There are many factors that affect an accurate estimation, including lack of a nationwide surveying protocol, monitoring efforts have historically focused on birds, surveyors assessing mortality in bats differ in their rates and ability of detection, and carcasses of bats often are devoured by scavengers before they can be recovered and documented (Kunz et al. 2007*a*, 2007*b*, Arnett et al. 2008, Hayes 2013, Smallwood 2013). Even with these limitations, Kunz et al. (2007*b*) projected that 33,000-111,000 bats will be killed by turbines annually by 2020 in the mid-Atlantic region alone. Two subsequent studies estimated that 888,000 bats and >600,000 bats were killed in the United States in 2012 (Hayes 2013, Smallwood 2013). Despite the wide range of estimated rates of mortality, it is clear that hundreds of thousands of bats die each year in the United States due to wind farms.

Not all species of bats are equally affected by wind turbines. Of the 47 species of bats in the United States, 11 are experiencing mortality due to wind turbines (Kunz et al. 2007*b*, Harvey et al. 2011). These include the eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), Seminole bat (*Lasiurus seminolus*), tri-colored bat (*Perimyotis subflavus*), little brown myotis (*Myotis* *lucifugus*), big brown bat (*Eptesicus fuscus*), and the Brazilian free-tailed bat (*Tadarida brasiliensis*). Together, hoary bats, eastern red bats, and silver-haired bats account for 75% of known fatalities at wind turbines throughout the United States (Kunz et al. 2007*b*). These are migratory tree-dwelling species, and can migrate long distances at high altitudes (Kuvlesky et al. 2007, Arnett et al. 2008, Cryan 2008, Johnson et al. 2011, Jameson and Willis 2014). Migratory tree bats tend to segregate themselves geographically during summer and generally roost alone or in small groups while migrating (Cryan 2008, Jameson and Willis 2014). Cryan (2008) hypothesized that bats are attracted to the tallest structure on a landscape because it is a landmark where conspecifics will be located, and serves as a rendezvous point for bats to congregate to mate. The majority of bats killed at turbines are adults, implying that adults are using the turbines as a resource that juveniles do not require (Arnett et al. 2008). Furthermore, timing of mortality at turbines is not evenly distributed across seasons. Mortality peaks in late summer and early autumn, coinciding with when these bats are migrating and mating (Cryan and Brown 2007, Arnett et al. 2008, Cryan 2008). It is important to note that migration in spring does not incur rates of mortality like the autumnal migration, insinuating that mating behavior in autumn many be a factor in mortality at turbines (Cryan and Brown 2007).

Because bats have historically been described as occurring in terrestrial habitats, it may be assumed that offshore wind farms will have little to no effect on bats. However, accounts have documented bats flying off the Atlantic coast, some even up to 209 km from the nearest shore (Nichols 1920, Norton 1929, Mackiewicz and Backus 1956). Most of the bats sighted were eastern red bats, and all sightings occurred during August and September; periods when mortalities due to wind farms peak. The authors of these accounts recorded weather conditions and believed the observed bats were following a routine migratory path and were not blown off course by strong winds. Data from almost 5 decades document that bats migrate past Southeast Farallon Island, which is about 32 km off the coast of California (Cryan and Brown 2007). This evidence suggests that bats routinely migrate over open ocean (Ahlen et al. 2009, Hatch et al. 2013, Sjollema et al. 2014).

Proposals for offshore wind farms have sparked surveys for offshore bats. Two recent studies documented bats flying off the mid-Atlantic coast. Hatch et al. (2013) documented that 12 bats were flying 16.9-41.9 km from shore in September 2012. Sjollema et al. (2014) detected bats at an average distance from shore of 8.4 km and up to 21.9 km, with no significant difference in activity between various distances from shore. Maximum distance from shore surveyed is unclear, but it is clear that bats migrate offshore more frequently than has been previously documented. It is possible that offshore wind farms could cause a similar level of mortality as terrestrial wind farms if their locations are chosen without the aid of research (Sjollema et al. 2014).

A proposal has been made for South Carolina to develop a 1,000-megawatt offshore wind farm (Clemson University Restoration Institute http://sti.clemson .edu/index.php?option=com_docman&task=cat_view&gid=293&Itemid=211), which could negatively impact populations of bats. Both nearshore and offshore wind farms could significantly impact both resident and migrant bats in the Lower Coastal Plain of South Carolina. How bats use habitats within the Lower Coastal Plain of South Carolina is largely unknown and it could be a mistake to place a wind farm in this area without first conducting adequate research.

Most research conducted in South Carolina to date has focused on how bats select terrestrial habitats in the Upper Coastal Plain (Menzel et al. 2001, Carter et al. 2004, Menzel et al. 2005*a*, 2005*b*, Ford et al. 2006). These studies revealed that a great diversity of roosts and presence of water were two important requirements for bats. The Lower Coastal Plain of South Carolina has the greatest level of structural diversity of roosts within the state, including Spanish moss (*Tillandsia usneoides*), bridges, and many trees with large diameters (Menzel et al. 2003, Johnson and Gates 2008). This fact, combined with the plethora of wetlands in this region, suggests that the Lower Coastal Plain is a landscape that provides ample habitats for bats.

In addition to habitats provided for summer or residential bats, presence of barrier islands along the coastline may be an important landscape feature for migrating bats. Previous studies have provided evidence that bats use barrier islands as resting sites during migration. Johnson et al. (2011) reported an increase in activity levels of bats during autumnal migration on Assateague Island off the coast of Maryland. In addition to the increase in overall activity, these researchers documented presence of bats in autumn that were not present in summer, suggesting bats use Assateague Island as a stopover point during migration. The fact that bats migrate over open ocean and use islands as stopovers has implications for nearshore and offshore wind farms in South Carolina. It is likely that bats migrating along the coast of South Carolina use barrier islands in the Lower Coastal Plain as resting sites.

Based upon the diversity of species in the Lower Coastal Plain, it appears that this region is of prime importance to bats. Of the 14 species that occur in South Carolina, 12 inhabit the Lower Coastal Plain. These include the eastern red bat, hoary bat, northern yellow bat (*Lasiurus intermedius*), Seminole bat, silver-haired bat, evening bat (*Nycticeius humeralis*), tri-colored bat, little brown myotis, southeastern myotis (*Myotis austroriparius*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), big brown bat, and Brazilian free-tailed bat (Menzel et al. 2003). Of the 11 documented species that have experienced mortality due to wind turbines in the United States, 8 occur in the Lower Coastal Plain of South Carolina (Menzel et al. 2003, Kunz et al. 2007*b*). Research and planning must be incorporated into the placement and management of future wind farms; collecting baseline data is the requisite first step (Kuvlesky et al. 2007, Johnson and Gates 2008).

It is important to gain a better understanding of how bats are using coastal habitats before investing in expensive and permanent offshore wind-energy infrastructure. This becomes especially important when considering that most species of bats in the Lower Coastal Plain have experienced fatalities by wind turbines, with three species comprising the majority of mortalities. Considering the plethora of optimal habitats for bats in the Lower Coastal Plain, it is surprising how few studies have evaluated use of this ecoregion by bats. My objectives were to determine if activity of bats vary between barrier islands and the mainland, if there is seasonal variation in activity on islands and the mainland, and if there are differences in species composition between islands and the mainland.

MATERIALS AND METHODS

Study sites.---More than 30 barrier islands are scattered along the coastline of South Carolina, and 12 of these islands are in Charleston County. Barrier islands in South Carolina are separated from the mainland by rivers and creeks and, unlike other barrier islands (e.g. Assateague Island in Maryland) do not have large expanses of water between islands and the mainland. Activity of bats was compared between three locations on islands and two locations on the mainland in Charleston County. Three study sites were at James Island County Park on James Island, one study site was at Church Creek on Johns Island, and two study sites were at Bear's Bluff National Fish Hatchery on Wadmalaw Island. Locations on the mainland were Magnolia Plantation (West Ashley, South Carolina) and Caw Caw Interpretive Center (Ravenel, South Carolina). There were six study sites at both locations on the mainland (Table 3.1, Figure 3.01).

Acoustic monitoring, insect surveys, and weather.---Acoustic monitoring, sampling of insects, and documentation of environmental conditions were identical to those described in Chapter 2.

Statistical analyses.---To determine if bats use coastal South Carolina during migration, recorded passes were divided into two groups. One group included activity during 7 June-15 August, which is before migration is believed to occur and the other group included activity during 16 August-24 October, which is when migration is on-going. The date of 15 August was chosen to divide the two periods because it is near the beginning of migration, which can be anywhere from late July to early October (Cryan and Brown 2007, Arnett et al. 2008).

I developed 11 a priori regression models to assess whether activity of bats varied by location and season. The models were as follows: HABITAT included location (islands or mainland), season (migration or pre-migration), and the interaction between location and season; HABITATM included location and season; WEATHER included temperature, wind speed, humidity, barometric pressure, and lunar illumination; INSECT included total abundance and diversity of insects; HABITAT + WEATHER; HABITATM + WEATHER; HABITAT + INSECT; HABITATM + INSECT; GLOBAL included all parameters; GLOBALM included all parameters minus the interaction between location and season; and NULL included the y-axis intercept and no other parameter. These models were evaluated using Akaike Information Criterion for small samples (AIC_c), differences in models from AIC_{min} (ΔAIC_c), and weights of models (ω). Competing models were ranked according to AIC_c. Only models within <3 units from AIC_{min} were considered as described by Burnham and Anderson (2002).

Before including all continuous weather variables in models, I tested for autocorrelation using Spearman's correlation test and removed variables if $r^2 > 0.5$ as described by Ford et al. (2006). Maximum wind gust was collinear with mean wind speed ($r^2 = 0.88$), and maximum wind gust was removed as mean wind speed was more representative of the effects of wind during most of the survey period. Average air temperature was collinear with daily maximum temperature ($r^2 = 0.75$) and daily minimum temperature ($r^2 = 0.95$). Average air temperature was more representative of the survey period, so maximum and minimum temperatures were removed from analyses. Once these variables were removed, the pairwise correlation was $r^2 \leq 0.5$.

My dependent variable was data for counts (i.e., number of passes) and I used Poisson regression for analyses. Because I had a repeated-measures design where I surveyed each night multiple times, I used night as a blocking variable to prevent pseudoreplication as recommended by Crawley (2005). In addition to analyzing passes, species richness of bats was compared between locations and between seasons using Poisson regression with night as a blocking variable.

Abundance and diversity of insects was compared between locations and between seasons to determine if abundance and diversity of insects were distributed equally among variables. Poisson regression was used to compare abundance of insects and an analysis of variance (ANOVA) was used to compare diversity of insects. Both analyses included an interaction term between location and season and also included night as a blocking variable.

RESULTS

When identifying calls to species, two species-groups were established due to certain species being difficult to distinguish from each other. One group included calls from eastern red bats and Seminole bats. The other group included calls from big brown bats and silver-haired bats. It is unlikely that there were many silver-haired bats in coastal South Carolina during summer (Menzel et al. 2003), and it is expected that the majority of calls in the big brown bat/silver-haired bat group from June through August were big brown bats. Rafinesque's big-eared bats have calls of such low amplitude that they are difficult to record (Kunz et al. 2007*a*). Only 8 passes from Rafinesque's big-eared bats were recorded and this species was eliminated from analyses. Neither northern yellow bats nor little brown myotis were recorded during this study. This resulted in five species (tri-colored bats, evening bats, southeastern myotis, hoary bats, and Brazilian free-tailed bats) and two groups (eastern red bats/Seminole bats and big brown bats/silver-haired bats) being included in analyses.

Because my dependent variable was data for counts and my dataset had over-dispersion (i.e., the variance was greater than the mean), I used negative-binomial regression for analyses instead of Poisson regression, as discussed by Burnham and Anderson (2002). Two species of bats were absent in many surveys, so I used zero-inflated regression for species when applicable. This resulted in using negative-binomial regression for the following species or groups: total number of passes, evening bats, tri-colored bats, eastern red bats/Seminole bats, big brown bats/silver-haired bats, and Brazilian free-tailed bats. Zero-inflated Poisson regression was used for hoary bats and southeastern myotis.

In total, 86,498 echolocation passes were recorded 7 June-24 October 2014. The weather station periodically malfunctioned, causing 38 surveys to be eliminated, which resulted in 76,090 passes being included in statistical analyses. About 40% of calls (30,811 passes) were unidentifiable due to ambiguity, poor quality, or calls with <3 pulses. Of the remaining passes, 36% (27,505 passes) were tri-colored bats, 9% (6,566 passes) were evening bats, 7% (5,063 passes) were Brazilian free-tailed bats, 5% (3,697 passes) were eastern red bats or Seminole bats, 3% (2,257 passes) were big brown bats or silver-haired bats, <1% (103 passes) were hoary bats, <1% (80 passes) were southeastern myotis, and <1% (8 passes) were Rafinesque's big-eared bats.

Overall activity of bats was best represented by the INSECT +HABITAT model with INSECT + HABITATM as the next-best model (Table 3.2, Appendices 20 and 21).

Season and diversity of insects were significant parameters in the INSECT + HABITAT model (Table 3.3). Overall activity of bats was significantly greater where there was a greater diversity of insects ($P < 0.001$; 95% CL = 1.41-3.80). Islands during migration had 2.92 times as many passes as islands during the pre-migration season ($P = 0.003$; 95% CL = 1.44-5.93; Figure 3.02[2]). There was neither significant difference in overall activity between islands and the mainland by season, nor was there a significant difference in activity on the mainland during pre-migration versus during migration.

Activity of evening bats was best represented by the WEATHER model with the GLOBALM model as the next-best model (Table 3.2, Appendices 22 and 23). Temperature was the only significant parameter in the WEATHER model (Table 3.3). For each 1°C increase in temperature, there were 1.16 times as many passes ($P = 0.001$; 95% CL = 1.06–1.26). There was no significant difference in activity by season or by location (Figure 3.03).

Activity of tri-colored bats was best represented by the INSECT + HABITATM model with the INSECT + HABITAT model also receiving some support (Table 3.2, Appendices 24 and 25). Location and diversity of insects were significant parameters in the INSECT + HABITATM model (Table 3.3). Mainland had 7.77 times as many passes as islands ($P < 0.001$; 95% CL = 4.55–13.34; Figure 3.04). Tri-colored bats were more active where there was a greater diversity of insects ($P = 0.002$; 95% CL = 1.40-4.34). There was no significant difference in activity by season.

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[2] Graphs depicting activity by location and activity by season reflect average number of passes without considering night as a blocking variable. This may cause the values in the graph to be different than the values reported from regression models.

Activity of Brazilian free-tailed bats was best represented by the WEATHER + HABITATM model, but the HABITATM, WEATHER + HABITAT, INSECT + HABITATM, HABITAT, and GLOBALM models also received some support (Table 3.2, Appendices 26 and 27). Temperature, humidity, and location were significant parameters in the WEATHER + HABITATM model (Table 3.3). For each 1°C decrease in temperature and for each 1% decrease in humidity, there were 1.12 times as many passes (P = 0.024 and 0.010, respectively; 95% CL = 0.81-0.98 and 0.82-0.97, respectively). Islands had 4.97 times as many passes as the mainland (P <0.001; 95% CL = 2.22-11.12; Figure 3.05). There was no significant difference in activity by season.

Activity of eastern red bats/Seminole bats was best represented by the HABITAT model, with WEATHER + HABITAT also receiving some support (Table 3.2, Appendices 28 and 29). Both season and location were significant parameters in the HABITAT model (Table 3.3). Islands had 9.06 times as many passes as the mainland during migration (P < 0.001; 95% CL = 4.01-20.49). Islands had 3.81 times as many passes during migration as during the pre-migration season (P = 0.009; 95% CL = 1.34–10.39; Figure 3.06). Islands had more passes than the mainland during the pre-migration season, but this was not significant. Mainland had more passes during the pre-migration season than during migration, but these results were not significant.

Activity of big brown bats/silver-haired bats was best represented by the INSECT + HABITATM model with the INSECT + HABITAT, HABITATM, and INSECT models also receiving some support (Table 3.2, Appendices 30 and 31). Location and abundance of insects were significant parameters in the INSECT + HABITATM model (Table 3.3). Islands had 2.38 times as many passes as the mainland (P = 0.012; 95% CL

= 1.21-4.68; Figure 3.07). Big brown bats/silver-haired bats were more active in areas where there was a greater abundance of insects ($P = 0.046$; 95% CL = 1.00-1.00). There was no significant difference in activity by season.

Activity of southeastern myotis was best represented by the NULL model, with no other model receiving strong support (Tables 3.2 and 3.3, Appendices 32 and 33). There was no significant difference in activity based on environmental variables, abundance and diversity of insects, location, or season (Figure 3.08).

Activity of hoary bats was best represented by the WEATHER + HABITATM model, with the HABITATM, WEATHER + HABITAT, and HABITAT models also receiving some support (Table 3.2, Appendices 34 and 35). Temperature and location were two significant parameters in the WEATHER + HABITATM model (Table 3.3). For each 1°C decrease in temperature, there were 1.12 times as many passes ($P = 0.044$; 95% CL = 0.80–1.00). Islands had almost 3.72 times as many passes as the mainland ($P = 0.005$; 95% CL = 1.48–9.35; Figure 3.09). There was no significant difference in activity by season.

Species richness of bats was not significantly affected by the interaction term between location and season, and the interaction term was removed to both simplify and more accurately reflect results, as recommended by Crawley (2005). Once the interaction term was removed, species richness of bats was greater on islands than the mainland and greater during migration than before migration, but these differences are not statistically significant (Table 3.2).

The interaction term between location and season was removed due to it not being a significant parameter in the negative-binomial regression for abundance of insects.

Once the interaction term was removed, abundance of insects varied significantly between location and season. Mainland had 1.74 times as many insects as islands (P = 0.054; 95% CL = 0.99-3.05). Pre-migration period had 4.10 times as many insects as the migration period ($P < 0.001$; 95% CL = 2.41-6.98; Figure 3.10).

The interaction between location and season was a significant parameter when looking at diversity of insects. Islands had significantly more diversity than the mainland during the pre-migration season ($P < 0.001$; 95% CL = 0.34-0.68; Figure 3.11). Islands had significantly more diversity during the pre-migration period than during migration ($P < 0.001$; 95% CL = 0.28-0.65). Although mainland had more diversity during migration than during pre-migration, it was not significant. Mainland had more diversity than islands during migration but these results were also not significant.

DISCUSSION

Location on islands or the mainland and timing of activity appear to explain the majority of variation in activity of bats, as evidenced by the HABITAT or HABITATM models being present in the best-approximating model for overall activity and for activity of five of the seven species or groups. Islands tended to have more activity and a greater species richness of bats than the mainland, although the association between species richness and location was not significant. Patterns in activity did not closely follow patterns of abundance and diversity of insects.

Effects of location and season.---Location appears to play a more important role in where bats are active than environmental conditions or abundance and diversity of insects. Although there were clear trends in activity by season, location appears to explain more variation in activity of bats for most species or groups than is accounted for during pre-migration or migration periods.

Overall activity and activity of four of the seven species or groups was greater on islands than the mainland, despite the mainland having a significantly greater abundance of insects. These groups included hoary bats, big brown bats/silver-haired bats, eastern red bats/Seminole bats, and Brazilian free-tailed bats. Few studies have been conducted that compare activity of bats on islands to activity on the mainland during the same study period, which makes it difficult to understand the nuances of why certain species or groups were more active at certain locations. However, it is interesting to note that the majority of species or groups of bats that were more active on islands have the long, narrow wings that Altringham (1996) associates with open-adapted species.

Activity on islands was more evenly distributed into species or groups than activity on the mainland, which was dominated by tri-colored bats (Figure 3.12). Tri-colored bats were the only species that had significantly greater amounts of activity on the mainland than on islands. Evening bats also had more activity on the mainland than on islands, but this was not statistically significant. These two species were recorded most often and were present in almost every acoustic survey. Johnson and Gates (2008) studied bats on Assateague Island, Maryland, and did not document presence of evening bats, despite their prevalence in previous studies along coastal Maryland.

There were trends in activity of bats due to season. Overall activity and activity of eastern red bats/Seminole bats were significantly greater during migration than the pre-migration period. Tri-colored bats, Brazilian free-tailed bats, big brown bats/silver-haired bats, and hoary bats also had more activity during migration, but it was not statistically significant. Not all species present in Charleston County, South Carolina, migrate, but most of them mate in autumn (Harvey et al. 2011). Jameson and Willis (2014) showed an increase in activity during autumn due to conspecifics congregating to mate, which could be what occurred during my study. This is also the time of year when bats are preparing to enter hibernation, and there is increased foraging during this time to build fat reserves to last bats through winter (Altringham 1996), which could partially explain the increase in activity in coastal South Carolina.

Considering that hoary bats are migratory, it is possible that I would have seen a stronger connection between hoary bats and season if more hoary bats had been recorded. Likewise, if I was able to distinguish calls of big brown bats from silver-haired bats with greater confidence, I may have detected a stronger association between activity of silver-haired bats and timing of migration.

The decision to choose 15 August as the cut-off date between the pre-migration and migration periods was based on documentation that migration begins between late July and early October (Cryan and Brown 2007). The specific start and end dates of migration are fluid and vary among species and years. It is likely that the weak connection between season and activity of bats is due to 15 August not being the best date for separating seasons. I may have obtained different results if I had chosen a date that was specific to each species.

The interaction term between season and location was significant for overall activity and activity of eastern red bats/Seminole bats. These results show that activity, both overall and for the eastern red bat/Seminole bat group was significantly greatest on islands during migration, implying that islands are important locations for bats during autumn. For the remaining species, where activity was significantly greater over islands, activity was greater on islands irrespective of season, and activity on islands during migration tended to be greatest of all interactions between location and season despite it not being statistically significant (Figure 3.13). This makes it difficult to separate the importance of location compared to season. It is apparent that islands are important locations for bats to be active, but their importance may potentially change as the season shifts towards migration. It is interesting to note that hoary bats, silver-haired bats, and eastern red bats had significantly greater levels of activity on islands. All of these three species are migratory tree bats that have been documented using Assateague Island as a resting point off the coast of Maryland (Johnson et al. 2011).

The activity of southeastern myotis was not significantly affected by location, season, environmental conditions, or abundance and diversity of insects as determined by the null model being the best-approximating model for this species. Few southeastern myotis were detected during my study, and this may explain why there was no clear association between any parameter and this species. Different results may have been obtained if more southeastern myotis had been recorded.

Because islands off the coast of South Carolina are not separated from the mainland by large bodies of water, it is possible that bats are using islands disproportionately more than the mainland due to proximity of islands to the coastline and not because of specific features of islands. Previous studies have documented the importance of vision during migration (Boonman et al. 2013) and there is some evidence that bats use rivers and coastlines in Europe as migration corridors (Altringham 2011). Perhaps bats are using the coastline of South Carolina as a landmark to follow during migration, in which case islands could be treated as an extension of the mainland. It is apparent that either islands or the coastline are important for bats, which potentially puts bats at risk from offshore wind farms. Future studies need to document how activity of bats changes with proximity to the coastline.

The type of habitat could be affecting activity on islands and the mainland. Of the habitats surveyed on islands, 67% were open (compared to 42% on mainland) and 33% were cluttered (compared to 58% on mainland). Considering the uniformity with which bats selected open habitats over cluttered habitats in chapter 2, it is possible that this effect is confounding results. However, it can also be argued that open waterways are features surrounding barrier islands and it would be difficult to distinguish selection of islands based on importance of the island itself from characteristics of habitat on islands. The bodies of water surveyed on islands consisted mostly of salt-water habitats (83%), which did not show selection by any species other than eastern red/Seminole bats, and this was not statistically significant in chapter 2. Mainland sites were comprised of 50% freshwater sites, 42% brackish-water sites, and 8% salt-water sites. Future efforts need to assess differences in activity based on proximity to the coast and based on differences in habitat between coastal areas and the mainland.

Effects of environmental variables and insects.---Although weather was not an important factor in where and when bats were active, three of the seven species or groups included weather in their best-approximating model. Of all the parameters in the weather model, temperature appeared to be the most important, but did not affect all three species equally. Activity of evening bats significantly increased as temperature increased, but the activity of hoary bats and Brazilian free-tailed bats significantly decreased as temperature increased. Previous studies have shown that higher nighttime temperatures are associated with increased activity of bats (Erickson and West 2002, Johnson et al. 2011) and this can explain the trend in activity of evening bats, which were not significantly affected by location or season. The association of low nighttime temperatures and activity of hoary bats may be related to the migratory nature of hoary bats in autumn. Menzel et al. (2003) discovered few historic records of hoary bats in South Carolina during spring and summer and suggest hoary bats are autumn migrants. It is unclear why Brazilian free-tailed bats would be positively associated with lower nighttime temperatures.

