An Ecological Characterization of Coastal Hammock Islands in South Carolina

Final Report
To
Ocean and Coastal Resources Management
South Carolina Department of Health and Environmental Control

Prepared by:
Marine Resources Division
South Carolina Department of Natural Resources
Charleston, South Carolina 1 December 2004

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by

J. David Whitaker[1], John W. McCord[1], Philip P. Maier[1],
Albert L. Segars[1], Megan L. Rekow[2], Norm Shea[3], Jason Ayers[4], and Rocky Browder[5]
Marine Resources Division
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Project Number 475774

[1] South Carolina Department of Natural Resources, Charleston, South Carolina

[2] College of Charleston

[3] Kiawah Island Community Association

[4] US Fish and Wildlife Service

[5] Ocean and Coastal Resource Management, SC Dept. of Health and Environ. Control

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Introduction

South Carolina has several thousand small coastal islands found in association with its larger Sea Islands. These small islands, ranging in size from less than an acre to several hundred acres, are most numerous between the Santee and Savannah Rivers. Termed marsh hammocks (=hummocks) or back barrier islands, they are typically located behind the oceanfront barrier islands and adjacent to the larger Sea Islands. Other hammocks are found along the intra-coastal waterway or adjacent to coastal rivers and estuaries. Almost all are surrounded by expanses of Salt Marsh, occasionally being bordered by tidal creeks or rivers. Many of those hammocks adjacent to the Intracoastal Waterway or other dredged waterways were constructed of dredged sediments, and some hammocks are the result of phosphate ore mining or causeway construction. Marsh hammocks, depending upon their size, age, location, and elevation, have various types of maritime forests. NatureServe (2004) describes a community type called the Maritime Live Oak Hammock that is dominated by Live Oak, Slash Pine, Cabbage Palmetto, Redbay, and Beautyberry.

Historically, few of South Carolina's marsh hammocks have been built upon or altered. However, as demand for marsh-front or water-front properties has increased, sale prices of properties have increased greatly, particularly in urbanized areas where available marsh-front areas are limited. Hammocks that have been protected by their remoteness and inaccessibility are now threatened with development, in part, because exceptionally high values of real estate make it cost-effective to construct bridges or to ferry building materials. This trend toward greater development or potential development of marsh hammocks has stimulated questions and concerns about the ecological significance of these islands.

It has been hypothesized that coastal marsh hammocks may have important functions related to critical feeding and resting habitats for wildlife, and marsh hydrology. Cox (1988) suggested that oak hammocks represent critical stopover habitat for neotropical songbirds. Somershoe (2000), in a study of eight hammocks near the Savannah River, found 41 species of neotropical migratory birds in spring and 30 species in fall. The survival of eastern neartic-neotropical migrants passing through the Southeast is dependent upon a "healthy distribution of maritime and near-coastal woodlands" (Moore *et al*., 1993). Wood Storks and other wading birds are known to utilize hammocks as roosting and resting locations (T. Murphy, SCDNR, Pers. Comm.). Marsh hammocks are also thought to provide important nesting habitat for diamondback terrapins (D. Owens, College of Charleston, Pers. Comm.) and may provide critical refugia for mammals such as deer, otter and mink. Notwithstanding their biological importance, islands offer aesthetic benefits to citizens. It is common to have significant opposition at public hearings related to development of small coastal islands (D. Whitaker, Pers. Obs.), when citizens state that development will alter scenic vistas, and cause biological damage to terrestrial and marine species. In a study of resident's attitudes relative to Charleston Harbor, 88.5% of the respondents reported that scenic vistas of forested areas are important (Martin *et al*., 1997).

There are approximately 3,467 coastal islands, not including the larger "Sea Islands" such as Hilton Head. Of these islands, 53.7% are less than one acre, 81.5% are less than five acres, and 88.0% are less than ten acres. Although ownership can be

difficult to determine, it appears that about 27.3% of the hammocks are protected from development (publicly owned or under a conservation easement) (Coastal Service Center, NOAA, Charleston, SC). The vast majority of the hammocks (87.0%) are in the central and southern coastal zones (40.9% in Beaufort County, 8.1% in Colleton County, and 38.0% in Charleston County).

The large Sea Islands are believed to be Pleistocene geomorphic units most commonly termed coastal terraces. These terraces are thought to have resulted from erosional and depositional processes during marine transgressions and regression (Mathews *et al*., 1980). There are eleven coastal terraces in the Middle and Lower Coastal Plain of the South Atlantic states, seven of which were formed in five cycles of coastal emergence and submergence (Dale and Park, 1999). Stapor and Mathews (1976) used radiometric dating of oyster shell beds to determine the age of coastal islands in Charleston County. They estimated that island formation began at least 2,500 years ago on Kiawah Island and was essentially completed by 1,000 years ago. Seabrook and Botany Bay Islands are no older than 1,200 years and Edisto Beach is no older than 1,600 years. The hammock islands often have widely spaced dune ridges and are Holocene in age while the Sea Islands are Pleistocene.

Relatively few biological studies have been conducted on these marsh hammocks, perhaps because of the greater accessibility of similar habitats and biota on the larger Sea Islands or the adjacent mainland. Sandifer *et al*. (1980) cataloged the biological characteristics of the larger sea islands of South Carolina and Georgia in a thorough review of existing literature. For the purposes of their report, they defined Maritime forest communities as "those forests found on barrier islands." Sharitz (1975) distinguished five major types of Maritime Forests based upon work at Kiawah Island: 1) Oak-Pine, 2) Oak-Palmetto-Pine, 3) Oak-Magnolia or Oak-Bay, 4) Palmetto, and 5) Low Oak Woods. Rayner (1974) concluded that transition shrub communities are the most immature of the maritime wooded communities and the live oak-palmetto-bay communities are the most mature. A study on Hunting Island by Radford (1976) found that Slash Pine, Live Oak, Laurel Oak, Cabbage Palmetto, and Red Bay dominated the canopy and sub-canopy. He noted that as one moves south through the region, Slash Pines replace Loblolly Pines, Cabbage Palmettos become more common, and Saw Palmetto replaces Dwarf Palmetto in the understory.

Marsh hammocks are also known for their rare maritime high-calcium communities (McMillan and Porcher *et al*., 2001). These communities, thought to be the result of shell deposited by Native Americans, are comprised of plant species that thrive in relatively high pH soils. Prominent among these calciphytes are rare species such as Smallflower Mock Buckthorn (*Sageretia minutiflora*) and Godfrey's Swamp Privet (*Forestiera godfreyi).*

Preceding South Carolina's efforts to examine the ecological importance of hammocks, research and surveys have been conducted recently in Georgia. In 2001 and 2002, conservation organizations conduced biological inventories on several marsh hammocks (Fabrizio and Calvi, 2003; Jones and Calvi, 2003). Albers and Alber (2003) examined species diversity of flora on eleven hammocks near Sapelo Island. Working in the Savannah National Wildlife Refuge, Somershoe (2000) examined the utilization of marsh hammocks by neotropical migrant songbirds.

The present study was primarily qualitative in nature. A truly quantitative effort was well beyond our means in terms of funding and personnel. Initially, we envisioned two basic approaches 1) using trained DNR staff to explore islands on a routine basis and 2) to use several volunteers once in fall and once in spring to cover several islands simultaneously – the so-called "Bioblast" technique. We conducted a fall Bioblast, modeled after a similar effort in Georgia (Fabrizio and Calvi, 2003), but had only limited success. We concluded that the range of expertise of participants was too broad, and it is critically important to have highly qualified observers in order to collect meaningful and consistent data. The diversity of biota, the difficulties in species identification and the need for consistency dictated that we abandon the Bioblast technique and use only well-qualified biologists.

When searching this report for references to specific plant or animal species, the reader is advised to not only examine the Island Flora and Island Fauna sections, but to examine the Island Descriptions. Observational information for many plants and animals is included within the discussions of specific islands, habitats, and communities.

Materials and Methods

Survey of Regional Naturalists

In August 2003, a survey of 218 coastal zone naturalists and scientists was conducted, primarily via email, to establish baseline data regarding knowledge and perceptions of the flora and fauna of hammock islands and their importance in the coastal ecosystem. We anticipated the survey results would assist us in planning our field activities and focusing our methods on key species or habitats. The survey was sent to individuals associated with coastal colleges and universities, wildlife agencies, conservation groups, and private naturalists.

Island Selection Process

During late summer 2003, DNR staff conducted an initial reconnaissance by boat to identify potential islands for field surveys. Islands were initially identified based on size, location, accessibility, and proximity to boat landings. After making an initial selection of islands, we attempted to determine ownership and permission to survey privately owned islands. Several islands were tentatively selected and marked on maps. A meeting of representative from DNR, OCRM, US Fish and Wildlife Service and local naturalists was held to evaluate the number and size of islands that would be manageable, and to preliminarily select islands from the initial pool.

We elected to divide the study into two regions: ACE Basin (Figure 1) and the Folly/Kiawah area (Figure 2). This was done in an effort to compare a developed region to a relatively undeveloped region. Twenty-two islands were selected: seven in the ACE Basin, four in the Folly Island area, nine in the Kiawah Island complex, and two on the Stono River. The islands were partitioned by the following size categories: less than two acres, 3 to ten acres, and greater than 10 acres. Of these initially identified islands, the Kiawah Island Community Association staff committed to sample four islands in the Kiawah Island area, and the USFWS staff committed to sample two islands in the upper Stono River area. Three additional islands in the Beaufort area were subsequently selected when it was determined staff from Beaufort OCRM, DNR and the Master Naturalist Program at Spring Island were available to assist in field surveys. This brought the total number of islands to be surveyed to 25, with 16 being sampled consistently by Charleston DNR staff in association with volunteers (Table 1). Islands ultimately selected for the study included the following regions: Folly Beach, Kiawah Island, upper Stono River, ACE Basin and Port Royal Sound. In addition to the comparison of biota by island size and region, three of the 25 islands (developed or otherwise manipulated) were used to more directly compare developed vs. undeveloped islands.

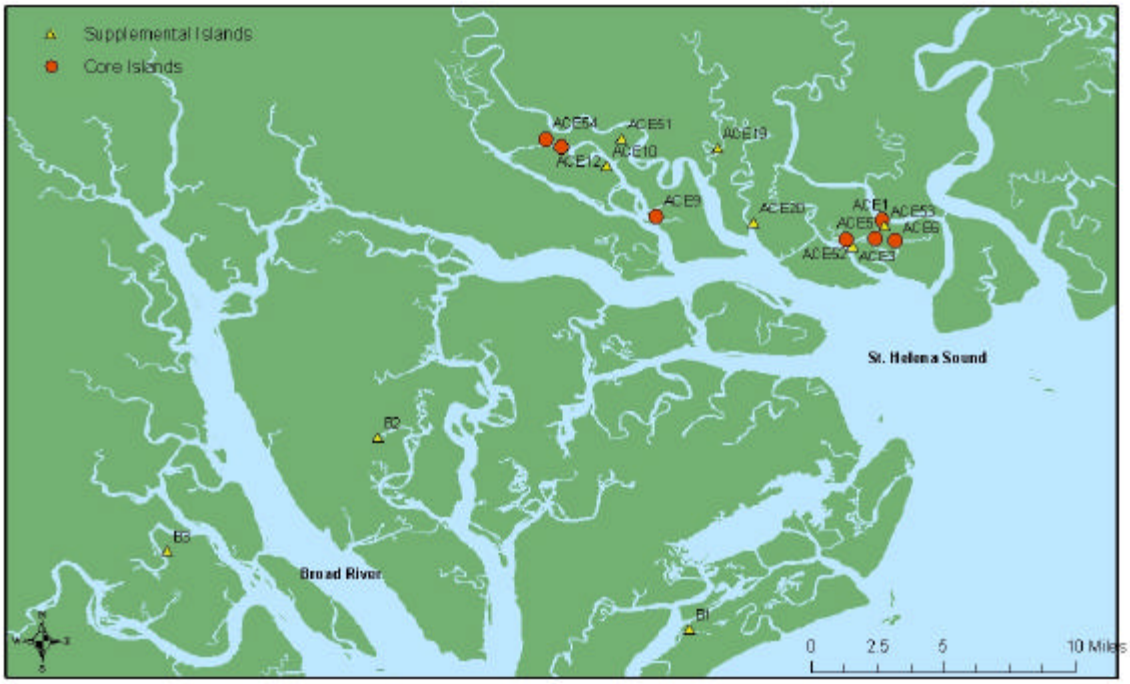

Figure 1. Location of islands in the Beaufort/ACE Basin region.

Figure 2. Location of islands in the Folly/Kiawah region.

Table 1. Island designations and associated physical data. Island K2 became a "disturbed" island during the study.

	Core	Disturbed	Total Area (acres)	Upland Area (acres)	Island Perimeter (meters)	Perimeter Upland (meters)	Coverboard (Sets Per Island)
ACE Basin Area							
ACE1	X		32.55	28.41	1258	1,847	3
ACE5	X		3.38	2.68	465	465	1
ACE6	X		3.66	3.06	518	501	2
ACE9	X		14.33	12.44	1414	1,380	2
ACE12	X		74.01	68.43	3805	4,139	8
ACE52	X		10.83	8.98	942	857	3
ACE54	X		11.63	10.44	1159	1,125	2
Beaufort Area							
B1			10.03	8.37	1300	1,325	2
B2			41.31	36.05	1697	1,899	2
B3			4.16	3.28	511	580	1
Upper Stono R.							
D3			9	7	1148	1,345	2
S1			4.96	3.78	609	538	1
Folly Area							
F7	X		19.53	12.09	1,782	2,389	2
F51	X		89.11	63.76	4905	12,989	4
F52	X	X	14.29	9.93	1988	1,646	2
F53	X		2	1.05	415	440	1
Kiawah Area							
K1	X		7.94	5.07	1130	1,618	2
K2			14.26	10.7	1406	1,432	3
K6	X		2.42	1.58	478	355	4
K51			1.18	0.55	308	286	1
K52	X		4.2	3.23	731	587	2
K53			6.17	5.13	865	1,017	2
K55	X		10.62	5.98	1007	1,425	2
K57		X	17.19	11.44	2494	4,176	2
K58	X	X	10.57	8.36	1212	2,782	2

Field Methods

The basic survey methodology was a timed foraging approach. Typically, one or two groups of three individuals conducted surveys, with each group consisting of biologists familiar with bird identification and general knowledge of biota of the coastal region. A survey team moved across the island slowly, stopping at appropriate intervals to call and observe birds. Birds were identified both visually and audibly. Recorded screech owl calls as well as mimic birdcalls were used to attract birds. Additionally, teams examined various natural cover objects such as logs and palmetto fronds to search for reptiles, amphibians, and small mammals. Identifiable evidence of animals (sign) was also recorded, including scat, skeletal remains, tree rubs, feathers, burrows, nests and tracks. Unless specified otherwise, multiple sign of a particular type on a given trip to an

island were treated as one observation since it is impossible to relate sign to numbers of individuals.

All plant species observed were recorded for each island. If a positive identification could not be made on site, samples were retained to be pressed and keyed out by plant taxonomists (P. McMillan of Clemson University, R. Porcher of the Citadel, and John Brubaker of the South Carolina Native Plant Society). The diameter of trees of extraordinary size was measured at 1.5m from the ground.

When possible, photographs were taken of representative biota or unusual findings. General data recorded included basic physical observations (tidal stage, air temperature, wind speed and direction, cloud cover), time arriving and departing from the island, and notes on island size and types of habitat. The strategy was to subsequently relate observations to time spent searching, although, time elapsed was generally a function of island size and habitat type (habitats difficult to traverse or more complex required more time). A Garmin GPS III was used on numerous trips to record the search path and locations of items of interest. The goal was to survey as much of the island's area as practical over the course of the study by randomly meandering through various habitats on all trips.

NatureServe rankings are provided for selected species throughout this document (Table 2). These rankings provide a broader context for interpreting the occurrence and abundance of specific species found in this survey.

Coverboards were employed to increase the likelihood that reptiles, amphibians, and small mammals would be observed. Each island had at least one set of coverboards and larger islands had more. A set was comprised of one flat wooden plywood board, one raised wooden plywood board (a two by four nailed to the bottom), one flat piece of roofing metal, and one slightly bent piece of roofing metal. All coverboards were approximately 0.6 by 1.2 meters. All four boards of a set were placed within about a 20-m radius. GPS coordinates were recorded for each set. Coverboards were checked each time the island was visited. When vertebrate species were found in association with a coverboard, the type of coverboard was noted for each observation.

Motion sensor cameras were deployed on a few islands in an effort to capture evidence of animals such as otter or armadillo, whose presence had been detected only through the presence of sign.

Data were entered into a Microsoft Access database. ArcView 3.2 was used to assess and map significant features of each island. Coordinates of significant features were established in the field using a GPS. Each island was hand digitized at a scale of 1:2000 to delineate the island plus associated fringe habitat. Features on the islands including wetlands, Man-made Ponds, and built structures on the developed islands were digitized as well.

Table 2. Definitions of NatureServe conservation status rankings (NatureServe, 2004).

S1	**Critically Imperiled**—Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
S2	**Imperiled**—Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
S3	**Vulnerable**—Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
S4	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
S5	**Secure**—Common, widespread, and abundant in the nation or state/province.
G1	**Critically Imperiled**—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
G2	**Imperiled**—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
G3	**Vulnerable**—At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
G4	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
G5	**Secure**—Common; widespread and abundant.
?	**Inexact Numeric Rank**—Denotes inexact numeric rank (e.g., G2?)

Results and Discussion

Survey of Regional Experts

Of the 218 individuals provided a copy of the survey, 71 individuals (32.6%) responded to the survey. Of the respondents, 56.3% indicated they had no information relative to hammock island biota or ecology, and 43.7% provided a variety of plant and animal species thought to occur on the islands (Appendix 1). Very few had specific information collected directly from marsh hammocks. Respondents identified thirty-three species as likely inhabitants of hammock islands **(**Table 3**)**. These species include reptiles, mammals, plants, and several groups of birds (neotropical migrants, shorebirds, and wading birds). Though the respondents included knowledgeable herpetologists, none suggested that amphibians would be found on the marsh hammocks. The animals and plants identified in the survey provided a list of topics for initial literature reviews and helped staff plan field-sampling techniques.

In addition to identifying species that might be found on the islands respondents were given an opportunity to identify concerns related to development of hammock islands. Respondents were concerned that development might negatively impact the function of hammock islands as migratory corridors for birds, refuges for wildlife, and erosional buffers. Concern was also voiced over potential effects of island development on groundwater and surface water, particularly with respect to increased fecal coliform loading.

Table 3. Species identified by regional experts as likely inhabitants of hammock islands.

Birds:

Black Skimmer, American Oystercatcher, Great Blue Heron, Wood Stork, Bald Eagle, Osprey, Wild Turkey, Brown Pelican, Painted Bunting, Red Tailed Hawk, Great Horned Owl, Screech Owl, Barred Owl, Marsh Wren, Boat-tailed Grackle, Red-winged Blackbird, Black Vulture, Seaside Sparrow, Marsh Sparrow, Red-eyed Vireo, Eastern Towhee, Summer Tanager, Yellow Throated Warbler, Ruddy Turnstone, Black Turnstone, Common Sandpiper, Marsh Sandpiper, White-faced Ibis, White Iibis, Great Egret, Little Egret, Reddish Egret, Various Warblers, Plover, Tern, Laughing Gull, Pigeon Hawk, Marsh Hawk

Reptiles:

Eastern Glass Lizard, Island Glass Lizard, Diamondback Rattlesnake, Diamondback Terrapin, Eastern Cottonmouth, Hognose Snake, Canebreak Rattlesnake, Eastern King Snake, Coachwhip

Amphibians:

None Identified

Mammals:

Otter, Mink, Bobcat, Marsh Rice Rat, Cotton Rat, Eastern Wood Rat, Cotton Mouse, White Footed Mouse, Pocket Gopher, Opossum, Feral Hog, Grey Fox, Marsh Rabbit, Eastern Cottontail, Grey Squirrel, Fox Squirrel, White-tailed Deer, Raccoon, White Footed Mouse

Plants:

Maritime forests and associated plants, live oaks, palmettos, calciphytes

Island Descriptions

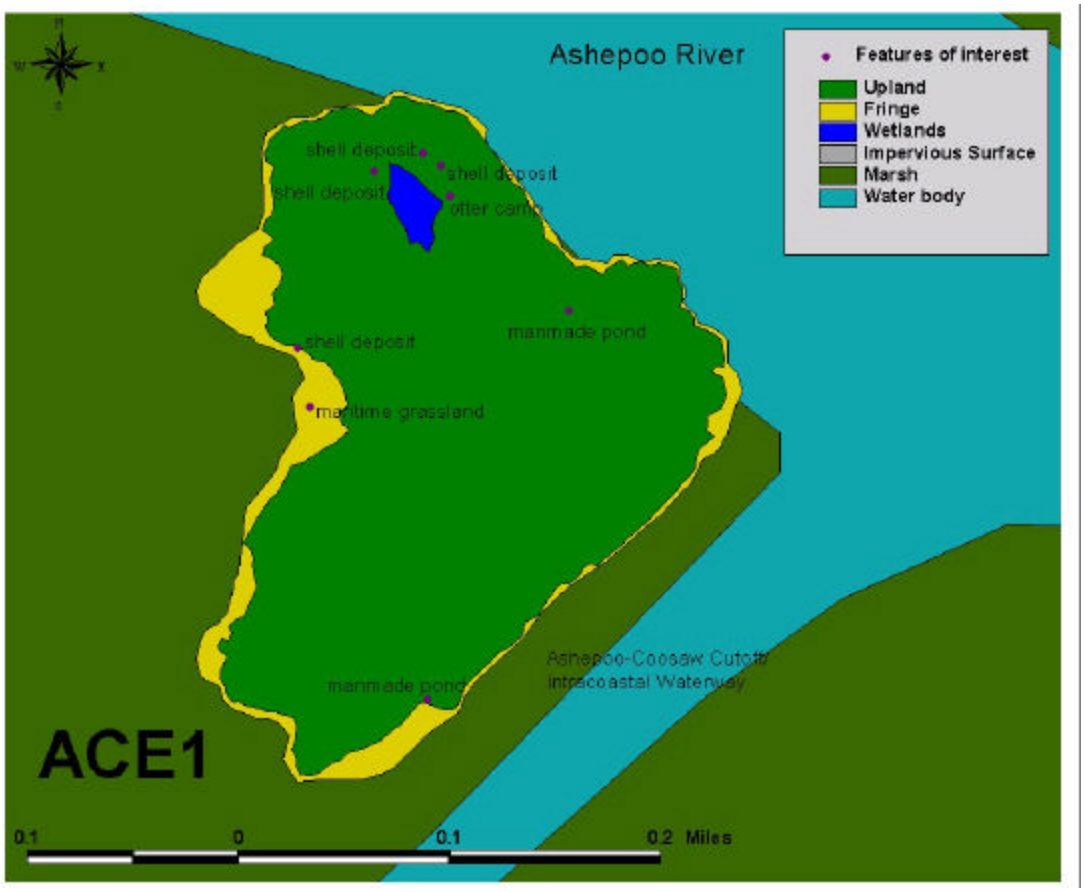

Figure 3. Map of ACE1.

ACE 1

ACE 1 is about 33 acres in size and is located in Colleton County at the confluence of the Ashepoo River and the Ashepoo-Coosaw Cutoff/Intracoastal Waterway (Figure 3). The island contains an excellent example of a *Spartina bakeri* Pond, with a permanent pool near its center. Smaller, more temporary pools are distributed throughout this wetland. The remnants of an apparent drainage ditch connect the wetland to the marsh on the west side, but the ditch has filled from weathering and currently provides poor drainage. The ditch does likely allow inflow of saline water during extreme high tide events. This wetland supports a dense colony of *Spartina bakeri* and several specimens of a regionally uncommon wetland species of vetch, *Viccia acutifolia*. A small colony of Golden Canna (*Canna flaccida*), a native wetland canna, which NatureServe ranks as G4 and S4 and is a species of State Concern (SC), occurs in this wetland as well. Salinity of the pool can be very low following rain events and remains sufficiently low to support thriving populations of Southern Leopard Frog (*Rana utricularia*) and Green Tree Frog (*Hyla cinerea*). The permanency and size of the pool in this wetland are likely the contributing factors in the occurrence of both Bullfrog (*Rana catesbeiana*) and American Alligator (*Alligator mississippiensis*). Neither of these

species was encountered on other surveyed islands. There are two small manmade ponds, one each at the extreme south and north ends of the island, likely created by hunters to provide a water source for deer. These ponds also provide permanent fresh water and breeding habitat for Southern Leopard Frog. This is the only island surveyed that contained permanent, low salinity water sources. There are two Northern River Otter (*Lutra canadensis*) camps on the island, one on the upland edge of the internal brackish wetland and another adjacent to the Intracoastal Waterway. ACE 1 appears to have a more diverse mammal population than most islands in the survey. In addition to deer, raccoon, and otter, either sign or sightings showed the presence of Bobcat (*Lynx rufus*), Mink (*Mustela vison*), Marsh Rabbit (*Sylvilagus palustris*), Marsh Rice Rat (*Oryzomys palustris*), Hispid Cotton Rat (*Sigmodon hispidus*) and Eastern Mole (*Scalopus aquaticus*). There is a small heron rookery on the most westerly portion of the island. Birds were not observed in the nests, but the nest characteristics are indicative of night herons. A Green Heron (*Butorides virescens*) nest occurs in the same vicinity. American Woodcock (*Scolopax minor*) was a winter visitor, and Bald Eagle (*Haliaeetus leucocephalus*) was frequently seen resting on or soaring above the island during winter and early spring. Northern Bobwhite (*Colinus virginianus*) was an unexpected find, but apparently occurs in low numbers. The most noteworthy breeding birds were Orchard Oriole (*Icterus spurius*), only observed as a breeder here, and Painted Bunting (*Passerina ciris*), observed as a breeder on most islands. Only four snakes were encountered during the survey period, two Southern Black Racers (*Coluber constrictor priapus*), one Yellow Rat Snake (*Elaphe obsoleta quadrivittata*) and one juvenile Eastern Cottonmouth (*Agkistrodon piscivorus*). Despite an apparently large population of small mammals and repeated warnings about Eastern Diamondback Rattlesnakes (*Crotolus adamanteus*) from the island's property manager, snakes were uncommon, possibly explained by the long-term use of the island by deer hunters. There are several Native American shell deposit sites on the island's west side, some of which are represented on the island image above. In association with some of these calcium-rich soils are small colonies of rare plants. Among these, Small-flowered Buckthorn (*Sageretia minutiflora*) and Piedmont Flatsedge (*Cyperus tetragonus*) are designated as being of "State Concern" (SC) and have a NatureServe rank of S1. Satincurls (*Clematis catesbyana*), with an S2 rank, was also found here. The southeast end of the island has widespread shell deposited from dredge disposal, and is colonized by a large population of the calciphilic Carolina Buckthorn (*Frangula caroliniana*). Portions of the island perimeter, particularly the west side, have abundant maritime grassland habitat, dominated by Sand Cordgrass (*Spartina bakeri*). There are a number of trees of noteworthy size, including a Black Cherry (*Prunus serotina*) (63 cm diameter), a three-trunked Sweet Gum (*Liquidambar styraciflua*) (78 cm, 50 cm, and 58 cm diameter), a Black Gum (*Nyssa sylvatica*) (48 cm diameter), a Loblolly Pine (*Pinus taeda*) (111 cm diameter) and a Pond Pine (*Pinus serotina*) (70 cm diameter). Most of the larger trees are located in the southwest center of the island, indicating that this area has not been significantly disturbed by logging or other human activities for many years.