Although the insect model appeared in three of the seven species or groups, the abundance of insects does not appear to have a significant impact on where or when bats are active. The big brown bat/silver-haired bat group showed significantly more activity where insects were less abundant, but it is likely that activity had less to do with abundance of insects than with timing of activity. Insects were significantly more abundant during pre-migration than migration, while bats were more active during the migration period. Because it is not likely that lack of insects is driving bats to be more active, the more realistic scenario is that the increase in activity of silver-haired bats during autumnal migration caused this group to have a negative association with abundance of insects.

As diversity of insects increased, overall activity and activity of tri-colored bats significantly increased. Activity of evening, Brazilian free-tailed, big brown/silver-haired, and hoary bats also increased with increasing diversity of insects, but this was not statistically significant. Only southeastern myotis and eastern red bats/Seminole bats had a negative association with increased diversity of insects, but this association was not statistically significant.

Because I did not conduct an analysis of stomach contents or guano, I cannot verify that bats were eating the same species of insects captured in my light trap. This makes it difficult to determine how important abundance and diversity of insects truly are to the bats in my study. The best-approximating model for activity of three of the seven species or groups included insects, implying that insects do play some kind of role in determining where and when bats are active. However, it is possible that the trends shown are more of a factor of islands having more diversity of insects while also having more activity of bats. This could mean that the connection between diversity of insects and activity of bats is weak.

Wind farms, migration, and conservation implications.---Bats in coastal South Carolina use islands disproportionately more than the mainland and activity increases during autumn, a time where most mortality due to wind turbines occurs (Cryan and Brown 2007, Arnett et al. 2008). This means that those who develop the proposed wind farm off the coast of South Carolina must consider bats during the process of building the turbines, but they must also think about bats when they are maintaining the functioning wind farm. There are ways that wind turbines can be managed that mitigate impacts to bats, including making turbines less attractive to bats and by reducing cut-in speeds (Arnett et al. 2011, Sjollema et al. 2014).

Mortality at wind turbines occurs either when bats are struck by rotating blades, the tips of which can rotate at speeds up to 310 km/hour (Kunz et al. 2007*b*), or due to barotrauma, which causes damage to organs due to dramatic decreases in air pressure

(Baerwald et al. 2008). Edges of rotating blades rotate at a faster speed than that of the center of the turbine blades, and it may be too late for the bat to avoid colliding with blades by the time it has detected them (Kunz et al. 2007*b*). As the blades rotate, they create an airfoil of low pressure that cannot be detected by the bat. Once the bat enters the low pressure area, its lungs expand and the bat experiences internal hemorrhaging (Baerwald et al. 2008). This means that even if the bat is able to detect the rotating turbine blades, it will be unable to detect the low-pressure areas surrounding the blades.

The problem of having an undetectable hazard becomes even more of a concern when considering that turbines might actually attract bats. Cryan (2008) posited the turbines-as-reproductive-landmarks hypothesis that is related to mating behavior in bats. Migratory tree-dwelling bats tend to roost alone or in small groups and have to find a way to locate conspecifics to mate. Tall structures (i.e., trees, powerlines, towers, and wind turbines) serve as indicators or landmarks where conspecifics will be located. Wind turbines become the tallest rendezvous point by default. Other studies have shown that individual bats that experience mortality at turbines are generally adults and that feeding buzzes are disproportionately absent from tall towers relative to lower-lying structures, implying that high levels of activity at tall structures are not associated with foraging (Arnett et al. 2008, Jameson and Willis 2014). These studies appear to support the reproductive-landmark hypothesis.

Considering that wind turbines may serve as an attractant to bats, it is possible that pre-build surveys aimed to assess risk of turbines to bats at a specific location will show that bats are not at risk. However, post-build monitoring could show significant mortality to bats simply because the presence of the turbines caused the bats to be active in an area in which they were not previously active (Cryan 2008). The individuals responsible for managing the proposed wind farm off the coastline of South Carolina should realize the potential to see these phenomena and should expect to continue to monitor fatalities after the turbines have been constructed.

Furthermore, bats use vision during migration and rely on tall, distant landmarks to aid in navigation, as sound generally attenuates after 30 m and is not useful in long-distance migration (Cryan and Brown 2007, Kunz et al. 2007*a*, Boonman et al. 2013). Cryan and Brown (2007) studied migration patterns of hoary bats on Southeast Farallon Island, which had a lighthouse. The authors believed that presence of the lighthouse may have been attracting bats to the island, as both an aid in navigation and to locate conspecifics. Baerwald et al. (2009) reported that bats are more likely to be killed at taller wind turbines than shorter wind turbines, although the strength of this conclusion appears to be connected to baseline activity at the site. Locations with greater activity of bats and short wind turbines had less mortality than locations with less activity and tall wind turbines. It is possible that height of the turbine is making it easier for bats to detect the turbine, which puts them at risk. Lowering height of the turbine may reduce mortality at offshore wind farms by preventing bats from being attracted to turbines over the ocean. It is also possible that building turbines farther from the coast may reduce mortality of bats (Sjollema et al. 2014), although it is unclear what the necessary distance from shore would be.

Cut-in speed is the lowest speed where the turbines begin to rotate and produce power, and is traditionally set at 3-4 m/s (Arnett et al. 2011). Controlling the cut-in speed may be another option in reducing fatalities. Bats tend to be more active at lower wind speeds, or speeds that are <6 m/s, which is also when the greatest mortality of bats due to wind farms has been documented (Baerwald et al. 2009, Arnett et al. 2011). Arnett et al. (2011) studied the effect on mortality when the cut-in speed was increased so the turbines did not begin rotating during times when bats were most likely to be active. Increasing the cut-in speed to 5 m/s and 6.5 m/s decreased mortality by 44% and 93%, respectively. The loss to the wind farm was ≤1% of its total annual output. Managers of the proposed wind farm on the coastline of South Carolina should consider the use of appropriate cut-in speeds to protect migratory bats.

Although it is admirable that South Carolina is investing in renewable energy, this decision should be an informed one. My study has shown that bats use islands significantly more than the mainland and that activity peaks during migration in autumn. Future research needs to be conducted that assesses risk of offshore wind turbines on coastal bats. Despite the best efforts of scientists and turbine operators, behavior of bats is different over the ocean than on land, and this may provide new challenges for operating offshore turbines. Documentation of migrating bats at sea show they change several of their behaviors, including flying at higher wind speeds and diurnal activity (Hatch et al. 2013, Sjollema et al. 2014); presumably, because there were no places for bats to rest during suboptimal conditions. These behavioral shifts may create new challenges, as bats migrating offshore may seek turbines as roosting sites. If this is the scenario, the best efforts to mitigate negative impacts of wind turbines on bats probably will not deliver the desired results.

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Table 3.1.---Number of acoustic surveys of bats at each location and in each season in Charleston County, South Carolina, June-October 2014.

Season	Location		Number of surveys
Pre-migration	Island		
		Bear's Bluff National Fish Hatchery	10
		Church Creek	5
		James Island County Park	11
	Mainland		
		Magnolia Plantation	25
		Caw Caw Interpretive Center	30
Migration	Island		
		Bear's Bluff National Fish Hatchery	12
		Church Creek	5
		James Island County Park	17
	Mainland		
		Magnolia Plantation	36
		Caw Caw Interpretive Center	32

Table 3.2.---Negative binomial and zero-inflated regression models within 3 units of AIC_{min}. These are the best approximating models for determining which parameters are providing the most influence on activity of bats among locations and season in Charleston County, South Carolina, June-October 2014. Models were ranked based on AIC_c.[a]

Model	K	AIC_c	ΔAIC_c	ω
Overall activity[b]				
INSECT + HABITAT	6	2,541.68	0	0.49
INSECT + HABITATM	5	2,542.24	0.56	0.37
Evening bat[b]				
WEATHER	6	1,628.88	0	0.55
GLOBALM	10	1,631.48	2.60	0.15
Tri-colored bat[b]				
INSECT + HABITATM	5	2,005.04	0	0.68
INSECT + HABITAT	6	2,007.18	2.14	0.23
Brazilian free-tailed bat[b]				
WEATHER + HABITATM	8	1,314.63	0	0.23
HABITATM	3	1,314.63	0.01	0.23
WEATHER + HABITAT	9	1,315.64	1.01	0.14
INSECT + HABITATM	5	1,316.04	1.41	0.11
HABITAT	4	1,316.23	1.60	0.10
GLOBALM	10	1,316.38	1.75	0.10
Eastern red bat/Seminole bat[b]				
HABITAT	4	1,239.93	0	0.63
WEATHER + HABITAT	9	1,242.64	2.72	0.16
Big brown bat/silver-haired bat[b]				
INSECT + HABITATM	5	1,131.24	0	0.33
INSECT + HABITAT	6	1,131.68	0.44	0.26
HABITATM	3	1,133.43	2.20	0.11
INSECT	3	1,133.43	2.20	0.11
Southeastern myotis[c]				
NULL	1	315.32	0	0.67
Hoary bat[c]				
WEATHER + HABITATM	8	343.53	0	0.37
HABITATM	3	345.13	1.61	0.17
WEATHER + HABITAT	9	345.24	1.71	0.16
HABITAT	4	346.02	2.50	0.11

[a] See text for parameters that comprise each model. K is the number of parameters in the model, including the intercept. ΔAIC_c is the difference in the AIC_c of the current model and the best approximating model, or AIC_{min}. ω is the Akaike weight, or the probability that the current model is the best representative model among the a priori models considered.
[b] Species or groups analyzed with negative binomial regression.
[c] Species analyzed with zero-inflated regression.

Table 3.3.---Description of parameters in the best approximating model on islands and mainland for each species or group as determined by acoustic monitoring in Charleston County, South Carolina, June-October, 2014.

Parameter	Coefficient estimate	*SE*	*P*-value	95%CL
Overall activity[a] (INSECT + HABITAT)				
Intercept	67.36	1.55	**<0.001**	28.57-157.60
Mainland	1.67	1.41	0.132	0.85-3.27
Migration	2.92	1.44	**0.003**	1.44-5.93
Mainland: Migration	0.48	1.56	0.097	0.20-1.14
Abundance of Insects	1.00	1.00	0.149	0.99-1.00
Diversity of Insects	2.32	1.28	**<0.001**	1.42-3.80
Evening bat[b] (WEATHER)				
Intercept	2.46E-38	5.76E23	0.113	6.62E-85-9.12E8
Temperature	1.16	1.05	**0.001**	1.06-1.26
Humidity	0.99	1.04	0.790	0.93-1.06
Wind Speed	0.96	1.09	0.638	0.81-1.14
Barometric Pressure	2.36	1.73	0.116	0.81-6.91
Lunar Illumination	1.00	1.00	0.551	0.99-1.00
Tri-colored bat[a] (INSECT + HABITATM)				
Intercept	5.05	1.56	**<0.001**	2.10-12.11
Mainland	7.77	1.32	**<0.001**	4.55-13.34
Migration	1.54	1.31	0.114	0.90-2.63
Abundance of Insects	1.00	1.00	0.147	1.00-1.00
Diversity of Insects	2.46	1.34	**0.002**	1.40-4.34
Brazilian free-tailed bat[c] (WEATHER + HABITATM)				
Intercept	3.04E-21	3.90E28	0.473	2.79E-77-3.31E35
Temperature	0.89	1.05	**0.024**	0.81-0.98
Humidity	0.89	1.05	**0.010**	0.82-0.97
Wind Speed	1.07	1.12	0.552	0.86-1.34
Barometric Pressure	1.82	1.93	0.360	0.50-6.61
Lunar Illumination	1.01	1.01	0.068	1.00-1.02
Island	4.97	1.51	**<0.001**	2.22-11.12
Migration	2.11	1.59	0.108	0.85-5.25

Table 3.3.---Continued.

Eastern red bat/Seminole bat[d] (HABITAT)				
Intercept	4.42	1.27	**<0.001**	2.78-7.04
Island	9.06	1.52	**<0.001**	4.00-20.49
Pre-migration	1.57	1.42	0.198	0.79-3.11
Island: Pre-migration	0.17	1.86	**0.004**	0.05-0.56
Big brown bat/silver-haired bat[d] (INSECT + HABITATM)				
Intercept	4.22	1.54	**<0.001**	1.83-9.82
Island	2.38	1.41	**0.012**	1.21-4.68
Pre-migration	1.01	1.41	0.970	0.52-1.98
Abundance of Insects	1.00	1.00	**0.046**	1.00-1.00
Diversity of Insects	1.28	1.44	0.490	0.63-2.62
Southeastern myotis[b] (NULL)				
Intercept	0.44	1.19	**<0.001**	0.31-0.62
Hoary bat[c] (WEATHER + HABITATM)				
Intercept	7.43E55	6.19E35	0.119	5.26E-15-1.05E126
Temperature	0.89	1.06	**0.044**	0.80-1.00
Humidity	0.96	1.05	0.435	0.87-1.06
Wind Speed	0.90	1.13	0.385	0.70-1.15
Barometric Pressure	0.29	2.28	0.136	0.06-1.47
Lunar Illumination	1.01	1.01	0.288	0.99-1.02
Island	3.72	1.60	**0.005**	1.48-9.35
Migration	2.18	1.73	0.155	0.74-6.41

[a]Island and Pre-migration were the reference groups for regression.
[b]Island and Migration were the reference groups for regression.
[c]Mainland and Pre-migration were the reference groups for regression.
[d]Mainland and Migration were the reference groups for regression.

Table 3.4.---Poisson regression for species richness of bats by location and season as determined by acoustic monitoring in Charleston County, South Carolina, June-October 2014.

Parameter	Coefficient estimate	*SE*	95% Confidence limit	*P*-value
Island[a]	1.13	1.08	1.05-1.22	0.086
Migration[b]	1.05	1.07	0.98-1.13	0.439

[a] Mainland is the reference group.
[b] Pre-migration is the reference group.

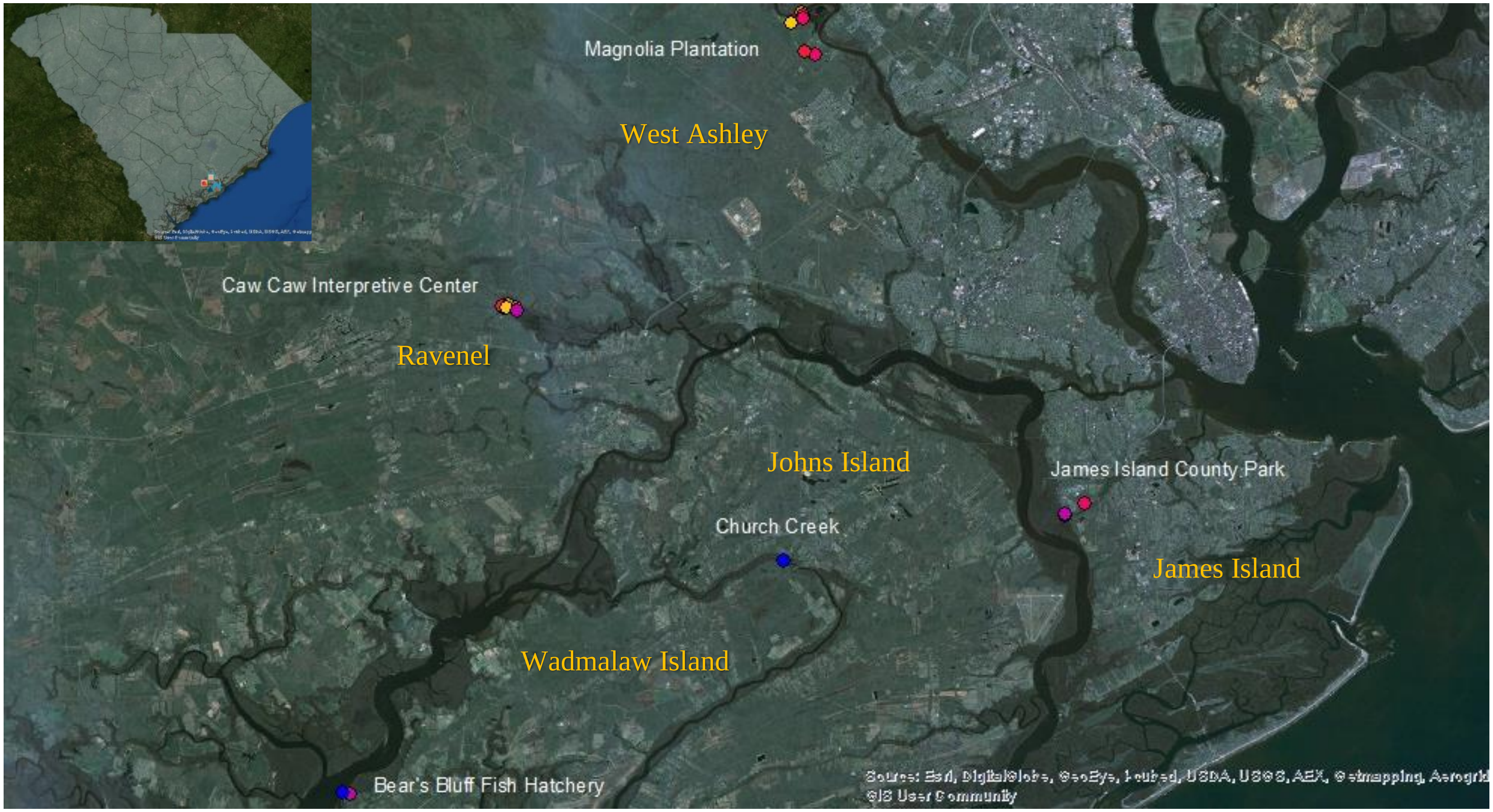

Figure 3.01.---Map of study sites on islands and mainland in Charleston County, South Carolina, June-October 2014.

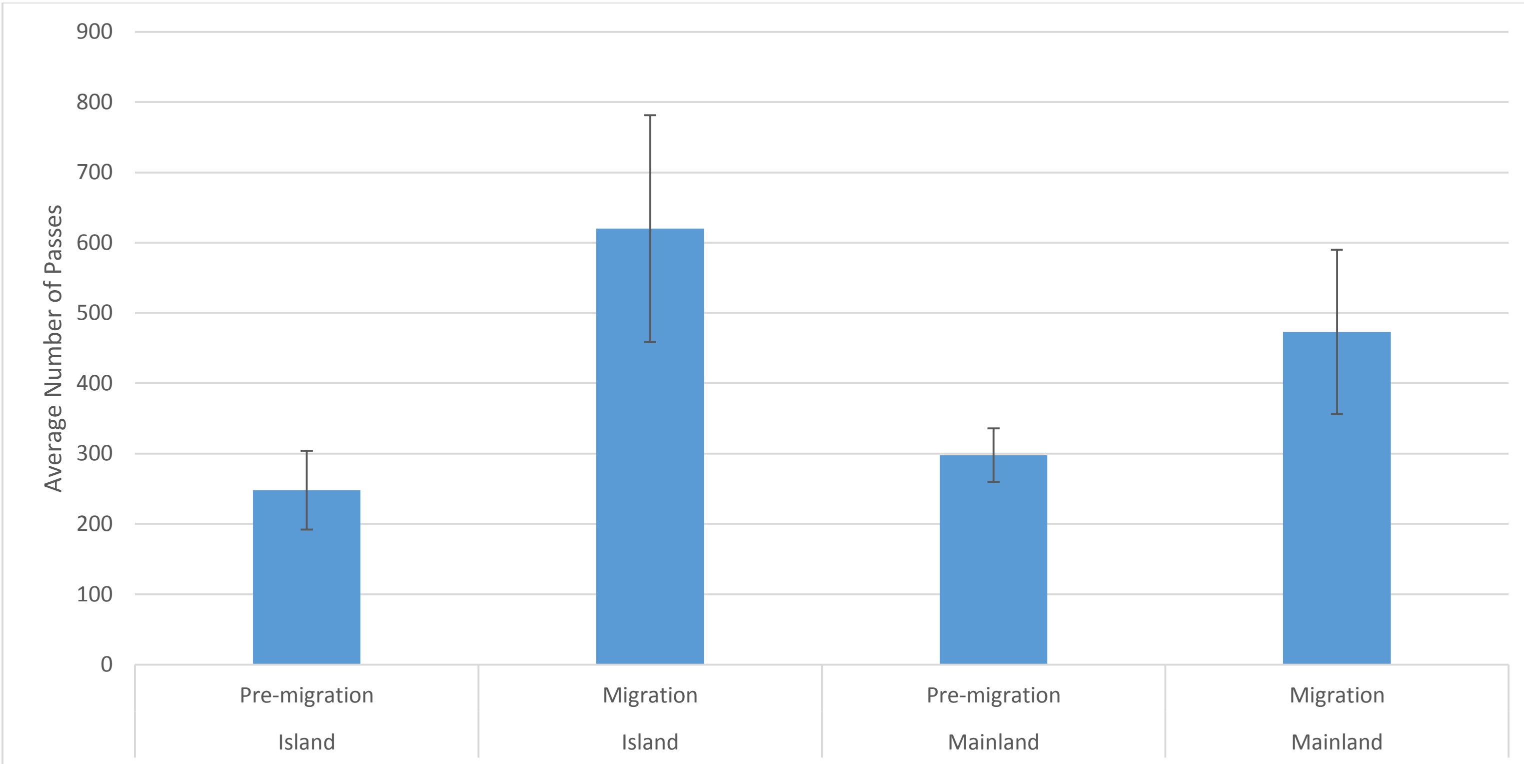

Figure 3.02.---Overall activity of bats in Charleston County, South Carolina by location and season.

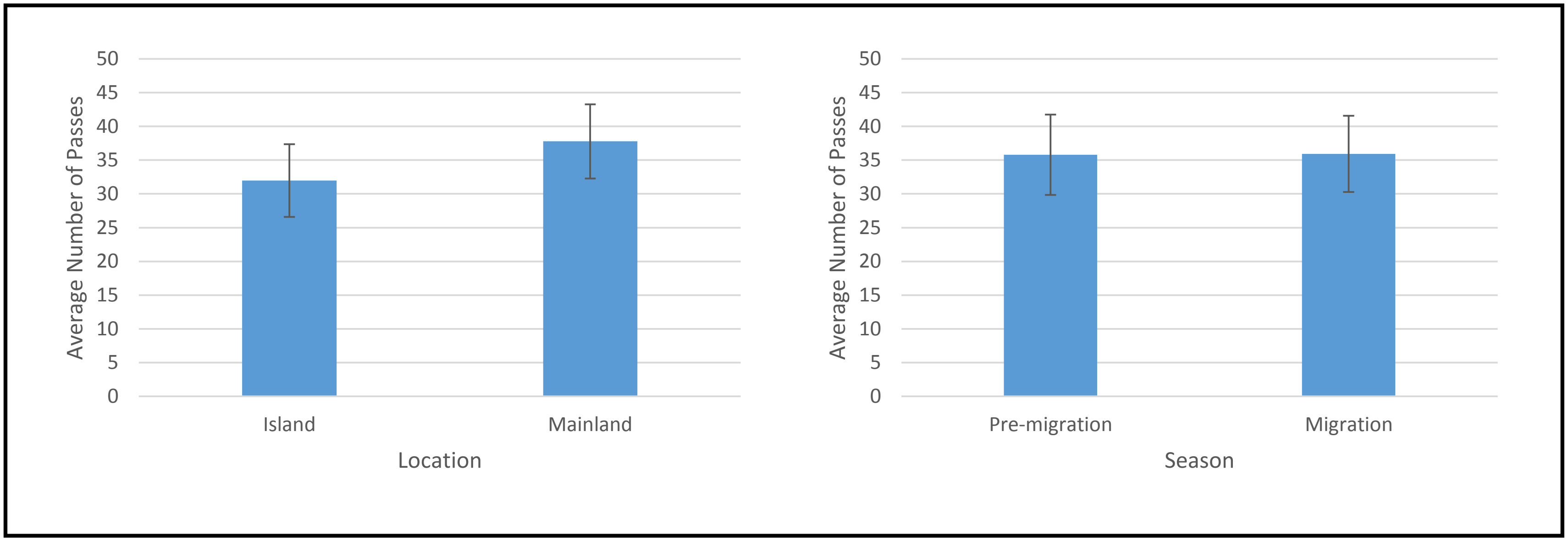

Figure 3.03.---Activity of evening bats (*Nycticeius humeralis*) in Charleston County, South Carolina, by location and season.

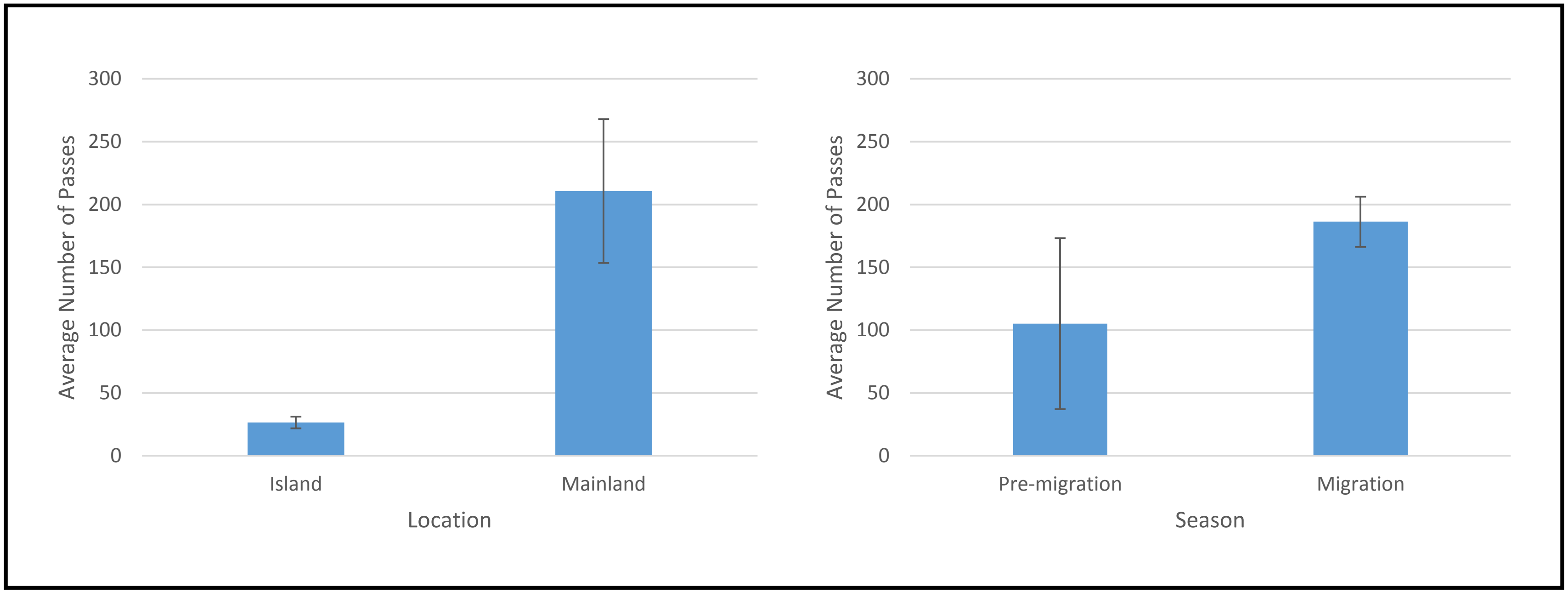

Figure 3.04.---Activity of tri-colored bats (*Perimyotis subflavus*) in Charleston County, South Carolina, by location and season

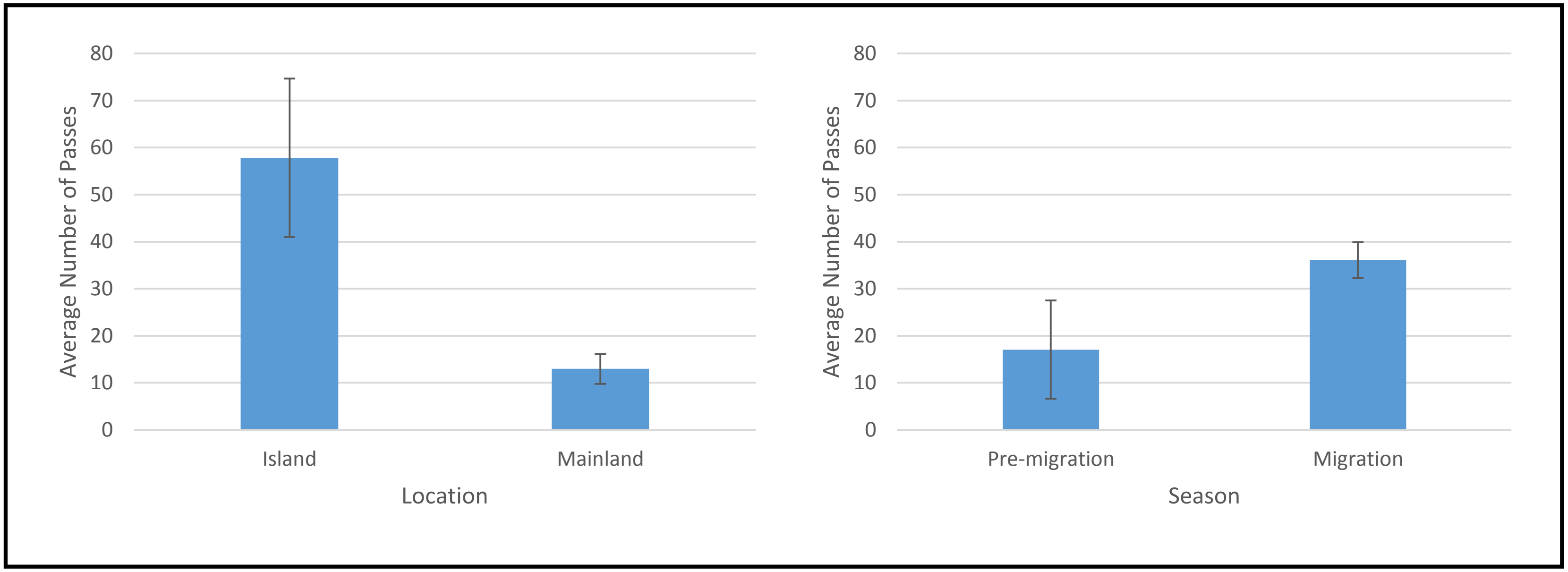

Figure 3.05.---Activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) in Charleston County, South Carolina, by location and season.

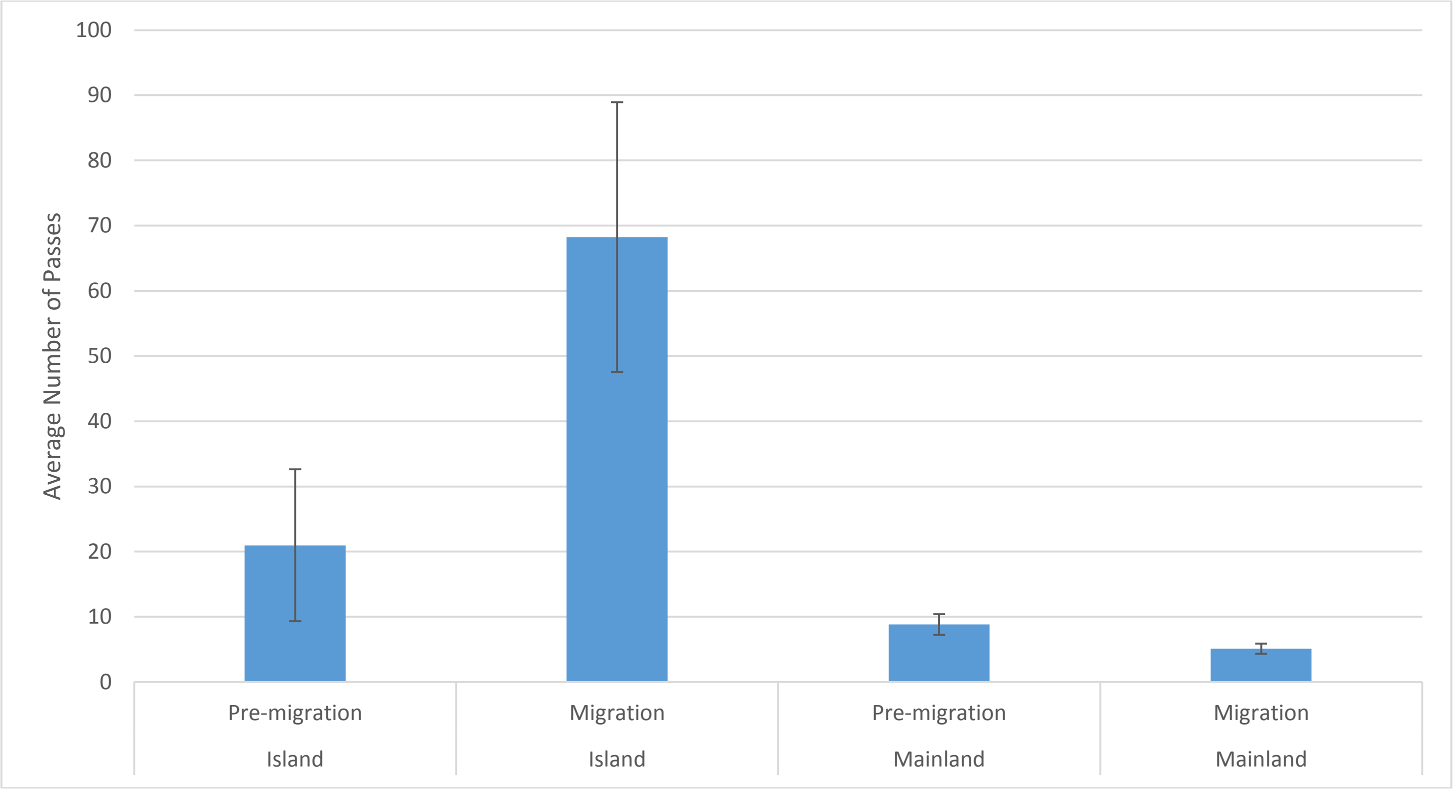

Figure 3.06.---Activity of eastern red bats (*Lasiurus borealis*)/Seminole bats (*Lasiurus seminolus*) in Charleston County, South Carolina, by interaction between location and season.

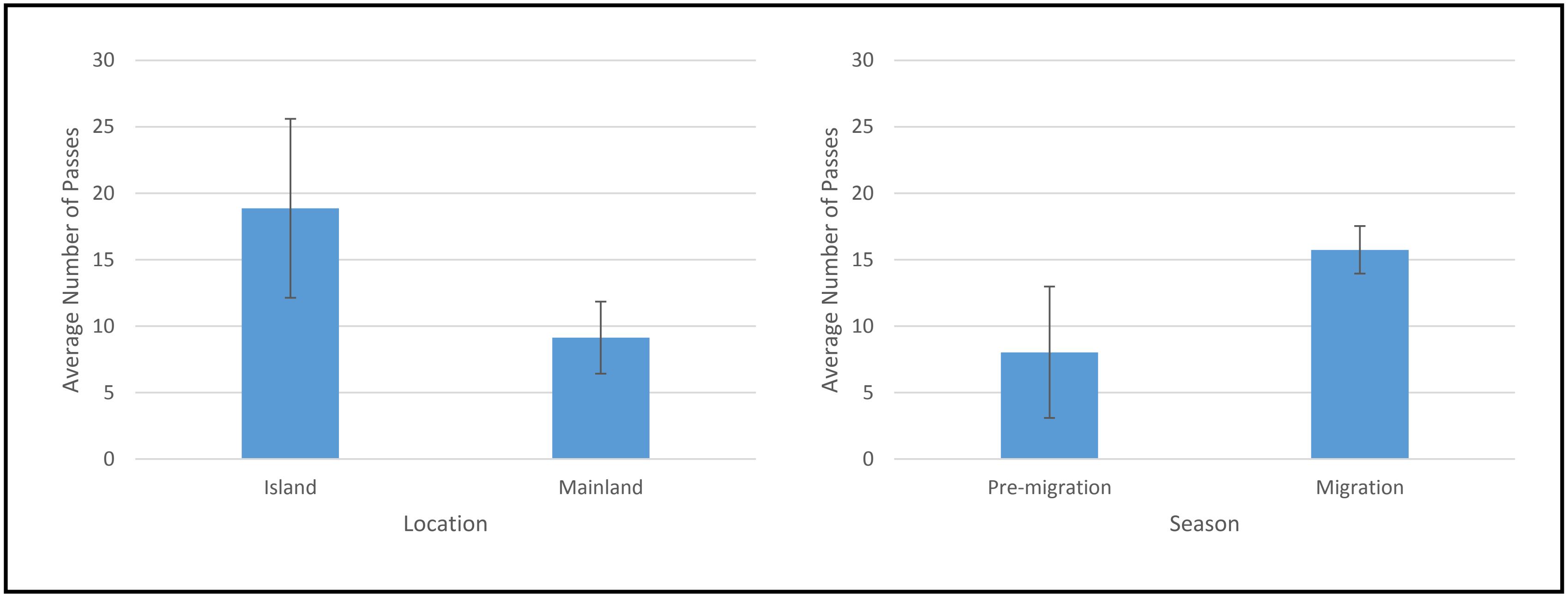

Figure 3.07.---Activity of big brown bats (*Eptesicus fuscus*)/silver-haired bats (*Lasionycteris noctivagans*) in Charleston County, South Carolina, by location and season.

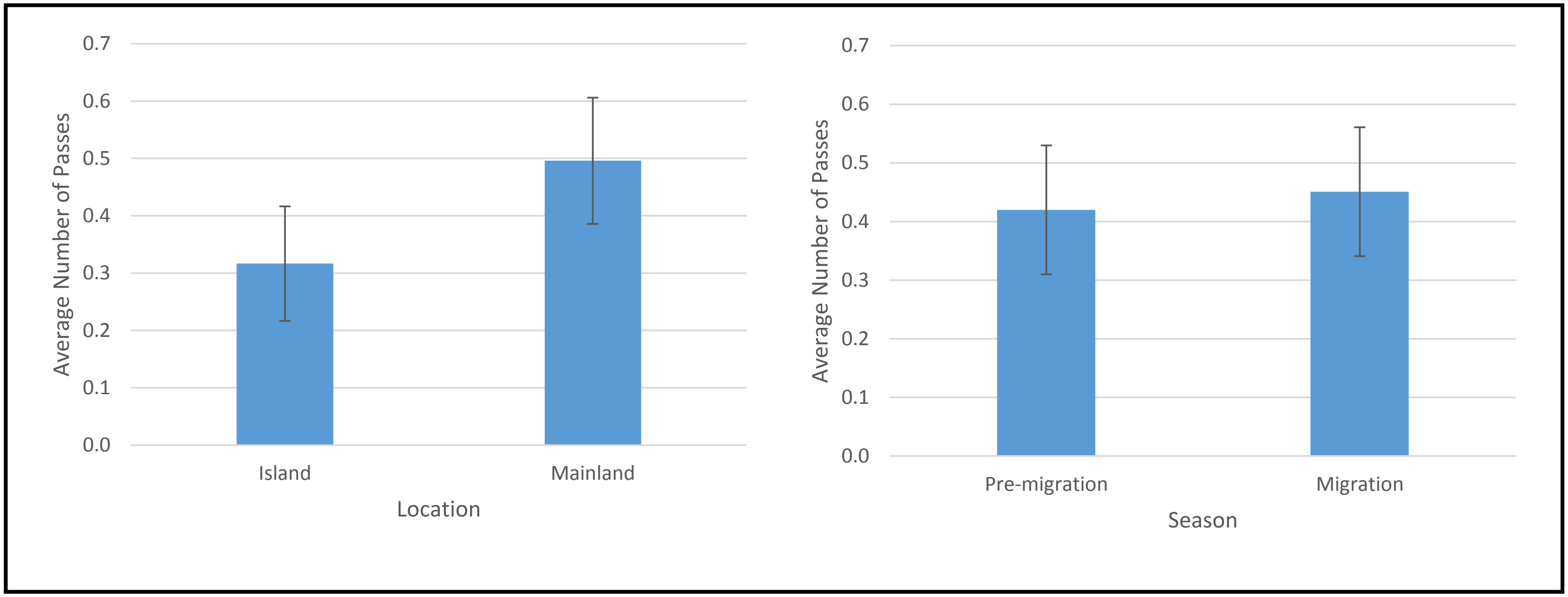

Figure 3.08.---Activity of southeastern myotis (*Myotis austroriparius*) in Charleston County, South Carolina, by location and season.

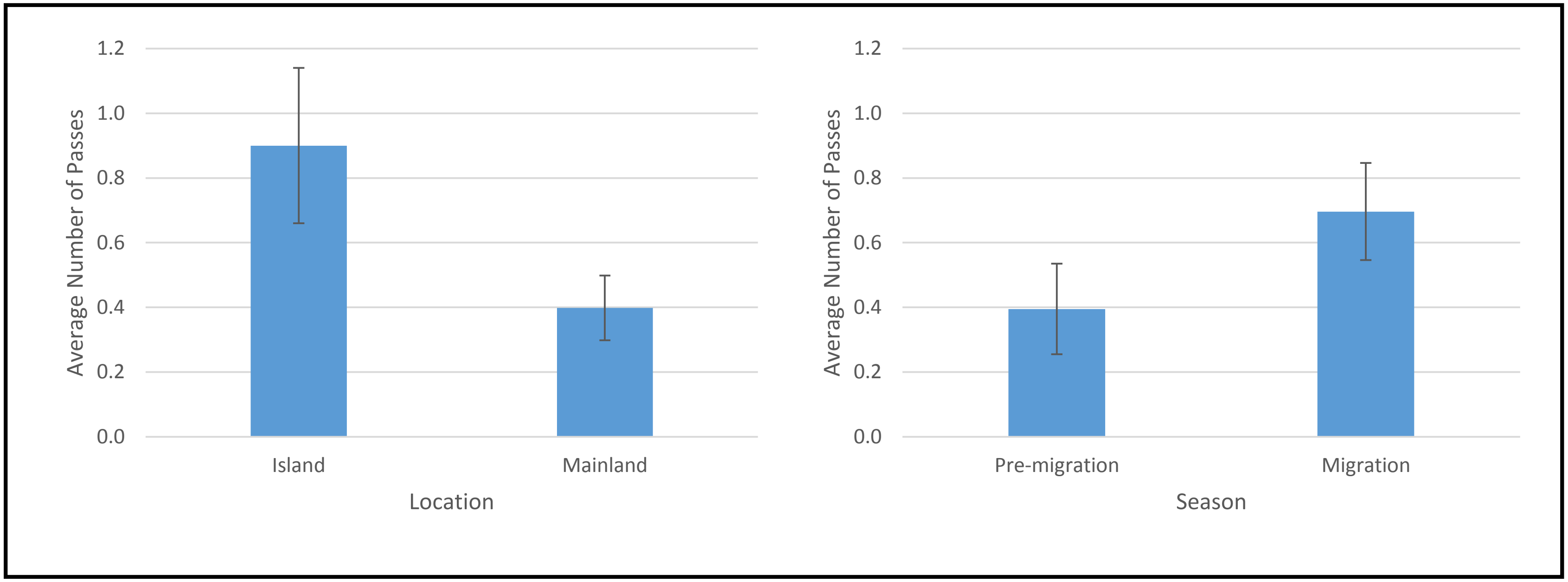

Figure 3.09.---Activity of hoary bats (*Lasiurus cinereus*) in Charleston County, South Carolina, by location and season.

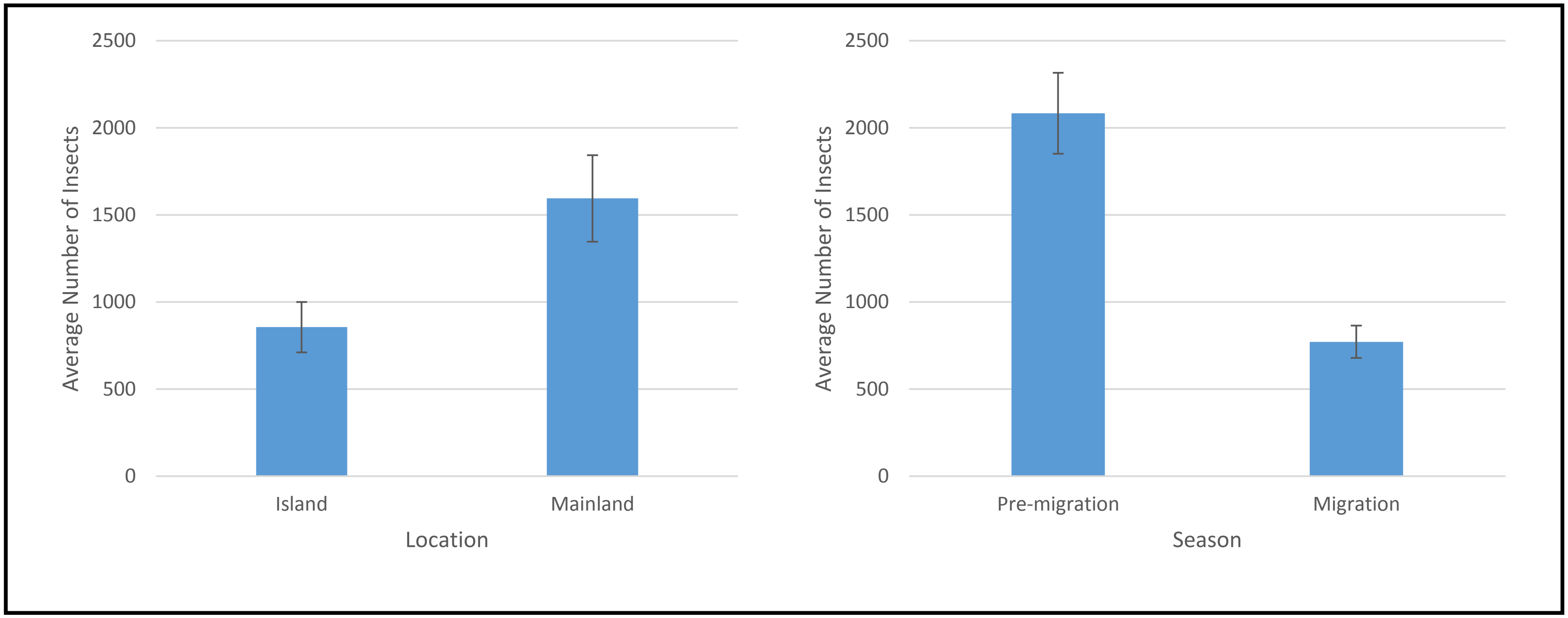

Figure 3.10.---Abundance of insects captured in Charleston County, South Carolina, as a function of location and season.