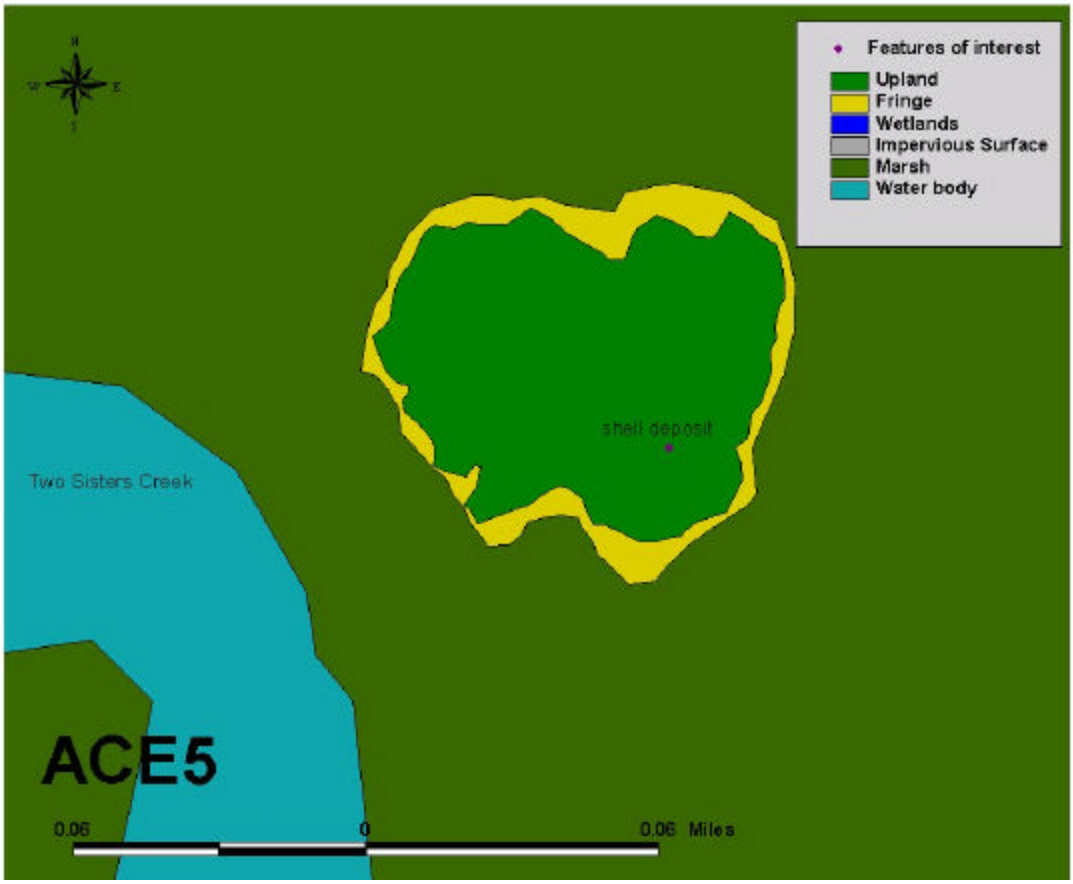

Figure 4. Map of ACE5.

ACE 5

ACE 5 is located in Colleton County on a small tidal creek that connects the Ashepoo-Coosaw Cutoff/Intracoastal Waterway and Two Sister's Creek (Figure 4). It is a little over 3 acres in area. There are Brackish Marsh incursions, dominated by Sea Ox-eye (*Borrichia frutescens*) on the edges of the island that penetrate beneath large Live Oaks and Cabbage Palmettos. There are also a number of depressions on the island that fill during significant rain events. Several small shellmounds occur in the southeast region. One of these shellmounds supports a small colony of Midden Prickly Pear (*Opuntia stricta*), an uncommon, nearly thornless variety of prickly pear cactus that is thought to have been selected for as a food by Native Americans. This island was labeled "Cedar Hammock" during the survey because it has the highest density of Southern Red Cedar (*Juniperus silicicola*) among the surveyed islands. Cedar fruit provide excellent forage for overwintering songbirds. Not coincidentally, on one winter survey trip following a storm event, a mixed flock of several hundred American Robins (*Turdus migratorius*) and Cedar Waxwings (*Bombycilla cedrorum*) was observed feeding both in the trees and on fruit that had fallen to the ground. The most notable breeding bird was the Painted Bunting.

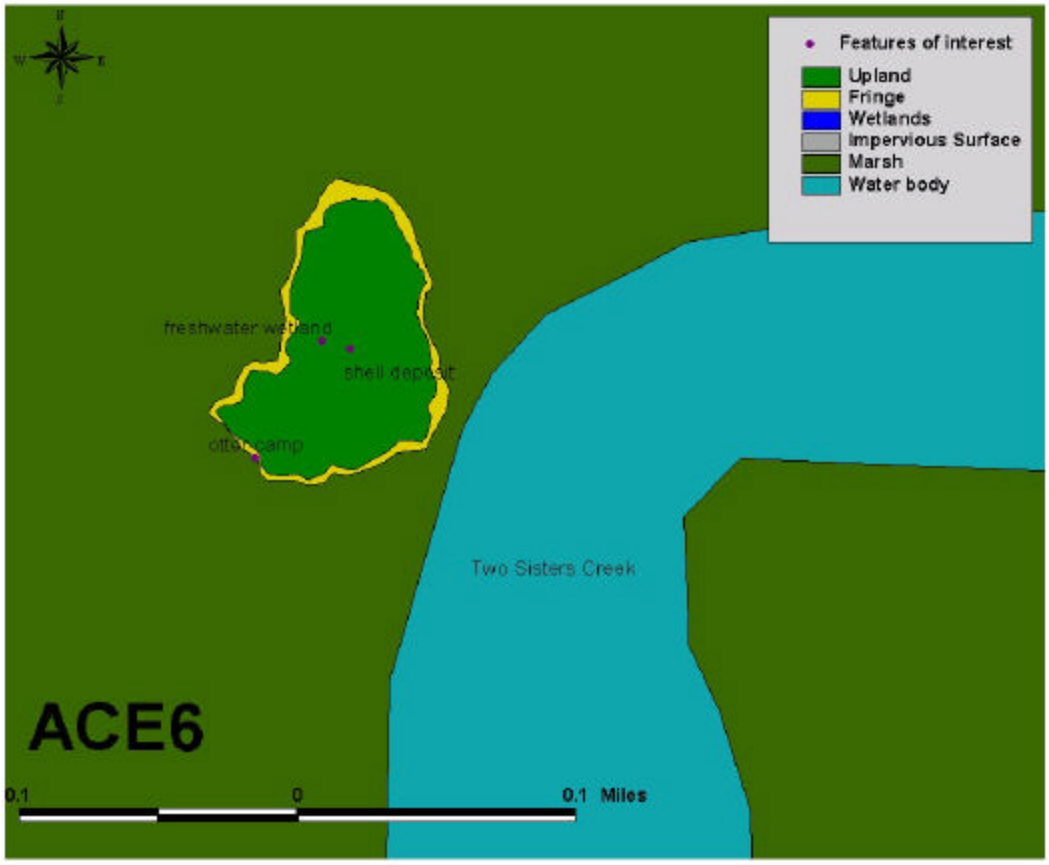

Figure 5. Map of ACE 6.

ACE 6

ACE 6 is within the East Hutchison Island group in Colleton County on Two Sisters Creek, near St. Helena Sound (Figure 5). The nearly 4-acre island contains substantial shell deposits, including several shellmounds on the eastern side. The high calcium content of the soil supports a diverse calcareous plant community, including Basswood (*Tilia americana* variety *caroliniana*), Coral-beads (*Cocculus carolinus*) and Angelpod (*Gonolobus* sps.). Included among the calcareous community are four rare plants of State Concern (SC) status and NatureServe state rank of S1 or S2, Small-flowered Buckthorn, Piedmont Flatsedge, Godfrey's Swamp Privet (*Forestiera godfreyi*) and Satincurls (*Clematis catesbyana*). Godfrey's Swamp Privet is known from only a few sites in South Carolina and from limited coastal locations in Georgia and northern Florida and has a NatureServe global ranking of G1. There is one bowl depression at the base of the root-ball of a large, fallen Southern Red Cedar near a central shell ridge. Though water was not observed there, the depression is the most likely source of seasonal surface freshwater that could support breeding of two amphibian species, Green Tree Frog and Southern Toad (*Bufo terrestris*). Reptiles are abundant on the island, dominated by the ubiquitous Green Anole (*Anolis carolinensis*) and Southeastern Five-lined Skink (*Eumeces inexpectatus*). Also encountered were Eastern Glass Lizard (*Ophisaurus ventralis*), Yellow Rat Snake, and one of only two Eastern Diamondback Rattlesnakes observed during the study. The Eastern Diamondback has SC status in South Carolina

and has NatureServe rankings of G4 and S3. Diamondbacks apparently move between upland areas, including hammocks, during population dispersal and likely during breeding season. The most notable breeding bird was Painted Bunting. A small tidal creek cuts along the southern tip of the island, and, as indicated in Figure 5, two otter camps occur immediately upland of the creek bank. Bobcat sign was also noted on this island, as the species apparently moves among islands in the Hutchison Island group, both east and west of the Ashepoo-Coosaw Cutoff/Intracoastal Waterway.

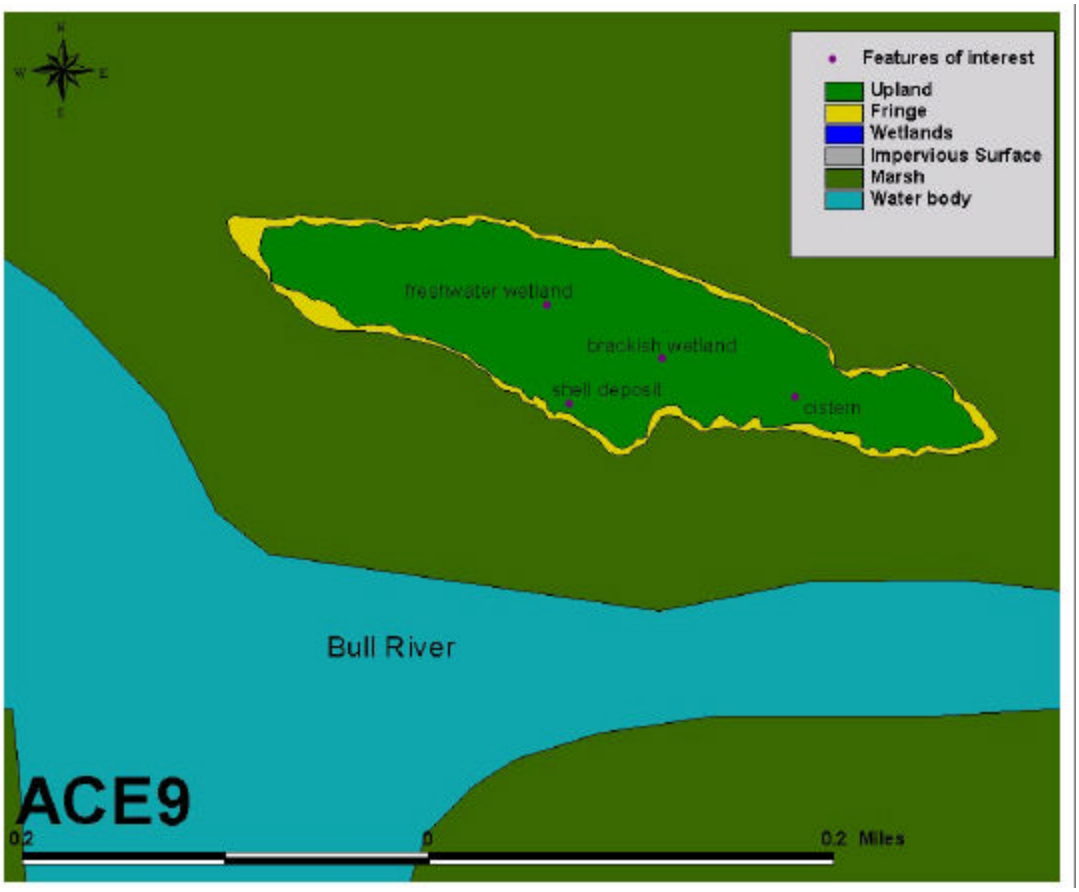

Figure 6. Map of ACE 9.

ACE 9

ACE 9, Buzzard Island, is located in Beaufort County on Bull River seaward of the junction of Wimbee and Williman Creeks (Figure 6). It is about 14 acres in area. This island contains a building foundation from habitation in the early 1900s. There is a cistern near the foundation that serves as a freshwater source. There is an enclosed Salt Marsh with brackish water present seasonally, located near the building foundation. A smaller wetland in the western, central part of the island contains a seasonal pool that retains fresh water at least during much of winter and spring. Terrestrial Water Starwort (*Callitriche terrestris*), a small, mat-forming, semi-aquatic herb that is rare in the lower Coastal Plain (state rank = S2), occurs here. Both wetlands are connected to the Salt Marsh on the island's west side via partially filled drainage ditches. The wetlands were

likely drained for mosquito control when the island had human habitation, but the ditches now provide water exchange only during exceptionally high tides or after periods of phenomenally high rainfall. Feral goats have been observed on this island on numerous occasions, and their long-term presence is indicated by skeletal remains throughout. Burrows on the island indicate the presence of Nine-Banded Armadillo (*Dasypus novemcinctus*), though none were sighted. The armadillo continues to expand its range into the southeastern part of the State and is not uncommon in Beaufort County. Also found on Buzzard Island, near the smaller wetland, was an American Beaver (*Castor canadensis*) skull. A similar find was made on ACE 12. Otter sign was frequently observed where a small tidal creek turns against a salt-shrub and grass collar on the extreme southwestern tip. Though this island is somewhat isolated and surrounded by a vast expanse of Salt Marsh, it supported a greater density of overwintering birds than did other islands in the survey. Dozens of Yellow-rumped Warblers (*Dendroica coronata*) were the predominant portion of large, multi-species foraging-flocks observed on each survey from November through March. Other species frequently seen in these groups were Ruby-crowned Kinglet (*Regulus calendula*), Carolina Chickadee (*Poecile carolinensis*) and Tufted Titmouse (*Baeolophus bicolor*). Blue-headed Vireo (*Vireo solitarius*), seldom encountered on the islands, was also seen within these flocks on several winter trips. The abundance of fruit-eating birds can be attributed to the islands botanical features. As is typical of the marsh islands, Buzzard Island is largely enshrouded with a mixture of Live Oak (*Quercus virginiana*), Cabbage Palmetto (*Sabal palmetto*) and Southern Red Cedar (*Juniperus virginiana var. silicicola*). There are many large Live Oaks near the island's center, including two particularly large specimens (147 cm and 200 cm diameter). This island also has a much higher density, and broader distribution of Sugarberry (*Celtis laevigata*) than does any of the others surveyed. Many of the Sugarberry and Southern Red Cedar are quite large (30 cm diameter) and provide abundant winter fruit, particularly in concert with the dense understory including Yaupon (*Ilex vomitoria*) and Chinese Privet (*Ligustrum sinense*). The most notable breeding bird was Painted Bunting, and a female was observed feeding several fledglings during a June survey. Despite the presence of freshwater on at least a seasonal basis, and likely permanently within the cistern, no amphibians were recorded. One of the two Eastern Diamondback Rattlesnakes observed during the island study was seen on Buzzard Island. The island seemed to have a relatively large population of Eastern Glass Lizard, as several were recorded despite a dense carpeting of St. Augustine Grass (*Stenotaphrum secundatum*) in the areas where glass lizard sightings were made. About half the length of the island's eastern side contained substantial shell deposits, with several low mounds. Low, heavily browsed stems (apparently by goats since deer are seemingly absent) and shoots of Shellmound Sageretia occur in this area. Several large colonies of Atamasco or "Easter"Lily (*Zephyranthes atamasco*) occur near the island's center, making a showy display when in bloom during April.

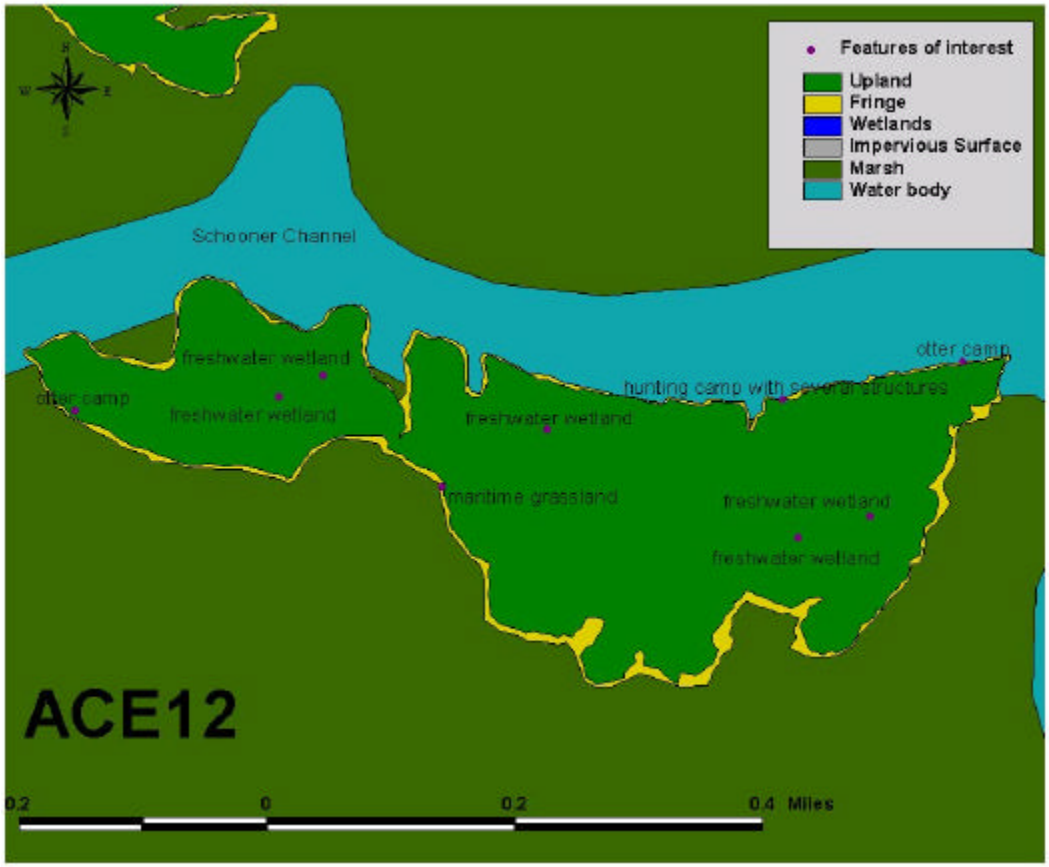

Figure 7. Map of ACE12.

ACE 12

ACE 12 is in Beaufort County within the South Williman Island complex and on the east side of Schooner Channel between Wimbee and Williman Creeks (Figure 7). It is a state-owned Heritage Preserve that allows hunters to camp on the island and use bow-and-arrow to hunt deer. This island supports various habitat types and a great variety of species of plants and animals. The size of this island (~74 acres), and its more inland location than others surveyed, likely contributes to its diversity of habitats, flora and fauna. The center of the island is best described as Oak – Hickory Forest, dominated by Cherrybark Oak (*Quercus pagoda*), Water Oak (*Quercus nigra*) and Sweet Gum (*Liquidambar styraciflua*). Evidence of logging, perhaps 50-100 years ago, includes logging roadways, drag-marks and rotted pine logs concentrated in one area near Schooner Creek. Despite such evidence of logging directed for pine, large Loblolly Pine specimens (one measured at 78 cm diameter) remain distributed throughout. There are four freshwater wetlands within this interior forest that vary in size and degree of saturation, three of which have seasonal ponds or pools. Three of these four wetlands support dense stands of Blue Flag Iris (*Iris virginica*). Other plants found in these wetlands and only on ACE 12 were Lizard's Tail (*Saururus cernuus*), Pickerelweed (*Pontederia cordata*), Buttonbush (*Cephalanthus occidentalis*) and Black Willow (*Salix*

nigra). There are numerous Depression Wetlands on the island and botanical features vary depending on distance from the Salt Marsh and extent of shade or canopy coverage. These Depression Wetlands support a diverse assemblage of grasses, with Switchgrass (*Panicum virgatum* var. *virgatum*) a dominant species, and sedges in the genera *Carex, Cyperus* and *Rhynchospora*. The outer, forested portion on the southwestern side and the northeastern tip are more typical of an Inland Maritime Forest with a mix of primarily Live Oak, Cabbage Palmetto and Loblolly Pine (*Pinus taeda*). The upland habitat bordering Schooner Creek generally has higher, sandy soils and supports a Mixed Pine-Hardwood Forest with both Pignut (*Carya glabra*) and Mockernut (*Carya tomentosa*) Hickory. As an indication of habitat diversity, there are eight oak species on the island; Live Oak, Water Oak, Cherrybark Oak, Laurel Oak (*Quercus laurifolia*), Black Oak (*Quercus velutina*), Post Oak (*Quercus stellata*), Willow Oak (*Quercus phellos*) and White Oak (*Quercus alba*). Notable understory and herbaceous plants found on this island, and not generally observed during the survey, include Eastern Redbud (*Cercis canadensis*), Devil's Walking Stick (*Aralia spinosa*), Indian Hemp (*Apocynum cannabinum*), a Mountain Mint (*Pycanthemum pycanthemoides*), Lyre-leaved Sage (*Salvia lyrata*), a Spring Ladies'-tresses Orchid (*Spiranthes vernalis*), and Mottled Trillium (*Trillium maculatum*). One particularly large Devil's Walking Stick measures 12 cm diameter. Another interesting find was a Camphor Tree (*Cinnamomum camphora*) near the western end. The presence of this unusal non-native plant and of a hand-pump wellhead near the opposite end provides evidence of past human habitation. There is substantial maritime grassland habitat dominated by *Spartina bakeri*, primarily on the western side. A small colony of Sweetgrass (*Muhlenbergia filipes*) was found in a clearing in a Palmetto-Pine forest on the western side. Sweetgrass has become imperiled on the mainland and has significant socioeconomic value to Gullah basket-weavers. Depressions occur throughout these grasslands as well, and surface water can be broadly distributed in the various wetland types during rainy periods, particularly during winter and spring. The diversity of habitat and, in particular, the availability of freshwater wetlands contributes to the greatest observed diversity of herptiles. Ten species of reptiles and eight species of amphibians were recorded. A robust population of South Carolina Slimy Salamander (*Plethodon variolatus*) was found on this island. Other amphibians found on ACE 12 were Mole Salamander (*Ambystoma talpoideum*), Central Newt (*Notophthalmus viridescens louisianensis*), Eastern Narrowmouth Toad (*Gastrophryne carolinensis*), Southern Toad, Southern Leopard Frog, Squirrel Tree Frog (*Hyla squirella*) and Green Tree Frog. Broadhead (*Eumeces laticeps*), Southeastern Five-lined and Ground (*Scincella lateralis*) Skinks are abundant, as is the Green Anole. Six snake species have been observed here as well, including Southern Black Racer, Yellow Rat Snake, Eastern Cottonmouth, and more notably, Rough Green Snake (*Opheodrys aestivus*) Southeastern Crowned Snake (*Tantilla coronata*) and Scarlet Snake (*Cemophora coccinea*). The latter two species were only encountered here. The most noteworthy breeding birds were Painted Bunting, Northern Parula (*Parula americana*), White-eyed Vireo (*Vireo griseus*), Summer Tanager (*Piranga rubra*) and Acadian Flycatcher (*Empidonax virescens*). ACE 12 was the only island surveyed where Summer Tanager and Acadian Flycatcher, a species with SC status, were confirmed as breeders. Acadian Flycatchers were associated with, and apparently nesting near, the three largest internal wetlands. An adult was observed feeding a juvenile near one of the wetlands on

a summer visit. There are otter camps at both ends of the island where creeks and sloping banks afford access. Numerous armadillo burrows are located throughout the island, but no animals were observed. Squirrel nests were also observed, but no squirrels were seen. A skull found on the island, feeding sign, and the structure of nests and habitat where such were seen are indicative of Eastern Gray Squirrel (*Sciurus carolinensis*). As indicated by scat sign, Bobcat also range onto the island, where Whitetail Deer are abundant. An American Beaver skull was also found on ACE 12. Though crustaceans such as fiddler crabs (*Uca* sps.) and Square-back Crab (*Sesarma* sp.) were commonly associated with all islands, this was the only island on which crayfish (*Procambarus lunzi*) were found.

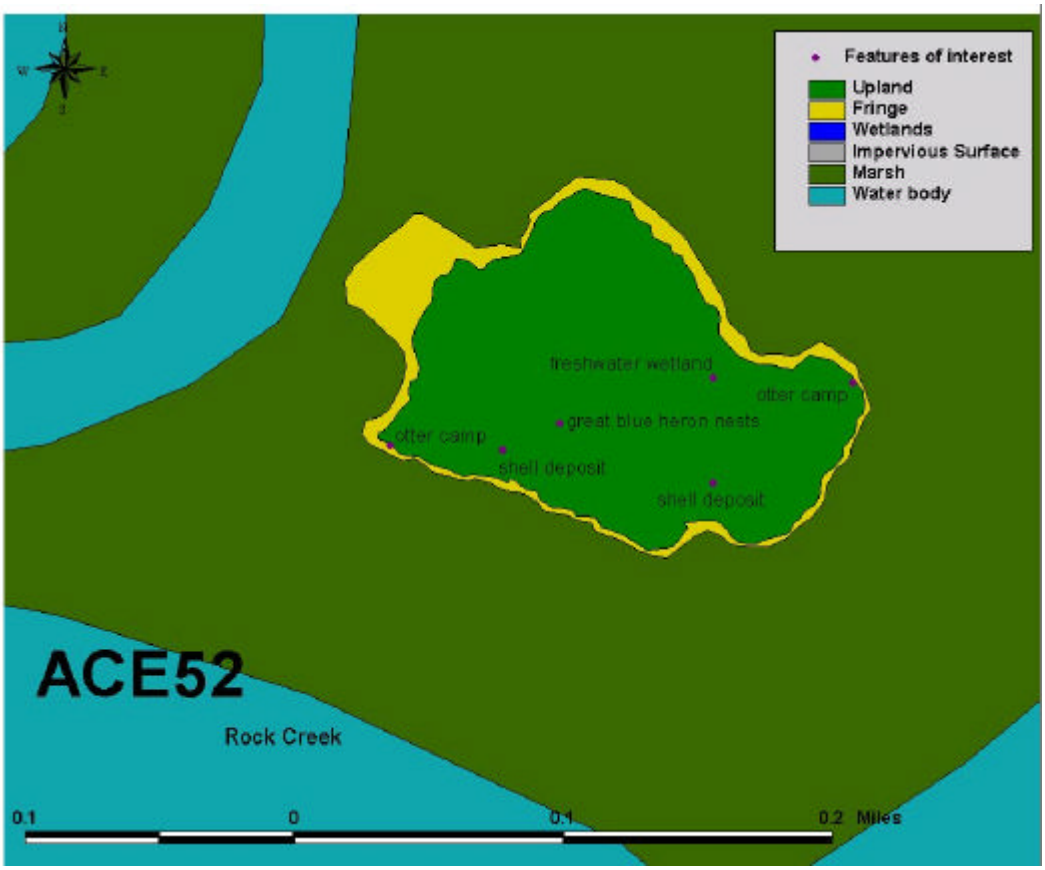

Figure 8. Map of ACE52.

ACE 52

ACE 52 is located in Colleton County at the confluence of the Ashepoo-Coosaw Cutoff/Intracoastal Waterway, Rock Creek and another smaller tidal creek (Figure 8). A large Salt Flat extends from the southwestern end of the island and out about 50 m to the tidal creek. There are substantial shell deposits throughout much of the island's nearly 11-acre interior, and particularly on the east side where there are a number of shell-mounds. Most of the upland is best described as maritime shell forest or "shell hammock" (McMillan & Porcher, 2001) or as maritime shell forest by SCDNR designation. The island supports a more diverse calcareous plant community than other

islands surveyed. Calciphiles are distributed throughout, including Basswood, Small-flowered Buckthorn, Carolina Buckthorn, Sugarberry, Red Buckeye (*Aesculus pavia*), Southern Sugar Maple (*Acer barbatum*), Satincurls (*Clematis catesbyana*), Angelpod (*Gonolobus* sps.) and Piedmont Flatsedge (*Cyperus tetragonus*). This is the only island within the survey on which Southern Sugar Maple was recorded. There are also many large trees on the island, including a Live Oak (204 cm diameter), a Southern Red Cedar (63 cm diameter), a Carolina Laurelcherry (37 cm diameter), and several Red Bay (*Persea borbonia*) (39 cm diameter). A very small colony of Midden Prickly Pear (*Opuntia stricta var. stricta*) occurs near the end of a narrow band of salt-shrub and Southern Red Cedar that stretches about 100 m from the southwest end. The island understory is densely vegetated with Yaupon, small trees, vines and Switchcane (*Arundinaria gigantea*) thickets. Within most of the interior, the ground is densely carpeted with sedges, Poison Ivy (*Toxicodendron radicans*) and seedling trees. There are several small bowl depressions on the western side that rarely hold rainwate, and only for brief periods. Raccoons have excavated small pits near the center of each, presumably in their attempts to maintain access to fresh water. Otherwise, there is no surface water on the island except following heavy rains when water may accumulate temporarily in depressions that are also primarily on the western side. Apparently, the shell deposits in the soil hold moisture and support lush plant growth at all levels. The interior resembles a rainforest, and the lush cover at ground level may be responsible for a relatively high population of Rice Marsh Rat. Despite the lack of significant surface water, the island has small populations of South Carolina Slimy Salamander, Southern Toad, Green Tree Frog and Southern Leopard Frog. This island contains a significant population of Eastern Cottonmouth (*Agkistridon piscivorous*), with multiple individuals encountered each survey except during late fall and winter. The only other snake observed was a Southern Black Racer (*Coluber constrictor priapus*). Also, a clutch of hatched Southern Black Racer eggs was found within a decaying Cabbage Palmetto log. Southeastern Five-lined Skink was also very abundant on this island. Abundant small mammals and other reptiles may largely provide the prey-base to support the relatively dense Cottonmouth population. There is a small Great Blue Heron (*Ardea herodias*) rookery with several nests near the southern center of the island. Other particularly significant breeding birds recorded on “Cottonmouth Island” were Painted Bunting and White-eyed Vireo. Acadian Flycatcher was heard singing on the island, but breeding was not substantiated. Also of significance, Barn Owl (*Tyto alba*), a species of State Concern, was recorded as a winter visitor. Owls were flushed from diurnal roosting sites concealed within dead fronds hanging beneath the living tufts at the crown of large Cabbage Palmettos. Otter camps are located on both the north and south end where small creeks approach the upland. In addition to the ubiquitous Raccoon and the Marsh Rice Rat, the only other mammals recorded here were Whitetail Deer and Marsh Rabbit.

Figure 9. Map of ACE54.

ACE 54

ACE 54 is 11.6 acres in area and is located in Beaufort County (Figure 9). It is a member of the North Williman Island complex, located on Schooner Channel between Wimbee Creek and Williman Creek and across Schooner Channel from ACE 12. The upland is characterized by Mixed Pine-Hardwood Forest, with the center dominated by a large colony of oaks, principally Cherrybark Oak. The southeastern half is dominated by Loblolly Pine. The eastern tip of the island and the outer southern side support a more typical maritime community with Cabbage Palmetto and Southern Red Cedar. This island also has a small colony of Sweetgrass in an opening on the western side near the Salt Marsh-upland ecotone. A small brackish wetland with a seasonal pool supports a population of marsh killifish (*Fundulus confluentus*). This is the only island on which Eastern Fox Squirrel (*Sciurus niger*), a species of concern, was encountered. Interestingly, the coat of the fox squirrels observed here was more reddish than that of mainland populations. ACE 54 lies within 100 m of a larger North Williman Island, which in turn, is near a much larger island. It seems probable that other, larger hammocks in the North Williman Island group support this species as well. Burrows of Nine-Banded Armadillo were also observed here, as was Bobcat scat. Feral goats frequent the island from the adjacent North Williman islands, and Whitetail Deer also range onto ACE 54. A tidal creek cuts against the upland on the northern side, and an otter latrine is located here. Trees overhanging the creek are used frequently as resting and roosting sites for wading birds, including the federally endangered Wood Stork

(*Mycteria americana*), Great Egret (*Ardea alba*), Snowy Egret (*Egretta thula*), Black-crowned Night Heron (*Nycticorax nycticorax*) and Yellow-crowned Night Heron (*Nyctanassa violacea*). Painted Bunting was also observed here during spring and summer.

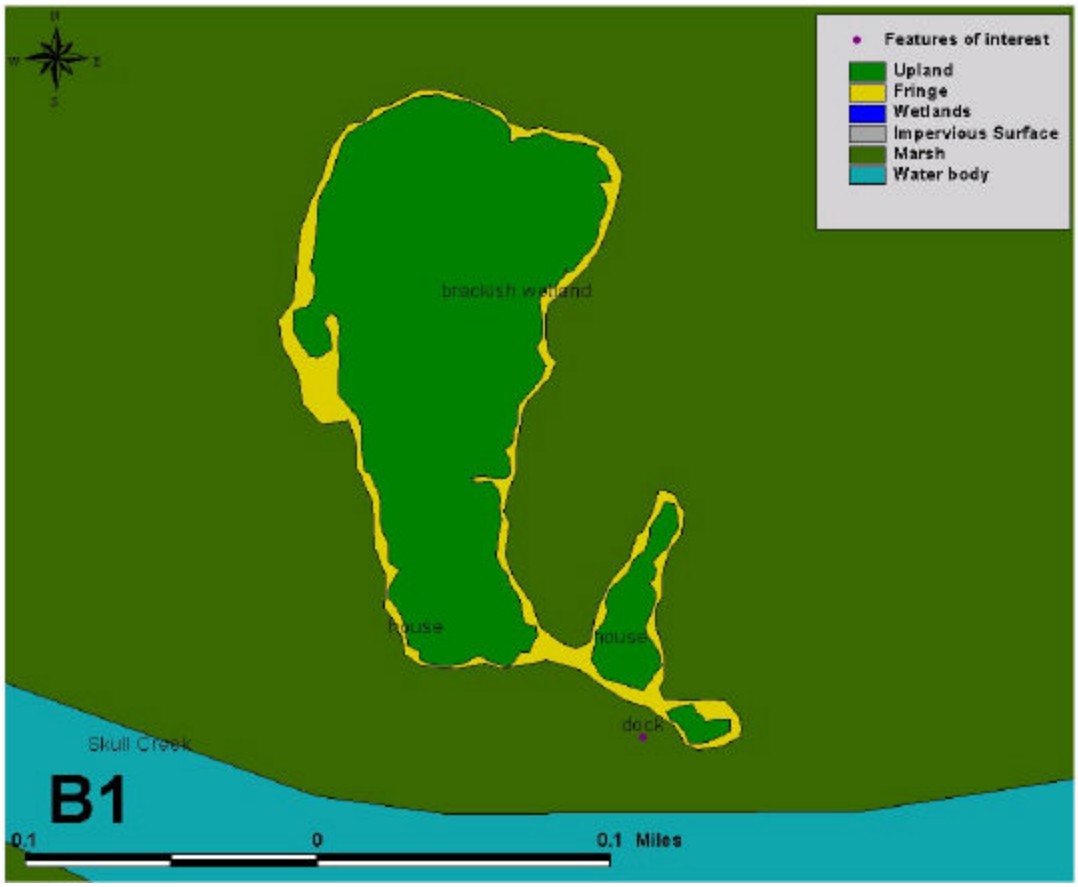

Figure 10. Map of B1.

B1

B1, locally known as Fish Camp Island, is located on a large tidal creek near Trenchards Inlet in Beaufort County (Figure 10). This 10-acre island is remote from the mainland and has two upland areas connected by a narrow isthmus of salt-shrub and Salt Flat. The smaller upland on the southeastern side, is about 1 acre in size, open and sandy, and has a maximum elevation of perhaps 1.5 m above mean high tide. Small Live Oak and Southern Red Cedar dominate the flora. The larger upland has high, relict dune ridges through the center with elevations reaching 3.5 to 4 m. Shell deposits occur on this island and the plant community is a blend of inland maritime and shell forest. The canopy is dominated by Live Oak, large Loblolly and Slash Pine, Pignut Hickory, Southern Magnolia (*Magnolia grandiflora*) and, surprisingly, exceptionally large Red Bays, with many specimens approximately 38 cm in diameter. The understory is also diverse and lush, with colonies of Saw Palmetto, American Beauty Berry (*Callicarpa americana*), Sparkleberry (*Vaccinium arboreum*) and Coral Bean (*Erythrina herbacea*). Calciphytes are abundant, including Tough Bumelia (*Sideroxylon tenax*), Carolina

Buckthorn, both Red and White Mulberry (*Morus alba*), and Small-flowered Buckthorn. Sandy openings support grasses, including Sweetgrass. Small wetland incursions are located on the east and west sides of the island. A shallow, highly seasonal pool occurs in the wetland on the east side. This pool likely retains water only following significant rain and/or high tide events. Vacation or weekend houses covering about 300 m^2 are located on the eastern, or creek-facing side of both upland areas, and there is also a small storage shed and building associated with the house on the smaller upland. This island was not among the core group, and was surveyed by volunteers on only two dates in addition to the initial visit. Accordingly, herbs, grasses and sedges were poorly inventoried. An otter camp occurs on Fish Camp Island, and there were signs of Whitetail Deer and Raccoon. Bird records were relatively scant, but apparent breeders included Northern Cardinal, Carolina Wren (*Thryothorus ludovicianus*), Carolina Chickadee and, most notably, Painted Bunting, all recorded as breeders on most hammocks surveyed. The only herptiles observed were Green Anole and Southeastern Five-lined Skink.

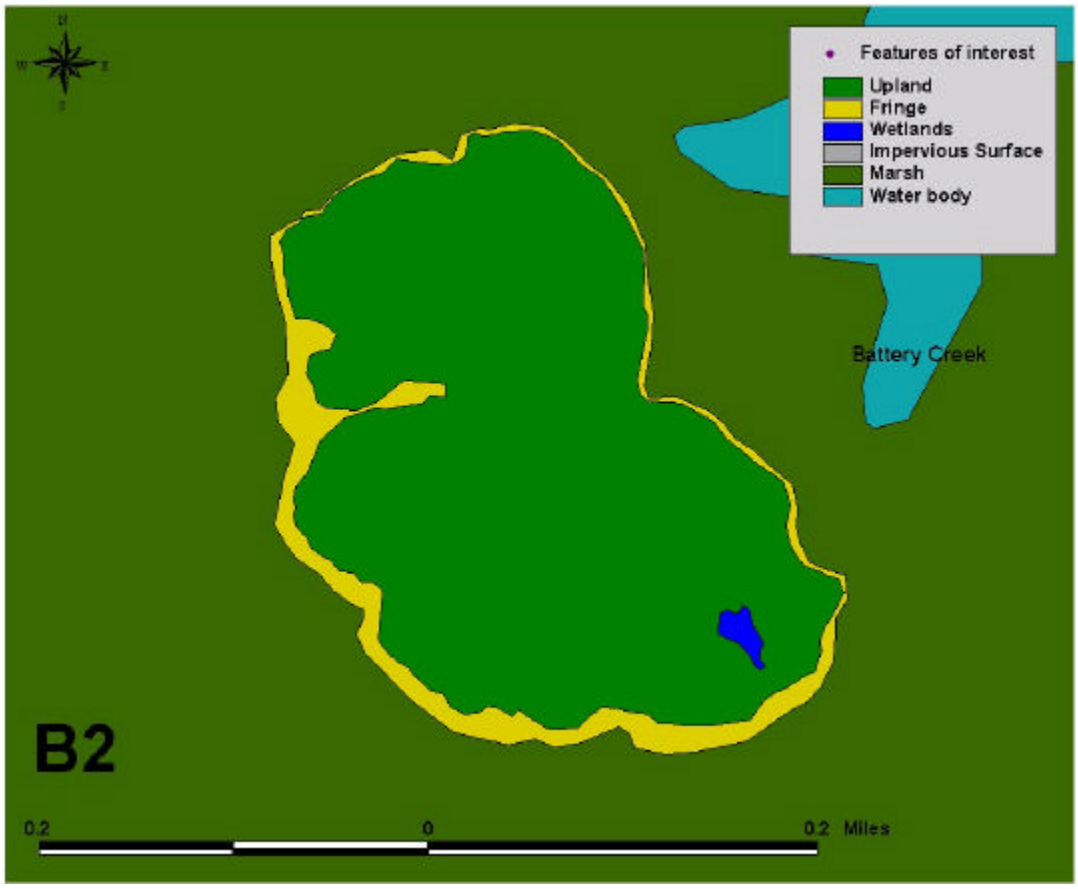

Figure 11. Map of B2.

B2

B2, Charlotte Island, is located within the Beaufort metropolitan area (Figure 11). This 41.3-acre island is separated from the mainland on the western side by only about 150 m of high Salt Marsh and Salt Flat. The highest point on the island attains perhaps 1.5 m above mean high tide. The island presents diverse habitat, much of which is atypical of other hammocks observed. A finger of brackish water wetland cuts into the western side and is flanked by a low Cabbage Palmetto-dominated forest with grasses, sedges, and both Dwarf Palmetto and shrub-stage Cabbage Palmetto. As depicted in Figure 11, a seasonal freshwater wetland with a central pool is located near the southern end. The northwestern portion of the island is higher than is the remainder and is pine-dominated forest. The only Long-leaf (*Pinus palustris*) and Short-leaf Pine (*Pinus echinata*) recorded during the survey occur in this area. The island's core resembles a mixed pine, oak and hickory forest adjacent to a river floodplain. Hardwoods, including six oak species and Mockernut Hickory, are abundant in the central portion of the island. Swamp Chestnut Oak (*Quercus michauxii*) was found only here. Both the shrub and herb layer contain species either rarely encountered, or not seen at all, on other hammocks. In addition to Yaupon, Wax Myrtle and Sparkleberry, Highbush Blueberry (*Vaccinium corymbosum*) and Inkberry (*Ilex glabra*) occur here. Highbush Blueberry, only found here, and Inkberry, only found here and on B3, are more typical of inland, acidic lowland pine forests. Also unique to Charlotte Island is Crane-fly Orchid (*Tipularia discolor*). Cinnamon Fern (*Osmunda cinnamomea*), another common species in acidic lowland forests, occurs within the island's interior and on the eastern side as elevation falls toward the wetland. This island was not among the core group, and was surveyed by volunteers on only two dates after the initial visit. Accordingly, herbs, grasses and sedges were poorly inventoried. Fauna were also undoubtedly not recorded at a level similar to that for the 16 core islands. Whitetail Deer and Raccoon sign were common, and both Marsh Rabbit and Eastern Gray Squirrel are apparently common. Eastern Gray Squirrel was uncommon on most hammocks we inventoried. However, it was common here presumably because of Charlotte Island's proximity to suburban areas, easier access across a narrow expanse of high marsh, and high population of mast-producing hardwoods. Bird records were probably not reflective of the diversity that would have been recorded had the island been in the core group. Nonetheless, the bird assemblage was more similar to that of a parkland or suburban setting than that of most hammocks. For example, Bluejay (*Cyanocitta cristata*) was abundant, and Chipping Sparrow (*Spizella passerine*) and Red-headed Woodpecker (*Melanerpes erythrocephalus*) were only encountered here. All three species are typically found in open, high-canopy, Mixed Pine-Hardwood Forest. Based on multiple sightings, it is also likely that Painted Bunting is part of the breeding-bird assemblage. The only herptiles observed were Green Anole, Ground Skink and Southeastern Five-lined Skink, but based on habitat diversity, additional survey effort would almost certainly have yielded additional species.

Figure 12. Map of B3.

B3

B3, named Cedar Hammock is part of the Spring Island complex. It is located on a small tidal creek northwest of Spring Island proper (Figure 12). This 4.2-acre island is very low with a maximum elevation of about 0.3 m, and is interspersed with Depression Wetlands colonized by grasses, sedges, herbs, salt-shrub, Cabbage Palmetto and Southern Red Cedar. Higher points throughout are densely covered with Saw Palmetto, except directly beneath scattered Live Oak. The highest point is near the center, and solitary specimens of Southern Magnolia and Water Oak occur there. Yaupon is abundant, and a few stems of Inkberry, only found here and on Charlotte Island, are also scattered in higher points. Although this island was only surveyed on three dates, the recorded fauna were relatively diverse. An otter camp was observed adjacent to the adjoining small creek, and besides Raccoon, the presence of both Marsh Rat and Marsh Rice Rat was validated. Particularly interesting bird sightings were a Red-tailed Hawk perched on the island and multiple Painted Buntings. The generally open, grassy terrain provides excellent cover for rabbits and rats, which in turn afford good foraging territory for Red-tailed Hawk. The habitat is also well suited for Painted Bunting, which, based on observations, likely breeds here. Only two herptile species were observed, albeit with limited survey effort. Green Anole is apparently common, and one Yellow Rat Snake was recorded. In addition to Marsh Rice Rat, small breeding bird species, likely including Carolina Wren, Carolina Chickadee and Red-winged Blackbird, as well as Painted Bunting, provide a sufficient prey-base for Yellow Rat Snake.

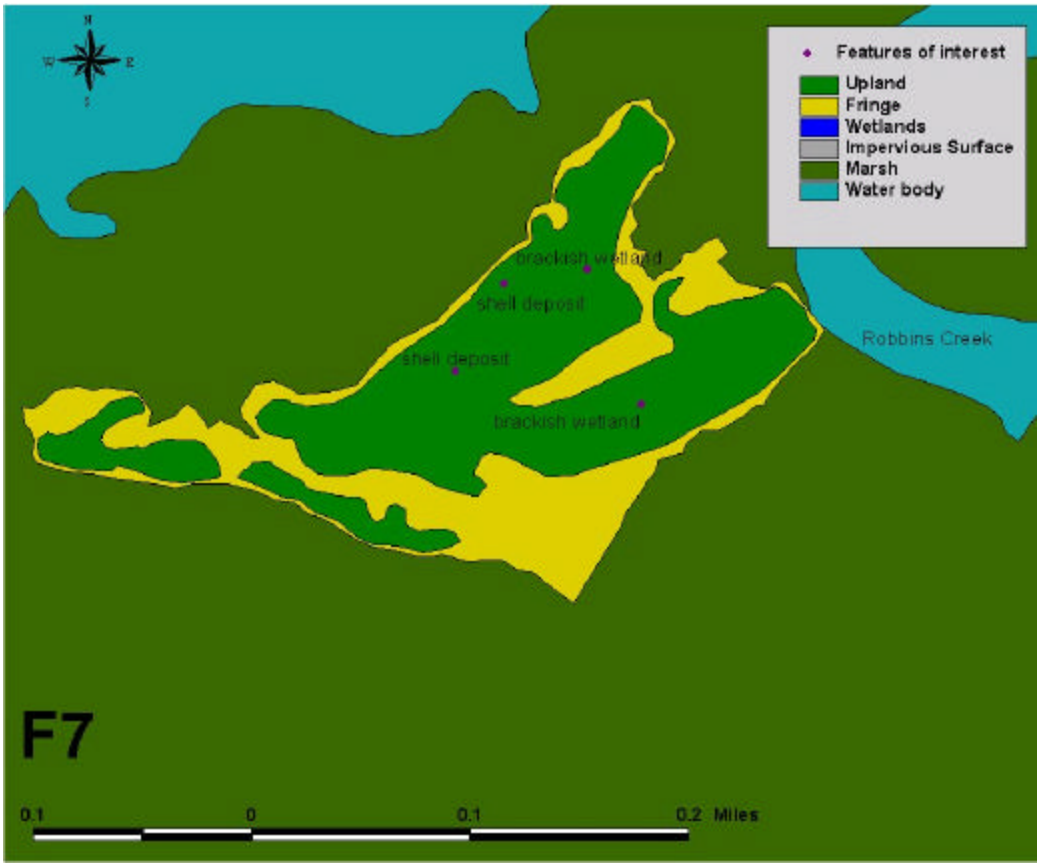

Figure 13. Map of F7.

F7

F 7, Apron Island, is located on Robbins Creek near Folly River (Figure 13). This 19.5-acre island is Y-shaped and characterized by relict dune ridges interspersed with Black Needlerush (*Juncus roemerianus*) wetlands. There are several areas of shell deposit on the island, but no apparent colonization by calcareous community plants. Small colonies of Sweetgrass are located on a fragmented sand ridge on the southwestern side of the island and near the access point on Robbins Creek. Several dune-mounds on the western side have elevations up to 3.5 m above the mean high tide zone. Pignut Hickory is a prevalent canopy species in this area, and, surprisingly, Dwarf Palmetto (*Sabal minor*) is distributed throughout this relict dune ridge habitat. A rare sedge, Sandy-woods Sedge (*Carex dasycarpa*), having S2/S3 (NatureServe) designation, occurs on Apron Island. Pinebarren Sunrose (*Helianthemum corymbosum*), also on the State list

of rare plants, occurs on the island as well. Diamondback Terrapins were observed frequently in Robbins Creek within a few meters of the island. Open, sandy areas on the relict dunes were apparently rather heavily used for nesting. Over a dozen Diamondback Terrapin nests were encountered, but all nests had been excavated, presumably by raccoons. An interesting find on this island was the Eastern Mud Turtle (*Kinosternon subrubrum*). Two individuals were observed, one of which was a female that had apparently nested, as indicated by a coating of moist soil on the rear half of her carapace. This species is known to be tolerant of some unknown level of salinity, and apparently inhabits the brackish needlerush wetlands on Acorn Island. No snakes or amphibians were observed here, but Eastern Glass Lizard, Green Anole, Southeastern Five-lined Skink and Ground Skink were encountered. The only mammaliam species recorded here other than Raccoon was Whitetail Deer, with at least one buck leaving obvious sign during the fall-early winter breeding season. Tall pines, principally Loblolly, are abundant and Pine Warbler (*Dendroica pinus*) was recorded as a breeding here. There is Inland Maritime Shrub Swamp dominated by Southern Red Cedar on the eastern side and several nesting pairs of Red-winged Blackbird were observed. This fringe habitat was frequented by at least one singing male Painted Bunting during late spring through early summer. Successful breeding of Painted Bunting was determined by the observation of a female feeding two juveniles. During all seasons, Acorn Island supported one of the highest ratios of bird diversity to island size.

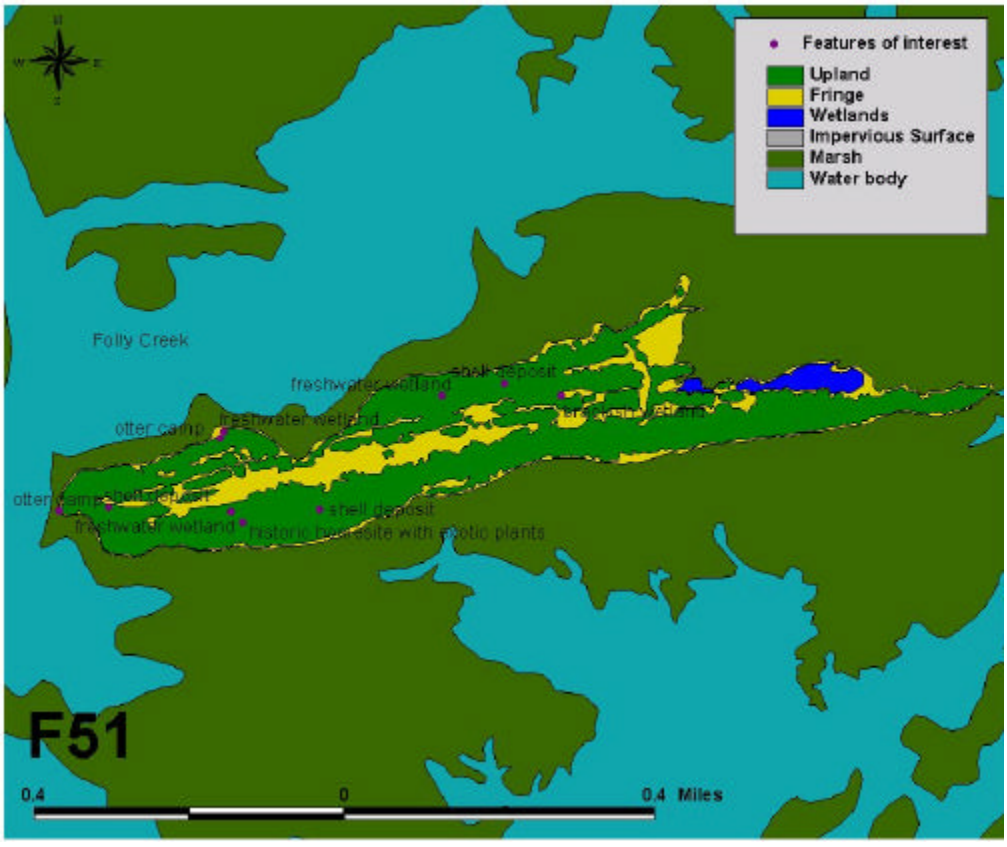

Figure 14. Map of F51.