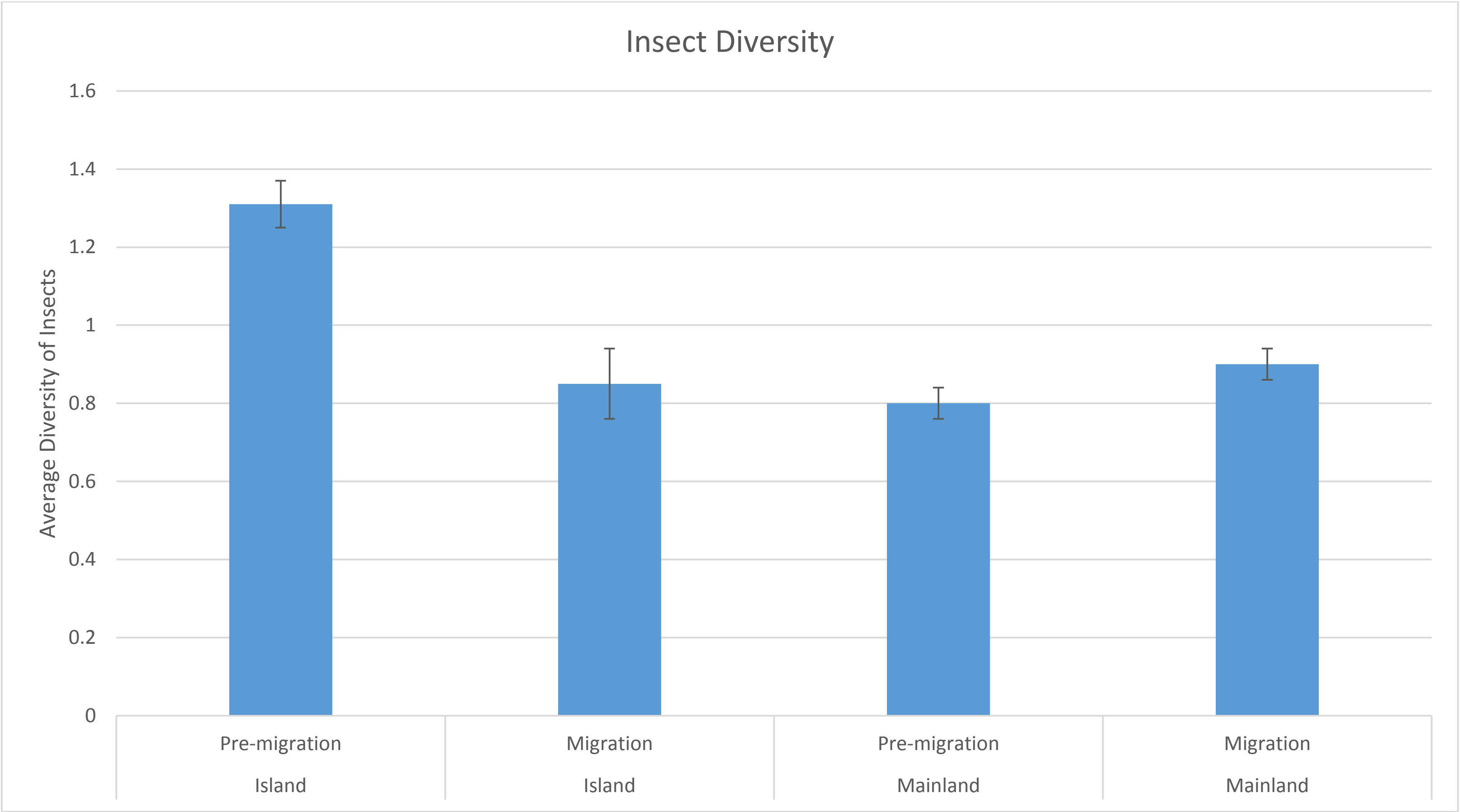

Figure 3.11.---Diversity of insects captured in Charleston County, South Carolina, as a function of location and season.

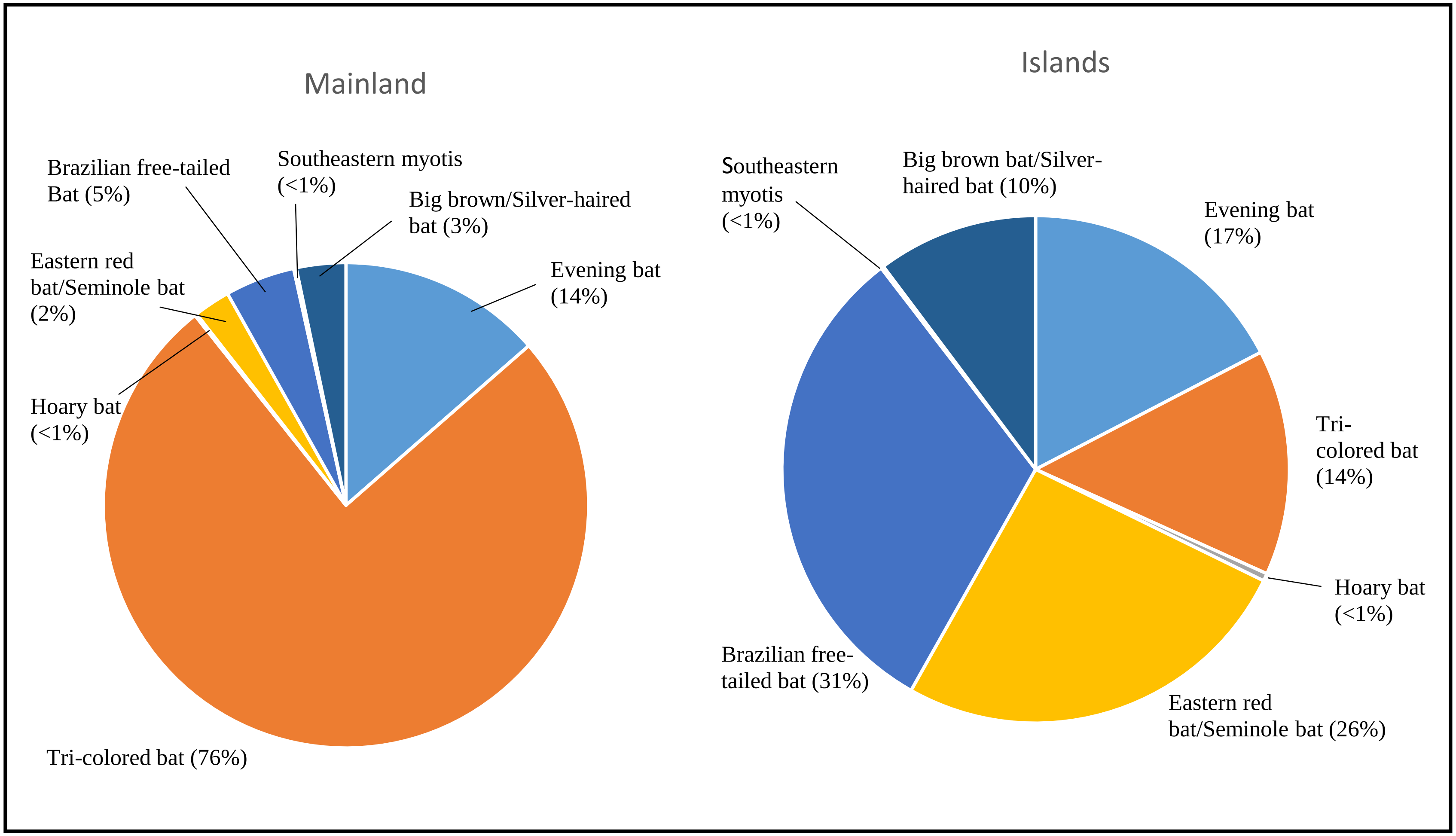

Figure 3.12.---Percentage of overall passes recorded on islands and the mainland in Charleston County, South Carolina, by species or group, June-October 2014.

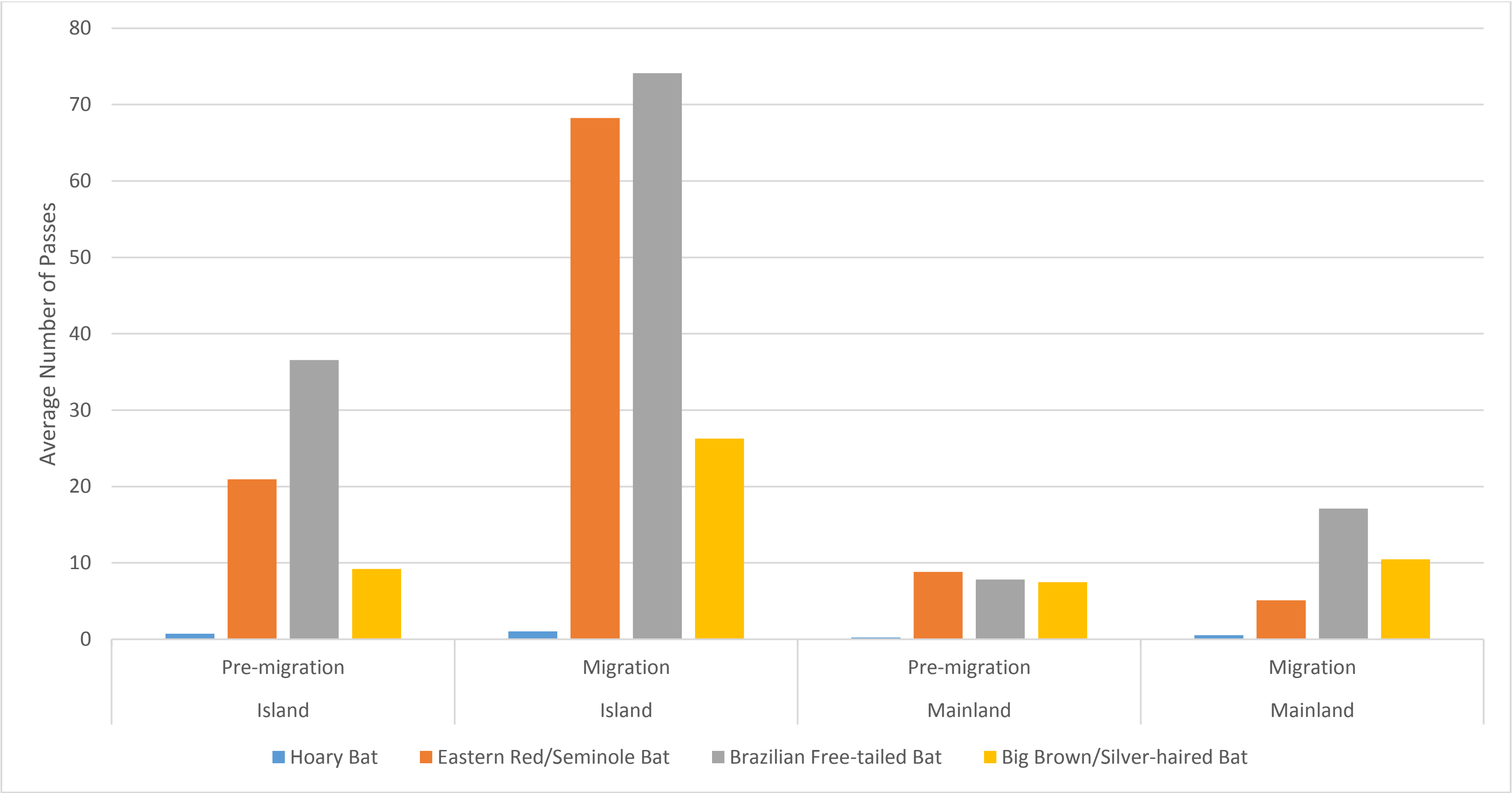

Figure 3.13.---The interaction term between location and season for passes recorded in Charleston County, South Carolina. The species included in this figure are those that had significantly more activity over islands than the mainland, but did not necessarily have a significant interaction term between islands and season.

Appendix 1.---Data recorded during 183 acoustic surveys on bats conducted in Charleston County, South Carolina, 7 June-24 October 2014.

Date	Site	Evening bat	Tricolored bat	Hoary bat	Eastern red/ Seminole bat	Brazilian free-tailed bat	Southeastern myotis	Big brown/ silver-haired bat	Unidentified	Number of passes	Number of species
7 June 2014	Church Creek open saltwater 1	20	35	8	3	74	2	71	247	460	7
8 June 2014	Bear's Bluff cluttered saltwater 3	3	4	1	1	10	0	7	14	40	6
8 June 2014	Bear's Bluff open saltwater 3	3	0	0	3	9	0	4	29	48	4
9 June 2014	Magnolia Plantation open freshwater 2	11	135	9	4	82	0	38	401	680	6
9 June 2014	Magnolia Plantation open freshwater 3	1	22	1	1	11	0	9	46	91	6
10 June 2014	Caw Caw Interpretive Center cluttered brackish-water 3	8	190	0	2	2	0	5	46	253	5
10 June 2014	Caw Caw Interpretive Center cluttered freshwater 1	2	77	0	1	0	0	1	17	98	4
12 June 2014	James Island County Park open freshwater 1	2	0	0	0	1	0	1	23	27	3
12 June 2014	James Island County Park cluttered saltwater 2	7	2	1	0	6	0	4	15	35	5
13 June 2014	Caw Caw Interpretive Center open brackish-water 3	34	60	0	1	0	0	5	46	146	4
13 June 2014	Caw Caw Interpretive Center cluttered saltwater 1	0	14	0	0	0	0	0	10	24	1
14 June 2014	Magnolia Plantation cluttered brackish-water 1	150	3	0	0	0	0	0	30	183	2
14 June 2014	Magnolia Plantation open brackish-water 1	25	35	0	1	36	1	2	82	182	6
15 June 2014	Bear's Bluff cluttered saltwater 3	4	10	0	0	1	0	0	6	21	3
15 June 2014	Bear's Bluff open saltwater 3	9	5	0	10	6	0	4	32	66	5
15 June 2014	Church Creek open saltwater 1	38	8	1	5	21	1	25	121	220	7
18 June 2014	James Island County Park cluttered saltwater 2	16	9	0	4	20	0	4	38	91	5
18 June 2014	James Island County Park open saltwater 2	36	8	0	2	15	0	2	27	90	5
19 June 2014	Magnolia Plantation cluttered brackish-water 1	413	19	0	3	8	1	8	104	556	6
19 June 2014	Magnolia Plantation cluttered freshwater 2	140	310	0	18	100	0	81	345	994	5
19 June 2014	Magnolia Plantation open freshwater 3	3	30	0	2	3	1	3	43	85	6
20 June 2014	Caw Caw Interpretive Center cluttered brackish-water 2	4	63	0	0	0	0	4	30	101	3
20 June 2014	Caw Caw Interpretive Center open brackish-water 3	27	18	0	35	5	0	23	65	173	5
21 June 2014	James Island County Park open freshwater 1	57	15	0	2	71	0	4	179	328	5
3 July 2014	Magnolia Plantation cluttered brackish-water 1	26	71	0	0	1	0	0	21	119	3
3 July 2014	Magnolia Plantation cluttered freshwater 2	31	272	0	7	11	0	21	147	489	5
4 July 2014	Caw Caw Interpretive Center open brackish-water 3	48	172	0	10	5	0	0	58	293	4
4 July 2014	Caw Caw Interpretive Center cluttered saltwater 1	23	88	0	3	0	1	0	43	158	4
5 July 2014	Caw Caw Interpretive Center cluttered brackish-water 2	3	61	0	0	0	0	0	19	83	2
5 July 2014	Caw Caw Interpretive Center open brackish-water 2	21	670	0	12	0	0	3	88	794	4

Appendix 1.---Continued.

6 July 2014	Magnolia Plantation cluttered freshwater 3	14	13	0	0	0	0	0	15	42	2
6 July 2014	Magnolia Plantation open freshwater 3	11	10	0	2	12	1	1	22	59	6
17 July 2014	Caw Caw Interpretive Center cluttered brackish-water 2	16	111	0	19	0	0	1	55	202	4
17 July 2014	Caw Caw Interpretive Center cluttered brackish-water 3	14	109	0	7	0	0	0	69	199	3
17 July 2014	Caw Caw Interpretive Center cluttered freshwater 1	19	86	0	7	0	0	2	56	170	4
18 July 2014	Caw Caw Interpretive Center open brackish-water 2	55	1,112	0	33	0	2	1	143	1,346	5
18 July 2014	Caw Caw Interpretive Center open brackish-water 3	136	199	0	55	1	1	0	189	581	5
18 July 2014	Caw Caw Interpretive Center cluttered saltwater 1	27	25	0	9	0	0	0	60	121	3
19 July 2014	Bear’s Bluff cluttered saltwater 3	6	21	0	3	0	0	4	26	60	4
19 July 2014	Bear’s Bluff open saltwater 3	19	47	1	19	20	0	5	38	149	6
19 July 2014	Church Creek open saltwater 1	38	30	2	73	106	4	5	271	529	7
21 July 2014	Magnolia Plantation cluttered brackish-water 1	10	17	0	0	1	0	1	28	57	4
21 July 2014	Magnolia Plantation cluttered freshwater 2	26	33	0	7	16	0	8	50	140	5
21 July 2014	Magnolia Plantation open freshwater 3	10	24	0	2	5	0	2	55	98	5
24 July 2014	Magnolia Plantation open brackish-water 1	20	39	0	2	24	2	10	71	168	6
24 July 2014	Magnolia Plantation cluttered freshwater 3	50	48	0	9	3	0	15	107	232	5
26 July 2014	Caw Caw Interpretive Center open brackish-water 2	66	763	0	13	0	3	1	206	1,052	5
26 July 2014	Caw Caw Interpretive Center open brackish-water 3	101	247	1	31	0	1	7	223	611	6
26 July 2014	Caw Caw Interpretive Center cluttered saltwater 1	25	116	0	8	0	0	0	51	200	3
27 July 2014	Caw Caw Interpretive Center cluttered brackish-water 2	40	116	0	8	0	0	1	84	249	4
27 July 2014	Caw Caw Interpretive Center cluttered brackish-water 3	13	87	0	2	0	0	4	68	174	4
27 July 2014	Caw Caw Interpretive Center cluttered freshwater 1	16	60	0	2	0	0	2	62	142	4
28 July 2014	Magnolia Plantation open brackish-water 1	8	43	0	0	4	2	4	72	133	5
28 July 2014	Magnolia Plantation cluttered freshwater 3	27	21	1	13	16	0	93	170	341	7
28 July 2014	Magnolia Plantation open freshwater 2	29	52	0	8	22	0	9	165	285	5
29 July 2014	James Island County Park open freshwater 1	95	12	0	10	225	0	18	532	892	5
29 July 2014	James Island County Park cluttered saltwater 2	27	14	0	17	72	0	13	123	266	5
29 July 2014	James Island County Park open saltwater 2	43	10	1	10	33	0	13	116	226	6
4 August 2014	Caw Caw Interpretive Center open brackish-water 2	54	593	0	21	2	6	8	178	862	6
4 August 2014	Caw Caw Interpretive Center open brackish-water 3	130	253	0	44	1	0	2	170	600	5
4 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	49	220	0	26	0	0	9	92	396	4
5 August 2014	Bear’s Bluff cluttered saltwater 3	13	24	0	5	2	0	4	30	78	5
5 August 2014	Bear’s Bluff open saltwater 3	18	27	0	7	18	0	7	46	123	5
5 August 2014	Church Creek open saltwater 1	43	69	1	30	46	0	12	269	470	6
6 August 2014	Magnolia Plantation cluttered brackish-water 1	12	9	0	1	6	0	3	43	74	5
6 August 2014	Magnolia Plantation cluttered freshwater 2	22	37	0	6	5	0	4	80	154	5
6 August 2014	Magnolia Plantation open freshwater 3	10	21	1	6	33	0	7	137	215	6
7 August 2014	James Island County Park open freshwater 1	79	36	2	7	89	2	8	290	513	7
7 August 2014	James Island County Park cluttered saltwater 2	26	23	0	1	27	0	3	53	133	5
7 August 2014	James Island County Park open saltwater 2	26	35	0	3	2	0	3	58	127	5
8 August 2014	Bear’s Bluff cluttered saltwater 3	1	18	0	2	0	0	1	16	38	4
8 August 2014	Bear’s Bluff open saltwater 3	27	63	0	25	8	0	4	89	216	5

Appendix 1.---Continued.

8 August 2014	Church Creek open saltwater 1	92	54	1	303	69	0	13	669	1,201	6
12 August 2014	Magnolia Plantation cluttered freshwater 3	23	5	0	9	4	0	6	66	113	5
12 August 2014	Magnolia Plantation open freshwater 2	18	232	0	2	0	0	0	27	279	3
12 August 2014	Magnolia Plantation open freshwater 3	11	14	0	17	9	0	2	91	144	6
13 August 2014	Caw Caw Interpretive Center open brackish-water 2	27	143	0	5	1	2	1	64	243	6
13 August 2014	Caw Caw Interpretive Center open brackish-water 3	29	338	0	8	0	0	3	135	513	4
13 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	13	199	0	0	0	0	0	74	286	2
14 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	40	176	0	0	1	0	2	65	284	4
14 August 2014	Caw Caw Interpretive Center cluttered freshwater 1	12	50	0	3	0	1	0	50	116	4
15 August 2014	Bear’s Bluff cluttered saltwater 3	6	10	0	1	0	0	0	18	35	3
15 August 2014	Bear’s Bluff open saltwater 3	49	49	1	272	20	0	14	433	838	6
15 August 2014	Church Creek open saltwater 1	73	74	0	154	69	1	7	769	1,147	6
16 August 2014	Caw Caw Interpretive Center open brackish-water 2	13	336	0	2	0	0	0	119	470	2
16 August 2014	Caw Caw Interpretive Center open brackish-water 3	18	371	0	17	0	0	3	183	592	4
16 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	5	58	0	3	1	0	1	95	163	5
17 August 2014	James Island County Park open freshwater 1	125	32	2	56	57	0	88	1,022	1,382	6
17 August 2014	James Island County Park cluttered saltwater 2	28	16	0	2	22	0	4	77	149	5
17 August 2014	James Island County Park open saltwater 2	29	30	0	4	14	0	2	95	174	5
20 August 2014	Magnolia Plantation cluttered brackish-water 1	4	13	3	0	0	0	0	16	36	3
20 August 2014	Magnolia Plantation cluttered freshwater 3	16	12	0	2	0	0	7	69	106	4
20 August 2014	Magnolia Plantation open freshwater 3	17	111	1	22	21	1	7	285	465	7
21 August 2014	Magnolia Plantation open brackish-water 1	13	43	0	2	3	0	2	95	158	5
21 August 2014	Magnolia Plantation cluttered freshwater 2	15	26	0	8	3	0	3	63	118	5
21 August 2014	Magnolia Plantation open freshwater 2	13	290	0	1	4	0	2	66	376	7
22 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	2	37	0	0	0	0	0	36	75	2
22 August 2014	Caw Caw Interpretive Center cluttered brackish-water 3	5	90	0	1	0	0	4	64	164	4
22 August 2014	Caw Caw Interpretive Center cluttered freshwater 1	37	92	0	0	1	2	5	52	189	6
24 August 2014	Caw Caw Interpretive Center open brackish-water 2	37	128	3	7	0	0	1	221	397	5
24 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	2	36	0	5	0	0	0	67	110	3
25 August 2014	Magnolia Plantation cluttered brackish-water 1	7	21	0	0	0	0	0	45	73	2
25 August 2014	Magnolia Plantation cluttered freshwater 2	63	33	0	1	2	0	0	125	224	4
25 August 2014	Magnolia Plantation open freshwater 3	132	393	0	27	32	1	10	461	1,056	6
26 August 2014	James Island County Park open freshwater 1	93	58	1	217	553	0	286	2,735	3,943	7
26 August 2014	James Island County Park cluttered saltwater 2	40	26	0	8	24	0	13	89	200	5
26 August 2014	James Island County Park open saltwater 2	255	239	0	5	23	0	14	160	696	5
27 August 2014	Magnolia Plantation open brackish-water 1	37	85	1	14	8	0	5	141	291	6
27 August 2014	Magnolia Plantation cluttered freshwater 3	8	18	0	5	2	2	4	54	93	6
27 August 2014	Magnolia Plantation open freshwater 2	289	500	0	8	4	0	0	278	1,079	4
28 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	8	60	0	3	3	1	3	35	113	5
28 August 2014	Caw Caw Interpretive Center cluttered brackish-water 3	10	123	0	16	3	0	3	72	227	5
28 August 2014	Caw Caw Interpretive Center open brackish-water 3	93	196	0	26	0	1	3	213	532	5
29 August 2014	Bear’s Bluff cluttered saltwater 3	4	18	0	6	5	1	3	41	78	6

Appendix 1.---Continued.