F51

F 51, Long Island, in part, is located on Folly Creek (Figure 14). Long Island, in entirety, is a fragmented chain of marsh islands, many of which are connected by weathered causeways. The island is bordered to the west by Folly Creek and extends toward Folly River and Folly Island. The surveyed portion of Long Island is most easily accessible from Folly Creek, as the remainder of the island chain is surrounded by relatively high Salt Marsh. This was the largest island examined in the study, with the total area surveyed approaching 90 acres. The island is nearly bisected by an estuarine wetland with a small tidal creek that cuts into the island on the western side. The center of the island is interspersed with Brackish Marsh, Sand-Flats, Salt-Shrub Thicket and small "islands" dominated by pine and/or Cabbage Palmetto. Depression Wetlands are abundant, particularly near the upland-brackish wetland ecotone. Two depressions, one near the middle, western portion and the other nearer the northwestern end, contain small, seasonal low-salinity pools. These two pools likely receive salt input only during extreme flood tide conditions, and both retain rainwater. Eastern Mud Turtle was observed at both sites and Southern Toad, and tadpoles of this species, were recorded at the first pool. There are two shallow permanently watered pools near the northeastern end of the island that cover several hectares. Three small semi-permanent brackish pools occur near the island's center. Grass Shrimp (*Paleomonetes* sps) and Sheepshead Minnow (*Cyprinodon variegatus*) inhabit all five pools. Wading birds, primarily Tricolored Heron (*Egretta tricolor*), Great Egret and Snowy Egret, frequent the high-salinity ponds, and a sandy beach at the larger of these ponds is used by shorebirds such as Semipalmated Plover (*Charadrius semipalmatus*) and Lesser Yellowlegs (*Tringa flavipes*). There are also bowl depressions and a small manmade pond, near the northeastern end of the island, which temporarily hold rainwater. Upland habitats are variable, with typical Maritime Forest generally near the perimeter and Cabbage Palmetto or Loblolly Pine-dominated forests at the Brackish Marsh and upland interface. Much of the upland on the northern half of the island's eastern exposure is dominated by high-crowned Loblolly Pine with relatively few large Live Oaks. At ground level, much of this part of the island is nearly impenetrable with tangles of greenbriar (*Smilax bona-nox* and *Smilax auriculata*) and Muscadine (*Vitis rotundifolia*). Due to its large size and proximity to Charleston, Long Island has been impacted by human occupation since antebellum times and apparently also supported livestock as recently as the middle 1900s. Remains of a building foundation and associated artifacts and exotic plants occur near the southern end on the east side. There are several areas of Native American shell deposits that support calciphiles, Small-Flowered Buckthorn being the most significant. This island is also a site of historical significance from the Civil War era, and artifact hunters frequent the island. Some mounds, berms and depressions are likely of human origin while others appear to be natural relict dune formations. One mound near the east-central portion rises 4 m or higher above sea-level. There are two otter camps, one at the edge of Folly Creek and the other near the low salinity seasonal pool on the western side. Raccoon is abundant, but mammals of note include Whitetail Deer and Bobcat, which were not anticipated here since the island is remote from the mainland and surrounded by a rather dense human population. The only Mink sighted during the survey was observed moving across a central Sand Flat. Also, this was the only island on which Virginia Opossum (*Didelphis virginiana*) was seen. This species is apparently rare on marsh

islands, as no other indication of its presence was made except for skeletal remains on a Dixie Plantation island (Stono River) located very near the mainland. Observations included a diverse avifauna, with an abundance of Neotropical migrants, winter visitor, breeders and year-round residents. The most noteworthy breeding species were Great Horned Owl (*Bubo virginianus*), Eastern Kingbird (*Tyrannus tyrannus*), Chuck-will's-widow (*Caprimulgus carolinensis*) and Painted Bunting. The island apparently supported at least five breeding pairs of Painted Bunting. Multiple pairs of Brown Thrasher (*Toxostoma rufum*), rarely confronted on the hammocks, were observed here. An adjacent, closely associated hammock in the Long Island chain had an active Osprey (*Pandion haliaetus*) nest in the central canopy of a large, living Loblolly Pine. Herptiles were generally not abundant, but diversity was relatively high. This is the only island on which Eastern Kingsnake (*Lampropeltis getula*) was observed. Other reptiles recorded included Southern Black Racer, Southeastern Five-lined Skink, Ground Skink and Green Anole. Also recorded were Southern Toad, Green Tree Frog and Narrowmouth Toad. Interestingly, Southern Leopard frog was not recorded here despite the presence of significant wetland habitat similar to habitats where it was observed on ACE Basin hammocks. Long Island also supported a small overwintering population of Monarch butterflies (*Danaus plexippus*). Five Monarchs were observed flitting along the canopy edge on one early March survey, which is too early for these butterflies to have returned from the primary overwintering sites in western, central Mexico. Another interesting butterfly find was the existence of a breeding colony of Queen (*Danaus gilippus berenice*), with adults becoming abundant by early June. This species has generally been considered as a transient or emigrant species in coastal South Carolina, with individuals moving into coastal areas principally in late summer and fall from more southern populations. Also, Scalloped Sooty Wing (*Staphylus hauhurstii*), a small skipper butterfly considered to be rare on the mainland, was common on Long Island. Scalloped Sooty Wing was invariably associated with colonies of Juda's Bush (*Iresine rhizomatosa*), which is a larval food plant for this species.

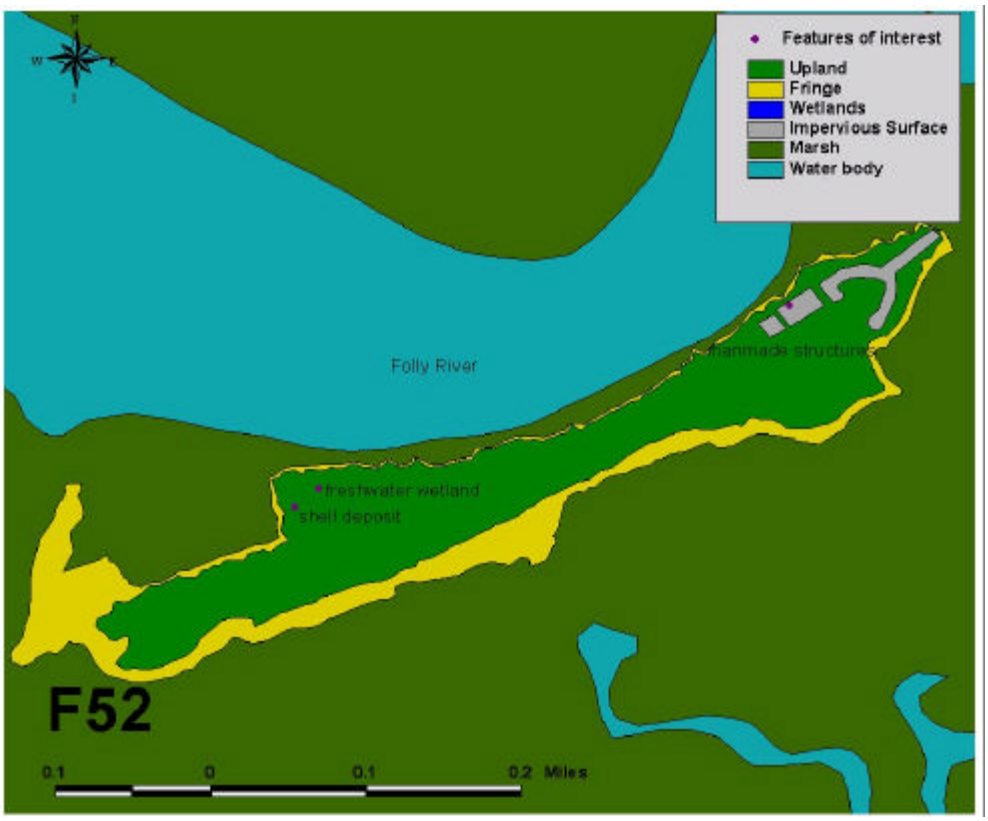

Figure 15. Map of F52.

F52

F 52, Truluck Island (14.3 acres), is located on Folly Creek and is connected to Folly Road by an asphalt-surfaced causeway (Figure 15). Most of the upland adjacent to Folly Road is significantly developed as subdivisions or seafood-related businesses. Truluck Island is classified as developed/disturbed, having a house, pool and storage building. Throughout most of the survey period, the house was under renovation, and was being transformed from a weekend retreat to a permanent family residence. There was additional, substantial activity on the island over the course of the survey, as fill dirt was distributed throughout the island, impacting much of the upland area. A dirt roadway intersects the island from the yard site to the southwestern upland tip. Bands of Palmetto Flatwoods extend along both sides of this roadway. The human disturbance and fill dirt dispersal introduced a significant number of ruderal or "weedy" plant species, which contributed greatly to plant diversity. The upland around the house is a maintained yard and recreation area, and a dock extends from the upland into Folly Creek. There are two small shell deposit sites, both of which support Small-flowered Buckthorn. One of these Small-flowered Buckthorn colonies is near the storage building and is generally cutover during lawn maintenance. The second colony is in the most protected portion of the island and contains impressive specimens. Despite the disturbance on the island, another uncommon plant, Pilpod Sandmat (*Chamaesyce hirta*), was recorded. Near the larger shell deposit is a single bowl depression that retains rainwater, as well as a large Loblolly Pine that was frequently used as a perch by Red-tailed Hawk (*Buteo jamaicensis*). Cooper's Hawk (*Accipiter cooperii*), a species of SC status, was observed

here during fall and winter. This was the only island in the survey for which Loggerhead Shrike (*Lanius ludovicianus*), a species of State Concern, G4 and S3 status, was recorded as a breeder. A pair was observed frequently throughout the survey. The open and weedy areas present excellent foraging habitat for this species. Red-winged Blackbird was a common breeder in Salt-Shrub and Maritime Shrub Thicket. During fall and winter, Ruderal Gardens and grassy openings near the island's perimeter supported an abundance of sparrows, primarily Song Sparrow (*Melospiza melodia*), but also Swamp Sparrow (*Melospiza georgiana*) and Savannah Sparrow (*Passerculus sandwichensis*). Atypical of more undisturbed hammocks, this island was also resident to Northern Mockingbird (*Mimus polyglottos*) and House Finch (*Carpodacus mexicanus*). Mourning Dove (*Zenaida macroura*) was common here, and the introduced Eurasian Collared Dove (*Streptopelia decaoto*) was recorded only on Truluck Island. Many of the bird species found here are most commonly encountered in open, disturbed and suburban habitats. Reptile diversity was low, as only Green Anole and Southeastern Five-lined Skink were recorded. Both Bobcat and Common Gray Fox (*Urocyon cinereoargenteus*) sign has been observed on this island. Hispid Cotton Rat is abundant, with obvious runs throughout grassy areas. These rodents likely provide the primary prey for Common Gray Fox and Bobcat. There is an otter camp on a small upland strip that is fragmented from the southwestern end by a narrow Salt Flat.

Figure 16. Map of F53.

F53

F53, Small Truluck Island, has an area of about 2 acres and is located about 200 m southwest of Truluck Island (Figure 16). It is separated from the larger island by an expanse of Salt Marsh. The interior of the island is very thick, with a mixture of Live Oak, Laurel Oak and Cabbage Palmetto providing a closed canopy. Yaupon and American Beauty-berry (*Callicarpa americana*) are the main components of the shrub layer. Greenbrier, particularly *Smilax bona-nox*, is distributed throughout. A small finger of Salt Marsh and Salt-Shrub nearly cuts through the eastern end. A rare State plant (S1), Spreading Sandwort (*Arenaria lauginosa*) occurs on a small sandy opening or "Xeric Sand-Bald" at the island's perimeter. Green Anole and Southeastern Five-lined Skink were the only herptiles encountered. Bird diversity was relatively high, but House Finch was the only surprising resident, likely occurring here because of this small island's proximity to Truluck Island and other suburban areas. Both Salt Marsh Sharp-tailed Sparrow (*Ammondramus caudacutus*) and Seaside Sparrow (*Ammondramus caudacutus*) were abundant in the salt-shrub collar during winter maximum flood-tides. Marsh Rice Rat was the only mammal recorded other than the ubiquitous Raccoon. A frequently used otter camp is located on the southwestern end of the island near a small tidal creek.

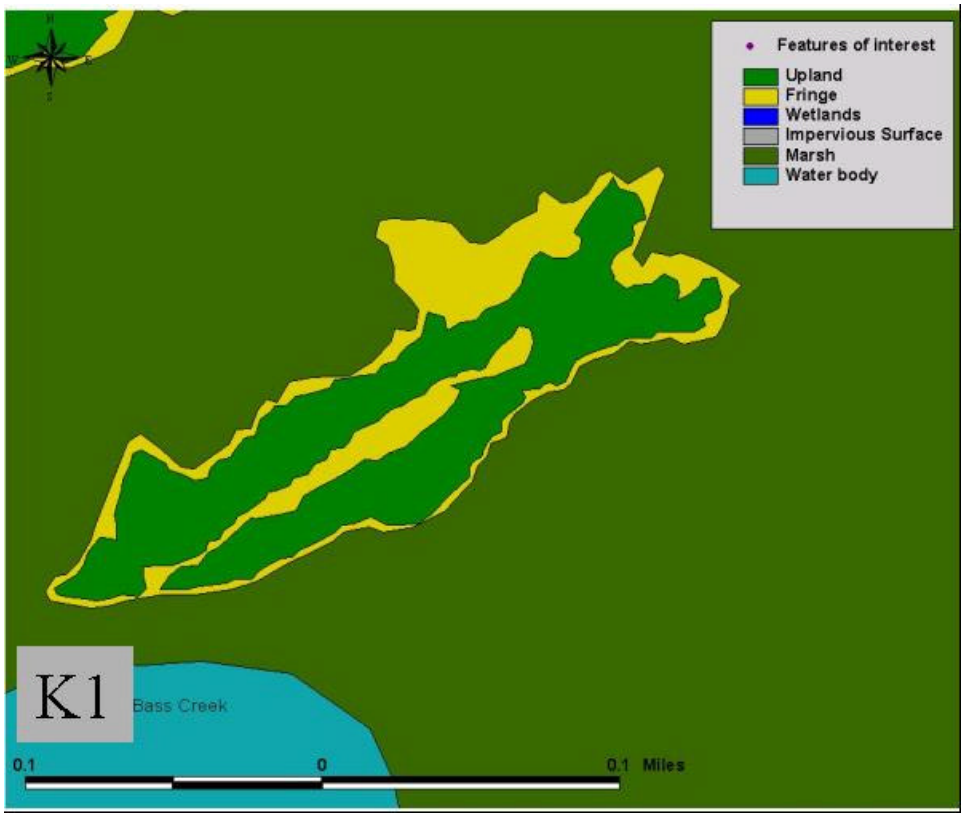

Figure 17. Map of K1.

K1

K1 is located on Bass Creek near the north end of the Kiawah Island complex (Figure 17). A marsh incursion with a small tidal drain and associated fringe habitat bisects a large portion of the 7.9-acre island. The southern half of the island has high relict dune ridges, perhaps as much as 3 m higher than the mean high tide line. Vegetation in this area is representative of a typical Maritime Forest community. The northern half gradually lowers from primarily Loblolly Pine to a Cabbage Palmetto dominated forest. The extreme northern end is Maritime Grassland. The soil is sandy and xeric with small, bare patches distributed throughout. Pinebarren Sunrose, on the State Heritage list of rare plants, occurs on the island in such open areas. Excavated Diamondback Terrapin nest sites were observed on a dune ridge adjacent to Bass Creek. Another significant find was a Chuck-will's-widow nest with a bird incubating three eggs. Painted Bunting was also recorded as a breeder here. Herptile diversity for K1 was very low, with only Eastern Glass Lizard and Diamondback Terrapin presence documented.

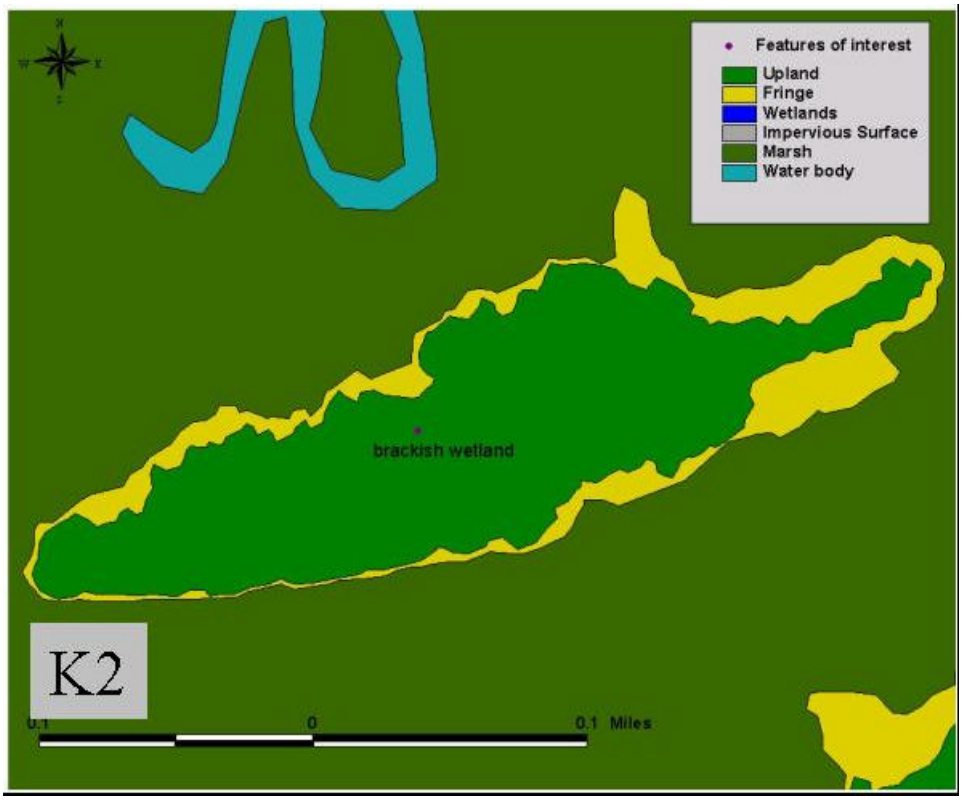

Figure 18. Map of K2.

K2

K2 is located immediately west of K1 and is a member of a chain of hammocks called Eagle Point (Figure 18). It too is in the Kiawah Island complex and is connected via a bridge to K57. The 14.2-acre island has very high (~4 m above mean high tide line) relict dune ridges in the center and near the eastern side. The upland is broken northward

by Salt-Shrub and Maritime Grassland with another narrow dune ridge extending in a northerly direction toward Stono River. This slender ridge is xeric with sandy balds, and the canopy is primarily Loblolly and Slash Pine. The eastern side of this single ridge is Maritime Grassland, dominated by *Spartina patens* and *Fimbristylis castanea* with scattered Southern Red Cedar. Vegetation on most of the island is typical Maritime Forest, but the west side falls in elevation and is densely vegetated by a Wax Myrtle (*Myrica cerifera*) dominated Evergreen Shrub Thicket. There are several marsh intrusions on the western side, and a small, enclosed wetland near the center colonized by *Spartina alterniflora*, receives overflow from high tide events. During the first portion of the survey (September through December 2003), this island had a lush understory of mixed shrubs and seedling trees. Saw Palmetto was a member of the shrub layer, and the population here represents one of the northernmost naturally occurring colonies for this species. In early January 2004, the understory on the majority of the island was slashed, and plots were surveyed for single-family homes. This island was not a "core" island in the survey and accordingly did not receive the same level of survey coverage as did the 16 core islands. Nonetheless, a high diversity of birds was observed in all seasons, including Painted Bunting during breeding season, and after the understory had been largely removed. Great Horned Owl was recorded on several trips, including a winter survey, indicating that it may nest on the island. The only Peregrine Falcon (*Falco peregrinus*) recorded for the survey was observed foraging along the canopy during early December 2003. Reptile and amphibian diversity was low, as only Green Anole and Southeastern Five-lined, Broadheaded and Ground Skink were recorded. Initially this island was included in the "undisturbed" category of islands, but after December could be moved into the "disturbed" category. Further evidence of human disturbance was several incidents in which cover-boards had been moved into stacks or otherwise redistributed.

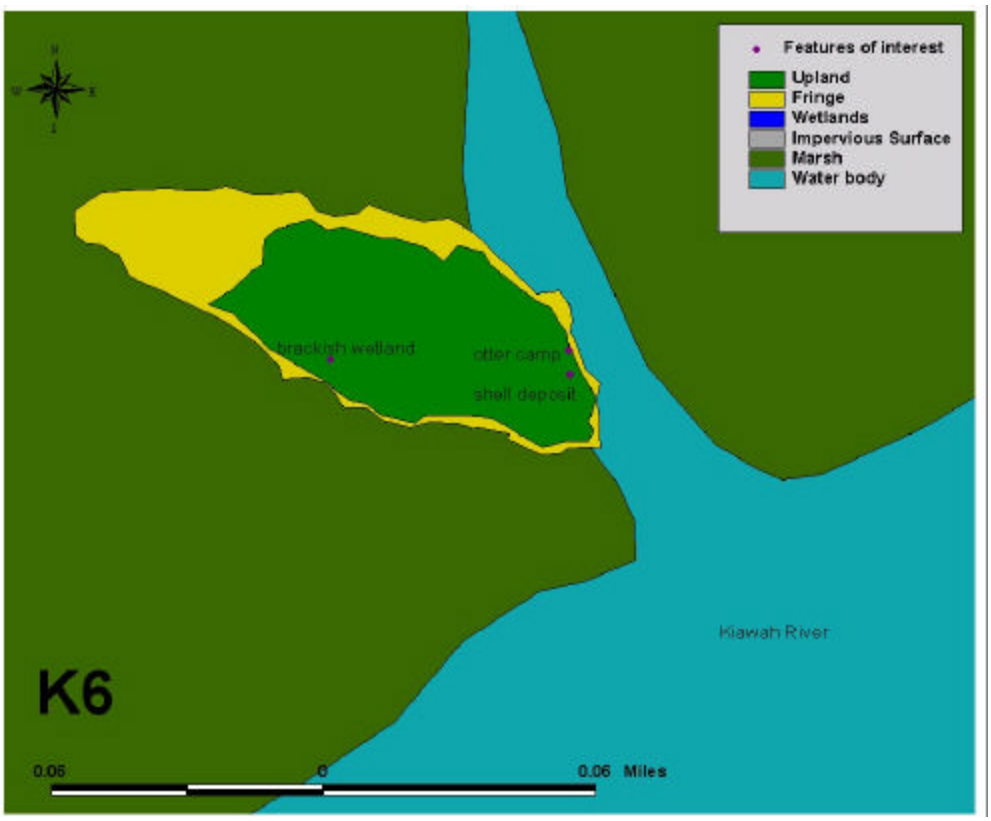

Figure 19. Map of K6.

K6

K6, Beck Island, is located at the confluence of Kiawah River and a small, unnamed tidal creek (Figure 19). The Kiawah Island Natural Habitat Conservancy protects this 2.4-acre island. A Cabbage Palmetto and Live Oak canopy characterizes most of the island. The western tip is lower, with a blend of grasses and Salt-Shrub. Southern Red Cedar is the primary constituent of the island's upland collar. Archaeologically significant shell deposits on the island support small colonies of the rare plant, Small-flowered Buckthorn. There is a small, seasonal brackish pool on the southwestern side that receives input from high tide events and rain. A well-used otter latrine is located at the access point near the junction of the small creek and Kiawah River. Otter sign was also observed near the brackish pool. Observations of note include Bobcat sign and an excavated Diamondback Terrapin nest. Skeletal remains of several Diamondback Terrapin were distributed around the perimeter of the island. Painted Bunting was recorded as a breeder as well, and a female was observed in summer as she fed two juveniles. Though rather small, Beck Island seemingly supports a relatively robust Eastern Glass Lizard population, as the reptile was recorded here more consistently than on other islands surveyed.

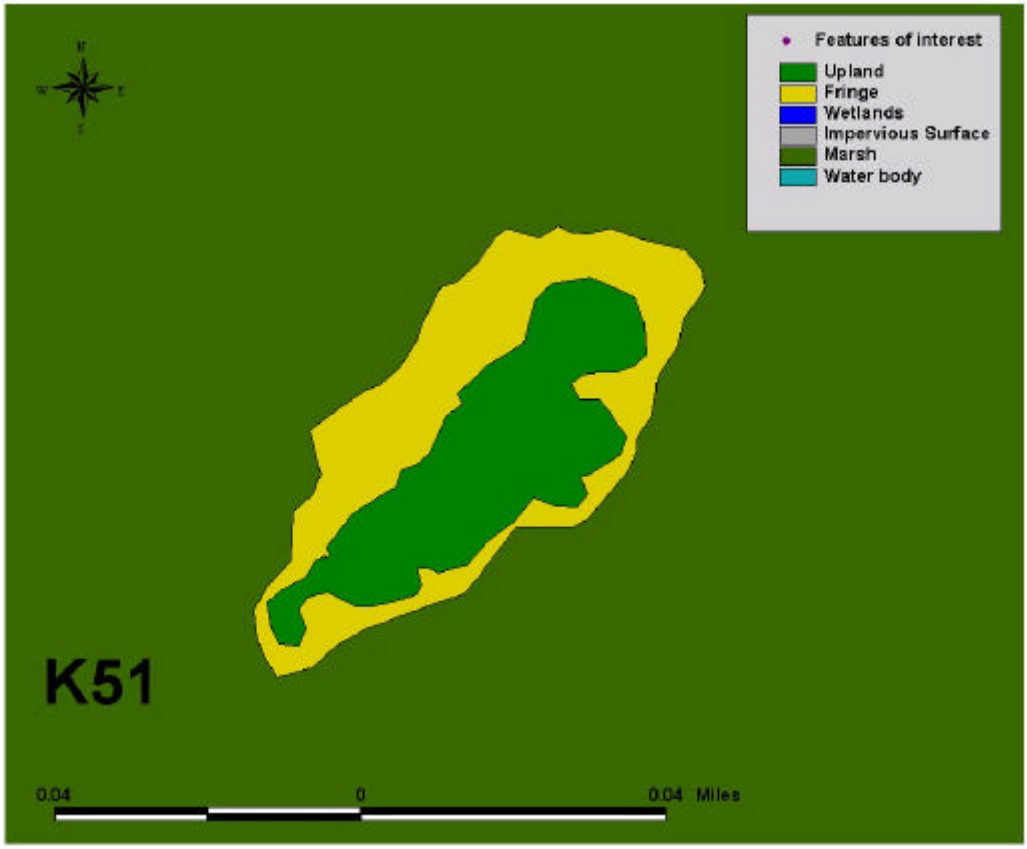

Figure 20. Map of K51.

K51

K51, Marsh Hawk Island, was the smallest island surveyed, only 1.2 acres (Figure 20). The island is located on the western side and near the middle of the Kiawah Island complex. It is separated by several hundred meters of Salt Marsh from a golf course on the barrier island portion of Kiawah. Marsh Hawk Island is very low in elevation, perhaps only 0.25 m above sea-level at the highest point. A single large-crowned Live Oak occurs at the north end. Most of the island is Maritime Grassland with a few small, stunted Live Oaks and the standing remains of dead pines scattered about. Red Cedar is abundant at the Salt-Shrub and upland interface. Very interesting observations were made here despite the island's small size, low elevation and treatment as a non-core island. Sweetgrass is a noteworthy plant found here, likely benefiting from the low elevation that results in reduced competition and the lack of canopy plants. Bird diversity was much greater than was anticipated, and Loggerhead Shrike, a species of State concern, was observed here on several winter visits. Loggerhead Shrike, and other species including Eastern Bluebird, House Finch and Red-tailed Hawk, apparently used the dead pines for resting or foraging platforms. Surprisingly, an excavated Diamondback Terrapin nest was found, as was an Eastern Glass Lizard. The most surprising observation of all was Green Tree Frog, observed beneath logs on two winter surveys.

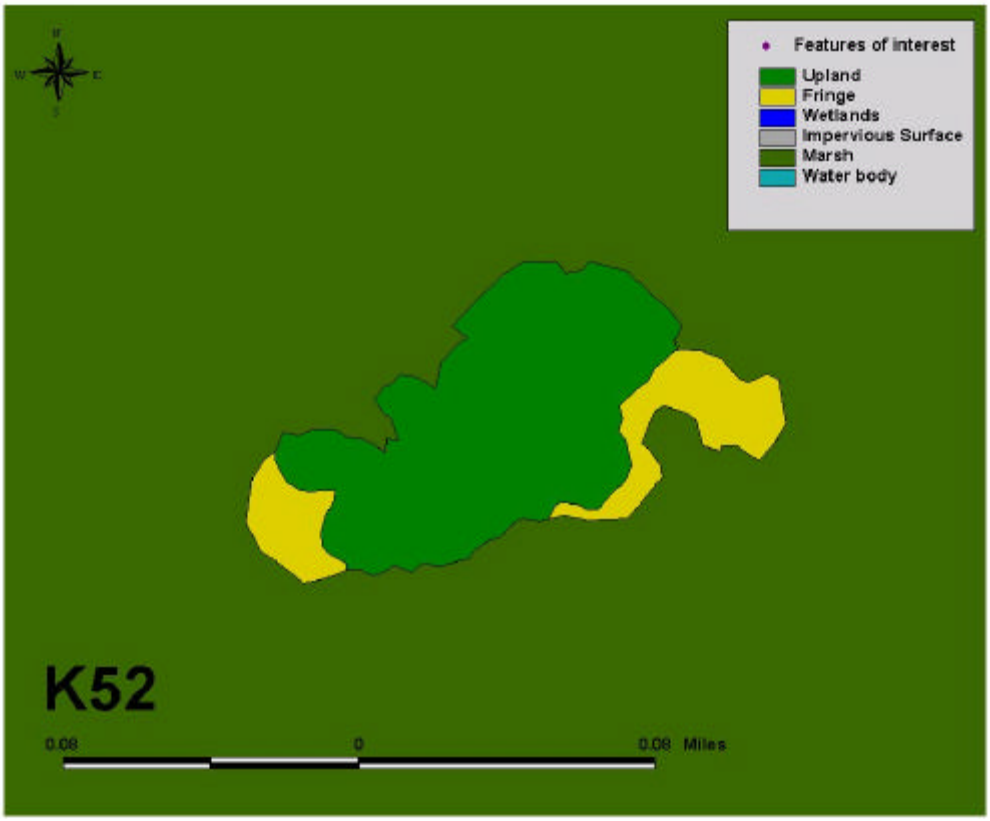

Figure 21. Map of K52.

K52

K52, Plenty's Island, is owned and protected by the Kiawah Island Conservancy. The 4.2-acre island lies to the west of Seabrook Island and is isolated from the larger barrier island and a small shopping center by several hundred meters of high Salt Marsh (Figure 21). Most of the island is Maritime Forest, but the southern end is dominated by Loblolly Pine. On the extreme southern end, a small Salt-Shrub knoll is separated from the upland by a narrow band of Black Needlerush marsh. A small opening near the southern tip supports a colony of Sweetgrass and a Salt Flat extends from the northeastern portion. Much of the island's interior is relatively open beneath the canopy; the understory was likely cleared for pending development in the past. Painted Bunting was observed on the island in late spring, including a singing male. Though breeding was not documented, a female Painted Bunting and three juveniles were recorded during a plant identification trip in late summer.

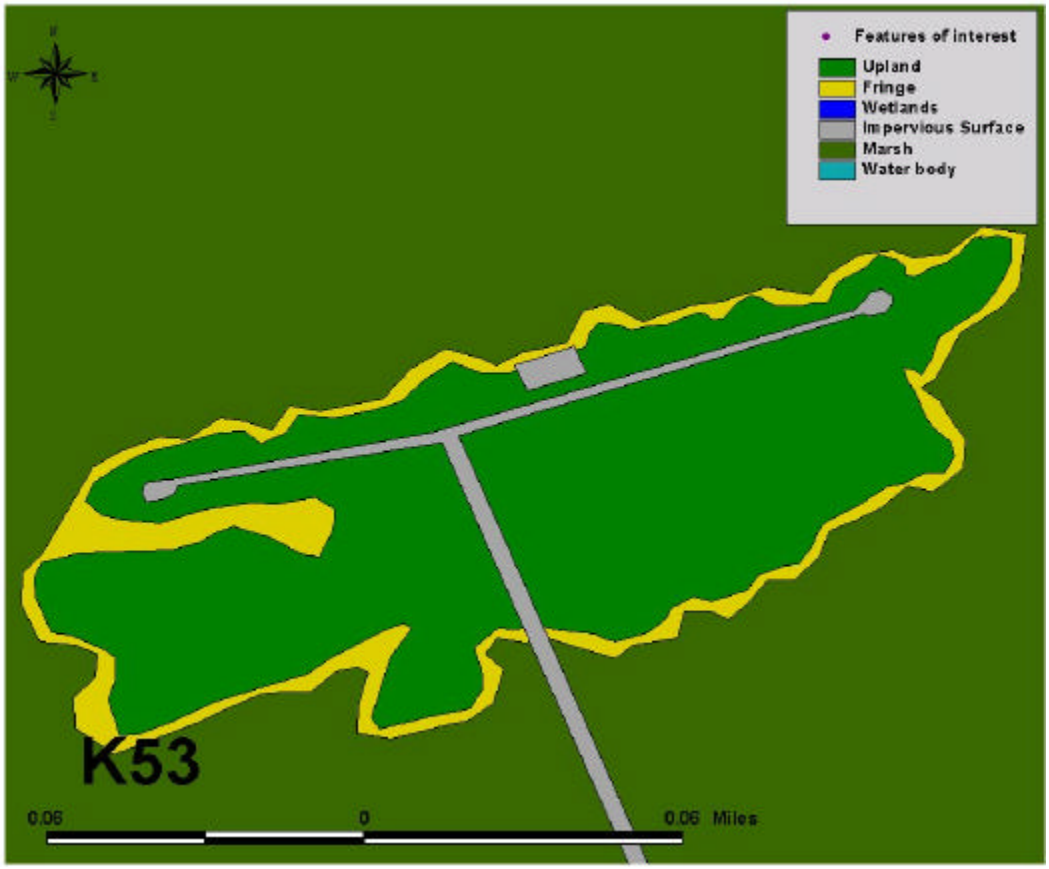

Figure 22. Map of K53.

K53

K53, Marsh Island Park, is located in the Kiawah Island complex and is connected to the mainland of the barrier island by a wooden footbridge (Figure 22). A narrow, paved trail leaves the footbridge, crosses the island and extends to the south and north. The trail runs nearly the entire length on the western side. A wooden three-story observation tower located near the middle of the paved trail overlooks the marsh. There are several Brackish Marsh wetlands on the island. One small wetland on the western, central portion is relatively isolated from saltwater intrusion. A small, seasonal pool in this wetland can be of very low salinity following rain events. The southern half of the island has fragmented upland areas separated by pockets and fingers of Salt Marsh and Salt Flat. Most of the island is a variant of Maritime Forest, with a dense shrub layer of Saw Palmetto. The southern end of fragmented uplands is predominantly Loblolly Pine. Observations of note include Southern Black Racer, Six-lined Racerunner (*Cnemidophorus sexlineatus*) and Southern Leopard Frog. Numerous raptors were observed migrating over the Kiawah hammocks in fall, but the only Merlin (*Falco columbarius*) seen during the survey was perched in a pine near the southern end of Marsh Island Park in early October 2003. Painted Bunting was a noteworthy breeder on this island, observed during April through June.

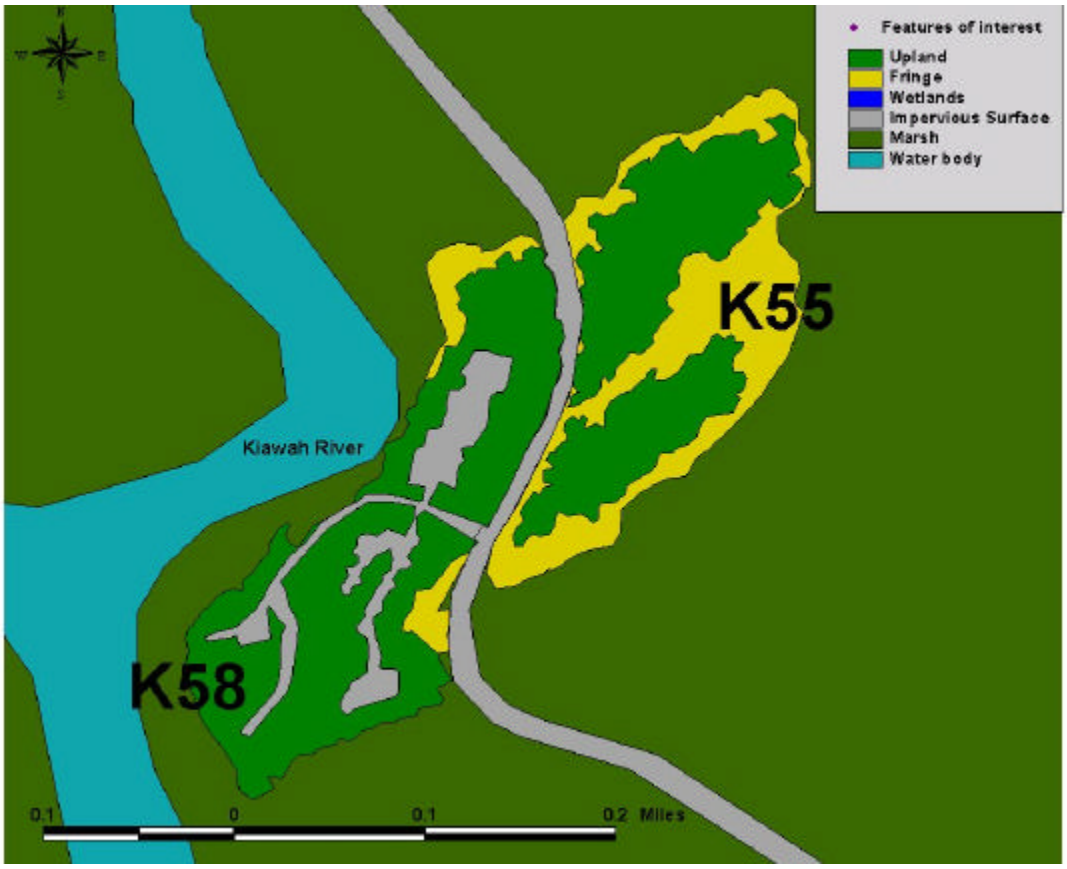

Figure 23. Map of K55 and K58.

K55

K55, Mingo Point, in part, is located near Kiawah River, and is actually the northern 10.6-acre portion of a nearly 21-acre hammock bisected by the entrance road to Kiawah Island (Figure 23). This half of the total island is relatively undisturbed, while the southern half (10.6-acre K58) is partially developed. The halves of Mingo Point were surveyed as individual islands in an attempt to discern differences attributable to the impacts of human disturbance. K55 is transected by a Salt Flat that extends from the northern tip to the roadway. The Salt Flat divides the island into two upland areas. The eastern upland is about 0.5 m in elevation. The highest, central portion is open Maritime Forest with large Live Oaks and Cabbage Palmettos. Maritime Grassland dominated by *Spartina patens* and *Fimbristylis castanea* covers much of the southern and northern ends. Sweetgrass is also scattered within this grassland community. Maritime Shrub Thicket and Salt-Shrub patches are distributed along the periphery, and a sliver of Salt Flat extends along the eastern side. Much of the western upland is of slightly higher elevation than is the eastern upland. The northern half is open Maritime Forest with a dense canopy of Live Oak with primarily Cabbage Palmetto and Yaupon beneath. Salt Flat also extends along the western side of this upland. The area bordering the roadway has shell-hash on the soil surface that was likely distributed from borrow taken during causeway and drainage ditch construction. Other than several large Live Oaks, this area

is densely covered with Evergreen Shrub Thicket dominated by Yaupon and Cabbage Palmetto. As is the case for most of the hammocks, Southern Red Cedar is abundant at the upland and Salt-Shrub ecotone. The Kiawah Island complex is known to have a significant Bobcat population. Based on an abundance of sign, K55 is frequently used by these animals. Several habitually used scat-deposit sites occur within the island's Salt Flats. Marsh Rice Rat, a potential Bobcat prey species, was recorded here, and the abundance of grassland habitat provides excellent cover for such small mammals. Bobcat also make use of road-killed Whitetail Deer, and evidence of such opportunistic feeding activity was observed on Mingo Point-Undisturbed. The island has a high density of Southern Red Cedar, thereby providing an abundance of fall and winter fruit. On consecutive winter survey trips, a flock of about 15 Eastern Bluebird, and a mixed flock of about 200 birds consisting of American Robin, Cedar Waxwing and Red-winged Blackbird was observed foraging on cedar fruit. Painted Bunting was observed here throughout the summer breeding season. The only Killdeer (*Charadrius vociferous*) recorded for the survey was foraging in the central Salt Flat in association with a Semipalmated Plover. There is no low-salinity water source near K55, and no amphibians were recorded. Reptiles were seemingly not abundant, but Southern Black Racer, Eastern Glass Lizard, Green Anole, Southeastern Five-lined Skink and Ground Skink were observed in low numbers.

K58

K58, Mingo Point, in part, is located very near Kiawah River and is the southern 10.6-acre portion of a nearly 21-acre hammock bisected by the entrance roadway to Kiawah Island proper (Figure 23). K55 is the northern half of Mingo Point that was compared to this "island" in an attempt to discern differences attributable to the impacts of human disturbance. It is considered a developed/disturbed island for our study, having a paved parking lot that covers a great portion of the island; an asphalt roadway leading to an open-air structure and associated wooden deck used for nature education; a storage building and a dock extending into Kiawah River. There is also a primitive landing site on Kiawah River for kayaks used in nature tours. Much of the southern end is maintained as a yard, with a high canopy of large Loblolly Pine and Live Oak. Sand ridges up to 3-4 m in height are located on both sides of the parking lots that extend from the entrance roadway to near the western and eastern extremities of the island. These ridges were likely created from soil pushed up during parking lot construction. Areas of upland not paved or maintained as yard are fragmented Maritime Forest with large Live Oak and Loblolly Pine and an understory dominated by Yaupon. The western side near the Kiawah entrance roadway is Maritime Grassland with a few Live Oaks, and patches of Salt-Shrub, Maritime Shrub Thicket, and Inland Maritime Shrub Swamp. This area is dominated by *Spartina patens*, *Fimbristylis catanea*, and in lower drainage areas by Black Needlerush. Similar habitat occurs on the eastern side near the Kiawah access roadway. No wetlands occur on F58 with the exception of the drainage ditch along the Kiawah entrance roadway and Black Needlerush depressions on the western side. No rare plants were recorded, but the island does have a diversity of plants that is bolstered by ruderal species in disturbed areas and by introduced non-native species. This island is also used by Bobcat, but sign was much scarcer here than on F55, across the roadway. Kiawah Island biologists have recorded Gray Fox on the Mingo Point islands (K55 and

K58). A mixed flock of several hundred Cedar Waxwing and American Robin was observed on a winter survey, as the birds bathed in water accumulated in low areas of the impervious parking lot, preened as they rested in trees and foraged on cedar and other fruit. Painted Bunting was recorded as a breeder here, and a Red-tailed Hawk nest was located in the central canopy of a large Loblolly Pine surrounded by a parking lot. Other interesting bird sightings here were the only Baltimore Oriole (*Icterus galbula*) and Black-throated Green Warbler (*Dendroica virens*) recorded during the survey, seen during the spring and fall neotropical migrations, respectively. The abundance of edge and thickets, with a significant contribution to such provided by human disturbance, produced excellent foraging and cover habitat for birds, particularly winter visitors. Large mixed-species foraging flocks were encountered here during winter and early spring. The only herptiles recorded for K58 were Green Anole, Southeastern Five-lined Skink, Ground Skink, and, most notably, Six-lined Racerunner.

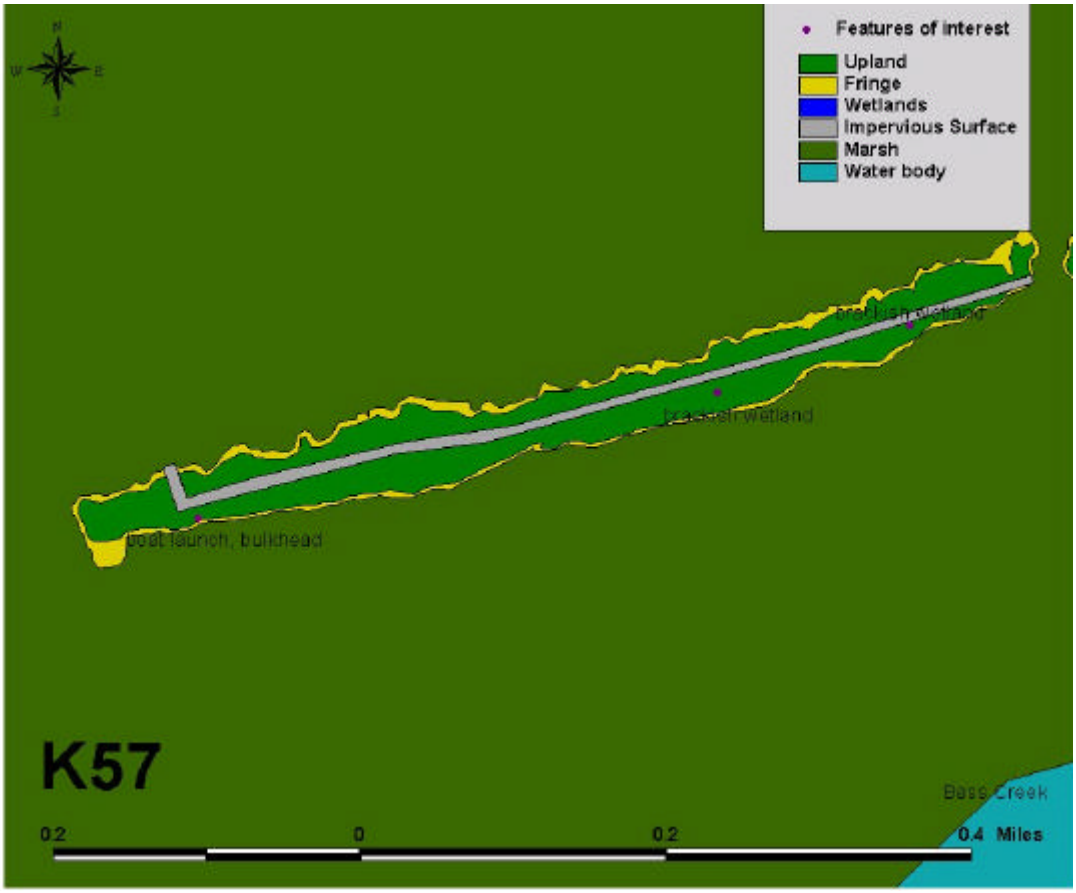

Figure 24. Map of K57.

K57

K57 is located near the northern end of the Kiawah Island complex and is part of the Eagle Point hammock chain that includes K2 (Figure 24). The long, narrow 17.2-acre island is adjacent to Bass Creek to the east. The island is under subdivision development, and areas of the understory as well as some trees have been cleared. A paved road extends the entire length of the island and it connects to a wooden bridge that leads to

island K2. Lawn-grass sod, specimen trees and a few small ornamental beds are planted along the roadway. The eastern side has a bulkhead where Bass Creek meets the upland, and two docks extend from the island to the creek. There is a boat landing that affords access to Bass Creek and an associated gravel parking lot near the southern end. Intruding fingers of Salt Marsh and Salt Shrub are abundant along the western side and a small Salt Flat extends toward Bass Creek on the southeastern end. Two partly isolated brackish Black Needle Rush wetlands occur near the eastern side and the northern end. These wetlands can receive saltwater during very high astrological and/or wind-blown tides, but otherwise are generally dewatered except after rain events. The woodland is best characterized as Pine-dominated Maritime Forest. High-canopied Loblolly and Slash Pine dominate with Live and Laurel Oak are sparsely scattered throughout. The remaining understory is primarily Yaupon, and sandy, barren or bald openings are common. Such openings provide suitable habitat for two rare plants. Sweetgrass was recorded on the island and Pinebarren Sunrose, recorded on adjacent islands, likely occurs here as well.

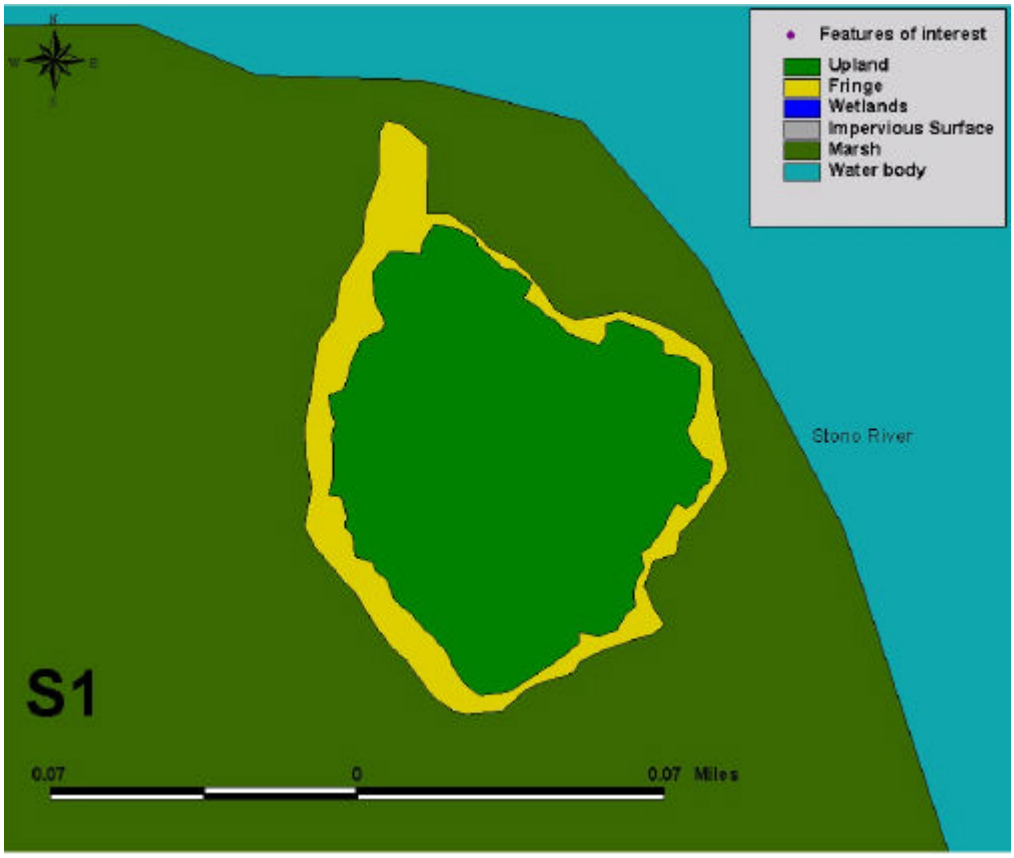

Figure 25. Map of S1.

S1

S1 is a privately owned, nearly 5-acre island located on the Stono River/Intracoastal Waterway between Johns Island and a subdivided development in the southern West Ashley region of the city of Charleston. This small hammock is circular in

outline and was apparently created from dredge disposal during construction of the Intracoastal Waterway in the 1940s. Marl and shell-hash are distributed throughout and Southern Red Cedar is the predominant plant. The highest portion of the island is near the center, perhaps reaching 1.5 m above sea level. Several tree species, Pecan (*Carya illinoensis*) and Sycamore (*Platanus occidentalis*), were found here, but on no other surveyed island. Both of these species are common around mainland homesites, only about 500 m to the northwest and southeast. A rare State plant (S1 and G5), Whisk Fern (*Psilotum nudum*) was also only found here. This plant is usually found in swamp forests, but was found on S1 in association with surface marl and shell-hash. Bird diversity was relatively low, and Northern Cardinal (*Cardinalis cardinalis*) was the only year-around resident species recorded. Both Yellow-rumped Warbler and Cedar Waxwing were observed in abundance during winter, undoubtedly subsisting on the abundant supply of cedar fruit. The only herptile observed was Green Anole. The only mammals occurring on S1, as confirmed by sign, were Whitetail Deer, Raccoon and Marsh Rabbit. This island was also not a core island and was primarily surveyed by USFWS staff.

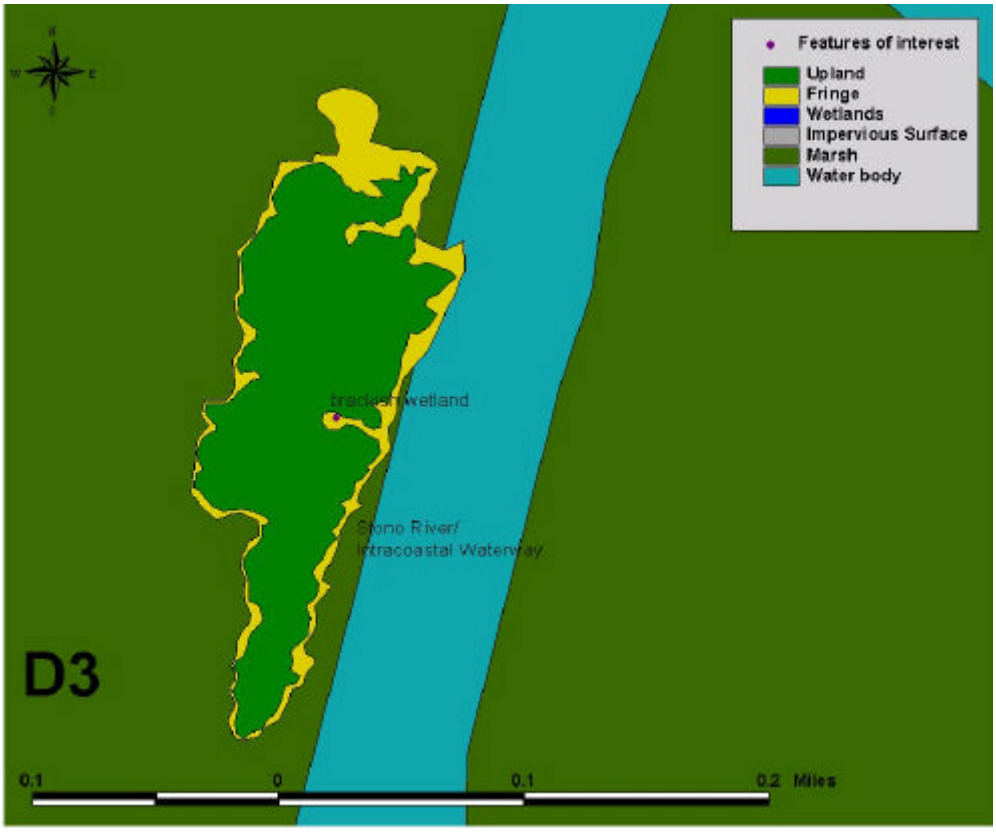

Figure 26. Map of D3.

D3

D3 is a 9.0-acre island located just south of Charleston and bordered on the east for its entire length by the Intracoastal Waterway, and a narrow beach has been formed by wave action (Figure 26). The island is part of Dixie Plantation, which is owned by the

College of Charleston. The plantation was willed to College of Charleston and is preserved in perpetuity as a center for environmental education. Much of D3 is a natural island, but marl and shell-hash deposits, particularly on the west side, are evidence that dredged material was dispersed broadly. Several small, adjacent hammocks are primarily of dredge-spoil origin. The northern tip of the island is very low and is primarily a mixture of Salt-Shrub and Maritime Grassland. A partially enclosed brackish wetland occurs about midway across the island and on the east side. A small pool in this wetland retains water except during drought. The wetland can receive saltwater input during particularly high tide events. The eastern side of the island is dominated by Loblolly Pine and Cabbage Palmetto and has several knolls with elevations reaching 1.5 m above the high tide line. The western side of the island is of similar elevation, but a narrow swale of Maritime Shrub Sawmp dominated by Southern Red Cedar, intrudes from the Salt Marsh. During very high tides saltwater moves into the wetland on the eastern side. Southern Red Cedar is also very abundant at the upland and Salt-Shrub interface. D3 is less than 500 m from the mainland, perhaps resulting in a forest community that is more diverse than typical of such small hammocks. Live Oak dominates the canopy on the western side, but the island's center has a mixed canopy including Water Oak, Laurel Oak, Cherrybark Oak, Black Cherry, Sweetgum and Black Gum. Yaupon dominates the understory, but Wax Myrtle and American Beauty Berry are also abundant. Small colonies of Sweetgrass occur in clearings near the periphery of the island. Particularly interesting observations included a single Bald Eagle perched in a tall, dead pine during a December trip. Tall, dead pines were also used by Eastern Bluebird, which was also seen on the nearby mainland. American Goldfinch (*Carduelis tristis*) and Purple Finch (*Carpodacus purpureus*) were also recorded here in winter. This was the only observation for Purple Finch, and both finches are often associated with Sweetgum (seeds) and bird-feeding stations, both of which are present on the adjacent mainland. No amphibians were encountered and Green Anole was the only reptile observed. Given the island's habitat and close proximity to the mainland, it seems very likely that other reptiles are present. Mammals occurring on S1, as confirmed by sign, were Whitetail Deer, Raccoon and Marsh Rabbit. This island was not a core island, and was surveyed primarily by USFWS staff.