29 August 2014	Bear’s Bluff open saltwater 3	4	13	0	244	8	0	6	338	613	5
29 August 2014	Church Creek open saltwater 1	52	88	4	392	69	0	23	959	1,587	6
30 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	7	42	0	0	0	1	0	29	79	3
30 August 2014	Caw Caw Interpretive Center cluttered brackish-water 3	18	109	0	6	3	0	1	102	239	5
30 August 2014	Caw Caw Interpretive Center cluttered freshwater 1	16	46	0	8	4	1	1	56	132	6
31 August 2014	Caw Caw Interpretive Center open brackish-water 2	13	218	0	16	0	0	1	136	384	4
31 August 2014	Caw Caw Interpretive Center open brackish-water 3	43	553	0	22	3	1	4	222	852	7
31 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	35	67	0	7	0	0	2	106	217	4
1 September 2014	Magnolia Plantation cluttered brackish-water 1	114	26	0	0	7	0	0	79	226	3
1 September 2014	Magnolia Plantation cluttered freshwater 2	82	103	0	0	5	0	9	156	355	4
1 September 2014	Magnolia Plantation open freshwater 3	11	51	0	5	5	1	2	83	158	6
2 September 2014	Magnolia Plantation cluttered freshwater 3	19	20	0	1	1	0	19	37	97	5
3 September 2014	James Island County Park open freshwater 1	51	54	0	70	403	0	21	1,161	1,760	6
3 September 2014	James Island County Park cluttered saltwater 2	35	34	0	1	47	1	15	55	188	6
3 September 2014	James Island County Park open saltwater 2	35	48	0	2	14	0	11	101	211	5
4 September 2014	Magnolia Plantation open brackish-water 1	20	44	0	13	18	0	1	209	305	5
4 September 2014	Magnolia Plantation open freshwater 2	31	1,625	0	1	4	0	0	379	2,040	4
6 September 2014	Bear’s Bluff cluttered saltwater 3	3	13	0	6	3	0	3	22	50	5
6 September 2014	Bear’s Bluff open saltwater 3	4	8	0	89	3	0	2	194	300	5
6 September 2014	Church Creek open saltwater 1	17	21	6	466	83	0	5	959	1,557	6
18 September 2014	Magnolia Plantation open brackish-water 1	14	29	0	5	16	0	0	80	144	4
18 September 2014	Magnolia Plantation cluttered freshwater 2	30	49	0	1	4	0	4	72	160	5
21 September 2014	Magnolia Plantation cluttered freshwater 3	7	8	0	0	5	0	2	35	57	4
21 September 2014	Magnolia Plantation open freshwater 3	57	907	0	1	3	0	6	380	1,354	5
24 September 2014	James Island County Park open freshwater 1	73	21	2	51	771	0	287	2,128	3,333	6
24 September 2014	James Island County Park open saltwater 2	2	31	0	7	22	0	3	79	144	5
25 September 2014	Caw Caw Interpretive Center open brackish-water 3	121	161	0	3	0	0	2	173	462	5
25 September 2014	Caw Caw Interpretive Center cluttered saltwater 1	3	24	0	1	1	0	0	31	60	4
27 September 2014	Bear’s Bluff cluttered saltwater 3	1	3	0	2	0	0	1	18	25	4
27 September 2014	Bear’s Bluff open saltwater 3	0	5	0	11	2	1	3	25	47	5
30 September 2014	Magnolia Plantation cluttered brackish-water 1	79	14	0	0	3	0	1	55	152	4
30 September 2014	Magnolia Plantation open freshwater 2	202	6,579	0	3	3	0	1	459	7,247	5
2 October 2014	Caw Caw Interpretive Center cluttered brackish-water 2	2	26	0	0	4	0	1	26	59	4
2 October 2014	Caw Caw Interpretive Center open brackish-water 2	2	88	0	2	4	1	0	74	171	5
4 October 2014	Caw Caw Interpretive Center cluttered brackish-water 3	0	22	1	7	9	0	18	97	154	5
4 October 2014	Caw Caw Interpretive Center cluttered freshwater 1	0	11	0	4	8	0	3	57	83	4
6 October 2014	Magnolia Plantation open brackish-water 1	18	23	1	4	98	1	8	86	239	8
6 October 2014	Magnolia Plantation open freshwater 2	263	1,513	0	5	302	0	295	840	3,218	5
7 October 2014	Magnolia Plantation cluttered freshwater 2	198	86	1	1	62	0	24	165	537	7
8 October 2014	Magnolia Plantation cluttered brackish-water 1	87	57	0	0	5	0	0	97	246	3
8 October 2014	Magnolia Plantation open freshwater 3	4	143	1	4	13	1	0	111	277	6
9 October 2014	Caw Caw Interpretive Center cluttered brackish-water 2	0	12	0	0	11	0	0	31	54	2

Appendix 1.---Continued.

9 October 2014	Caw Caw Interpretive Center open brackish-water 2	1	31	4	0	14	0	0	38	88	4
10 October 2014	Bear's Bluff cluttered saltwater 3	2	2	0	5	3	0	2	10	24	5
10 October 2014	Bear's Bluff open saltwater 3	2	1	0	23	10	3	3	123	165	7
11 October 2014	Church Creek open saltwater 1	50	85	7	196	55	0	5	975	1,373	6
12 October 2014	Caw Caw Interpretive Center open brackish-water 3	36	190	1	8	23	0	24	193	477	8
12 October 2014	Caw Caw Interpretive Center cluttered saltwater 1	2	69	0	0	124	0	89	406	690	4
13 October 2014	James Island County Park cluttered saltwater 2	27	2	0	1	17	0	3	20	70	5
13 October 2014	James Island County Park open saltwater 2	24	5	0	0	13	0	5	34	81	4
15 October 2014	James Island County Park open freshwater 1	83	3	1	16	29	2	18	186	338	8
16 October 2014	Magnolia Plantation cluttered freshwater 3	1	8	1	2	5	1	3	30	51	7
17 October 2014	Caw Caw Interpretive Center cluttered brackish-water 3	0	107	3	6	11	0	14	95	236	5
17 October 2014	Caw Caw Interpretive Center cluttered freshwater 1	0	176	1	0	3	5	2	87	274	5
18 October 2014	Caw Caw Interpretive Center cluttered brackish-water 2	0	47	2	7	27	0	13	101	197	6
18 October 2014	Caw Caw Interpretive Center cluttered brackish-water 3	4	386	0	1	17	0	6	118	532	5
18 October 2014	Caw Caw Interpretive Center cluttered freshwater 1	0	280	0	2	8	1	6	170	467	5
20 October 2014	Magnolia Plantation cluttered brackish-water 1	2	12	3	1	8	0	0	33	59	5
20 October 2014	Magnolia Plantation cluttered freshwater 3	2	31	2	7	2	0	0	21	65	5
20 October 2014	Magnolia Plantation open freshwater 3	0	317	1	2	0	6	0	158	484	4
21 October 2014	Magnolia Plantation open brackish-water 1	11	9	0	4	16	1	3	55	99	6
21 October 2014	Magnolia Plantation cluttered freshwater 2	30	14	5	7	80	0	46	170	352	7
21 October 2014	Magnolia Plantation open freshwater 2	65	580	1	10	136	7	39	399	1,237	8
22 October 2014	James Island County Park open freshwater 1	0	1	1	3	18	1	6	41	71	6
22 October 2014	James Island County Park cluttered saltwater 2	2	7	0	0	26	0	10	56	101	4
22 October 2014	James Island County Park open saltwater 2	2	8	7	4	115	0	11	109	256	6
24 October 2014	Bear's Bluff cluttered saltwater 3	0	2	1	1	1	0	0	9	14	4
24 October 2014	Bear's Bluff open saltwater 3	0	0	0	1	0	0	1	4	6	2

Appendix 2.---Data recorded by weather station in Charleston County, South Carolina, June-October 2014.

Date	Average temperature (°C)	Average humidity (%)	Average wind speed (km/h)	Average barometric pressure (kPa)	Lunar illumination (percent at midnight)
7 June 2014	21.72	90.62	0	101.506	63
8 June 2014	24.63	91.88	1.25	101.28	73
9 June 2014	26.07	84.88	1.05	101.431	81
10 June 2014	25.03	86.69	0.17	101.544	89
12 June 2014	24.71	83.62	5.46	101.26	99
13 June 2014	24.12	86.85	0.28	101.384	100
14 June 2014	22.01	92.23	0.52	101.743	98
15 June 2014	24.59	87.58	0	101.081	94
18 June 2014	26.35	81.5	2.86	102.111	68
19 June 2014	23.47	85.77	0.69	101.824	57
20 June 2014	25.17	83.92	0.46	101.514	45
21 June 2014	27.05	84.54	1.43	101.088	35
3 July 2014	24.71	86.85	0.88	101.456	29
4 July 2014	24.33	85.96	0.04	101.952	38
5 July 2014	23.59	84.81	0.94	102.122	47
6 July 2014	22.23	90.38	0.19	101.85	57
17 July 2014	23.03	92.12	0	101.864	70
18 July 2014	22.52	89.77	0.1	101.998	60
19 July 2014	25.64	86.12	1.05	101.827	49
21 July 2014	24.6	83.54	0	101.805	29
24 July 2014	27.66	85.77	2.95	101.482	7
26 July 2014	26.52	91.38	0.28	101.611	1
27 July 2014	26.92	86.88	0	101.339	0
28 July 2014	25.83	80.15	0.47	101.133	2
29 July 2014	24.8	82.58	0.79	101.47	5
4 August 2014	23.4	93.38	0.6	101.56	52
5 August 2014	27.22	88.23	6.13	101.654	62
6 August 2014	23.79	91.31	0	101.478	73
7 August 2014	27.32	87.08	0.42	101.561	82
8 August 2014	25.92	87.77	3.07	101.743	90
12 August 2014	24.9	93.46	1.83	101.202	97
13 August 2014	24.63	91.65	0.22	101.46	91
14 August 2014	22.37	94.54	0	101.614	83
15 August 2014	25.97	87.04	0.36	101.596	74
16 August 2014	25.01	94.42	0.27	101.699	64
17 August 2014	27.51	83.04	6.24	101.601	53
20 August 2014	25.72	92.96	0.32	101.718	24
21 August 2014	26.49	93.04	0.08	101.797	17
22 August 2014	26.21	94.69	0	101.45	10
24 August 2014	22.35	81.27	1.44	101.607	2
25 August 2014	23.38	82.65	4.55	101.74	0
26 August 2014	23.39	78.77	3.04	101.684	0

Appendix 2.---Continued.

27 August 2014	21.77	90.19	0.12	101.648	2
28 August 2014	19.9	95.77	0	101.755	6
29 August 2014	24.5	91.92	0.08	102.071	12
30 August 2014	23.04	95.92	0	102.135	19
31 August 2014	24.7	95	0.28	102.016	27
1 September 2014	25.41	94.69	0.18	101.93	37
2 September 2014	25.68	93.38	0.55	101.796	47
3 September 2014	26.62	87.12	1.41	101.998	58
4 September 2014	25.63	91.54	0.61	102.11	69
6 September 2014	25.42	91.77	1.13	101.564	88
18 September 2014	22.52	95.23	0.57	101.607	30
21 September 2014	20.85	95.42	0.31	101.45	8
24 September 2014	18.58	96.69	6.33	102.054	0
25 September 2014	20.78	97.62	0.87	101.92	1
27 September 2014	22.14	92.04	8.61	101.895	8
30 September 2014	17.92	97.42	0.08	101.257	33
2 October 2014	18.11	97.27	0	101.775	55
4 October 2014	10.31	89.58	0	101.253	76
6 October 2014	16.07	94.58	0.28	101.923	93
7 October 2014	19.58	96.35	0	101.821	98
8 October 2014	20.97	96.31	0.5	101.83	100
9 October 2014	17.19	93.42	0	101.958	99
10 October 2014	22.3	93.23	0.415	101.756	96
11 October 2014	22.68	95.62	0.08	101.705	90
12 October 2014	22.37	95.65	1.17	102.128	83
13 October 2014	25.22	90.31	6.01	101.906	75
15 October 2014	16.5	89.04	1.03	101.127	56
16 October 2014	12.1	96.27	0	101.097	46
17 October 2014	14.02	97.85	0	101.102	37
18 October 2014	15.15	92.15	0.18	101.29	28
20 October 2014	16.32	98.08	0.22	101.474	13
21 October 2014	15.7	87.04	3.39	101.312	7
22 October 2014	12.3	82.42	2.29	101.644	3
24 October 2014	13.34	93.08	0.39	101.437	0

Appendix 3.---Insects and spiders collected from light traps in Charleston County, South Carolina, June-October 2014.

Date	Site	Total Insects	Diptera	Odonata	Hymenoptera	Coleoptera	Lepidoptera	Orthoptera	Hemiptera	Spiders	Neuroptera	Trichoptera	Ephemeroptera	Strepsiptera	Psocoptera	Blattodea	Dermaptera	Mantodea	Isoptera
7 June 2014	Church Creek open saltwater 1	166	29	0	33	28	6	0	69	0	0	0	0	0	0	1	0	0	0
8 June 2014	Bear's Bluff cluttered saltwater 3	6,271	66	0	50	175	26	1	5,925	1	0	9	4	2	12	0	0	0	0
8 June 2014	Bear's Bluff open saltwater 3	143	12	0	20	31	8	0	72	0	0	0	0	0	0	0	0	0	0
9 June 2014	Magnolia Plantation open freshwater 2	1,954	392	3	28	1,387	38	0	63	0	0	27	0	0	16	0	0	0	0
9 June 2014	Magnolia Plantation open freshwater 3	8,050	141	1	81	6,695	184	0	910	0	0	28	0	0	5	0	2	0	3
10 June 2014	Caw Caw Interpretive Center cluttered brackish-water 3	2,607	15	0	30	2,008	293	0	244	0	0	17	0	0	0	0	0	0	0
10 June 2014	Caw Caw Interpretive Center cluttered freshwater 1	4,063	35	1	46	3,086	365	0	457	0	0	73	0	0	0	0	0	0	0
12 June 2014	James Island County Park open freshwater 1	589	244	0	29	165	13	1	57	1	0	16	26	0	1	0	0	0	36
12 June 2014	James Island County Park cluttered saltwater 2	104	48	0	32	13	4	0	7	0	0	0	0	0	0	0	0	0	0
13 June 2014	Caw Caw Interpretive Center open brackish-water 3	346	17	0	4	249	62	0	6	0	0	8	0	0	0	0	0	0	0
13 June 2014	Caw Caw Interpretive Center cluttered saltwater 1	5,125	59	0	50	4,614	86	0	301	0	0	4	0	0	1	0	4	0	6
14 June 2014	Magnolia Plantation cluttered brackish-water 1	2,396	184	0	49	1,873	41	0	243	0	0	6	0	0	0	0	0	0	0
14 June 2014	Magnolia Plantation open brackish-water 1	1,907	204	0	161	1,151	131	0	242	0	1	17	0	0	0	0	0	0	0
15 June 2014	Bear's Bluff cluttered saltwater 3	2,231	105	1	353	468	15	8	1,121	0	0	1	145	5	9	0	0	0	0
15 June 2014	Bear's Bluff open saltwater 3	1,025	374	2	363	167	28	7	83	0	0	0	0	0	1	0	0	0	0
15 June 2014	Church Creek open saltwater 1	505	133	0	121	145	15	1	77	1	0	5	1	0	3	0	0	0	3

Appendix 3.---Continued.

18 June 2014	James Island County Park cluttered saltwater 2	65	16	0	4	36	4	1	3	1	0	0	0	0	0	0	0	0	0
18 June 2014	James Island County Park open saltwater 2	188	29	0	37	88	15	0	18	1	0	0	0	0	0	0	0	0	0
19 June 2014	Magnolia Plantation cluttered brackish-water 1	2,283	305	0	45	1,788	60	0	79	1	0	4	1	0	0	0	0	0	0
19 June 2014	Magnolia Plantation cluttered freshwater 2	1,409	53	1	101	1,107	59	1	54	0	1	31	0	1	0	0	0	0	0
19 June 2014	Magnolia Plantation open freshwater 3	3,377	219	0	119	2,708	122	1	186	1	2	18	1	0	0	0	0	0	0
20 June 2014	Caw Caw Interpretive Center cluttered brackish-water 2	1,117	1	2	103	960	6	1	44	0	0	0	0	0	0	0	0	0	0
20 June 2014	Caw Caw Interpretive Center open brackish-water 3	791	3	1	23	731	12	2	19	0	0	0	0	0	0	0	0	0	0
21 June 2014	James Island County Park open freshwater 1	1,733	279	2	563	620	84	14	34	0	1	49	83	1	2	0	0	0	1
3 July 2014	Magnolia Plantation cluttered brackish-water 1	1,907	129	1	306	1,342	35	0	82	0	0	7	3	0	1	0	1	0	0
3 July 2014	Magnolia Plantation cluttered freshwater 2	932	28	0	619	242	26	0	10	1	0	6	0	0	0	0	0	0	0
4 July 2014	Caw Caw Interpretive Center open brackish-water 3	7,671	63	0	7	7,045	64	3	477	0	0	12	0	0	0	0	0	0	0
4 July 2014	Caw Caw Interpretive Center cluttered saltwater 1	12,446	108	0	16	11,637	92	22	555	0	0	16	0	0	0	0	0	0	0
5 July 2014	Caw Caw Interpretive Center cluttered brackish-water 2	1,990	273	0	197	1,283	123	2	98	1	1	11	0	0	0	1	0	0	0
5 July 2014	Caw Caw Interpretive Center open brackish-water 2	1,054	94	0	22	831	69	2	27	1	0	7	1	0	0	0	0	0	0
6 July 2014	Magnolia Plantation cluttered freshwater 3	1,009	89	0	24	763	76	0	45	0	1	11	0	0	0	0	0	0	0
6 July 2014	Magnolia Plantation open freshwater 3	3,668	52	1	128	3,346	55	4	72	1	0	8	0	0	1	0	0	0	0
17 July 2014	Caw Caw Interpretive Center cluttered brackish-water 2	4,498	254	0	149	3,708	81	0	296	0	0	4	0	0	0	0	6	0	0
17 July 2014	Caw Caw Interpretive Center cluttered brackish-water 3	3,329	53	1	27	3,044	47	0	154	1	1	1	0	0	0	0	0	0	0
17 July 2014	Caw Caw Interpretive Center cluttered freshwater 1	2,555	171	1	73	2,071	99	0	126	0	0	10	1	0	0	0	3	0	0

Appendix 3.---Continued.

18 July 2014	Caw Caw Interpretive Center open brackish-water 2	6,244	231	1	58	5,691	60	1	192	0	0	10	0	0	0	0	0	0	0
18 July 2014	Caw Caw Interpretive Center open brackish-water 3	3,054	50	0	46	2,842	55	0	59	1	0	0	0	0	0	0	1	0	0
18 July 2014	Caw Caw Interpretive Center cluttered saltwater 1	1,158	121	0	62	886	33	2	52	0	0	2	0	0	0	0	0	0	0
19 July 2014	Bear’s Bluff cluttered saltwater 3	1,565	116	0	354	280	76	1	239	0	0	58	433	2	6	0	0	0	0
19 July 2014	Bear’s Bluff open saltwater 3	643	46	0	307	198	7	1	73	1	0	2	3	0	4	0	0	1	0
19 July 2014	Church Creek open saltwater 1	448	63	0	207	49	11	0	117	0	0	1	0	0	0	0	0	0	0
21 July 2014	Magnolia Plantation cluttered brackish-water 1	2,669	107	2	875	1,543	50	0	82	2	0	2	0	4	0	0	2	0	0
21 July 2014	Magnolia Plantation cluttered freshwater 2	723	67	1	138	433	51	1	26	0	0	5	0	0	1	0	0	0	0
21 July 2014	Magnolia Plantation open freshwater 3	2,958	44	0	329	2,408	48	6	117	0	0	4	0	0	0	2	0	0	0
24 July 2014	Magnolia Plantation open brackish-water 1	2,721	66	1	144	2,462	12	2	32	1	0	1	0	0	0	0	0	0	0
24 July 2014	Magnolia Plantation cluttered freshwater 3	2,408	48	0	184	2,030	77	0	54	0	9	5	0	0	0	0	0	0	1
26 July 2014	Caw Caw Interpretive Center open brackish-water 2	6,447	359	2	331	4,962	119	2	625	0	1	37	3	1	1	0	4	0	0
26 July 2014	Caw Caw Interpretive Center open brackish-water 3	1,489	43	0	157	964	145	11	163	0	0	4	1	0	1	0	0	0	0
26 July 2014	Caw Caw Interpretive Center cluttered saltwater 1	3,568	108	1	2,037	1,089	78	1	238	1	0	13	1	0	1	0	0	0	0
27 July 2014	Caw Caw Interpretive Center cluttered brackish-water 2	1,763	152	1	111	1,053	82	3	337	0	1	18	0	2	3	0	0	0	0
27 July 2014	Caw Caw Interpretive Center cluttered brackish-water 3	876	40	0	34	496	132	1	162	0	2	8	0	1	0	0	0	0	0
27 July 2014	Caw Caw Interpretive Center cluttered freshwater 1	1,215	41	0	26	975	36	1	122	0	0	13	1	0	0	0	0	0	0
28 July 2014	Magnolia Plantation open brackish-water 1	1,297	66	0	11	1,132	33	1	52	0	0	2	0	0	0	0	0	0	0
28 July 2014	Magnolia Plantation cluttered freshwater 3	651	61	0	14	518	32	0	21	2	0	3	0	0	0	0	0	0	0

Appendix 3.---Continued.

28 July 2014	Magnolia Plantation open freshwater 2	1,148	317	3	17	688	63	0	50	2	0	6	0	1	1	0	0	0	0
29 July 2014	James Island County Park open freshwater 1	1,316	298	1	190	458	51	1	87	0	0	15	213	0	2	0	0	0	0
29 July 2014	James Island County Park cluttered saltwater 2	574	213	0	149	148	31	1	18	1	0	3	2	0	8	0	0	0	0
29 July 2014	James Island County Park open saltwater 2	152	25	0	49	59	5	0	12	0	0	0	2	0	0	0	0	0	0
4 August 2014	Caw Caw Interpretive Center open brackish-water 2	3,242	136	0	50	2,801	52	0	187	1	0	12	0	2	1	0	0	0	0
4 August 2014	Caw Caw Interpretive Center open brackish-water 3	988	23	0	29	801	88	6	25	1	1	3	0	11	0	0	0	0	0
4 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	1,012	120	0	522	239	75	4	34	2	0	4	0	12	0	0	0	0	0
5 August 2014	Bear’s Bluff cluttered saltwater 3	3,602	226	0	875	728	38	3	1,715	5	0	7	1	2	2	0	0	0	0
5 August 2014	Bear’s Bluff open saltwater 3	190	113	0	4	38	3	0	30	0	0	0	0	0	0	0	2	0	0
5 August 2014	Church Creek open saltwater 1	716	35	0	140	256	8	2	268	1	0	4	0	0	1	0	1	0	0
6 August 2014	Magnolia Plantation cluttered brackish-water 1	1,438	46	0	108	1,201	30	0	45	4	0	4	0	0	0	0	0	0	0
6 August 2014	Magnolia Plantation cluttered freshwater 2	746	58	0	39	456	141	0	22	1	23	4	0	0	0	2	0	0	0
6 August 2014	Magnolia Plantation open freshwater 3	2,960	22	1	187	2,540	76	1	120	1	0	11	0	1	0	0	0	0	0
7 August 2014	James Island County Park open freshwater 1	1,835	163	1	389	854	48	2	267	0	0	30	80	0	1	0	0	0	0
7 August 2014	James Island County Park cluttered saltwater 2	664	54	0	81	352	15	0	152	0	0	2	0	5	2	0	1	0	0
7 August 2014	James Island County Park open saltwater 2	616	147	0	77	116	14	0	260	1	0	0	0	0	0	0	1	0	0
8 August 2014	Bear’s Bluff cluttered saltwater 3	1,255	589	0	60	178	45	0	359	0	0	8	3	9	4	0	0	0	0
8 August 2014	Bear’s Bluff open saltwater 3	1,007	722	0	24	46	21	0	189	0	0	1	1	1	2	0	0	0	0
8 August 2014	Church Creek open saltwater 1	1,501	1339	0	33	37	4	2	82	1	0	3	0	0	0	0	0	0	0
12 August 2014	Magnolia Plantation cluttered freshwater 3	360	27	0	13	242	27	0	47	2	1	0	0	0	0	0	0	0	1

Appendix 3.---Continued.

12 August 2014	Magnolia Plantation open freshwater 2	174	28	3	20	84	32	0	3	3	0	1	0	0	0	0	0	0	0
12 August 2014	Magnolia Plantation open freshwater 3	1,015	66	1	21	846	25	1	47	0	5	2	0	0	1	0	0	0	0
13 August 2014	Caw Caw Interpretive Center open brackish-water 2	3,528	85	2	47	3,103	57	7	183	0	1	41	0	0	0	0	2	0	0
13 August 2014	Caw Caw Interpretive Center open brackish-water 3	1,982	28	0	10	1,800	74	2	55	1	1	11	0	0	0	0	0	0	0
13 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	3,578	48	0	148	3,069	79	8	205	3	0	13	1	1	0	0	3	0	0
14 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	983	52	1	63	773	40	0	45	0	0	5	4	0	0	0	0	0	0
14 August 2014	Caw Caw Interpretive Center cluttered freshwater 1	833	32	0	260	496	23	0	13	1	1	4	3	0	0	0	0	0	0
15 August 2014	Bear’s Bluff cluttered saltwater 3	1,748	161	0	208	363	31	3	908	0	0	5	51	7	10	0	1	0	0
15 August 2014	Bear’s Bluff open saltwater 3	475	139	0	13	52	14	0	253	0	0	1	0	0	3	0	0	0	0
15 August 2014	Church Creek open saltwater 1	295	106	0	41	73	6	0	58	0	0	1	0	2	2	0	6	0	0
16 August 2014	Caw Caw Interpretive Center open brackish-water 2	721	24	0	8	603	38	1	30	0	0	14	3	0	0	0	0	0	0
16 August 2014	Caw Caw Interpretive Center open brackish-water 3	904	86	0	24	654	95	1	39	0	1	4	0	0	0	0	0	0	0
16 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	895	44	0	77	697	42	0	28	1	0	4	0	2	0	0	0	0	0
17 August 2014	James Island County Park open freshwater 1	718	182	0	71	240	49	0	60	1	0	17	98	0	0	0	0	0	0
17 August 2014	James Island County Park cluttered saltwater 2	211	135	0	0	48	9	0	19	0	0	0	0	0	0	0	0	0	0
17 August 2014	James Island County Park open saltwater 2	766	218	0	5	292	3	0	241	1	0	3	2	1	0	0	0	0	0
20 August 2014	Magnolia Plantation cluttered brackish-water 1	1,480	147	0	116	1,035	54	0	119	0	1	8	0	0	0	0	0	0	0
20 August 2014	Magnolia Plantation cluttered freshwater 3	894	42	0	55	716	46	0	32	0	1	2	0	0	0	0	0	0	0
20 August 2014	Magnolia Plantation open freshwater 3	2,474	111	0	192	2,026	75	4	57	0	1	8	0	0	0	0	0	0	0
21 August 2014	Magnolia Plantation open brackish-water 1	5,083	83	0	44	4,736	69	3	137	0	0	3	0	0	1	0	6	0	1

Appendix 3.---Continued.

21 August 2014	Magnolia Plantation cluttered freshwater 2	787	50	1	75	504	98	0	55	0	0	4	0	0	0	0	0	0	0
21 August 2014	Magnolia Plantation open freshwater 2	815	53	2	278	294	133	0	49	1	0	5	0	0	0	0	0	0	0
22 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	1,013	66	1	23	743	64	0	101	3	0	7	4	0	0	0	1	0	0
22 August 2014	Caw Caw Interpretive Center cluttered brackish-water 3	2,482	140	0	13	1,774	198	1	256	0	2	18	78	0	0	1	1	0	0
22 August 2014	Caw Caw Interpretive Center cluttered freshwater 1	1,862	131	0	33	1,499	24	0	135	0	0	10	27	0	1	0	1	0	1
24 August 2014	Caw Caw Interpretive Center open brackish-water 2	582	123	0	14	383	34	0	14	0	0	13	0	0	1	0	0	0	0
24 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	327	114	0	11	131	46	0	18	0	0	5	1	0	0	0	1	0	0
25 August 2014	Magnolia Plantation cluttered brackish-water 1	124	69	0	2	23	19	0	9	0	0	2	0	0	0	0	0	0	0
25 August 2014	Magnolia Plantation cluttered freshwater 2	2,030	1,492	1	2	383	63	0	26	1	5	57	0	0	0	0	0	0	0
25 August 2014	Magnolia Plantation open freshwater 3	808	302	0	3	325	137	0	20	1	3	17	0	0	0	0	0	0	0
26 August 2014	James Island County Park open freshwater 1	2,689	1,012	0	3	1,492	65	0	26	0	0	24	66	0	1	0	0	0	0
26 August 2014	James Island County Park cluttered saltwater 2	745	202	0	23	406	5	0	106	0	0	0	0	0	2	0	0	0	1
26 August 2014	James Island County Park open saltwater 2	307	45	0	7	81	1	0	173	0	0	0	0	0	0	0	0	0	0
27 August 2014	Magnolia Plantation open brackish-water 1	1,554	64	0	7	1,437	22	0	19	1	1	1	0	1	0	0	1	0	0
27 August 2014	Magnolia Plantation cluttered freshwater 3	365	92	0	2	165	89	0	14	0	0	3	0	0	0	0	0	0	0
27 August 2014	Magnolia Plantation open freshwater 2	402	54	0	31	226	78	2	4	1	0	6	0	0	0	0	0	0	0
28 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	543	62	0	8	452	12	0	5	1	0	3	0	0	0	0	0	0	0
28 August 2014	Caw Caw Interpretive Center cluttered brackish-water 3	1,118	170	0	4	880	37	2	14	1	0	10	0	0	0	0	0	0	0
28 August 2014	Caw Caw Interpretive Center open brackish-water 3	383	22	0	4	314	22	0	17	1	0	2	0	1	0	0	0	0	0

Appendix 3.---Continued.

29 August 2014	Bear's Bluff cluttered saltwater 3	565	32	0	27	288	8	1	172	3	0	3	23	7	1	0	0	0	0
29 August 2014	Bear's Bluff open saltwater 3	209	41	0	5	57	2	2	101	0	0	1	0	0	0	0	0	0	0
29 August 2014	Church Creek open saltwater 1	222	39	0	14	56	7	1	67	0	0	2	0	30	5	0	1	0	0
30 August 2014	Caw Caw Interpretive Center cluttered brackish-water 2	1,193	122	0	13	946	37	1	59	1	0	3	10	0	0	0	1	0	0
30 August 2014	Caw Caw Interpretive Center cluttered brackish-water 3	1,246	199	0	6	972	27	1	40	1	0	0	0	0	0	0	0	0	0
30 August 2014	Caw Caw Interpretive Center cluttered freshwater 1	1,063	115	2	24	860	32	0	22	1	0	4	2	0	0	0	1	0	0
31 August 2014	Caw Caw Interpretive Center open brackish-water 2	3,950	149	1	8	3,629	25	1	128	1	0	7	0	0	0	0	1	0	0
31 August 2014	Caw Caw Interpretive Center open brackish-water 3	1,131	32	0	8	995	37	3	54	0	0	1	0	1	0	0	0	0	0
31 August 2014	Caw Caw Interpretive Center cluttered saltwater 1	1,837	53	0	58	1,549	89	6	69	1	1	7	1	0	1	0	2	0	0
1 September 2014	Magnolia Plantation cluttered brackish-water 1	1,950	73	0	51	1,739	18	2	67	0	0	0	0	0	0	0	0	0	0
1 September 2014	Magnolia Plantation cluttered freshwater 2	499	82	0	9	265	83	0	55	0	0	4	0	1	0	0	0	0	0
1 September 2014	Magnolia Plantation open freshwater 3	2,134	127	0	85	1,803	49	0	63	0	0	6	0	0	1	0	0	0	0
2 September 2014	Magnolia Plantation cluttered freshwater 3	1,778	257	0	14	1,369	74	0	53	0	2	9	0	0	0	0	0	0	0
3 September 2014	James Island County Park open freshwater 1	1,323	313	0	358	277	48	0	120	1	0	12	187	7	0	0	0	0	0
3 September 2014	James Island County Park cluttered saltwater 2	1,433	1,267	0	4	80	20	0	57	0	0	0	0	0	5	0	0	0	0
3 September 2014	James Island County Park open saltwater 2	525	99	0	130	192	8	0	93	0	0	0	0	3	0	0	0	0	0
4 September 2014	Magnolia Plantation open brackish-water 1	1,982	137	3	160	1,414	49	1	214	0	0	2	1	1	0	0	0	0	0
4 September 2014	Magnolia Plantation open freshwater 2	659	80	0	129	191	212	0	35	1	0	6	0	3	0	0	0	2	0
6 September 2014	Bear's Bluff cluttered saltwater 3	1,435	164	0	19	87	14	0	1,093	2	0	1	3	50	2	0	0	0	0
6 September 2014	Bear's Bluff open saltwater 3	305	234	0	4	42	1	0	21	0	0	0	0	0	3	0	0	0	0

Appendix 3.---Continued.

6 September 2014	Church Creek open saltwater 1	89	57	0	4	11	1	0	16	0	0	0	0	0	0	0	0	0	0
18 September 2014	Magnolia Plantation open brackish-water 1	1,001	57	0	13	822	39	0	17	0	0	0	51	0	0	0	2	0	0
18 September 2014	Magnolia Plantation cluttered freshwater 2	169	53	0	1	74	36	0	4	0	0	0	0	1	0	0	0	0	0
21 September 2014	Magnolia Plantation cluttered freshwater 3	228	142	0	1	63	16	0	3	0	0	3	0	0	0	0	0	0	0
21 September 2014	Magnolia Plantation open freshwater 3	1,604	267	0	10	1,196	44	2	39	1	2	43	0	0	0	0	0	0	0
24 September 2014	James Island County Park open freshwater 1	131	116	0	0	0	10	0	0	0	0	0	5	0	0	0	0	0	0
24 September 2014	James Island County Park open saltwater 2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 September 2014	Caw Caw Interpretive Center open brackish-water 3	531	77	0	1	351	51	0	29	0	0	10	2	0	2	0	8	0	0
25 September 2014	Caw Caw Interpretive Center cluttered saltwater 1	290	49	0	0	168	36	0	19	2	0	7	3	0	0	0	6	0	0
27 September 2014	Bear’s Bluff cluttered saltwater 3	15	11	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
27 September 2014	Bear’s Bluff open saltwater 3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 September 2014	Magnolia Plantation cluttered brackish-water 1	138	68	0	0	43	12	0	8	0	0	7	0	0	0	0	0	0	0
30 September 2014	Magnolia Plantation open freshwater 2	265	37	0	9	152	34	0	4	1	1	24	0	1	0	0	2	0	0
2 October 2014	Caw Caw Interpretive Center cluttered brackish-water 2	141	46	0	1	83	7	0	2	0	0	1	0	0	0	0	1	0	0
2 October 2014	Caw Caw Interpretive Center open brackish-water 2	88	23	0	0	27	11	0	0	0	0	27	0	0	0	0	0	0	0
4 October 2014	Caw Caw Interpretive Center cluttered brackish-water 3	62	51	0	0	0	3	0	0	0	0	1	7	0	0	0	0	0	0
4 October 2014	Caw Caw Interpretive Center cluttered freshwater 1	7	5	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
6 October 2014	Magnolia Plantation open brackish-water 1	24	15	0	0	3	5	0	1	0	0	0	0	0	0	0	0	0	0
6 October 2014	Magnolia Plantation open freshwater 2	44	25	0	0	5	13	0	0	0	0	1	0	0	0	0	0	0	0

Appendix 3.---Continued.

7 October 2014	Magnolia Plantation cluttered freshwater 2	118	23	0	7	47	38	0	3	0	0	0	0	0	0	0	0	0	0
8 October 2014	Magnolia Plantation cluttered brackish-water 1	1,619	133	0	20	1,372	13	0	78	0	0	1	1	0	1	0	0	0	0
8 October 2014	Magnolia Plantation open freshwater 3	1,320	195	0	78	966	35	0	32	0	0	14	0	0	0	0	0	0	0
9 October 2014	Caw Caw Interpretive Center cluttered brackish-water 2	102	83	0	0	10	4	0	0	0	0	4	1	0	0	0	0	0	0
9 October 2014	Caw Caw Interpretive Center open brackish-water 2	107	48	0	0	7	15	0	2	0	0	34	1	0	0	0	0	0	0
10 October 2014	Bear's Bluff cluttered saltwater 3	297	142	0	5	105	6	0	24	0	0	0	14	0	1	0	0	0	0
10 October 2014	Bear's Bluff open saltwater 3	2,937	2,889	0	6	23	5	0	7	0	0	0	1	2	4	0	0	0	0
11 October 2014	Church Creek open saltwater 1	3,654	3,503	0	5	94	2	1	32	0	0	3	3	6	4	0	1	0	0
12 October 2014	Caw Caw Interpretive Center open brackish-water 3	183	47	0	6	102	19	1	6	0	0	2	0	0	0	0	0	0	0
12 October 2014	Caw Caw Interpretive Center cluttered saltwater 1	325	167	0	36	90	21	0	9	0	0	1	0	0	1	0	0	0	0
13 October 2014	James Island County Park cluttered saltwater 2	288	252	0	0	12	0	0	20	0	0	0	0	0	4	0	0	0	0
13 October 2014	James Island County Park open saltwater 2	210	45	0	3	70	0	0	92	0	0	0	0	0	0	0	0	0	0
15 October 2014	James Island County Park open freshwater 1	406	117	0	0	13	6	0	2	0	0	6	261	1	0	0	0	0	0
16 October 2014	Magnolia Plantation cluttered freshwater 3	27	25	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
17 October 2014	Caw Caw Interpretive Center cluttered brackish-water 3	94	80	0	0	0	9	0	1	2	0	2	0	0	0	0	0	0	0
17 October 2014	Caw Caw Interpretive Center cluttered freshwater 1	38	34	0	0	0	2	0	1	0	0	1	0	0	0	0	0	0	0
18 October 2014	Caw Caw Interpretive Center cluttered brackish-water 2	11	10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
18 October 2014	Caw Caw Interpretive Center cluttered brackish-water 3	199	157	0	0	11	25	0	2	2	0	2	0	0	0	0	0	0	0
18 October 2014	Caw Caw Interpretive Center cluttered freshwater 1	88	73	0	0	6	6	0	0	0	0	3	0	0	0	0	0	0	0

Appendix 3.---Continued.

20 October 2014	Magnolia Plantation cluttered brackish-water 1	182	146	0	0	10	16	0	1	0	0	9	0	0	0	0	0	0	0
20 October 2014	Magnolia Plantation cluttered freshwater 3	153	136	0	1	5	10	0	0	0	0	0	1	0	0	0	0	0	0
20 October 2014	Magnolia Plantation open freshwater 3	76	55	0	0	2	5	0	0	0	0	14	0	0	0	0	0	0	0
21 October 2014	Magnolia Plantation open brackish-water 1	39	9	0	0	4	26	0	0	0	0	0	0	0	0	0	0	0	0
21 October 2014	Magnolia Plantation cluttered freshwater 2	48	31	0	0	3	11	0	0	0	0	1	1	0	1	0	0	0	0
21 October 2014	Magnolia Plantation open freshwater 2	48	28	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0
22 October 2014	James Island County Park open freshwater 1	44	13	0	0	0	0	0	0	0	0	0	31	0	0	0	0	0	0
22 October 2014	James Island County Park cluttered saltwater 2	40	39	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
22 October 2014	James Island County Park open saltwater 2	22	21	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
24 October 2014	Bear’s Bluff cluttered saltwater 3	53	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 October 2014	Bear’s Bluff open saltwater 3	53	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 October 2014	Church Creek open saltwater 1	8	6	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Appendix 4.---Coefficient estimate of negative-binomial regression models ranked according to AIC_c for overall activity of bats in Charleston, South Carolina, June-October 2014.

Model	HabitatM	Habitat	Weather + HabitatM	Insect + HabitatM	Weather + Habitat	Insect + Habitat	GlobalM	Global	Null	Weather	Insect
Number of parameters	4	6	9	6	11	8	11	13	1	6	3
AIC_c	2,449.92	2,452.68	2,453.34	2,453.58	2,456.14	2,456.43	2,457.24	2,460.25	2,461.92	2,464.28	2,465.63
ΔAIC_c	0.00	2.75	3.42	3.65	6.22	6.50	7.32	10.33	12.00	14.35	15.71
ω_i	0.58	0.15	0.11	0.09	0.03	0.02	0.02	0.00	0.00	0.00	0.00
Intercept	110.28	105.43	0.00	94.63	0.00	89.12	0.00	0.00	288.01	0.00	254.68
Temperature (°C)			1.00		1.00		0.99	0.99		1.00	
Humidity (%)			1.01		1.01		1.01	1.01		1.00	
Wind speed (km/h)			0.97		0.96		0.97	0.97		0.97	
Barometric pressure (kPa)			1.58		1.59		1.58	1.58		1.59	
Lunar illumination (%)			1.00		1.00		1.00	1.00		1.00	
Freshwater[a]	2.18	1.94	2.14	2.21	1.89	2.01	2.12	1.97			
Brackish-water[a]	1.30	1.69	1.20	1.34	1.59	1.76	1.23	1.65			
Open[b]	3.41	3.75	3.27	3.39	3.63	3.82	3.25	3.74			
Freshwater: open		1.26			1.27	1.20		1.16			
Brackish-water: open		0.59			0.56	0.57		0.55			
Abundance of insects				1.00		1.00	1.00	1.00			1.00
Diversity of insects				1.15		1.14	1.19	1.17			1.12

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 5.---Standard errors of negative-binomial regression models ranked according to AIC_c for overall activity of bats in Charleston, South Carolina, June-October 2014.

Model	HabitatM	Habitat	Weather + HabitatM	Insect + HabitatM	Weather + Habitat	Insect + Habitat	GlobalM	Global	Null	Weather	Insect
Number of parameters	4	6	9	6	11	8	11	13	1	6	3
AIC_c	2,449.92	2,452.68	2,453.34	2,453.58	2,456.14	2,456.43	2,457.24	2,460.25	2,461.92	2,464.28	2,465.63
ΔAIC_c	0.00	2.75	3.42	3.65	6.22	6.50	7.32	10.33	12.00	14.35	15.71
ω_i	0.58	0.15	0.11	0.09	0.03	0.02	0.02	0.00	0.00	0.00	0.00
Intercept	1.31	1.36	1.65E+10	1.39	1.65E+10	1.45	1.78E+10	1.78E+10	1.23	2.05E+10	1.32
Temperature (°C)			1.02		1.02		1.022	1.02		1.02	
Humidity (%)			1.01		1.01		1.02	1.02		1.02	
Wind Speed (km/h)			1.04		1.04		1.04	1.04		1.04	
Barometric pressure (kPa)			1.27		1.26		1.27	1.27		1.27	
Lunar illumination (%)			1.00		1.00		1.00	1.00		1.00	
Freshwater[a]	1.39	1.55	1.40	1.39	1.55	1.55	1.39	1.55			
Brackish-water[a]	1.39	1.55	1.40	1.39	1.55	1.55	1.40	1.55			
Open[b]	1.30	1.52	1.30	1.30	1.50	1.52	1.30	1.50			
Freshwater: open		1.85			1.83	1.85		1.84			
Brackish-water: open		1.85			1.83	1.85		1.82			
Insect abundance				1.00		1.00	1.00	1.00			1.00
Insect diversity				1.19		1.19	1.23	1.24			1.19

[a] Salt water sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 6.---Coefficient estimates of negative binomial regression models ranked according to AIC_c for activity of evening bats (*Nycticeius humeralis*) in Charleston County, South Carolina, June-October 2014.

Model	GlobalM	Weather + HabitatM	Weather	Insect	Global	Insect + HabitatM	Weather + Habitat	Insect + Habitat	Null	HabitatM	Habitat
Number of parameters	11	9	6	3	13	6	11	8	1	4	6
AIC_c	1,603.94	1,604.64	1,605.48	1,607.63	1,608.15	1,608.28	1,608.74	1,612.23	1,616.22	1,616.62	1,620.58
ΔAIC_c	0.00	0.70	1.53	3.69	4.21	4.33	4.80	8.28	12.28	12.68	16.63
ω_i	0.37	0.26	0.17	0.06	0.05	0.04	0.03	0.01	0.00	0.00	0.00
Intercept	0.00	0.00	0.00	8.76	0.00	4.10	0.00	3.46	26.95	13.30	12.12
Temperature (°C)	1.09	1.12	1.12		1.09		1.12				
Humidity (%)	0.99	0.98	0.99		0.99		0.99				
Wind speed (km/h)	1.02	0.99	0.99		1.02		0.99				
Barometric pressure (kPa)	2.11	1.88	1.80		2.12		1.90				
Lunar illumination (%)	1.00	1.00	1.00		1.00		1.00				
Freshwater[a]	2.64	2.66			2.83	2.01	2.52	2.49		1.90	2.03
Brackish-water[a]	1.98	1.81			2.57	1.58	2.28	2.10		1.41	1.75
Open[b]	2.17	2.24			2.72	2.12	2.52	2.95		2.13	2.56
Freshwater: open					0.86		1.12	0.66			0.88
Brackish-water: open					0.59		0.63	0.57			0.65
Insect abundance	1.00			1.00	1.00	1.00		1.00			
Insect diversity	2.00			2.46	2.00	2.46		2.46			

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 7.---Standard errors of negative binomial regression models ranked according to AIC_c for activity of evening bats (*Nycticeius humeralis*) in Charleston County, South Carolina, June-October 2014.

Model	GlobalM	Weather + HabitatM	Weather	Insect	Global	Insect + HabitatM	Weather + Habitat	Insect + Habitat	Null	HabitatM	Habitat
Number of parameters	11	9	6	3	13	6	11	8	1	4	6
AIC_c	1,603.94	1,604.64	1,605.48	1,607.63	1,608.15	1,608.28	1,608.74	1,612.23	1,616.22	1,616.62	1,620.58
ΔAIC_c	0.00	0.70	1.53	3.69	4.21	4.33	4.80	8.28	12.28	12.68	16.63
ω_i	0.37	0.26	0.17	0.06	0.05	0.04	0.03	0.01	0.00	0.00	0.00
Intercept	6.45E+14	2.36E+14	2.03E+14	1.45	6.45E+14	1.63	2.54E+14	1.75	1.23	1.43	1.54
Temperature (°C)	1.03	1.03	1.03		1.03		1.03				
Humidity (%)	1.02	1.02	1.02		1.02		1.02				
Wind speed (km/h)	1.06	1.06	1.06		1.06		1.06				
Barometric pressure (kPa)	1.40	1.39	1.39		1.40		1.39				
Lunar illumination (%)	1.00	1.00	1.00		1.00		1.00				
Freshwater[a]	1.59	1.60			1.90	1.57	1.92			1.54	1.84
Brackish-water[a]	1.60	1.61			1.90	1.58	1.93			1.54	1.84
Open[b]	1.45	1.46			1.89	1.45	1.91			1.42	1.84
Freshwater: open					2.47		2.50				2.37
Brackish-water: open					2.45		2.50				2.37
Insect abundance	1.00			1.00	1.00	1.00		1.00			
Insect diversity	1.35			1.31	1.35	1.31		1.31			

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 8.---Coefficient estimates of negative binomial regression models ranked according to AIC_c for activity of tri-colored bats (*Perimyotis subflavus*) in Charleston County, South Caroline, June-October, 2014.

Model	Insect + HabitatM	HabitatM	Insect	Weather + HabitatM	Null	Insect + Habitat	Habitat	GlobalM	Weather	Weather + Habitat	Global
Number of parameters	6	4	3	9	1	8	6	11	6	11	13
AIC_c	1,963.88	1,964.02	1,967.03	1,967.04	1,967.12	1,968.23	1,968.28	1,968.94	1,969.28	1,971.44	1,973.45
ΔAIC_c	0.00	0.15	3.16	3.16	3.24	4.35	4.40	5.07	5.40	7.57	9.58
ω_i	0.34	0.32	0.07	0.07	0.07	0.04	0.04	0.03	0.02	0.01	0.00
Intercept	10.80	18.07	41.68	0.00	67.83	10.07	18.18	0.00	0.00	0.00	0.00
Temperature (°C)				1.05				1.03	1.05	1.05	1.03
Humidity (%)				1.02				1.03	1.02	1.02	1.03
Wind speed (km/h)				0.95				0.97	0.95	0.95	0.97
Barometric pressure (kPa)				1.13				1.09	1.15	1.13	1.10
Lunar illumination (%)				0.99				0.99	0.99	0.99	0.99
Freshwater[a]	3.53	3.38		3.24		3.82	3.20	3.13		3.14	3.39
Brackish-water[a]	3.53	3.33		3.01		3.94	3.45	3.03		3.41	3.56
Open[b]	2.72	2.81		2.80		3.10	2.77	2.72		2.97	3.22
Freshwater: open						0.86	1.12			1.07	0.84
Brackish-water: open						0.80	0.93			0.78	0.72
Insect abundance	1.00		1.00			1.00		1.00			1.00
Insect diversity	1.48		1.45			1.48		1.44			1.44

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 9.---Standard errors of negative binomial regression models ranked according to AIC_c for activity of tri-colored bats (*Perimyotis subflavus*) in Charleston County, South Carolina, June-October 2014.