Hammock Island Habitat Description

General Discussion

The habitats and associated plant communities on the hammocks are diverse and vary by hammock depending upon island size, age, location, elevation, topography and the extent and vintage of human impacts. Identification and delineation of plant communities is somewhat arbitrary and subjective, since many plant species may be members of multiple community types and because transition zones generally occur both between and within various plant communities. Variant community types also occur, some of which are rather distinct, and smaller habitats and plant associations may be imbedded within larger communities. The physical and associated botanical diversity of hammocks may largely determine faunal diversity, in concert with island size, location and extent of human impact.

Typically, the interior of islands is of the highest elevation with a gradual decline in elevation toward the perimeter. Many hammocks are characterized by the presence of relict sand dunes or sand ridges that are oriented on a north to south axis. The potential for recognizable relict dunes decreases with distance from the ocean. Maximum elevations on some islands, particularly those with dune ridges and raised shell mounds, may reach 5 m above sea-level, while some, usually small hammocks, have maximum elevations less than 0.3 m above sea-level. Many hammocks have mounds and ridges created by Native American shell deposits, and such mounds are frequently the highest points on islands. Long Island (F51) has mounds and ridges from the combined affects of natural relict dunes, shell deposits and Civil War earthworks, as well as raised man-made causeways connecting fragmented uplands.

In general, soil type also varies by distance inland, with islands nearer the coast having more sandy, xeric soils and those nearer the mainland and nearer river deltas having more organic, mesic soils. Additionally, contours in island topography create a diversity of soil types, particularly on larger hammocks. In general, the likelihood of wetland or palustrine habitats and hydric soils increases with island size. Anthropogenic impacts also affect the topography, soil characteristics and plant communities on some hammocks. Examples of human activity resulting in habitat changes on hammocks include shell deposits (primarily by Native Americans), phosphate mining, agriculture and animal husbandry, logging, wetlands drainage, Civil War earthworks, and game management. Islands adjacent to the Intracoastal Waterway may be completely man-made from dredge disposal of sediments or may have disposed sediments distributed over at least part of pre-existing hammocks.

Diversity of habitats, plant communities and associated fauna generally increases with hammock size. Islands of less than an acre may be of uniformly low elevation and may become partially or completely inundated by salt water during extreme high tides. Such hammocks have few if any large trees and may be predominantly Salt-Shrub or Maritime Grassland. Some very small hammocks with elevations precluding inundation except during extreme storm driven tides may have a few stunted specimens of Live Oak and/or Cabbage Palmetto, but frequently have nearly pure stands of Southern Red Cedar with a narrow Salt-Shrub collar.

Most marsh islands of at least one acre in size may be described as variants of Maritime or Inland Maritime Forest. In general, regardless of size, islands nearer the

Atlantic Ocean beaches with sandy, xeric soils are dominated by more typical Maritime Forest vegetation. Cabbage Palmetto becomes more dominant and there is generally a narrow band of Salt-Shrub Thicket encircling the island at the marsh and upland interface. A broken band of Red Cedar and Maritime Shrub Thicket dominated by Wax Myrtle frequently occupies the transition zone directly upland of the Salt-Shrub Thicket. Seasonally flooded depressions and high marsh or Salt-Shrub incursions or sloughs may extend beneath Cabbage Palmetto dominated swales or flatwoods. Frequently salt-tolerant grasses, sedges and herbs colonize these hydric soils where the shrub layer is absent or sparse. Portions of hammocks abutted by tidal waterways often have an abrupt transition from mature canopy forest to the high tide zone, with only a very narrow Salt-Shrub or high marsh collar if such occurs at all. Islands adjacent to large waterways are particularly susceptible to erosion from water currents and wave action. Hammocks bordering the Intracoastal Waterway may show severe erosion from boat wakes, accompanied by frequent toppling of trees.

Hammocks located farther inland usually have more diverse habitats and vegetation and may support variants of Inland Maritime Forest with additional plant communities in more mesic or hydric soils. Palustrine habitats are more common and uplands may be a blend of several forest types, including Inland Maritime, Mixed Pine-Hardwood, Oak-Hickory and Successional Pine-Hardwood. The variety of forest types is dependent on soil type, topography and the extent, type, and vintage of any human disturbance. Similar sized islands nearer the mainland or within the lower delta of river basins support more diversity of plant communities and habitats that are less typical of the Maritime Forests associated with barrier islands.

Larger islands, of 10 acres or greater, are often of more irregular shape and many are at least partially transected by small tidal drains. Small drains are generally bordered by high Salt Marsh, Salt-Shrub Thicket or Salt Flat and occasionally contain permanent saline pools that are fed by flood tides. Tidal drains often terminate in sand flats or intertidal mud flats teaming with fiddler crabs (*Uca* sps.). The drains or small creeks have an abundance of small fishes, primarily Mummichog (*Fundulus heteroclitus*) and Sheepshead Minnow (*Cyprinodon variegatus*). Saline and brackish pools, both permanent and semi-permanent, are often populated by grass shrimp (*Palaemonetes* sps.) and Sheepshead Minnow and/or Marsh Killifish (*Fundulus confluentus*). These secluded wetlands with abundant food supplies attract an assortment of wading birds.

Practically all hammocks, except those with very small, low elevation uplands covered by Salt-Shrub Thicket, are composed of multiple habitats and associated plant communities. The smallest islands covered by this survey have at least three distinct plant communities, with imbedded habitats as well. Marsh Hawk Island (K51) is only 1.18 acres, but has Maritime Grassland, Salt-Shrub Thicket and Maritime Shrub Thicket. Two-acre Small Truluck Island (F53) is mostly Maritime Forest bordered by Salt-Shrub Thicket, but has a small Salt Flat near one end and imbedded Evergreen Shrub Thicket and "Xeric Sand Bald" as well. The largest islands surveyed, ACE 12 and Long Island (F51) are very diverse, displaying examples of a dozen or more habitats and plant communities.

The following are descriptions of habitats and associated plant communities present on islands visited during this survey. Examples are presented of islands with

various major and imbedded habitats. Included are both unique floral and faunal features of specific habitats.

Upland Habitats and Communities

High Calcium Communities

The soil on hammocks is typically acidic. However, pH of the soil is elevated significantly in locations where shell or marl has been deposited. This higher pH soil encourages development of the High Calcium Community that is composed of plants that are otherwise not common in the lower coastal region of South Carolina. Several of the most rare plants in the lower coastal region occur in shell-enhanced soils on hammocks (McMillan *et al*., 2001). Three distinct High Calcium Communities have been recognized. Each is dependent upon topographic characteristics that determine soil moisture and salt content and the extent of canopy closure (McMillan *et al*., 2001). These communities are: Maritime Shell Forest (or Shell Hammock), High Shell Mound Forest and Shell Midden Scrub. The three community types may support some plant species in common, but support unique species as well. All three communities were observed on hammocks visited during the survey. Most were associated with Native American shell deposits that are generally significant archaeological sites as well (Chris Judge, SCDNR archaeologist, pers. comm.).

Elevation, primarily determined by the extent of accumulation of shell and the level of calcium in the soil, determines species assemblages. Transitional sites also occur. The High Shell Mound Forest is the least common shell community and supports the most diverse and noteworthy assemblages of rare and geographically isolated flora. The elevation of such sites reaches 2 to 6 m above mean high tide. This unique habitat or community may be restricted to coastal South Carolina (McMillan *et al*., 2001). Only one island exemplifying High Shell Mound Forest was visited during the study. This hammock is in Charleston County near North Edisto River, but was not included in the ecological survey. However, an open shell-ridge in the center of survey island ACE 6, on Two Sisters Creek in Colleton County, rises a meter or more above sea level and supports a similar plant community. Godfrey's Swamp Privet (*Forestiera godfreyi*) (S1/G3) is among the rarest shrubs in South Carolina and is restricted to High Shell Mound Forests and similar habitats. This species is only recorded from a few hammocks in the State's southern coastal marshes and occurs on the two aforementioned hammocks. Leafless Swallow-wort (*Cynanchum scoparium*) (S1/G4?) is another rare species, only recorded from High Shell Mound Forest on a single hammock in South Carolina (McMillan *et al*., 2001).

Several islands in the survey (ACE 1, ACE 5, ACE 6, ACE 9 and ACE 52) provide excellent examples of Maritime Shell Forest and/or Shell Midden Scrub. Shell deposits producing these communities are not as deep or thick as those in High Shell Mounds, but frequently overlay natural contours resulting in variable elevation. Maritime Shell Forest may include shell mounds and/or middens. This habitat generally occurs within an island's interior and includes canopy-forming species such as Carolina Basswood (*Tilia americana* var. *caroliniana*) and Sugarberry (*Celtis laevigata*). Sub-canopy species include Carolina Buckthorn (*Frangula caroliniana*), Red Buckeye (*Aesculus pavia*) and Tough Bumelia (*Sideroxylon tenax*). Red Bay (*Persea borbonia*) is generally a constituent of many upland hammock communities, but seems to particularly

prosper in shell forests. Huge specimens occur on B1, Fish Camp Island (Old Island, in part) near Trenchards Inlet, Beaufort County. Some of these trees approach 60 cm diameter, and exceptional specimens occur in the shell forest of ACE 52 as well. Other rare calciphiles occur in this community, including Satincurls (*Clematis catesbyana*) (S2/G?) and Piedmont Flatsedge (*Cyperus tetragonus*) (S2/G4?). Satincurls was recorded in shell-based soils on ACE 1, ACE 5, ACE 6 and ACE 52. Piedmont Flatsedge was recorded for ACE 6 and ACE 1, but additional *Cyperus* sps. have been archived from other ACE Basin islands with similar habitats.

A hammock visited only once in southern Charleston County, near North Edisto River, has Maritime Shell Forest with a noteworthy colony of Southern Sugar Maple. The terrain in this forest is generally flat with shell middens throughout, but subtle and regularly-spaced surface undulations are archaeologically significant relict furrows from Sea Island-cotton agriculture over a century ago (R. Porcher, pers. comm.).

Small-flowered Buckthorn (*Sageretia minutiflora*) (S3/G4) is also a high-calcium soil specialist and is much more widespread in association with shell deposits than is Godfrey's Swamp Privet. Small-flowered Buckthorn was recorded on eight of the 25 surveyed islands, including islands in the Folly Beach-Kiawah, ACE Basin, and Port Royal Sound regions. Additional rare calciphiles, such as Bluff Oak (*Quercus austrina*) (S1/G5), Large-tuber Mourning-glory (*Ipomoea macrorhiza*) and Widow Sedge (*Carex basiantha*) (S2/G5) have been recorded on South Carolina hammocks with shell deposits, but these species were not encountered on the 25 surveyed islands. Species associated with Maritime Shell Forest habitat may also occur in High Shell Mound Forest.

The Maritime Shell Forest on ACE 52 is particularly lush, resembling a tropical rainforest, with a dense canopy and shrub layer interconnected by climbing vines. The forest floor is generally densely covered with herbs and seedling trees and shrubs. This is the only island in the survey on which Southern Sugar Maple (*Acer barbatum*) was recorded. Carolina Basswood, Southern Magnolia (*Magnolia grandiflora*) and Sugarberry are dominant canopy species in the central portion of the island, and large Cabbage Palmettos create an intermediate subcanopy with Carolina Laurelcherry, Red Bay and Carolina Buckthorn. Poison Ivy (*Toxicodendron radicans*), Virginia Creeper (*Parthenocissus quinquefolia*) and grapes (*Vitis* sps.) are abundant and large specimens twine high into the canopy. Other vines primarily limited to the subcanopy include Satincurls, Coral-beads (*Cocculus carolinus*), Florida Yam (*Dioscorea floridana*) and Anglepod (*Gonolobus* sps.). The herb layer includes Poison Ivy, Canadian Blacksnakeroot (*Sanicula canadensis*), bedstraw (*Galium* sps.) and sedges (*Cyperus* sps.). The soil has abundant shell and a relatively high organic content, rendering it more mesic than the soil on most hammocks. The lushness of vegetation at ground level and abundant cover provided by logs and dead palmetto fronds may explain the presence of a thriving Marsh Rice Rat (*Oryzomys palustris*) population. This island also has perhaps the most robust population of Southeastern Five-lined Skink (*Eumeces inexpectatus*) of any island surveyed. The abundance of cover and potential prey species, in concert with an apparent lack of human visitation, probably accounts for the observed density of Eastern Cottonmouth (*Agkistrodon piscivorus*) well above that recorded for other islands despite the absence of fresh or brackish wetlands other than highly seasonal depressions. Barn Owl (*Tyto alba*) was recorded only on ACE 52 as a winter visitor (on both

occasions flushed from within the canopy of tall Cabbage Palmettos), perhaps also because of the availability of rodents.

ACE 9, Buzzard Island, has a very different Maritime Shell Forest community with the canopy dominated by Live Oak and Sugarberry. Diversity is very low compared to shell habitats on other islands surveyed or visited. Buzzard Island is inhabited by feral Goat (*Capra hircus*) and has likely been resident for many decades. The shrub layer is almost exclusively Yaupon and shrub-stage Cabbage Palmetto, even adjacent to shell mounds. Small specimens and seedlings of most trees and shrubs are virtually absent. A few specimens of Carolina Laurelcherry, Carolina Buckthorn and Tough Bumelia were found, but most were large. Small-flowered Buckthorn, the only highly calciphylic shrub present, was found only as small shoots near ground level and is obviously heavily grazed. Most specimens of grapes and Virginia Creeper are very large and most foliage is restricted to heights out of reach of goats. The herbaceous layer is composed mostly of Slender Woodoats, Bristle Basketgrass, bedstraws (*Galium* sps.), Canadian Blacksnakeroot, Virginia Snakeroot (*Aristolochia serpentaria*) and Poison Ivy. Surprisingly, Atamasco Lily (*Zephyranthes atamasco*) occurs on the periphery of shell mounds and large colonies are present as the upland slopes away from the Maritime Shell Forest. Presumably, most of these herbs are not palatable to goats. Seedling trees are uncommon on the island, and most Sugarberry trees are very large (many >36 cm diameter), indicating that most are very old specimens, possibly predating the arrival of goats.

Many of the trees and shrubs occurring most abundantly in Maritime Shell Forest produce high-energy fruits that ripen in fall and winter. Both the density of cover in such forests and the abundance of fruit make this forest type highly valuable to transient and wintering birds. Dense foliage, including many evergreen or tardily deciduous species, also provides abundant insect resources for insectivores. Yellow-rumped Warbler (*Dendroica coronata*) was particularly abundant in these habitats as a winter visitor or resident.

Shell Midden Scrub is usually associated with small, low elevation hammocks or with the upland-marsh ecotone of larger islands and the mainland (McMillan *et al*., 2001). These sites are often exposed and restricted in size. Additionally, high soil salinity, reduced organic material, and at least occasional inundation restricts colonization by most trees and shrubs. The high calcium, xeric soil supports two rare species, Florida Privet (*Forestiera segregata*) (S1/G4?) and Midden Prickly Pear (*Opuntia stricta*). Florida Privet has been recorded in Jasper County (McMillan *et al*., 2001), but was not recorded during this survey. Midden Prickly Pear was observed on two ACE Basin islands (ACE 5 and ACE 52) in Colleton County.

Dredge material containing marl and shell-hash was deposited in decades past on some existing hammocks near excavated or maintained waterways. Additionally, some hammocks, particularly those adjacent to the intracoastal waterway, are apparently composed entirely of dredged sediments. Several islands included in this survey have upland areas that have been at least supplemented by dredged sediments. D3, part of Dixie Plantation, has substantial deposits of marl, but these deposits have apparently had little or no influence on habitats and plant communities. S1, also in Charleston County, and adjacent to Stono River, was likely created with dredged materials during construction of the Intracoastal Waterway. This island is heavily colonized with

Southern Red Cedar from the Salt-Shrub and inland to near the center. Live Oak is sparse, but the center contains several plant species only found on this hammock including Pecan (*Carya illinoensis*) and Sycamore (*Platanus occidentalis*). The occurrence of these two species on S1 likely has no relationship to calcium content of the soil, but is more likely due to the proximity of this island to human-populated uplands with an abundance of both species. A unique plant was recorded here, Whisk Fern (*Psilotum nudum*), that has a NatureServe rank of S1/G5. This plant may not be dependent on high-calcium soils, but the specimen on S1 was growing in a mound of marl-rubble.

An unusual Maritime Shell Forest variant or "Shell-Hash Forest" is present within several acres of the northeastern portion of ACE 1. This part of ACE 1 is adjacent to the Intracoastal Waterway and shell-hash is abundantly distributed throughout. This area is densely populated with Yaupon and Carolina Buckthorn beneath a canopy largely of Live Oak , Sugarberry and Carolina Laurelcherry. American Beauty Berry is common as well, and the principal groundcovers are Bristle Basketgrass and Ebony Spleenwort.

Isolated shell deposits, presumably of Native American origin, were detected as imbedded habitats on a number of hammocks where the area of coverage was not sufficient to warrant community status. These deposits were usually in the form of low mounds in upland terrain, but occasionally were observed within eroded banks and drains. Isolated shell habitat was observed on six of the 25 surveyed hammocks (ACE1, B1, F7, F51, F52 and K6) and on three Morgan Island hammocks visited once. Only on F7 did such shell deposits not support at least one species of calcium-loving plant, presumably because shell deposits there are within brackish wetlands. Small-flowered Buckthorn was found at shell sites on B1, F51, F52 and K6; Satincurls was recorded on an isolated shell mound on ACE1; and Carolina Basswood is associated with shell on the three Morgan Island hammocks. The most impressive colony of Small-flowered Buckthorn observed during the survey is near a shell-mound in a small remnant of native Maritime Forest on F52, Large Truluck Island. Unfortunately, fill-dirt dispersal continues on this privately owned island, and the shell site is very near where such activities have previously occurred.

Maritime Forest

Maritime Forest communities occur in the interior, more elevated portions of most hammocks. These areas are often dominated by a dense canopy primarily of Live Oak (*Quercus virginiana*), Laurel Oak (*Quercus laurifolia*) and Loblolly (*Pinus taeda*) and/or Slash Pine (*Pinus elliottii*). Live Oak may have outward branches draped with Spanish Moss (*Tillandsia usneoides*) and large forked branches partially enveloped by Resurrection Fern (*Pleopeltis polypodioides michauxiana*). Cabbage Palmetto is frequently interspersed within the lower canopy and a shrub layer of Yaupon (*Ilex vomitoria*), Red Bay (*Persea borbonia*), Wild Olive (*Osmanthus americana*) and Wax Myrtle (*Morella cerifera*) further shades the forest floor, where the herbaceous layer can be sparse. American Beauty Berry (*Callicarpa americana*) can be abundant as well as Coral Bean (*Erythrina herbacea*). Woodoats (*Chasmanthium* sps.) are among the most common grasses. *Chasmanthium sessiliflorum* is common in Maritime Forest on most hammocks very near the coast, but in the ACE Basin this plant is replaced in similar habitats by a variety of unidentified woodoats (*Chasmanthium* cf. *sessiliflorum* = sps.

nov.). As the elevation drops toward the outside of these islands, other habitats dominate. Although many small hammocks are not of sufficient elevation to support any upland community, others like Small Truluck Island (F53) are almost entirely of this community type. Even the most inland hammock in the survey, South Williman Island, in part, (ACE 12) has this habitat on the extreme eastern end.

Pine-dominated Maritime Forest

Interesting variants and derivations of Maritime Forest can be found where more unique soil characteristics and human impacts occur or converge. Live Oak, and perhaps Laurel Oak as well, was likely harvested from many hammocks for shipbuilding and other uses, and some hammocks have xeric upland features that are now primarily forested by pine, generally a mixture of Loblolly and Slash. "Pine-dominated Maritime Forest" with a high canopy and dense understory of mixed vines, principally greenbrier (*Smilax* sps.), Muscadine Grape (*Vitis rotundifolia*), and shrubs (mostly Yaupon with Wax Myrtle) covers much of the northern half of Long Island, in part (F51) and of adjacent Long Island hammocks. Sparkleberry (*Vaccinium arboreum*) occurs in colonies where it is not out-competed by Yaupon. Portions of many other hammocks in Charleston County have similar habitat, though frequently with a more open forest floor. Grasses, including Blackseed Speargrass (*Piptochaetium avenaceum*) and Slender Woodoats (*Chasmanthium laxum*) and sedges (*Cyperus* and *Carex* sps.) inhabit more open areas. Other low-growth species include Bracken Fern (*Pteridium aquilinum* var. *pseudocaudatum*), Sarsparilla Vine (*Smilax pumila*), Wild Indigo (*Indigofera caroliniana*), Tread-softly (*Cnidoscolus stimulosus*), Sand Ticktrefoil (*Desmodium lineatum*) and Narrowleaf Silkgrass (*Pityopsis graminifolia* var *latifolia*). Spurred Butterfly Pea (*Centrosema virginianum*) and Downy Milkpea (*Galactia volubilis*) are common sprawling, herbaceous vines. Pinebarren Sunrose (*Helianthemum corymbosum*), a rare species not yet having a NatureServe rank, was also found in this habitat on several islands. Some examples of islands with "Pine-dominated Maritime Forest" are Bass Creek Island (K1), Eagle Point (K2) Lunch Island (K57), Mingo Point-Disturbed (K58) and Apron Island (F7). Sandy-woods Sedge (*Carex dasycarpa*) (NatureServe rank: S2/S3/G?) is associated with this habitat on Apron Island. Of the hammocks surveyed in Colleton and Beaufort Counties, small bands of "Pine-dominated Maritime Forest" are present on the highest portions of ACE 1 and ACE 12 adjacent to large waterways. Charlotte Island (B2) has pine-dominated forest in several perimeter areas, but this entire island has forest characteristics more typical of the Lower Coastal Plain mainland. Great Horned Owl (*Bubo virginianus*) was encountered most frequently in association with this forest type and an active nest was discovered on Long Island. An active Osprey (*Pandion haliaetus*) nest was observed in the canopy of a large, living Loblolly Pine in this forest type on another Long Island hammock adjacent to the surveyed portion of the Long Island complex. Dead pines are more frequently used for nesting by Osprey, and a dead pine in a similar forest on a Morgan Island hammock visited once during the survey contained an Osprey nest as well. Both Bald Eagle (*Haliaeetus leucocephalus*) and Red-tailed Hawk (*Buteo jamaicensis*) often nest in tall, living pines. Red-tailed Hawk was frequently observed over these hammock-forests in a soaring, foraging mode. Only one nest was spotted, on Mingo Point-Disturbed (K58), but nesting may be relatively common in this forest type based on the frequency in which

hawks were seen in association with such habitat. Bald Eagle nests have been recorded on South Carolina hammocks (Tom Murphy, SCDNR, pers. comm.) and during the survey there was an active nest on Kiawah Island very near several surveyed hammocks. The nest was destroyed by tropical storm winds in summer 2004, and the eagles have now rebuilt in a tall pine on a nearby hammock (Norm Shea, Kiawah Island Community Association, pers. comm.). A Chuck-will's-widow (*Caprimulgus carolinensis*) nest with eggs was found on the forest floor within a similar forest on Bass Creek Island (K1). Bald Eagle, Osprey and various wading birds, including the endangered Wood Stork (*Mycteria americana*) were most frequently encountered is association with hammocks as the birds perched in large dead or live pines adjacent to waterways. Brown-headed Nuthatch (*Sita pusilla*) is a state species of concern and was only found in this habitat and only on Kiawah hammocks (K2, K57 and K58).

Pignut Hickory Dune Ridge

This Maritime Forest variant was observed only along the western arm of Apron Island (F7) in association with relict sand dune ridges. Pignut Hickory (*Carya glabra* var. *megacarpa*) is a dominant canopy species in mixed association primarily with pine and an occasional Live or Laurel Oak. Colonies of both Sparkleberry and Dwarf Palmetto (*Sabal minor*) are interspersed in an unusual association on the relict dunes where elevation reaches 3-4 m above the high tide line. Atlantic Pigeonwings (*Clitoria mariana*) is an abundant herb.

Xeric Sand-Bald

Clearings or "balds" with poor, xeric, sandy soils are found near the perimeter of many hammocks, particularly those with relict dune ridges. Trees and shrubs are nearly absent, presumably from the synergistic impacts of low organic content in xeric, sandy soils and the exacerbating effects of salt spray at such exposed sites. The only shrubs observed in this harsh, imbedded habitat were a colony of Hercules Club (*Zanthoxylum clava-herculis*) on Long Island (F51), where "balds" are relatively abundant, and Sparkleberry, which occasionally crowds the inland perimeter of these areas. These sparsely vegetated "balds" frequently contain Dune Prickly Pear (*Opuntia pusilla*) and/or Prickly Pear (*Opuntia humifusa* var. *australis*). This imbedded habitat may occupy an area as small as only a few square meters, but "Xeric Sand-Balds" may be larger or in beaded-chains interrupted by Live Oak or pine. Several infrequently encountered species were found only in this habitat. Forked Bluecurls (*Trichostema dichotomum*) was recorded only on Long Island, Small Truluck Island (F53) and Mingo Point-Disturbed (K58). Rabbitbells (*Crotolaria angulata* var. *vulgaris*) was only encountered on Apron Island (F7), and Spreading Sandwort (*Arenaria lanuginosa*) (NatureServe rank S1/G5) occurs with Forked Bluecurls in a very small "Xeric Sand-Bald" on Small Truluck Island. Six-lined Racerunner (*Cnemidophorus sexlineatus sexlineatus*) was observed only in "Xeric Sand-Balds" on a few Kiawah hammocks.

South Atlantic Inland Maritime Forest

This community is highly variable in species composition in the canopy, shrub and herbaceous layers depending on hammock location, size and elevation and associated soil characteristics. Frequently, changes in the assemblage of plants are related to

differences in elevation. On the smallest hammocks with low-elevation uplands, Southern Red Cedar and Cabbage Palmetto are the dominant trees. As elevation increases, Loblolly Pine (and occasionally Slash Pine) and Live Oak become major constituents. Pignut Hickory, Post Oak (*Quercus stellata*), Laurel Oak may occur in higher, drier soils. Persimmon (*Diospyros virginiana*) and Black Cherry (*Prunus serotina*) may occur in a sub-canopy with Tallowtree, particularly in areas disturbed by past logging activities. The shrub layer is mostly Wax Myrtle and *Baccharis* sps. at lower elevations, but much more diverse in higher elevation variants of South Atlantic Inland Maritime Forest. Yaupon and Sparkleberry blend with Wax Myrtle in higher forests, and the herb layer transitions from mostly grasses (*e.g.* Switchgrass and Marsh Fimbry) to a much more diverse assemblage, typically including Slender Woodoats (*Chasmanthium laxum*), Bracken Fern, Witch Grasses (*Dichanthelium* sps.), Thoroughworts (*Eupatorium* sps.), Coral Bean and American Beauty Berry. Poison Ivy (*Toxicodendron radicans*) is often abundant at intermediate elevations. In some forests, as Live Oak becomes more dominant, the forest transitions into Maritime Forest more typical of Barrier Islands. Larger hammocks, such as ACE 12, have several transitional types of South Atlantic Inland Maritime Forest. This habitat/community type is often used as a catch-all and can include some of the habitats listed independently here.