Model	Insect + HabitatM	HabitatM	Insect	Weather + HabitatM	Null	Insect + Habitat	Habitat	GlobalM	Weather	Weather + Habitat	Global
Number of parameters	6	4	3	9	1	8	6	11	6	11	13
AIC_c	1,963.88	1,964.02	1,967.03	1,967.04	1,967.12	1,968.23	1,968.28	1,968.94	1,969.28	1,971.44	1,973.45
ΔAIC_c	0.00	0.15	3.16	3.16	3.24	4.35	4.40	5.07	5.40	7.57	9.58
ω_i	0.34	0.32	0.07	0.07	0.07	0.04	0.04	0.03	0.02	0.01	0.00
Intercept	1.71	1.60	1.46	2.09E+13	1.33	1.90	1.77	1.76E+13	2.37E+13	2.11E+13	1.76E+13
Temperature (°C)				1.03				1.03	1.03	1.03	1.03
Humidity (%)				1.02				1.02	1.02	1.02	1.02
Wind speed (km/h)				1.05				1.06	1.05	1.05	1.06
Barometric pressure (kPa)				1.36				1.35	1.36	1.36	1.35
Lunar illumination (%)				1.00				1.00	1.00	1.00	1.00
Freshwater[a]	1.77	1.78		1.79		2.26	2.25	1.77		2.28	2.25
Brackish-water[a]	1.78	1.78		1.79		2.26	2.25	1.77		2.28	2.24
Open[b]	1.60	1.60		1.60		2.26	2.26	1.58		2.26	2.23
Freshwater: open						3.19	3.16			3.17	3.13
Brackish-water: open						3.19	3.16			3.17	3.10
Insect abundance	1.00		1.00			1.00		1.00			1.00
Insect diversity	1.26		1.26			1.26		1.32			1.32

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 10.---Coefficient estimates of negative binomial regression models ranked according to AIC_c for activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	GlobalM	Weather + Habitat	Global	Weather	Insect + HabitatM	Insect + Habitat	Insect	Habitat M	Habitat	Null
Number of parameters	9	11	11	13	6	6	8	3	4	6	1
AIC_c	1,277.34	1,278.94	1,279.14	1,280.05	1,280.40	1,292.68	1,293.13	1,296.93	1,300.73	1,302.38	1,303.52
ΔAIC_c	0.00	1.60	1.80	2.71	3.04	15.34	15.79	19.59	23.38	25.04	26.18
ω_i	0.43	0.19	0.17	0.11	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Intercept	0.00	0.00	0.00	0.00	0.00	5.64	7.61	23.81	3.08	4.47	12.27
Temperature (°C)	0.84	0.86	0.84	0.86	0.84						
Humidity (%)	0.94	0.93	0.93	0.93	0.93						
Wind speed (km/h)	1.04	1.02	1.04	1.01	1.05						
Barometric pressure (kPa)	2.77	2.70	2.86	2.80	2.95						
Lunar illumination (%)	1.01	1.01	1.01	1.01	1.01						
Freshwater[a]	4.99	4.81	2.09	1.97		4.44	1.78		4.13	1.68	
Saltwater[a]	4.20	3.86	3.49	3.53		3.53	3.42		3.26	2.46	
Open[b]	2.47	2.55	1.33	1.47		3.22	1.88		2.84	1.34	
Freshwater: open			5.48	5.75			6.05			5.98	
Saltwater: open			1.40	1.14			1.03			1.75	
Insect abundance		1.00		1.00		1.00	1.00	1.00			
Insect diversity		0.86		0.82		0.64	0.63	0.65			

[a] Brackish-water sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 11.---Standard errors of negative binomial regression models ranked according to AIC_c for activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	GlobalM	Weather + Habitat	Global	Weather	Insect + HabitatM	Insect + Habitat	Insect	HabitatM	Habitat	Null
Number of parameters	9	11	11	13	6	6	8	3	4	6	1
AIC_c	1,277.34	1,278.94	1,279.14	1,280.05	1,280.40	1,292.68	1,293.13	1,296.93	1,300.73	1,302.38	1,303.52
ΔAIC_c	0.00	1.60	1.80	2.71	3.04	15.34	15.79	19.59	23.38	25.04	26.18
ω_i	0.43	0.19	0.17	0.11	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Intercept	1.03E+18	1.17E+18	9.80E+17	1.05E+18	1.05E+18	1.71	1.78	1.59	1.60	1.73	1.37
Temperature (°C)	1.03	1.04	1.03	1.04	1.03						
Humidity (%)	1.03	1.03	1.03	1.03	1.03						
Wind speed (km/h)	1.07	1.08	1.07	1.08	1.07						
Barometric pressure (kPa)	1.52	1.52	1.52	1.52	1.52						
Lunar illumination (%)	1.00	1.00	1.00	1.00	1.00						
Freshwater[a]	1.79	1.76	2.16	2.10		1.76	2.09		1.80	2.19	
Saltwater[a]	1.81	1.79	2.12	2.09		1.76	2.06		1.79	2.11	
Open[b]	1.56	1.55	2.18	2.12		1.55	2.10		1.57	2.18	
Freshwater: open			2.95	2.83			2.83			3.01	
Saltwater: open			2.73	2.66			2.72			2.82	
Insect abundance		1.00		1.00		1.00	1.00	1.00			
Insect diversity		1.44		1.44		1.38	1.39	1.38			

[a] Brackish-water sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 12.---Coefficient estimates of negative binomial regression models ranked according to AIC_c for activity of eastern red bats (*Lasiurus borealis*)/Seminole bats (*Lasiurus seminolus*) in Charleston County, South Carolina, June-October 2014.

Model	HabitatM	Weather + HabitatM	Habitat	Insect + HabitatM	Weather + Habitat	GlobalM	Weather	Null	Insect + Habitat	Global	Insect
Number of parameters	4	9	6	6	11	11	6	1	8	13	3
AIC_c	1,200.72	1,201.54	1,203.58	1,204.08	1,204.44	1,205.24	1,205.68	1,206.22	1,206.63	1,208.55	1,209.63
ΔAIC_c	0.00	0.82	2.85	3.35	3.72	4.52	4.95	5.50	5.90	7.83	8.91
ω_i	0.39	0.26	0.09	0.07	0.06	0.04	0.03	0.02	0.02	0.01	0.00
Intercept	5.69	0.00	4.14	4.81	0.00	0.00	0.00	7.84	3.19	0.00	6.36
Temperature (°C)		1.02			1.02	1.03	1.02			1.03	
Humidity (%)		0.97			0.97	0.97	0.97			0.97	
Wind speed (km/h)		0.93			0.93	0.92	0.95			0.92	
Barometric pressure (kPa)		1.87			1.87	1.87	1.98			1.85	
Lunar illumination (%)		1.00			0.99	0.99	1.00			0.99	
Freshwater[a]	0.58	0.62	1.10	0.58	1.21	0.62			1.17	1.15	
Brackish-water[a]	0.39	0.40	0.55	0.38	0.61	0.38			0.56	0.57	
Open[b]	5.10	4.88	9.71	5.10	9.94	4.81			10.49	9.58	
Freshwater: open			0.28		0.26				0.25	0.29	
Brackish-water: open			0.52		0.44				0.46	0.45	
Insect abundance				1.00		1.00			1.00	1.00	1.00
Insect diversity				1.10		0.75			1.15	0.80	1.14

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 13.---Standard errors of negative binomial regression models ranked according to AIC_c for activity of eastern red bats (*Lasiurus borealis*)/Seminole bats (*Lasiurus seminolus*) in Charleston County, South Carolina, June-October.

Model	HabitatM	Weather + HabitatM	Habitat	Insect + HabitatM	Weather + Habitat	GlobalM	Weather	Null	Insect + Habitat	Global	Insect
Number of parameters	4	9	6	6	11	11	6	1	8	13	3
AIC_c	1,200.72	1,201.54	1,203.58	1,204.08	1,204.44	1,205.24	1,205.68	1,206.22	1,206.63	1,208.55	1,209.63
ΔAIC_c	0.00	0.82	2.85	3.35	3.72	4.52	4.95	5.50	5.90	7.83	8.91
ω_i	0.39	0.26	0.09	0.07	0.06	0.04	0.03	0.02	0.02	0.01	0.00
Intercept	1.55	9.12E+16	1.67	1.74	8.38E+16	1.93E+17	8.01E+16	1.36	1.87	1.74E+17	1.54
Temperature (°C)		1.03			1.03	1.03	1.03			1.03	
Humidity (%)		1.02			1.02	1.03	1.02			1.03	
Wind speed (km/h)		1.07			1.07	1.07	1.07			1.07	
Barometric pressure (kPa)		1.48			1.48	1.49	1.48			1.49	
Lunar illumination (%)		1.00			1.00	1.00	1.00			1.00	
Freshwater[a]	1.71	1.73	2.06	1.71	2.09	1.73			2.05	2.10	
Brackish-water[a]	1.71	1.75	2.08	1.73	2.12	1.76			2.07	2.13	
Open[b]	1.55	1.56	2.06	1.55	2.07	1.56			2.05	2.09	
Freshwater: open			2.78		2.81				2.77	2.86	
Brackish-water: open			2.79		2.82				2.77	2.83	
Insect abundance				1.00		1.00			1.00	1.00	1.00
Insect diversity				1.34		1.40			1.34	1.41	1.33

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 14.---Coefficient estimates of negative binomial regression models ranked according to AIC_c for activity of big brown bats (*Eptesicus fuscus*)/silver-haired bats (*Lasionycteris noctivagans*) in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	Insect + HabitatM	GlobalM	HabitatM	Insect + Habitat	Weather	Weather + Habitat	Global	Habitat	Insect	Null
Number of parameters	9	6	11	4	8	6	11	13	6	3	1
AIC_c	1,127.74	1,128.28	1,128.54	1,130.72	1,131.53	1,131.68	1,132.14	1,132.75	1,134.48	1,134.53	1,134.92
ΔAIC_c	0.00	0.54	0.80	2.98	3.79	3.94	4.40	5.01	6.74	6.79	7.18
ω_i	0.31	0.24	0.21	0.07	0.05	0.04	0.03	0.03	0.01	0.01	0.01
Intercept	0.00	3.97	0.00	2.38	4.39	0.00	0.00	0.00	2.71	11.47	7.21
Temperature (°C)	0.91		0.94			0.91	0.91	0.94			
Humidity (%)	0.93		0.92			0.93	0.93	0.93			
Wind speed (km/h)	1.07		1.05			1.09	1.07	1.04			
Barometric pressure (kPa)	1.84		1.81			1.85	1.83	1.74			
Lunar illumination (%)	1.00		1.00			1.00	1.00	1.00			
Freshwater[a]	4.40	5.42	4.44	5.14	3.94		4.12	3.82	3.78		
Saltwater[a]	2.03	2.33	1.89	2.31	2.54		2.02	2.12	2.15		
Open[b]	1.61	1.85	1.66	1.76	1.60		1.54	1.63	1.36		
Freshwater: open					1.87		1.14	1.35	1.84		
Saltwater: open					0.83		1.01	0.81	1.16		
Insect abundance		1.00	1.00		1.00			1.00		1.00	
Insect diversity		0.72	0.79		0.72			0.77		0.75	

[a] Brackish-water sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 15.---Standard errors of negative binomial regression models ranked according to AIC_c for activity of big brown bats (*Eptesicus fuscus*)/silver-haired bats (*Lasionycteris noctivagans*) in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	Insect + HabitatM	GlobalM	HabitatM	Insect + Habitat	Weather	Weather + Habitat	Global	Habitat	Insect	Null
Number of parameters	9	6	11	4	8	6	11	13	6	3	1
AIC_c	1,127.74	1,128.28	1,128.54	1,130.72	1,131.53	1,131.68	1,132.14	1,132.75	1,134.48	1,134.53	1,134.92
ΔAIC_c	0.00	0.54	0.80	2.98	3.79	3.94	4.40	5.01	6.74	6.79	7.18
ω_i	0.31	0.24	0.21	0.07	0.05	0.04	0.03	0.03	0.01	0.01	0.01
Intercept	1.44E+18	1.55	1.05E+18	1.47	1.63	3.22E+18	2.50E+18	1.92E+18	1.60	1.51	1.29
Temperature (°C)	1.03		1.04			1.03	1.03	1.04			
Humidity (%)	1.03		1.03			1.03	1.03	1.03			
Wind speed (km/h)	1.07		1.08			1.08	1.07	1.08			
Barometric pressure (kPa)	1.53		1.52			1.54	1.53	1.53			
Lunar illumination (%)	1.00		1.00			1.00	1.00	1.00			
Freshwater[a]	1.53	1.53	1.49	1.60	1.78		1.83	1.75	1.94		
Saltwater[a]	1.55	1.55	1.53	1.60	1.79		1.86	1.79	1.93		
Open[b]	1.41	1.41	1.38	1.47	1.78		1.84	1.76	1.94		
Freshwater: open					2.24		2.35	2.22	2.53		
Saltwater: open					2.26		2.34	2.22	2.53		
Insect abundance		1.00	1.00		1.00			1.00		1.00	
Insect diversity		1.38	1.45		1.38			1.46		1.38	

[a] Brackish-water sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 16.---Coefficient estimates of zero-inflated regression models ranked according to AIC_c for activity of southeastern myotis (*Myotis austroriparius*) in Charleston County, South Carolina, June-October 2014.

Model	Insect + HabitatM	GlobalM	HabitatM	Weather + HabitatM	Habitat	Global	Insect + Habitat	Weather + Habitat	Null	Insect	Weather
Number of parameters	6	11	4	9	6	13	8	11	1	3	6
AIC_c	306.88	307.24	307.42	307.84	308.78	308.95	309.13	309.34	313.02	313.33	314.68
ΔAIC_c	0.00	0.37	0.55	0.96	1.90	2.08	2.25	2.47	6.14	6.46	7.80
ω_i	0.21	0.18	0.16	0.13	0.08	0.08	0.07	0.06	0.01	0.01	0.00
Intercept	0.22	7.36E+38	0.10	4.67E+20	0.10	8.81E+36	0.17	1.67E+18	0.32	0.70	6.97E+14
Temperature (°C)		0.93		0.95		0.91		0.94			0.93
Humidity (%)		1.07		1.05		1.06		1.04			1.02
Wind speed (km/h)		0.86		0.84		0.88		0.85			0.91
Barometric pressure (kPa)		0.39		0.60		0.41		0.64			0.70
Lunar illumination (%)		0.99		0.99		0.99		0.99			0.99
Freshwater[a]	2.83	1.20	2.83	1.49	4.62	2.90	4.71	2.16			
Brackish-water[a]	1.39	0.67	1.71	1.03	1.00	0.74	0.99	0.56			
Open[b]	3.90	5.50	3.62	4.84	4.14	10.50	4.90	4.78			
Freshwater: open					0.42	0.25	0.41	0.54			
Brackish-water: open					2.02	0.86	1.53	2.38			
Insect abundance	1.00	1.00				1.00	1.00			1.00	
Insect diversity	0.39	0.67				0.84	0.45			0.40	

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 17.---Standard errors of zero-inflated regression models ranked according to AIC_c for activity of southeastern myotis (*Myotis austroriparius*) in Charleston County, South Carolina, June-October 2014.

Model	Insect + HabitatM	GlobalM	HabitatM	Weather + HabitatM	Habitat	Global	Insect + Habitat	Weather + Habitat	Null	Insect	Weather
Number of parameters	6	11	4	9	6	13	8	11	1	3	6
AIC_c	306.88	307.24	307.42	307.84	308.78	308.95	309.13	309.34	313.02	313.33	314.68
ΔAIC_c	0.00	0.37	0.55	0.96	1.90	2.08	2.25	2.47	6.14	6.46	7.80
ω_i	0.21	0.18	0.16	0.13	0.08	0.08	0.07	0.06	0.01	0.01	0.00
Intercept	1.93	2.68E+29	1.64	2.22E+35	1.89	7.26E+28	2.33	3.36E+28	1.34	1.76	6.45E+28
Temperature (°C)		1.05		1.05		1.05		1.05			1.05
Humidity (%)		1.04		1.05		1.04		1.04			1.04
Wind speed (km/h)		1.14		1.14		1.13		1.13			1.13
Barometric pressure (kPa)		1.97		2.25		1.95		1.93			1.94
Lunar illumination (%)		1.01		1.01		1.01		1.01			1.01
Freshwater[a]	1.63	1.75	1.64	1.79	2.10	2.32	2.23	2.19			
Brackish-water[a]	1.66	1.82	1.65	1.90	2.45	2.63	2.51	2.51			
Open[b]	1.51	1.59	1.51	1.53	2.11	2.60	2.22	2.13			
Freshwater: open					2.47	2.84	2.75	2.49			
Brackish-water: open					2.80	3.32	3.03	2.81			
Insect abundance	1.00	1.00				1.00	1.00			1.00	
Insect diversity	1.61	1.75				1.68	1.61			1.66	

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 18.---Coefficient estimates of zero-inflated regression models ranked according to AIC_c for activity of hoary bats (*Lasiurus cinereus*) in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	Weather + Habitat	Weather	GlobalM	Global	Insect + HabitatM	Insect	Insect + Habitat	Habitat	Null	HabitatM
Number of parameters	9	11	6	11	13	6	3	8	6	1	4
AIC_c	336.34	337.34	337.88	340.64	341.75	343.08	343.43	343.53	344.18	345.92	347.02
ΔAIC_c	0.00	1.00	1.54	4.30	5.41	6.74	7.09	7.19	7.84	9.58	10.68
ω_i	0.42	0.25	0.20	0.05	0.03	0.01	0.01	0.01	0.01	0.00	0.00
Intercept	3.11E+60	2.62E+53	1.89E+46	4.68E+61	1.43E+55	0.65	1.21	0.27	0.10	0.44	0.26
Temperature (°C)	0.86	0.86	0.86	0.86	0.86						
Humidity (%)	0.99	0.98	0.97	0.99	0.99						
Wind speed (km/h)	1.00	1.00	1.02	0.99	1.01						
Barometric pressure (kPa)	0.26	0.31	0.37	0.25	0.29						
Lunar illumination (%)	1.00	1.00	1.00	1.00	1.00						
Freshwater[a]	1.06	2.30		1.06	2.22	1.52		3.08	3.92		1.26
Brackish-water[a]	0.75	2.70		0.75	2.67	0.90		3.28	4.00		0.87
Open[b]	4.22	12.81		4.22	12.94	3.24		10.75	14.47		2.63
Freshwater: open		0.31			0.31			0.31	0.14		
Brackish-water: open		0.12			0.12			0.10	0.06		
Insect abundance				1.00	1.00	1.00	1.00	1.00			
Insect diversity				1.12	1.28	0.39	0.42	0.46			

[a] Saltwater sites are the reference group for the salinity of water.
[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 19.---Standard errors of zero-inflated regression models ranked according to AIC_c for activity of hoary bats (*Lasiurus cinereus*) in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	Weather + Habitat	Weather	GlobalM	Global	Insect + HabitatM	Insect	Insect + Habitat	Habitat	Null	HabitatM
Number of parameters	9	11	6	11	13	6	3	8	6	1	4
AIC_c	336.34	337.34	337.88	340.64	341.75	343.08	343.43	343.53	344.18	345.92	347.02
ΔAIC_c	0.00	1.00	1.54	4.30	5.41	6.74	7.09	7.19	7.84	9.58	10.68
ω_i	0.42	0.25	0.20	0.05	0.03	0.01	0.01	0.01	0.01	0.00	0.00
Intercept	3.99E+32	1.85E+32	6.94E+30	2.26E+33	1.51E+33	1.91	1.68	2.34	1.93	1.29	1.65
Temperature (°C)	1.05	1.05	1.05	1.06	1.06						
Humidity (%)	1.04	1.04	1.04	1.04	1.04						
Wind speed (km/h)	1.12	1.12	1.12	1.12	1.12						
Barometric pressure (kPa)	2.12	2.11	2.04	2.16	2.15						
Lunar illumination (%)	1.01	1.01	1.01	1.01	1.01						
Freshwater[a]	1.77	2.49		1.77	2.47	1.78		2.40	2.20		1.72
Brackish-water[a]	1.83	2.50		1.82	2.48	1.79		2.38	2.18		1.74
Open[b]	1.64	2.35		1.64	2.35	1.60		2.33	2.10		1.55
Freshwater: open		3.03			3.10			3.05	2.56		
Brackish-water: open		3.06			3.03			3.00	2.61		
Insect abundance				1.00	1.00	1.00	1.00	1.00			
Insect diversity				1.80	1.82	1.58	1.58	1.61			

[a] Saltwater sites are the reference group for the salinity of water.

[b] Cluttered vegetation is the reference group for the type of vegetation

Appendix 20.---Coefficient estimate of negative-binomial regression models ranked according to AIC_c for overall activity of bats on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Insect + Habitat	Insect + HabitatM	Insect	HabitatM	Habitat	Global	GlobalM	Weather	Weather + HabitatM	Weather + Habitat	Null
Number of parameters	6	5	3	3	4	11	10	6	8	9	1
AIC_c	2,541.68	2,542.24	2,545.03	2,547.33	2,548.42	2,551.14	2,551.58	2,554.28	2,555.03	2,556.54	2,559.82
ΔAIC_c	0.00	0.56	3.36	5.66	6.75	9.47	9.90	12.60	13.35	14.86	18.14
ω_i	0.49	0.37	0.09	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Intercept	67.36	97.33	167.34	256.65	218.33	0.00	0.00	0.00	0.00	0.00	416.13
Temperature (°C)						0.99	0.99	1.01	1.03	1.03	
Humidity (%)						1.01	1.00	1.01	0.99	1.00	
Wind speed (km/h)						1.00	0.99	0.98	0.96	0.96	
Barometric pressure (kPa)						1.48	1.54	1.78	1.48	1.43	
Lunar illumination (%)						1.00	1.00	1.00	1.00	1.00	
Mainland[a]	1.67	1.08		0.98	1.24	1.57	1.03		0.96	1.16	
Migration[b]	2.92	1.78		1.58	2.11	2.46	1.55		1.66	2.12	
Mainland: migration	0.48				0.65	0.47				0.69	
Insect abundance	1.00	1.00	1.00			1.00	1.00				
Insect diversity	2.32	2.11	1.91			2.43	2.15				

[a] Islands are the reference group for location.

[b] Pre-migration is the reference group for season.

Appendix 21.---Standard errors of negative-binomial regression models ranked according to AIC_c for overall activity of bats on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Insect + Habitat	Insect + HabitatM	Insect	HabitatM	Habitat	Global	GlobalM	Weather	Weather + HabitatM	Weather + Habitat	Null
Number of parameters	6	5	3	3	4	11	10	6	8	9	1
AIC_c	2,541.68	2,542.24	2,545.03	2,547.33	2,548.42	2,551.14	2,551.58	2,554.28	2,555.03	2,556.54	2,559.82
ΔAIC_c	0.00	0.56	3.36	5.66	6.75	9.47	9.90	12.60	13.35	14.86	18.14
ω_i	0.49	0.37	0.09	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Intercept	1.55	1.46	1.33	1.25	1.31	5.25E+16	1.17E+17	1.34E+17	2.10E+17	1.86E+17	1.08
Temperature (°C)						1.03	1.03	1.03	1.03	1.03	
Humidity (%)						1.03	1.03	1.03	1.03	1.03	
Wind speed (km/h)						1.07	1.07	1.07	1.07	1.07	
Barometric pressure (kPa)						1.47	1.48	1.48	1.49	1.49	
Lunar illumination (%)						1.00	1.00	1.00	1.00	1.00	
Mainland[a]	1.41	1.24		1.25	1.39	1.42	1.29		1.30	1.42	
Migration[b]	1.44	1.24		1.23	1.44	1.47	1.32		1.32	1.49	
Mainland: migration	1.56				1.55	1.57				1.56	
Insect abundance	1.00	1.00	1.00			1.00	1.00				
Insect diversity	1.28	1.28	1.28			1.32	1.31				

[a] Islands are the reference group for location.
[b] Pre-migration is the reference group for season

Appendix 22.---Coefficient estimate of negative-binomial regression models ranked according to AIC_c for activity of evening bats (*Nycticeius humeralis*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Weather	GlobalM	Weather + HabitatM	Insect	Global	Weather + Habitat	Insect + HabitatM	Insect + Habitat	HabitatM	Habitat	Null
Number of parameters	6	10	8	3	11	9	5	6	3	4	1
AIC_c	1,628.88	1,631.48	1,632.33	1,632.73	1,633.54	1,634.54	1,635.34	1,636.88	1,638.53	1,640.62	1,645.72
ΔAIC_c	0.00	2.60	3.45	3.86	4.67	5.66	6.46	8.00	9.66	11.75	16.84
ω_i	0.55	0.15	0.10	0.08	0.05	0.03	0.02	0.01	0.00	0.00	0.00
Intercept	0.00	0.00	0.00	9.87	0.00	0.00	7.46	8.08	18.25	18.25	36.01
Temperature (°C)	1.16	1.14	1.16		1.14	1.16					
Humidity (%)	0.99	0.99	0.98		0.99	0.98					
Wind speed (km/h)	0.96	1.00	0.99		1.00	0.99					
Barometric pressure (kPa)	2.36	2.59	2.22		2.54	2.24					
Lunar illumination (%)	1.00	1.00	1.00		1.00	1.00					
Mainland[a]		1.59	1.42		1.40	1.51	1.36	1.12	1.16	1.16	
Pre-migration[b]		1.05	0.90		0.89	0.99	1.28	0.93	1.41	1.41	
Mainland: pre-migration					1.31	0.88		1.60		1.00	
Insect abundance		1.00		1.00	1.00		1.00	1.00			
Insect diversity		1.73		2.39	1.80		2.39	2.55			

[a] Islands are the reference group for location.
[b] Migration is the reference group for season.

Appendix 23.---Standard errors of negative-binomial regression models ranked according to AIC_c for activity of evening bats (*Nycticeius humeralis*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Weather	GlobalM	Weather + HabitatM	Insect	Global	Weather + Habitat	Insect + HabitatM	Insect + Habitat	HabitatM	Habitat	Null
Number of parameters	6	10	8	3	11	9	5	6	3	4	1
AIC_c	1,628.88	1,631.48	1,632.33	1,632.73	1,633.54	1,634.54	1,635.34	1,636.88	1,638.53	1,640.62	1,645.72
ΔAIC_c	0.00	2.60	3.45	3.86	4.67	5.66	6.46	8.00	9.66	11.75	16.84
ω_i	0.55	0.15	0.10	0.08	0.05	0.03	0.02	0.01	0.00	0.00	0.00
Intercept	5.76E+23	1.55E+24	3.86E+24	1.45	1.40E+24	5.27E+24	1.56	1.57	1.36	1.44	1.10
Temperature (°C)	1.05	1.05	1.05		1.05	1.05					
Humidity (%)	1.04	1.04	1.04		1.04	1.04					
Wind speed (km/h)	1.09	1.10	1.10		1.10	1.10					
Barometric pressure (kPa)	1.73	1.74	1.76		1.74	1.76					
Lunar illumination (%)	1.00	1.00	1.00		1.00	1.00					
Mainland[a]		1.44	1.45		1.59	1.61	1.36	1.49	1.38	1.54	
Pre-migration[b]		1.47	1.48		1.75	1.76	1.36	1.68	1.36	1.70	
Mainland: pre-migration					1.88	1.87		1.86		1.91	
Insect abundance		1.00		1.00	1.00		1.00	1.00			
Insect diversity		1.42		1.38	1.43		1.39	1.41			

[a] Islands are the reference group for location.
[b] Migration is the reference group for season.

Appendix 24.---Coefficient estimates of negative-binomial regression models ranked according to AIC_c for activity of tri-colored bats (*Perimyotis subflavus*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Insect + HabitatM	Insect + Habitat	HabitatM	Habitat	GlobalM	Global	Weather + HabitatM	Weather + Habitat	Weather	Insect	Null
Number of parameters	5	6	3	4	10	11	8	9	6	3	1
AIC_c	2,005.04	2,007.18	2,010.33	2,012.12	2,012.98	2,015.14	2,016.23	2,018.04	2,038.78	2,045.63	2,103.32
ΔAIC_c	0.00	2.14	5.30	7.09	7.94	10.10	11.19	13.00	33.74	40.60	98.28
ω_i	0.68	0.23	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Intercept	5.05	4.81	15.39	17.28	0.00	0.00	0.00	0.00	0.00	32.46	149.61
Temperature (°C)					1.01	1.01	1.06	1.06	1.04		
Humidity (%)					1.03	1.03	1.02	1.01	1.06		
Wind speed (km/h)					0.99	0.99	0.95	0.95	0.77		
Barometric pressure (kPa)					1.83	1.81	1.71	1.77	2.08		
Lunar illumination (%)					1.00	1.00	1.00	1.00	0.99		
Mainland[a]	7.77	8.25	7.32	6.17	7.03	7.46	6.63	5.51			
Migration[b]	1.54	1.65	1.30	1.06	1.20	1.29	1.32	1.04			
Mainland: migration		0.91		1.36		0.89		1.43			
Insect abundance	1.00	1.00			1.00	1.00				1.00	
Insect diversity	2.46	2.50			2.44	2.49				1.96	

[a] Islands are the reference group for location.
[b] Pre-migration is the reference group for season.

Appendix 25.---Standard errors of negative-binomial regression models ranked according to AIC_c for activity of tri-colored bats (*Perimyotis subflavus*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Insect + HabitatM	Insect + Habitat	HabitatM	Habitat	GlobalM	Global	Weather + HabitatM	Weather + Habitat	Weather	Insect	Null
Number of parameters	5	6	3	4	10	11	8	9	6	3	1
AIC_c	2,005.04	2,007.18	2,010.33	2,012.12	2,012.98	2,015.14	2,016.23	2,018.04	2,038.78	2,045.63	2,103.32
ΔAIC_c	0.00	2.14	5.30	7.09	7.94	10.10	11.19	13.00	33.74	40.60	98.28
ω_i	0.68	0.23	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Intercept	1.56	1.71	1.32	1.42	3.48E+21	3.48E+21	1.12E+22	1.39E+22	1.13E+25	1.49	1.11
Temperature (°C)					1.04	1.04	1.04	1.04	1.04		
Humidity (%)					1.03	1.03	1.03	1.03	1.04		
Wind speed (km/h)					1.09	1.09	1.09	1.09	1.10		
Barometric pressure (kPa)					1.64	1.64	1.66	1.66	1.78		
Lunar illumination (%)					1.00	1.00	1.00	1.00	1.00		
Mainland[a]	1.32	1.54	1.33	1.53	1.38	1.57	1.40	1.56			
Migration[b]	1.31	1.60	1.30	1.60	1.42	1.66	1.42	1.68			
Mainland: migration		1.77		1.76		1.79		1.77			
Insect abundance	1.00	1.00			1.00	1.00				1.00	
Insect diversity	1.34	1.35			1.37	1.39				1.40	

[a] Islands are the reference group for location.
[b] Pre-migration is the reference group for season.

Appendix 26.---Coefficient estimates of negative-binomial regression models ranked according to AIC_c for activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	HabitatM	Weather + Habitat	Insect + HabitatM	Habitat	GlobalM	Insect + Habitat	Global	Weather	Insect	Null
Number of parameters	8	3	9	5	4	10	6	11	6	3	1
AIC_c	1,314.63	1,314.63	1,315.64	1,316.04	1,316.22	1,316.38	1,318.08	1,318.14	1,330.28	1,335.43	1,368.62
ΔAIC_c	0.00	0.01	1.01	1.41	1.60	1.75	3.45	3.52	15.65	20.81	53.99
ω_i	0.23	0.23	0.14	0.11	0.10	0.10	0.04	0.04	0.00	0.00	0.00
Intercept	0.00	3.78	0.00	4.36	3.38	0.00	4.21	0.00	0.00	10.28	27.80
Temperature (°C)	0.89		0.89			0.89		0.89	0.87		
Humidity (%)	0.89		0.88			0.90		0.89	0.89		
Wind speed (km/h)	1.07		1.08			1.08		1.08	1.30		
Barometric pressure (kPa)	1.82		1.97			2.00		2.09	2.30		
Lunar illumination (%)	1.01		1.01			1.01		1.01	1.01		
Island[a]	4.97	7.45	7.48	6.53	10.06	4.26	7.52	5.64			
Migration[b]	2.11	1.92	2.87	1.64	2.31	1.81	1.78	2.24			
Island: migration			0.45		0.59		0.79	0.61			
Insect abundance				1.00		1.00	1.00	1.00		1.00	
Insect diversity				1.23		1.52	1.19	1.40		1.48	

[a] Mainland is the reference group for location.
[b] Pre-migration is the reference group for season.

Appendix 27.---Standard errors of negative-binomial regression models ranked according to AIC_c for activity of Brazilian free-tailed bats (*Tadarida brasiliensis*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	HabitatM	Weather + Habitat	Insect + HabitatM	Habitat	GlobalM	Insect + Habitat	Global	Weather	Insect	Null
Number of parameters	8	3	9	5	4	10	6	11	6	3	1
AIC_c	1,314.63	1,314.63	1,315.64	1,316.04	1,316.22	1,316.38	1,318.08	1,318.14	1,330.28	1,335.43	1,368.62
ΔAIC_c	0.00	0.01	1.01	1.41	1.60	1.75	3.45	3.52	15.65	20.81	53.99
ω_i	0.23	0.23	0.14	0.11	0.10	0.10	0.04	0.04	0.00	0.00	0.00
Intercept	3.90E+28	1.38	5.66E+28	1.80	1.44	1.03E+28	1.82	1.87E+28	1.06E+30	1.65	1.15
Temperature (°C)	1.05		1.05			1.06		1.06	1.05		
Humidity (%)	1.05		1.05			1.04		1.05	1.05		
Wind speed (km/h)	1.12		1.12			1.12		1.13	1.12		
Barometric pressure (kPa)	1.93		1.94			1.90		1.92	2.00		
Lunar illumination (%)	1.01		1.01			1.01		1.01	1.01		
Island[a]	1.51	1.47	1.75	1.48	1.80	1.51	1.86	1.80			
Migration[b]	1.59	1.44	1.72	1.47	1.58	1.58	1.62	1.75			
Island: migration			2.06		2.17		2.21	2.10			
Insect abundance				1.00		1.00	1.00	1.00		1.00	
Insect diversity				1.52		1.56	1.53	1.58		1.54	

[a] Mainland is the reference group for location.
[b] Pre-migration is the reference group for season.

Appendix 28.---Coefficient estimates of negative-binomial regression models ranked according to AIC_c for activity of eastern red bats (*Lasiurus borealis*)/Seminole bats (*Lasiurus seminolus*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Habitat	Weather + Habitat	Insect + Habitat	Global	HabitatM	Weather + HabitatM	Global M	Insect + HabitatM	Weather	Insect	Null
Number of parameters	4	9	6	11	3	8	10	5	6	3	1
AIC_c	1,239.92	1,242.64	1,243.98	1,244.94	1,245.53	1,247.43	1,248.58	1,248.74	1,260.58	1,261.73	1,312.12
ΔAIC_c	0.00	2.72	4.05	5.02	5.61	7.50	8.65	8.81	20.65	21.81	72.20
ω_i	0.63	0.16	0.08	0.05	0.04	0.01	0.01	0.01	0.00	0.00	0.00
Intercept	4.42	0.00	4.62	0.00	5.64	0.00	0.00	6.17	0.00	8.25	20.31
Temperature (°C)		1.08		1.11		1.08	1.12		1.06		
Humidity (%)		0.99		0.98		0.98	0.97		0.97		
Wind speed (km/h)		0.89		0.87		0.88	0.86		1.04		
Barometric pressure (kPa)		1.91		2.00		2.12	2.09		2.48		
Lunar illumination (%)		1.00		1.00		1.00	1.00		1.00		
Island[a]	9.06	8.97	9.12	9.03	4.15	4.44	4.81	4.53			
Pre-migration[b]	1.57	1.26	1.50	1.17	0.89	0.71	0.65	0.84			
Island: pre-migration	0.17	0.20	0.18	0.22							
Insect abundance			1.00	1.00			1.00	1.00		1.00	
Insect diversity			0.93	0.57			0.49	0.83		1.00	

[a] Mainland is the reference group for location.
[b] Migration is the reference group for season.

Appendix 29.---Standard errors of negative-binomial regression models ranked according to AIC_c for activity of eastern red bats (*Lasiurus borealis*)/Seminole bats (*Lasiurus seminolus*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Habitat	Weather + Habitat	Insect + Habitat	Global	HabitatM	Weather + HabitatM	Global M	Insect + HabitatM	Weather	Insect	Null
Number of parameters	4	9	6	11	3	8	10	5	6	3	1
AIC_c	1,239.92	1,242.64	1,243.98	1,244.94	1,245.53	1,247.43	1,248.58	1,248.74	1,260.58	1,261.73	1,312.12
ΔAIC_c	0.00	2.72	4.05	5.02	5.61	7.50	8.65	8.81	20.65	21.81	72.20
ω_i	0.63	0.16	0.08	0.05	0.04	0.01	0.01	0.01	0.00	0.00	0.00
Intercept	1.27	8.89E+23	1.54	9.40E+23	1.27	1.03E+25	9.37E+24	1.53	4.39E+27	1.56	1.14
Temperature (°C)		1.04		1.05		1.05	1.05		1.05		
Humidity (%)		1.04		1.04		1.04	1.04		1.04		
Wind speed (km/h)		1.10		1.10		1.10	1.10		1.10		
Barometric pressure (kPa)		1.73		1.73		1.78	1.77		1.89		
Lunar illumination (%)		1.00		1.00		1.00	1.00		1.01		
Island[a]	1.52	1.56	1.52	1.55	1.40	1.45	1.45	1.41			
Pre-migration[b]	1.42	1.53	1.45	1.55	1.36	1.47	1.47	1.38			
Island: pre-migration	1.86	1.82	1.89	1.84							
Insect abundance			1.00	1.00			1.00	1.00		1.00	
Insect diversity			1.45	1.49			1.49	1.45		1.47	

[a] Mainland is the reference group for location.
[b] Migration is the reference group for season.

Appendix 30.---Coefficient estimates of negative-binomial regression models ranked according to AIC_c for activity of big brown bats (*Eptesicus fuscus*)/silver-haired bats (*Lasionycteris notcivagans*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Insect + HabitatM	Insect + Habitat	HabitatM	Insect	Habitat	GlobalM	Weather	Weather + HabitatM	Global	Weather + Habitat	Null
Number of parameters	5	6	3	3	4	10	6	8	11	9	1
AIC_c	1,131.24	1,131.68	1,133.43	1,133.43	1,134.82	1,135.18	1,135.78	1,136.23	1,136.44	1,138.24	1,184.52
ΔAIC_c	0.00	0.44	2.20	2.20	3.59	3.94	4.54	4.99	5.20	7.00	53.28
ω_i	0.33	0.26	0.11	0.11	0.05	0.05	0.03	0.03	0.02	0.01	0.00
Intercept	4.22	3.46	4.40	5.16	4.06	1.41E+23	2.33E+21	1.28E+28	2.82E+25	2.21E+29	12.39
Temperature (°C)						0.96	0.94	0.96	0.96	0.96	
Humidity (%)						0.93	0.93	0.93	0.94	0.93	
Wind speed (km/h)						1.10	1.20	1.10	1.09	1.10	
Barometric pressure (kPa)						0.65	0.68	0.58	0.61	0.56	
Lunar illumination (%)						1.00	1.00	1.00	1.00	1.00	
Island[a]	2.38	3.46	2.70		3.43	1.66		1.84	2.28	2.15	
Pre-migration[b]	1.01	1.37	0.86		1.03	0.79		0.68	1.03	0.76	
Island: pre-migration		0.41			0.58				0.50	0.73	
Insect abundance	1.00	1.00		1.00		1.00			1.00		
Insect diversity	1.28	1.41		1.47		1.40			1.54		

[a] Mainland is the reference group for location.
[b] Migration is the reference group for season.

Appendix 31.---Standard errors of negative-binomial regression models ranked according to AIC_c for activity of big brown bats (*Eptesicus fuscus*)/silver-haired bats (*Lasionycteris notcivagans*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Insect + HabitatM	Insect + Habitat	HabitatM	Insect	Habitat	GlobalM	Weather	Weather + HabitatM	Global	Weather + Habitat	Null
Number of parameters	5	6	3	3	4	10	6	8	11	9	1
AIC_c	1,131.24	1,131.68	1,133.43	1,133.43	1,134.82	1,135.18	1,135.78	1,136.23	1,136.44	1,138.24	1,184.52
ΔAIC_c	0.00	0.44	2.20	2.20	3.59	3.94	4.54	4.99	5.20	7.00	53.28
ω_i	0.33	0.26	0.11	0.11	0.05	0.05	0.03	0.03	0.02	0.01	0.00
Intercept	1.54	1.58	1.29	1.52	1.32	1.03E+27	3.10E+26	2.21E+27	9.33E+26	2.84E+27	1.13
Temperature (°C)						1.05	1.04	1.05	1.05	1.05	
Humidity (%)						1.04	1.04	1.04	1.04	1.04	
Wind speed (km/h)						1.11	1.10	1.11	1.11	1.11	
Barometric pressure (kPa)						1.86	1.84	1.87	1.86	1.88	
Lunar illumination (%)						1.01	1.00	1.01	1.00	1.01	
Island[a]	1.41	1.56	1.41		1.58	1.47		1.47	1.65	1.66	
Pre-migration[b]	1.41	1.51	1.39		1.50	1.53		1.53	1.65	1.64	
Island: pre-migration		2.00			1.99				1.98	1.96	
Insect abundance	1.00	1.00		1.00		1.00			1.00		
Insect diversity	1.44	1.45		1.42		1.47			1.49		

[a] Mainland is the reference group for location.
[b] Migration is the reference group for season.

Appendix 32.---Coefficient estimates of zero-inflated regression models ranked according to AIC_c for activity of southeastern myotis (*Myotis austroriparius*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Null	Insect	Weather	HabitatM	Weather + HabitatM	Habitat	Insect + HabitatM	GlobalM	Insect + Habitat	Weather + Habitat	Global
Number of parameters	1	3	6	3	8	4	5	10	6	9	11
AIC_c	315.32	319.13	319.88	320.63	321.43	322.52	322.84	322.98	323.28	323.64	324.74
ΔAIC_c	0.00	3.81	4.56	5.31	6.11	7.20	7.52	7.66	7.96	8.32	9.42
ω_i	0.67	0.10	0.07	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01
Intercept	0.44	0.79	5.85E+23	0.33	1.53E+13	0.29	0.60	8.93E+23	0.53	2.93E+13	6.52E+22
Temperature (°C)			0.95		0.91			0.90		0.90	0.90
Humidity (%)			1.03		1.07			1.07		1.07	1.06
Wind speed (km/h)			0.90		0.93			0.95		0.93	0.94
Barometric pressure (kPa)			0.57		0.71			0.56		0.71	0.58
Lunar illumination (%)			0.99		0.99			0.99		0.99	0.99
Mainland[a]				1.56	0.79	1.80	1.33	0.67	2.04	0.78	0.89
Pre-migration[b]				0.94	2.29	1.18	0.95	1.76	2.09	2.23	2.68
Mainland: pre-migration						0.73			0.32	1.04	0.53
Insect abundance		1.00					1.00	1.00	1.00		1.00
Insect diversity		0.48					0.54	0.90	0.41		0.75

[a] Island is the reference group for location.
[b] Migration is the reference group for season.

Appendix 33.---Standard errors of zero-inflated regression models ranked according to AIC_c for activity of southeastern myotis (*Myotis austroriparius*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Null	Insect	Weather	HabitatM	Weather + HabitatM	Habitat	Insect + HabitatM	GlobalM	Insect + Habitat	Weather + Habitat	Global
Number of parameters	1	3	6	3	8	4	5	10	6	9	11
AIC_c	315.32	319.13	319.88	320.63	321.43	322.52	322.84	322.98	323.28	323.64	324.74
ΔAIC_c	0.00	3.81	4.56	5.31	6.11	7.20	7.52	7.66	7.96	8.32	9.42
ω_i	0.67	0.10	0.07	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01
Intercept	1.19	1.68	1.46E+29	1.44	5.24E+33	1.55	1.89	3.71E+30	1.89	1.51E+34	4.06E+30
Temperature (°C)			1.05		1.06			1.06		1.06	1.06
Humidity (%)			1.04		1.05			1.05		1.05	1.05
Wind speed (km/h)			1.13		1.13			1.13		1.13	1.13
Barometric pressure (kPa)			1.96		2.16			2.02		2.18	2.02
Lunar illumination (%)			1.01		1.01			1.01		1.01	1.01
Mainland[a]				1.47	1.67	1.68	1.49	1.60	1.69	1.97	1.84
Pre-migration[b]				1.42	1.66	1.92	1.53	1.67	2.12	2.07	2.19
Mainland: pre-migration						2.17			2.45	2.19	2.47
Insect abundance		1.00					1.00	1.00	1.00		1.00
Insect diversity		1.63					1.69	1.76	1.77		1.87

[a] Island is the reference group for location.
[b] Migration is the reference group for season.

Appendix 34.---Coefficient estimates of zero-inflated regression models ranked according to AIC_c for activity of hoary bats (*Lasiurus cinereus*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	HabitatM	Weather + Habitat	Habitat	GlobalM	Insect + HabitatM	Insect + Habitat	Global	Null	Weather	Insect
Number of parameters	8	3	9	4	10	5	6	11	1	6	3
AIC_c	343.53	345.13	345.24	346.02	347.08	347.44	348.78	349.24	349.32	350.68	351.13
ΔAIC_c	0.00	1.61	1.71	2.50	3.55	3.91	5.25	5.72	5.79	7.15	7.61
ω_i	0.37	0.17	0.16	0.11	0.06	0.05	0.03	0.02	0.02	0.01	0.01
Intercept	7.43E+55	0.15	3.48E+53	0.11	2.87E+56	0.28	0.23	1.43E+55	0.57	8.99E+35	0.79
Temperature (°C)	0.89		0.89		0.88			0.88		0.87	
Humidity (%)	0.96		0.96		0.97			0.97		0.97	
Wind speed (km/h)	0.90		0.90		0.91			0.90		1.04	
Barometric pressure (kPa)	0.29		0.31		0.29			0.30		0.47	
Lunar illumination (%)	1.01		1.01		1.01			1.01		1.01	
Island[a]	3.72	3.07	5.39	5.55	3.60	2.96	5.15	4.48			
Migration[b]	2.18	2.37	2.95	3.59	2.10	1.84	2.67	2.52			
Island: pre-migration			0.54	0.40			0.43	0.70			
Insect abundance					1.00	1.00	1.00	1.00			1.00
Insect diversity					1.57	0.79	0.71	1.46			0.76

[a] Mainland is the reference group for location.
[b] Pre-migration is the reference group for season.

Appendix 35.---Standard errors of zero-inflated regression models ranked according to AIC_c for activity of hoary bats (*Lasiurus cinereus*) on islands and mainland in Charleston County, South Carolina, June-October 2014.

Model	Weather + HabitatM	HabitatM	Weather + Habitat	Habitat	GlobalM	Insect + HabitatM	Insect + Habitat	Global	Null	Weather	Insect
Number of parameters	8	3	9	4	10	5	6	11	1	6	3
AIC_c	343.53	345.13	345.24	346.02	347.08	347.44	348.78	349.24	349.32	350.68	351.13
ΔAIC_c	0.00	1.61	1.71	2.50	3.55	3.91	5.25	5.72	5.79	7.15	7.61
ω_i	0.37	0.17	0.16	0.11	0.06	0.05	0.03	0.02	0.02	0.01	0.01
Intercept	6.19E+35	1.62	1.93E+36	1.81	1.83E+36	2.29	2.40	4.51E+36	1.20	1.76E+34	1.80
Temperature (°C)	1.06		1.06		1.07			1.07		1.06	
Humidity (%)	1.05		1.05		1.05			1.05		1.05	
Wind speed (km/h)	1.13		1.13		1.14			1.14		1.13	
Barometric pressure (kPa)	2.28		2.30		2.30			2.32		2.20	
Lunar illumination (%)	1.01		1.01		1.01			1.01		1.01	
Island[a]	1.60	1.55	2.04	2.09	1.60	1.55	2.15	2.12			
Migration[b]	1.73	1.54	2.02	1.83	1.75	1.61	1.91	2.09			
Island: pre-migration			2.37	2.43			2.53	2.52			
Insect abundance					1.00	1.00	1.00	1.00			1.00
Insect diversity					1.84	1.69	1.71	1.90			1.63

[a] Mainland is the reference group for location.
[b] Pre-migration is the reference group for season.