Pine-Palmetto Flatwoods

This variant of Inland Maritime Forest is most prevalent on Charleston County hammocks and often transitions with "Palmetto Faltwoods" as discussed below. "Pine - Palmetto Flatwoods" occur where the upland elevation grades very gradually inland of Salt-Shrub Thicket. Fingers of Salt-Shrub Thicket and Inland Maritime Shrub Swamp often extend into this terrain. Loblolly Pine and Cabbage Palmetto dominate and hardwoods are nearly absent. Slender Woodoats and Switchgrass are common, though the forest floor is often sparsely vegetated. Poison Ivy is often very abundant, particularly near ecotones between the upland and Salt-Shrub Thicket and Inland Maritime Shrub Swamp. On Long Island, this habitat is prevalent where much of the upland is adjacent to a partially enclosed estuarine marsh system that extends for most of the island's length.

Palmetto Flatwoods

As the name suggests, "Palmetto Flatwoods" are dominated by Cabbage Palmetto. This habitat is typically found in low elevation uplands near the perimeter of hammocks, or adjacent to marshlands within hammocks. The best examples of this habitat are found on the interior of Long Island where low elevation uplands border Brackish Marsh and on the perimeter of less disturbed portions of Large Truluck Island (F52). Wax Myrtle is the principal shrub, but Groundsel Tree and Saltwater False Willow may colonize more open areas. The herb layer is sparse beneath dense stands of Cabbage Palmetto, but Switchgrass, Fireweed (*Erechtites hieracifolia*), Southern Dewberry (*Rubus trivialis*) and St. Andrew's Cross (*Hypericum hypericoides*) may be common.

Palmetto Slope

At least part of the outer portion of many hammocks, particularly those with Maritime Forest, is characterized by a gradual slope away from higher, central uplands

toward the Salt-Shrub Thicket. This zone is dominated by Cabbage Palmetto, but often has largeLive Oak interspersed. Depression Wetlands are common and fingers of Salt-Shrub Thicket usually extend beneath palmettos. This community generally includes Southern Red Cedar as well, and the prevalence of cedar increases as elevation decreases, until cedar frequently transitions into Maritime Shrub Thicket or Salt-Shrub Thicket at the island's perphery. Live Oak becomes less abundant as elevation decreases. These slopes may best be considered Palmetto-Marsh Complex types (Aulbach-Smith, 1996). The canopy of these areas is often thick and shrubs such as Groundsel Tree, Saltwater False Willow and Marsh Elder are restricted primarily to openings. Grasses, most often Switchgrass and Marsh Fimbry, dominate the herb layer. Much of ACE 5 and the western side of ACE 6 and ACE 52 display this habitat. On ACE 9, an interesting variant of this community occurs on an acre or more of the western end and within a narrow band along the central, northern side. Beneath Cabbage Palmetto and Southern Red Cedar is a dense carpeting of St. Augustine Grass (*Stenotaphrum secundatum*) with tufts of Marsh Fimbry. Small pockets of similar habitat occur on ACE 6, ACE 52, K2, K6 and K52. Eastern Glass Lizard (*Ophisaurus ventralis*), though found in other hammock habitats as well, was seen in such areas with some frequency during warmer seasons, but the extent of cover made capture of these reptiles particularly difficult.

Mixed Pine-Hardwood Forest

This forest type generally is restricted to the mainland, but several hammocks in the survey have forest communities that are very different from a more typical Inland Maritime Forest and from forest communities on other surveyed islands. A large part of the upland interior of ACE 1 has a canopy dominated by large Loblolly Pine (several specimens 100-111 cm diameter) and Live Oak, but including Pond Pine (*Pinus serotina*), Black Cherry, Sweetgum (*Liquidambar styraciflua*) and Black Gum. The shrub layer is generally thick with Yaupon and Wax Myrtle intermingled with tangles of Yellow Jessamine (*Gelsimum sempervirens*), Muscadine Grape (*Vitis rotundifolia*) and Lanceleaf Greenbrier (*Smilax smallii*). The herb layer is virtually absent. Mixed Pine-Hardwood Forest occupies the extreme eastern end of ACE 12 and much of ACE 54. In order of decreasing abundance Loblolly Pine, Post Oak and Sweetgum are the principal trees at both sites. On ACE 12, Wax Myrtle is the dominant shrub in this habitat type though some Yaupon is present. In contrast, Yaupon is very dense on ACE 54. Slender Woodoats is the primary member of a very sparse herbaceous layer in this community on both islands. Of particular note, Eastern Fox Squirrel (*Sciurus niger*) was encountered several times in this forest community on ACE 54 and is likely also present on other hammocks in the North Williman Island-complex. A similar forest community covers much of D3, part of Dixie Plantation, which is very near the Charleston County mainland in the Hollywood area. Charlotte Island (B2) in Beaufort County, is very near the mainland as well and at the north end has a Mixed Pine-Hardwood Forest much like that associated with bluffs adjacent to river floodplains in the Coastal Plain. Long-leaf Pine (*Pinus palustris*), Short-leaf Pine (*Pinus echinata*) and Loblolly Pine occur in association with Mockernut Hickory (*Carya alba*), Swamp Chestnut Oak (*Quercus michauxii*), Water Oak (*Quercus nigra*), Willow Oak (*Quercus phellos*), White Oak (*Quercus alba*) and American Holly (*Ilex opaca*). The shrub layer includes Horsesugar (*Symplocos*

tinctoria) and Wax Myrtle. Interesting herbs found in this community were Crippled Cranefly (*Tipularia discolor*) and Arrowleaf Heartleaf (*Hexastylis arifolia*).

Successional Loblolly Pine-Hardwood Forest

This community was encountered in restricted areas on ACE 12 where logging operations in decades past, apparently primarily for Loblolly Pine, created openings in the canopy of other forest types. Pine and Tallowtree are quick to colonize such disturbed areas. Young and medium age Loblolly Pine are dense and other trees, also likely survivors of logging based on their size, are distributed throughout. These dense stands of trees have few shrubs or herbs beneath. Hardwoods within this forest type are diverse including many of the species found in the Oak-Hickory Forest on ACE12. This community is common on other parts of both the South Williman Island-complex and North Williman Island-complex (Aulbach-Smith, 1996).

Oak-Hickory Forest

Much of the interior of ACE 12 and a small potion of ACE54 is mature Oak-Hickory Forest. The diversity of oaks is impressive, including Water Oak, Black Oak (*Quercus velutina*), Laurel Oak, White Oak, Willow Oak and Live Oak. As the terrain gradually rises toward the outside of the island, forest communities begin to blend, and Loblolly Pine, Post Oak and Pignut Hickory enter the canopy. Sweetgum is also abundant and Black Gum is scattered about as well. Cabbage Palmetto is dispersed throughout the subcanopy with smaller specimens of the canopy species. Other subcanopy species include Red Mulberry (*Morus rubra*), Eastern Redbud (*Cercis canadensis*), Red Maple (*Acer rubrum*), Devil's Walking Stick (*Aralia spinosa*) and Red Buckeye. In disturbed areas such as logging roads and drag-ways and near wetlands, Tallowtree is abundant. The shrub layer is frequently dense with Evergreen Shrub Thicket and is composed primarily of Wax Myrtle and Yaupon. A few Dwarf Palmetto colonies also occur and young Cabbage Palmetto is scattered about. Vines, particularly Muscadine Grape, Virginia Creeper (*Parthenocissus quinquefolia*) and Supplejack (*Berchemia scandens*), are plentiful. The herb layer is very diverse, but moderate to sparse depending on sunlight penetration. Slender Woodoats is an abundant grass and Witchgrasses (*Dichanthelium* sps.) and Bristle Basketgrass are common where the forest floor is open. Partridge Berry (*Mitchella repens*) is a common groundcover. Herbs include Atamasco Lily (*Zephranthes atamasco*), Spring Ladies'-tresses (*Spiranthes vernalis*) and Carolina Wild Petunia (*Ruellia carolinensis*). In one relict logging road there are colonies of Indian Hemp (*Apocynum cannabilum*) and Southern Mountainmint (*Pycnanthemum pycnanthemoides*). These two species were found only here, and Southern Mountainmint is considered rare in the Coastal Plain, this finding perhaps a new Beaufort County record (P. McMillan, Pers. Comm.). Aulbach-Smith (1996) recorded additional plant species in the Oak-Hickory Forest on North Williman, including Flowering Dogwood (*Cornus florida*) and Horsesugar. Eastern Gray Squirrel (*Sciurus carolinensis*), generally absent from hammocks in the survey, was found in this forest type on both ACE 12 and B2. Broad-headed Skink (*Eumeces laticeps*) is a very arboreal skink that takes cover in hardwood tree cavities. This species is most often associated with hardwood forests, and a population was confirmed only on ACE 12.

Bottomland Hardwood Forest

Imbedded within the Oak-Hickory Forest of ACE 12, and adjacent to the Forested Wetlands discussed below, are small pockets of Bottomland Hardwood Forest dominated by Red Maple and Water Oak. Cane (*Arundinaria* sps.) thickets and Red Bay dominate the forest floor. On Charlotte Island (B2) a small, central area with rather hydric soil supports a canopy of Water Oak and a colony of Cinnamon Fern (*Osmunda cinnamomea*) below.

Evergreen Shrub Thicket

This assemblage is often found as an embedded habitat or community in upland areas and beneath the canopy in various forest types, including Maritime Forest, Inland Maritime Forest, "Pine-dominated Maritime Forest", Oak-Hickory Forest, *etc*. The particular plant assemblage forming this community varies dramatically depending on soil characteristics. On most hammocks, major constituents are Yaupon, Red Bay, Wax Myrtle and shrub-stage Cabbage Palmetto. Wild Olive and Carolina Laurelcherry are also often found in inland shrub thickets. In shell forests, Carolina Buckthorn may occur as well, and in xeric soils Sparkleberry may form nearly monoculture thickets. Greenbrier (*Smilax* sps.) and other vines may climb through Evergreen Shrub Thickets, rendering such thickets virtually impenetrable. Nearly all hammocks in the survey support such communities. On parts of Long Island and much of Small Truluck Island, the Evergreen Shrub Thicket is enveloped in Saw Greenbrier (*Smilax bona-nox*) and/or Dune Greenbrier (*Smilax auriculata*). In lower, more hydric soils on Long Island, Wax Myrtle is dominant. An expansive Wax Myrtle thicket occupies much of the eastern part of ACE 1 near the Intracoastal Waterway. On the opposite side of this hammock, a low, sandy trough nearly transects the island and is densely colonized primarily with Yaupon and Chinese Privet (*Ligustrum sinense*). Much of this area has a carpeting of Slender Woodoats, but where it is absent, Bristle Basketgrass (*Oplismenus hirtellus*) and Ebony Spleenwort (*Asplenium platyneuron*) are abundant. American Woodcock (*Scolopax minor*) was regularly encountered during winter in this habitat. As the terrain slopes away to the west from the Maritime Shell Forest in the center of ACE 52, there is an Evergreen Shrub Thicket variant of a nearly pure stand of Giant Cane (*Arundinaria gigantea*), with sedges (*Cyperus* sps.) and Ebony Spleenwort carpeting the ground beneath. The diversity of soil and forest characteristics on ACE 12 is cause for the presence of an abundance of Evergreen Shrub Thicket types, including thickets dominated by Wax Myrtle, Yaupon, Sparkleberry and Cane (possibly *Arundinaria tecta*, though the taxonomy of canes is not completely resolved). On ACE 54, the Evergreen Shrub Thicket is composed almost entirely of Yaupon. However, ACE 54 is heavily browsed by feral Goat, and other species have likely been eliminated. In Beaufort County, Charlotte Island (B2) has Wax Myrtle-Inkberry (*Ilex glabra*) thickets, more characteristic of Evergreen Shrub Thicket in low, acidic pinelands of the Lower Coastal Plain mainland. Evergreen Shrub Thicket beneath "Pine-dominated Maritime Forest" of Long Island supports an impressive resident population of Eastern Towhee (*Pipilo erythrophthalmus*). Both Northern Cardinal (*Cardinalis cardinalis*) and Carolina Wren (*Thryothorus ludovicianus*) are generally common resident species in Evergreen Shrub Thicket on most hammocks. Gray Catbird is an abundant transient in all thicket habitats

and White-throated Sparrow (*Zonotrichia albicollis*) was abundant during winter in thickets on Long Island in particular.

Saw Palmetto Thicket

Much of Cedar Hammock (B3) has a dense Evergreen Shrub Thicket of Saw Palmetto (*Serenoa repens*). Marsh Island Park (K53) has significant coverage in this community as well, and smaller stands of Saw Palmetto on Eagle Point (K2) and Beck Island (K6) are the most northerly, naturally occurring populations of this species in South Carolina (N. Shea, pers. comm.).

Maritime Shrub Thicket

This community occurs at the upland and Salt-Shrub ecotone where the transition in elevation is gradual. Wax Myrtle is the primary component, but Cabbage Palmetto and Southern Red Cedar may be included. Pockets of this shrub thicket type are often dispersed along the upland periphery and generally blend with Salt-Shrub Thicket to the outside and into more upland habitats toward a hammock's center. Practically all hammocks, except the very smallest islands with only grasses and Salt-Shrub Thicket, have at least small areas of this community.

Salt-Shrub Thicket

Salt-Shrub Thickets may be isolated on very small, low elevation hammocks or on fragmented low uplands separated from the primary upland by Salt Flat or Brackish Marsh. This habitat is located immediately above the usual high-tide line and is included here as an upland habitat. Smooth Cordgrass, Black Needlerush and Inland Saltgrass (*Distichlis spicata*) may blend into the outward transition zone between Salt-Shrub Thicket and Salt Marsh or Brackish Marsh. Sea Ox-eye (*Borrichia frutescens*) often dominates when Salt-Shrub Thicket is isolated from higher elevation uplands. When shrubs are sparse and elevation is appropriate, there is frequently a mixture of shrubs and grasses. Sea Ox-eye, Saltmeadow Cordgrass and Marsh Fimbry are common constituents in such assemblages. Seaside Goldenrod occurs often in these mixed communities as well. A "Salt-Shrub Collar" frequently occupies the transition ecotone from upland to estuarine habitats and often forms a complete band or collar around forested hammocks. In this setting, diversity increases and Marsh Elder (*Iva frutescens*) is generally present with Sea Ox-eye. The upland side of this collar may include Groundsel Tree, Saltwater False Willow or Big Cordgrass (*Spartina cynosuroides*). In addition to Seaside Goldenrod, herbs that often occupy the ecotone immediately upland of Salt-Shrub Thicket include Spear Orach (*Atriplex patula*), Juda's Bush (*Iresine rhizomatosa*) and Maritime Pokeweed (*Phytolacca rigida*). Song Sparrow (*Melospiza melodia*), Swamp Sparrow (*Melospiza georgiana*) and Common Yellowthroat (*Geothlypis trichas*) were associated with this habitat during fall and winter and Saltmarsh Sharp-tailed Sparrow (*Ammodramus caudacutus*), Seaside Sparrow (*Ammodramus maritimus*) and Clapper Rail (*Rallus longirostris*) move into this area to find cover, particularly during exceptionally high tides.

Maritime Grassland

Many larger islands have bands or isolated pockets of non-tidal Maritime Grassland that occurs immediately upland of Salt-Shrub Thicket. This community is associated with low elevation uplands that are subject to flooding during storm driven tides. Soils are generally sandy with little organic matter. Small, fragmented hammocks, often occurring as satellites to larger hammocks and frequently separated from each other and from the larger island by Salt Flat and Brackish Marsh, often present a similar habitat and plant assemblage. Harsh conditions limit colonization by most trees and shrubs, with sparse occurrence of Loblolly Pine, Southern Red Cedar and stunted Live Oak. The absence of shade allows salt-tolerant grasses, sedges and herbs to thrive, including Sweet Grass (*Muhlenbergia filipes*), Marsh Fimbry (*Fimbristylis castanea*), Finger Grass (*Chloris petraea*), Marsh Bristlegrass (*Setaria parviflora*), Seashore Dropseed (*Sporobolus virginicus*) and Coastal Bermuda Grass (*Cynodon dactylon*). A salt-shrub collar generally separates these grasslands from saltmarsh, Brackish Marsh or Salt Flat. Seaside Goldenrod (*Solidago sempervirens*) frequently occurs along this blend zone. These grasslands are occasionally a nearly monoculture of Saltmeadow Cordgrass (*Spartina patens*), as may be seen on either end of ACE 9, Buzzard Island. A similar community may develop in low-lying uplands colonized largely with pine and near the periphery of hammocks when salt-spray or flood tides kill the pines, thereby producing openings. Marsh Hawk Island (K51), immediately west of Kiawah Island, is an excellent example of this habitat. There the grasslands developed following the death of a stand of Loblolly Pine and some small Live Oaks. With the exception of a single large Live Oak, a Southern Red Cedar, and Salt-Shrub Thicket, this small, low elevation island is Maritime Grassland with no remaining live pine. Sedge Wren (*Cistothorus platensis*) was encountered in this habitat on ACE 9 and ACE 12 during fall. Swallow-wort (*Cynanchum angustifolium*) may occur at the transition between such grasslands and Salt-Shrub Thicket. Swallow-wort is a member of the milkweed family, Asclepidaceae, and is particularly common in such habitats on islands surveyed in the Folly Beach area. This plant provides nectar for many butterfly species, other insects, and for migrating Ruby-throated Hummingbirds (*Archilochus colubris*). It is also the primary larval host for both Monarch (*Danaus plexippus*) and Queen (*Danaus gilippus*) butterflies. A resident population of Queen was recorded on Long Island during this survey, which is significant since this species is generally more southern in distribution, except as a late summer and fall emigrant.

Ruderal Gardens

Human disturbances such as clearing or filling creates artificial habitat not naturally occurring on hammocks and leads to the introduction of "weedy" or waif species. Much of Large Truluck Island (F52) was cleared decades ago for a small-airplane landing strip and a large amount of fill-dirt has been off-loaded and distributed over at least a third of the upland in recent years. These activities have dramatically impacted the plant community, causing a concurrent reduction in the diversity of the natural plant community, but a substantial increase in the total plant species diversity. Mimosa (*Albizia julibrissin*) and Crape Myrtle (*Lagerstromia indica*) are non-native tree species encountered only within this ruderal community. Herbs are very diverse, with many species identified and others never in bloom or fruit during the survey period.

Southern Dewberry is common in dense tangles enveloping other low vegetation. Examples of species not, or rarely, encountered elsewhere are Evening Primrose (*Oenothera biennis*), Chocolateweed (*Melochia corchorifolia*), Mexican-tea (*Chenopodium ambrosioides*), American Pokeweed (*Phytolacca americana*), Golden Tickseed (*Coreopsis tinctoria*), Windowbox Wood-sorrel (*Oxalis rubra*), Bladderpod (Glottidium vesicarium), White Sweet Clover (*Melilotus alba*), Brazilian Vervain (*Verbena brasiliensis*) and Cuban Jute (*Sida rhombifolia*). Interestingly, Pillpod Sandmat (*Chamaesyce hirta*), a rare member of the spurge family, was found in this Ruderal Garden. A small Ruderal Garden with a thicket of Groundsel-tree and Bladderpod was located near the northwestern end of K57, another disturbed hammock. These "weedy" communities had brushy thickets that supplied both cover and seeds, and such sites on both islands were used extensively by overwintering Song and Swamp Sparrows. The Ruderal Garden on F52 provided excellent habitat for Hispid Cotton Rat (*Sigmodon hispidus*), and "runs" were very prevalent and indicative of a robust population. The abundance of rodents is the probable reason that both Bobcat (*Lynx rufus*) and Common Gray Fox (*Urocyon cinereoargenteus*) sign was found in this area. Red-tailed Hawk was frequently seen in this vicinity as well, either perched in a nearby tall pine or soaring above. Cooper's Hawk (*Accipiter cooperii*), a state species of concern, was also encountered during winter in this area with more frequency than at any other island habitat, possibly preying on Hispid Cotton Rat as well.

Lawns

Open, maintained lawn areas occur on all three of the originally selected disturbed islands, F52, K57 and K58. Lawn on K57 is located in narrow strips, primarily of St. Augustine sod, on either side of an asphalt roadway that extends the length of the hammock. Lawns on Large Truluck Island and Mingo Point-Disturbed are blends of "lawn grasses", St Augustine and Centipede (*Eremochloa ophiuroides*), with Coastal Bermuda Grass and other grasses and lawn "weeds". Portions of lawn on F52 and K58 extend beneath high-canopy trees with little or no shrub layer. These lawns were used by birds that forage on open ground, including Mourning Dove (*Zenaida macroura*) and Boat-tailed Grackle (*Quiscalus major*) through all seasons and Palm Warbler (*Dendroica palmarum*) during fall and winter. Open habitats around buildings and lawns also attracted Northern Mockingbird (*Mimus polyglottos*), which was otherwise not widely distributed on hammocks. Loggerhead Shrike (*Lanius ludovicianus*) was recorded as a breeding species only on Large Truluck Island, as this species forages in open meadow-like habitats for insects when brooding young. Eurasian Collared Dove (*Streptopelia decaocto*), an introduction from Europe that thrives in suburban habitats, is a ground-feeding species that was only recorded on Large Truluck Island.

Foundation Plantings

Hammocks with man-made structures and human occupation usually have non-native species planted adjacent to buildings or in landscaped areas. The three "disturbed" islands selected for survey, F52, K57 and K58, have such plantings, but these botanical features were not recorded. Foundation remnants were found on F51 and ACE 9 where there was human occupation decades ago. "Escaped" non-native plants were recorded when mixed with natural communities. An assemblage of non-native plants surrounds

the building foundation remains on Long Island (F51). Japanese Privet (*Ligustrum japonica*) and China-berry (*Melia azedarach*) mixed in the subcanopy beneath Live Oak and Sugarberry, and English Ivy (*Hedera helix*) covers much of the building foundation and partially envelopes trees. Kudzu (*Pueraria lobata*) also twines through the shrub layer in this area. Japanese Privet and China-berry were also found near the remnants of a foundation on ACE 9. China-berry was also recorded on ACE 1, indicating the possibility of human occupation within the past century. Pampus Grass (*Cortaderia selloana*) was encountered on both F52 and K58, and Russian Olive (*Eleagnus pungens*) occurs in woodlands on F7, F51, K58 and K55. *Eleagnus* species produce fruit that are consumed by many birds and these plants are easily dispersed from seed in bird droppings. Russian Olive was only recorded as a few isolated specimens on islands in the survey, but *Eleagnus* species are considered as potential nuisance non-endemics because of the ease at which these plants are distributed (J. Brubaker, SC Native Plant Society, pers. comm.).

Palustrine and Estuarine Wetlands

Salt Flat

This habitat occupies the upper extreme of the high Salt Marsh where the slope is practically flat and soils are sandy. The soil is hydric and highly saline. The most abundant plants are Slender Glasswort (*Salicornia virginica*) and Saltwort (*Batis maritima*). Inland Saltgrass may be present and dominant as well. As the Salt Flat merges with Salt-Shrub Thicket, Perennial Saltmarsh Aster (*Symphyotrichum tenuifolium*) and Sea Lavender (*Limonium carolinianum*) are common. Most hammocks in the survey have associated Salt Flat in isolated patches or expanses. On Long Island, Salt Flat borders much of a partially enclosed tidal drain and permanent saline pools near the northwest end. This habitat is heavily populated by fiddler crabs, particularly Chinaback Crab (*Uca pugilator*). Eastern Pygmy Blue (*Brephidium isophthalma*), the smallest butterfly species in eastern North America, was found in abundance in this habitat as well. The larvae of this butterfly feed on *Salicornia* sps. and adults are rarely seen more than a few meters away from Salt Flat. Salt Flat are used as foraging habitat by some shorebirds, and both Killdeer (*Charadrius vociferous*) and Semipalmated Plover (*Charadrius semipalmatus*) were recorded in this habitat. Whimbrel (*Numenius phaeopus*) and Laughing Gull (*Larus atricilla*) were observed while using Salt Flat as resting habitat.

Salt and Brackish Marsh

Marshlands, either saline or brackish, may be partially or completely enclosed within uplands. Enclosed high salinity marshlands are colonized primarily by Smooth Cordgrass (*Spartina alterniflora*) and are isolated from surrounding Salt Marsh by low elevation uplands, allowing input of salt water during unusually high tide events. Enclosed Salt Marsh was only observed on Buzzard Island (ACE 9) in Beaufort County and Eagle Point, in part (K2) in Charleston County. The enclosed marsh on Buzzard Island may have originally been Brackish Marsh, but a degraded drainage ditch, presumably dug many years ago for mosquito control, allows occasional flooding from the outside Salt Marsh during exceptionally high tides. A small brackish to saline pool in this wetland is populated by Sailfin Molly (*Poecilia latipinna*) and Marsh Killifish

(*Fundulus confluentus*). A tidal drain that extends through much of the length of the interior of Long Island (F51) contains small patches of Salt Marsh, but the majority of wetland near this small creek is Brackish Marsh and Salt Flat. A small tidal drain also penetrates well into Bass Creek Island (K1) and terminates in an intertidal mud flat. The mud flat supports a dense population of *Uca pugnax*, a fiddler crab species that prefers mud sediments. Narrow bands of Salt Marsh borders this drain and also encircle the mud flat. A 15-20-m^2 seasonal pool, fed by high tides through a depression that accesses the outside marsh, is located near the eastern center of D2 and is surrounded by Smooth Cordgrass. An embayment of high Salt Marsh at the northern end of Long Island (F51) contains two large saline pools with total surface area of five acres or so, that are separated from each other and from the upland by narrow strips of Brackish, Black Needlerush Marsh and Salt Flat. These pools are permanently watered and are colonized by dense populations of Sheepshead Minnow and grass shrimp (*Palaemonetes* sps.). Wading birds, including Great Egret (*Ardea alba*), Snowy Egret (*Egretta thula*), Little Blue Heron (*Egretta caerulea*) and Tricolored Heron (*Egretta tricolor*) were frequently recorded at these isolated pools. A sandbar on one pool was used as a resting site by shorebirds, including Lesser Yellowlegs (*Tringa flavipes*), Semipalmated Plover (*Charadrius semipalmatus*) and Spotted Sandpiper (*Actitis macularia*).

Brackish wetlands receive saltwater input with less frequency than does Salt Marsh. Brackish Marsh supports a more diverse plant community, though the lowermost portion of such wetlands may be densely colonized by Black Needlerush (*Juncus roemerianus*). These wetlands may be either partially or completely enclosed by uplands. When enclosed, there is invariably a trough of Salt-Shrub Thicket, Brackish Marsh or Salt Marsh connecting to the island's exterior that allows saltwater input on an occasional or infrequent basis. Small basins or pools may be distributed within these wetlands, with both the permanency and salinity of the water contained therein being highly variable depending on the timing, frequency and magnitude of rain and tidal inundation. A small, seasonal brackish pool on the periphery of Beck Island (K6) is surrounded by Salt-Shrub, and a 10-12 m^2 seasonal brackish pool at the upland border of ACE 54 is fed during exceptionally high tides by a Salt Marsh depression, but the presence of surface water is more dependent on rain events. The small pool on ACE 54 sustains a population of Marsh Killifish despite frequent dewatering. Marsh Morning-glory (*Ipomoea sagittata*) is a common species found in the perimeter of low salinity brackish wetlands, particularly in enclosed sites. Dotted Smartweed (*Polygonum punctatum*) may be common in less saline Brackish Marsh. Salt-shrub species typically border and transition into these Brackish Marshes, with Groundsel-tree (*Baccharis halimifolia*), Saltwater False Willow (*Baccharis angustifolia*) and Wax Myrtle (*Morella cerifera*) frequently occuring along the margins. Eastern Mud Turtle is dependent upon such pools on Apron Island (F7). Similar habitats are used by Eastern Narrowmouth Toad for breeding and larval development on Long Island (F51), where tadpoles were abundant following heavy, tropical summer rains in 2004.

Spartina bakeri Ponds

A unique wetland type occurs infrequently and only on ACE Basin hammocks (Aulbach-Smith, 1996). *Spartina bakeri* (Sand Cordgrass) Ponds are approximately circular in shape and are poorly studied, partly because few undisturbed sites exist. This

habitat and plant community type was identified during aerial surveys and aerial photo examination as part of the Edisto River Basin Natural Areas Inventory in 1992 and 1993 (Aulbach-Smith, 1996). Aulbach-Smith located such a wetland on the largest island in the North Williman Island-complex in Beaufort County. The *Spartina bakeri* Pond on North Williman has a diversity of small trees, shrubs, sedges and grasses scattered throughout (Aulbach-Smith, 1996). A small island (ACE 54) in this complex was included in this survey, but no such wetland occurs on that hammock. However, a *Spartina bakeri* Pond in excellent condition occurs on ACE 1, a member of the Hutchison island-complex in Colleton County. Unlike the pond on North Williman, this nearly 0.5-acre wetland supports a near monoculture of *Spartina bakeri* with tufts throughout except near the perimeter where plant diversity increases dramatically. At least two rare plant species, Golden Canna (*Canna flacida*) (S2/G4) and Fourleaf Vetch (*Vicia acutifolia*) (not yet ranked) occur near the edge of this wetland. A colony of Jamaica Swamp Sawgrass (*Cladium jamaicense*) occurs here as well, and this species was only found on one other island in the survey (Long Island, F51). Small basins are dispersed throughout the wetland and a centralized, roughly rectangular pool about 5m x 8m provides a permanent source of very low salinity to fresh water. A weathered and largely nonfunctional drainage ditch transects about 50m of upland between the wetland and Salt Marsh. The ditch presumably served to drain the wetland decades ago for mosquito control. The degraded ditch presently has little impact on the wetland, with the possible exceptions of allowing some drainage after torrential rains and possible input of salt water during storm driven tides. The permanent pool provides habitat for breeding and larval development for American Alligator (*Alligator mississippiensis*) and Bullfrog (*Rana catesbeiana*). This is the only surveyed island where these species were encountered. Both were also observed in a freshwater wetland on the largest hammock in the North Williman Island-complex during a one-time visit. Both species require permanent water for larval development. Green Tree Frog (*Hyla cinerea*) and Southern Leopard Frog (*Rana utricularia*) are common breeders associated with this wetland. Southern Leopard Frog is very abundant, as up to 50 individuals were observed on a single survey. Though not determined with certainly and not recorded, Southern Cricket Frog (*Acris gryllus*) was tentatively encountered in this wetland based on calls partially obscured by a raucous Green Tree Frog chorus during a rain event on a summer survey and on a single sighting when the frog escaped capture and positive identification. Southern Cricket Frog was substantiated as present in the freshwater wetland on the largest North Williman Island, but again, this island was not in the group of 25 islands selected for in depth survey.

Depression Wetlands

Depression wetlands, either forested or not, occur on most hammocks of several acres or larger. Depression Wetlands are quite variable in soil type and salinity depending on their distance inland from the Salt Marsh and the topography or terrain of the island in vicinity of depressions. These characteristics, in concert with extent of canopy cover, largely determine associated plant communities. Many hammocks have depressions distributed throughout "Palmetto Slopes" that frequently characterize gently sloping, low upland perimeter areas. Such depressions usually are near, or incorporated within, fingers of Salt-Shrub Thicket that protrude into the upland. The extent of canopy

closure controls the associated plant assemblage. In open areas, Groudsel-tree may dominate with various grasses and sedges. Fireweed (*Erechtites hieracifolia*) is often a common herb. On small hammocks, salt-shrub fingers or intrusions frequently extend beneath a high Live Oak canopy or thickets of Southern Red Cedar. Vegetation is usually very sparse in such situations, with a few grasses and sedges, including Marsh Fimbry and Switchgrass (*Panicum virgatum* var. *virgatum*). On some hammocks, such depressions are the primary source of surface freshwater, generally only ephemerally, following heavy rains.

Forested Depression Wetlands of several more unusual types were observed, particularly in the ACE Basin. The 66-acre South Williman Island (ACE 12) has Depression Wetlands within "Palmetto-Loblolly Pine Forest" that occur as a variant of, or transition to, Inland Maritime Shrub Swamp, and within more typical Inland Maritime Shrub Swamp (Aulbach-Smith, 1996). Similar communities and habitats also occur on ACE 1. These plant communities are located near an island's perimeter where elevation is low and the terrain gently slopes from more inland forests to the Salt Marsh. Some depressions, and related plant communities, apparently resulted from, or were accentuated by, logging operations decades ago. Remnants of relict logging roads and drag-ways in more inland areas have frequently become narrow bands or restricted pockets of Successional Loblolly Pine-Hardwood Forest within other forest types and depression in these sites support similar plant communities to more natural habitats nearer an island's perimeter. Depressions within Successional Loblolly Pine-Hardwood Forest are generally colonized primarily by grasses and sedges, with beaksedges (*Rhynchospora* sps.), nutrushes (*Scleria* sps.) and Slender Woodoats often dominating.

On ACE 12, "Palmetto-Loblolly Pine Forest" occur at the inland transition point or head of Inland Maritime Shrub Swamp. Depressions and ruts are dispersed throughout and rainwater is retained well as soils are rather hydric. Pennywort (*Hydrocotyle* sps.) is abundant as are various grasses, sedges and herbs, including Switchgrass, Redroot Flatsedge (*Cyperus erythrorhizos*), Marsh Fleabane (*Pluchea odorata*) and Lateflowering Thoroughwort (*Eupatorium serotinum*). Higher spots are often covered by Wax Myrtle. As the elevation slopes downward, Sand Cordgrass becomes dominant beneath Cabbage Palmetto, and "Palmetto-Loblolly Pine Forest" transitions into Inland Maritime Shrub Swamp, which merges near the island's perimeter into Salt-Shrub Thicket, Salt Flat, Salt Marsh or Brackish Marsh. As the wetland slopes toward the Salt Marsh, pines give way to Cabbage Palmetto. Small "hummocks" within the grassland-swamp support Wax Myrtle and Groundsel-tree, and even Marsh Elder (*Iva frutescens*) may be distributed nearer the outer edge. Some "hummocks" within the wetland and higher, perimeter transition ecotones support a mixture of Cabbage Palmetto and stunted Live Oak and Southern Red Cedar with Sand Cordgrass beneath, particularly near the outside edge. The ecotone on either outside border of Inland Maritime Shrub Swamp is typically an abrupt transition, as a more typical Martime Forest community quickly takes over, providing a dense canopy of Cabbage Palmetto, Live Oak and Loblolly Pine. Switchgrass and Flat-top Goldenrod (*Euthamia tenuifolia*) are among the most frequently encountered species at the sparsely-vegetated forest floor in these transition zones.

Inland Maritime Shrub Swamp is reminiscent of western chaparral in an eastern wetland. Small pockets of similar habitat may be found on many hammocks where Salt-Shrub Thicket merges into low-lying uplands with thickets of species such as Southern

Red Cedar, Wax Myrtle, *Baccharis* sps. and Sea Myrtle. Small, higher "hummocks" with stunted, stressed or dead pines and stunted Live Oak may be interspersed. Outside of the ACE Basin, Marsh Fimbry and *Juncus* sps. are among the dominant grasses, replacing Sand Cordgrass. Maritime swamps are much used by Painted Bunting (*Passerina ciris*), as males were frequently encountered as they sang during summer breeding season from perches within the more chaparral-like communities. Females were also observed, and with young during summer, in similar sites. Painted Bunting may nest in these habitats as well.

Some depressions, particularly on larger islands, are more isolated from Salt Marsh and may be adjacent to Brackish Marsh and "Palmetto Slopes". Open Depression Wetland of this type occur on Long Island and support a more diverse plant community typical of fresher water wetlands, including Soft Needlerush (*Juncus effusus*), *Ludwigia* sps., Climbing Hempweed (*Mikania scandens*), Alligatorweed (*Alternathera philoxeroides*) and White-topped Sedge (*Dichromena colorata*). The lower portion of one such wetland on Long Island is nearer the terminal end of a brackish swash which traverses an Inland Maritime Shrub Swamp (Aulbach-Smith, 1996) variant and which allows infrequent infusions of saltwater. As the wetland opens, Seashore Mallow (*Kosteletzkya virginica*) and Bigpod Sesbania (*Sesbania herbacea*) dominate with grasses including Giant Bristlegrass (*Setaria magna*) and Dotted Smartweed. Several of such wetlands on Long Island include seasonal fresh to slightly brackish pools that provide breeding and larval development habitat for Eastern Mud Turtle (*Kinosternon subrubrum*), American Toad (*Bufo terrestris*), and Eastern Narrowmouth Toad (*Gastrophryne carolinensis*). A depression wetland on ACE 9 has a centralized seasonal pool that retains some surface water through much of the year. The associated plant community is indicative of low salinity and rainwater is the usual source of surface water. Late-flowering Thoroughwort and Carolina Bristlemallow (*Modiola caroliniana*) are abundant. The latter species and Terrestrial Water-starwort (*Callitriche terrestris*), a rare species with S2/G5 rank, were only recorded here. Valdivia Duckweed (*Lemna valdiviana*) covered the water's surface in spring. Like the enclosed Salt Marsh wetland with brackish pools on the same island, a relict drainage ditch extends through about 50 meters of upland to the outside Salt Marsh. The wetland is heavily used by feral Goat, Raccoon and birds. Despite the presence of this seemingly appropriate breeding habitat, no amphibians were recorded on ACE 9, perhaps because the island is very near the coast and is isolated by expansive estuarine systems. A similar enclosed freshwater depression and pool is located on the southeast end of Charlotte Island (B2). This wetland holds up to 100-m^2 of surface water during wet seasons. No amphibians were recorded on Charlotte Islands despite its close proximity to mainland habitats. Based on this and other habitat on the island, the occurrence of amphibians is probable. The presence of amphibians on B2 could have easily been overlooked since it was not a core-island and was only surveyed on three dates.

Bowl-shaped depressions are another depression type seen on most islands having large trees. Uprooted large trees apparently produce these small, circular and cone-shaped depressions. On many islands, such bowl depressions are the most permanent source of surface freshwater. However, unless such depressions are associated with a wetland, water retention is only brief following substantial rain events since most upland soils on the hammocks are xeric to mesic. Invariably, these depressions have a

centralized excavation, likely the result of raccoons digging to maintain access to drinking water.

Forested Wetlands

Palustrine habitats were located within the mesic, Oak-Hickory Forest on ACE 12. The hammock has four freshwater wetlands, three with seasonal pools, that are well-removed from Salt Marsh influence. The wetlands have hydric soils that retain surface water during much of the winter and spring, and after heavy rain events in summer and fall. Much of the vegetation in and adjacent to these wetlands was unique to this island. Three of the wetlands have dense stands of Blue flag Iris (*Iris virginica*) and Lizard's-tail (*Sarurus cernuus*). Hop Sedge (*Carex lupulina*), Pickerelweed (*Pontedaria cordata*) and Frog's Bit (*Limnobium spongia*) are present as well. Trees and shrubs in these wetlands include Red Maple (*Acer rubrum*), Black Willow (*Salix nigra*), Swamp Gum (*Nyssa biflora*), Button-bush (*Cephalanthus occidentalis*) and Dahoon Holy (*Ilex cassine*). The latter two species were only encountered on ACE 12. Unfortunately, portions of these wetlands not enclosed by the canopy have been and continue to be invaded by Tallowtree (*Triadica sebiferum*). These wetlands support populations of Eastern Mud Turtle and Eastern Cottonmouth (*Agkistrodon piscivorus*) and are undoubtedly the sustaining source of many of the island's amphibian species, in particular, Central Newt (*Notophthalmus viridescens*), Mole Salamander (*Ambystoma annulatum*), Eastern Narrowmouth Toad (*Gastrophryne carolinensis*) and Southern Toad (*Bufo terrestris*). Crayfish (*Procambarus lunzi*) inhabit these Forested Wetlands, and Eastern Mosquitofish (*Gambusia holbrooki*) were also present in one wetland during late winter, though the large population died when surface water disappeared in late spring. These two species were only encountered on ACE 12. Woodlands adjacent to these wetlands also provide breeding territory for Acadian Flycatcher (*Empidonax virescens*), and this was the only island in the survey where successful brooding of this species was recorded.

Similar freshwater palustrine habitats were also recorded on the largest North Williman Island (Aulbach-Smith, 1996). A freshwater wetland on North Williman has a permanent pool. This wetland is adjacent to the relict Eastern Seaboard Railroad causeway, which transects the island. The wetland was apparently the inland portion of a salt and Brackish Marsh finger that was dammed by railroad causeway construction. The inland wetland transformed over time into the freshwater system of present. The southernmost large island (several hundred acres) in the South Williman Island group has a dozen or more permanent freshwater ponds that were created by phosphate mining many decades ago. Islands with permanent freshwater have great potential for a significant increase in diversity of both plants and animals. Some bird species, in particular Prothonotary Warbler (*Protonotaria citrea*), only recorded in transient mode on surveyed hammocks may breed on such large islands with substantial wetlands. The potential for increased diversity of amphibians on such hammocks was indicated by the discovery of an abundance of both Bull Frog and Southern Cricket at the North Williman wetland described above during a brief site visit by this survey's lead biologist in summer 2004. On the same 2004 visit, an American Alligator brood and a Black-crowned Night-heron (*Nycticorax nycticorax*) rookery were observed at the wetland. Waterfowl (Wood Duck, *Aix sponsa*, perhaps the most likely species) have been recorded here as well (Aulbach-Smith, 1996). Eastern Mosquitofish was seen in abundance in this wetland

during the brief 2004 visit, and other freshwater fishes likely occur here as well. Aulbach-Smith (1996) recorded plants in association with this wetland that were not encountered during this survey, a further indication of increased diversity with permanent surface freshwater.

Man-made Ponds

Excavated ponds were found on two of the surveyed islands. These excavations are, or presumably were, of sufficient depth to tap the water table. A rectangular pond of about 50-m^2 on the eastern upland of Long Island was likely created for livestock watering several decades ago, but now remains dewatered except following heavy rains. ACE 1 has two circular, approximately 20-25 m^2, pit-like ponds that were apparently excavated within the past several years for White-tail Deer management or hunting. These small ponds retain freshwater on a permanent basis and support populations of Southern Leopard Frog in addition to providing freshwater for mammals and birds. The largest, several 100-acre hammock in the South Williman Island-complex has a dozen or more much larger, permanently-watered ponds that are the byproduct of phosphate-mining many decades ago. The ponds are easily seen on aerial photographs. Most of these ponds are within the forested upland of an island that otherwise likely has many habitats and plant communities in common with its sister island, ACE 12. Given the substantial diversity of fauna and flora recorded on ACE 12, it is very intriguing to consider the likelihood of even higher diversity on a larger, though similar hammock with permanent freshwater sources.

Island Flora

This study produced a plant list containing 422 species. An additional 25 potentially different species were identified to genus only. A complete list of plant species found on the hammock islands surveyed is shown in Appendix 2. Only eight non-saltmarsh plant species were found on each of the sixteen core islands. These were Live Oak (*Quercus virginiana),* Cabbage Palmetto (*Sabal palmetto*), Saw Greenbrier (*Smilax bona-nox*), Seaside Goldenrod (*Solidago sempervirens),*Yaupon (*Ilex vomitoria),* Marsh Fimbry (*Fimbristylis castanea*), Seashore Dropseed (*Sporobolus virginicus*), and Groundsel Tree (*Baccharis halimifolia*). Saltmarsh species found at all islands included Smooth Cordgrass (*Spartina alterniflora),* Saltmeadow Cordgrass (*Spartina patens),* Sea Ox-eye (*Borrichia frutescens*), and Marsh Elder (*Iva frutescens).*

A graph of number of plant species versus island size shows that all islands had at least 35 species and the maximum number per island was about 179 species (Figure 27).

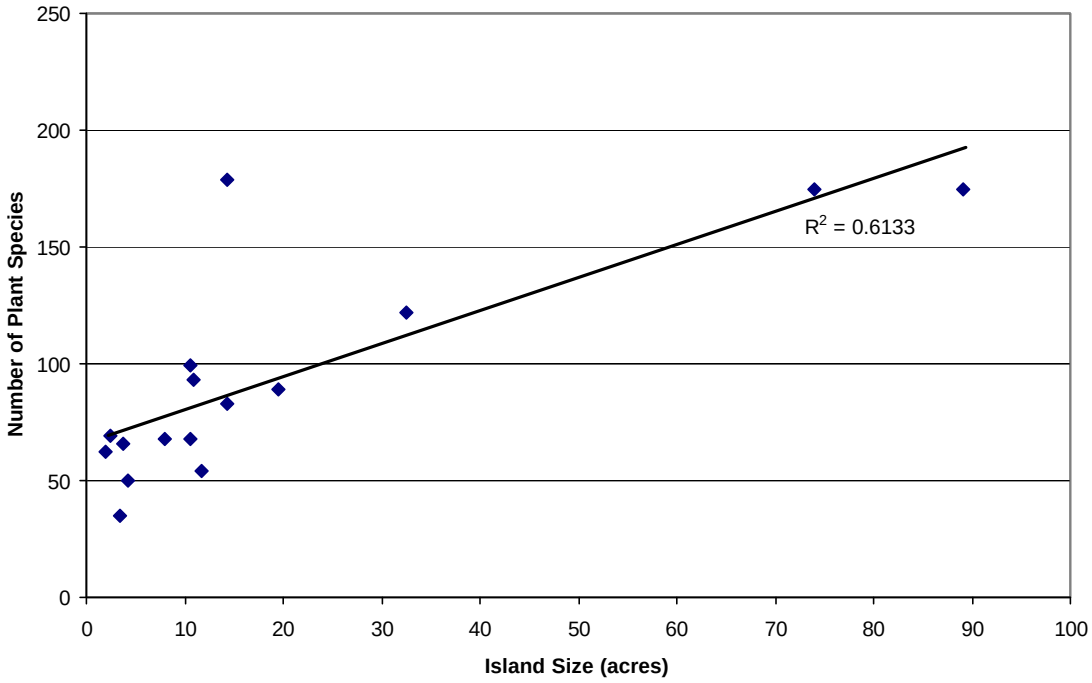

Figure 27. Relationship between number of plant species and island size.

The dominant plant community for the uplands of the marsh hammocks is the Maritime Forest. NatureServe (2004) calls this community the Maritime Live Oak Hammock that is dominated by Live Oak, Slash Pine, Cabbage Palmetto, Red Bay, and Beauty-berry. However, they note that slash pine is more common from mid-South Carolina south with Loblolly (*Pinus taeda*) being more common with increasing latitude. Coker (1905) first described the flora of the Isle of Palms noting that the forested portion of the island was dominated by loblolly pines, live oaks and laurel oaks (*Quercus laurifolia*). Other plants that were less common but reaching tree size were Red Cedars, Red Bays, Yaupon Holly, Mulberry (*Morus rubra*), Devilwood Osmanthus **(***Osmanthus americana)*, Sugarberry (*Celtis laevigata*), Black Cherry (*Prunus serotina*), Bumelia (*Bumelia tenax*), and Willow (*Salix fluviatilis*). Porcher and Rayner (2001) characterized the evergreen trees of South Carolina's Maritime Forests as Live Oak, Bull Bay (also known as Southern Magnolia, *Magnolia grandiflora*), Loblolly Pine, and Laurel Oak. They list the following species as common in the subcanopy: Cabbage Palmetto, American Holly (*Ilex opaca*), Red Bay, and Hercules club (*Zanthoxylum clava-herculis*). For more open locations, common species are Wax Myrtle (*Myrica cerifera*), Yaupon Holly (*Ilex vomitoria*), Wild Olive (*Cordia boissieri*), and Southern Red Cedar (*Juniperus silicicola*).

Nelson (1986) includes the Maritime Forest, Maritime Shrub Thicket, Middens and Salt-Shrub Thickets among the natural communities of South Carolina. He lists the same canopy species as shown above and the following additional species among the understory plants: Eastern Red Cedar (*Juniper virginiana*), American Holly (*Ilex opaca*), Redbay (*Persea borbonia*), Rusty Staggerbush (*Lyonia ferruginea)*, Eastern Baccharis

(Baccharis halimifolia), spurge "finger rot" (*Cnidoscolus stimulosus*), Partridgeberry (*Mitchella repens*), Roundleaf Bluet (*Houstonia procumbens*), Purple Passionflower (*Passiflora incarnate*), Yellow Passionflower (*P. lutea*), Poison Ivy (*Toxicodendron radicans*) and Sedge "whip nutrush" (*Scleria triglomerata*). He notes "Hammock-like islands of vegetation identical to Maritime Forest communities may be situated well away from the influence of the ocean within marsh systems." Maritime Shrub Thickets are described as shrubby zones seaward of Maritime Forest. These areas typically do not occur on hammocks. The Middens are described as being of Native American origin supporting "calcicoles". Species listed as being common are Live Oak, Cabbage Palmetto, Red Buckeye, Carolina Laurelcherry, Eastern Red Cedar, Yaupon Holly, Poison Ivy, American Beautyberry, American Basswood, and Hercules' club.

Sharitz (1975) suggested subdividing the Maritime Forest community of Kiawah Island into five major types with sub-types: 1. Oak-Pine Forests – This is dominated by laurel oak. Loblolly Pine make up 85-90 percent of pines with longleaf (*Pinus palustris*) making up most of the balance. Also found here in relatively low numbers were hickories (*Carya glabra* and *C. ovalis*), Sweet Gum (*Liquidambar styraciflua*), Southern Magnolia, Red Bay, Sassafras (*Sassafras albidum*), Yaupon, and Trumpet Creeper (*Campsis radicans*). Also associated with this community type is the Oak-palmetto-pine forest. This forest is dominated by Laurel Oaks with pine species and sabal palmetto. The subcanopy has Live Oak, Red Cedar and Sugarberry. 2) Mixed Oak Hardwood – This is divided into two groups – the Oak-Magnolia forest with Laurel Oaks and a subcanopy of Bull Bay and the Oak-Bay sub-type where Live Oak takes dominance along with Red Bay and Yaupon; 3) Palmetto Forests – the areas are dominated by a 20-30 ft. subcanopy of Sabal Palmetto and Laurel Oak. Some pines are mixed in. The understory is dominated by Yaupon; 4) Oak Thicket – These thickets are dominated by Live Oak with a few Laurels mixed in. Some pines are present. Red Bay and Wax Myrtle make up most of the understory with some Winged Sumac (*Rhus copallina*) and 5) Miscellaneous Wooded Areas – These are salt marsh thickets, or Wax Myrtle thickets that are behind the dunes of Kiawah, serving as transition zones near Salt Marshes.

Live Oaks in the marsh hammocks, along with the Sea Islands and the mainland, undoubtedly were cut to harvest timber for building wooden shops. This began in the 1700s and boomed after the War of 1812. Very little original growth exists today (Porcher and Rayner, 2001).

Also of special note is the Maritime Shell Forest. These forest patches are scattered through the woodlands of the coastal Sea Islands and marsh hammocks. These forests originated through the deposition of oyster shells by Native Americans. These shell forests have plants call "calcicoles" that are calcium loving plants. Shell mounds within the Maritime Forest harbor species such as: Tough Bumelia (*Sideroxylon tenax*), Carolina Basswood (*Tilia americana* var.*caroliniana*), Red Buckeye (*Aesculus pavia*), Sugarberry, Small-flowered Buckthorn (*Sageretia minutiflora*), Rough-Leaved Dogwood (*Cornus florida*), Southern Sugar Maple (*Acer barbatum*), and Godfrey's Swamp Privet (*Forestiera godfreyi*) (Porcher and Rayner, 2001). McMillan *et al*. (2001) surveyed much of the coastal region for these calcium-loving plants and documented the location and presence on several coastal marsh hammocks.

Details on plant communities by island can by found in the Island Description section of this report. The complete list of plants found and identified is provided in

Appendix 2. The relationship between number of plant species found and island size was roughly linear. The smallest islands contained about 20 species compared to about 140 species for the largest islands (Fig. 27). The total number of plant species exceeds 400. In the Georgia Bioblast study, the smallest island, similar to our study, found about 20 species of plants, while the larger islands had only about 70-80 species (Fabrizio and Calvi, 2003). The difference may be related to the more intensive nature of our study. Albers and Alber (2003) used the North Carolina Vegetation Survey methods in Georgia to examine the flora on 11 marsh hammocks ranging in size from 0.01 to 41.8 hectares. They found 43 species although grasses and sedges were not included. Of the 43 species, 25 were present in less than 10% of the plots sampled, suggesting relatively low diversity. They noted that species richness appeared to increase with increasing island size.

Rare or uncommon species as listed by DNR Heritage Preserve Program are shown in Table 4. Additional rare species warrant inclusion on the State's list (P. McMillan, pers. com.); several of these plants are included in Table 4. Most of these plants were found on three or fewer of the islands sampled, although Sweetgrass (*Muhlenbergia filipes*) and Small-flowered Buckthorn (*Sageretia minutiflora*) Satincurls (*Clematis catesbyana*), and Pinebarren Sunrose (*Helianthemum corymbosum*) were more widespread. With hundreds of plant specimens awaiting identification, additional species are likely to be added to the list produced by this survey.

Our survey of a relatively few coastal hammocks provided a substantial increase in the knowledge base of the distribution of many of South Carolina's rare or uncommon plant species. We believe a thorough search of other coastal hammocks could provide many more examples of important plant species.

Table 4. Rare plants found on hammocks based upon DNR Heritage Program "List of Rare plants of South Carolina".

Common Name	Species Name	Plant Location(s)
Spreading Sandwort	*Arenaria lanuginosa*	F53
Terrestrial water-starwort	*Callitriche terrestris*	ACE9
Golden Canna	*Canna flaccida*	ACE1
Sandy-woods sedge	*Carex dasycarpa*	F7
Satincurls	*Clematis catesbyana*	ACE1, ACE5, ACE52, ACE6
Piedmont Flatsedge	*Cyperus tetragonus*	ACE1, ACE6
Pillpod Sandmat	*Euphorbia hirta*	F52
Godfrey's Swamp Privet	*Forestiera godfreyi*	ACE6
Pinebarren Sunrose	*Helianthemum corymbosum*	F51, F7, K1, K55, K58
Sweetgrass	*Muhlenbergia filipes*	ACE12, ACE54, F51, F52, F7, K52, K55
Midden Prickly Pear	*Opuntia stricta var. stricta*	ACE5, ACE52
Florida Pellitory	*Parietaria floridana*	ACE1, ACE9, F52
Shellmound Buckthorn/Small-flowered Buckthorn	*Sageretia minutiflora*	ACE1, ACE52, ACE6, ACE9, F51, F52, K6
Fourleaf Vetch	*Vicia acutifolia*	ACE1

Island Fauna

Amphibians

It appears that number of amphibian species was positively related to island size (Figure 28). This apparent relationship between number of amphibian species and island size may, however, may be the result of a higher probability for the presence of freshwater wetlands and suitable habitats on larger islands.

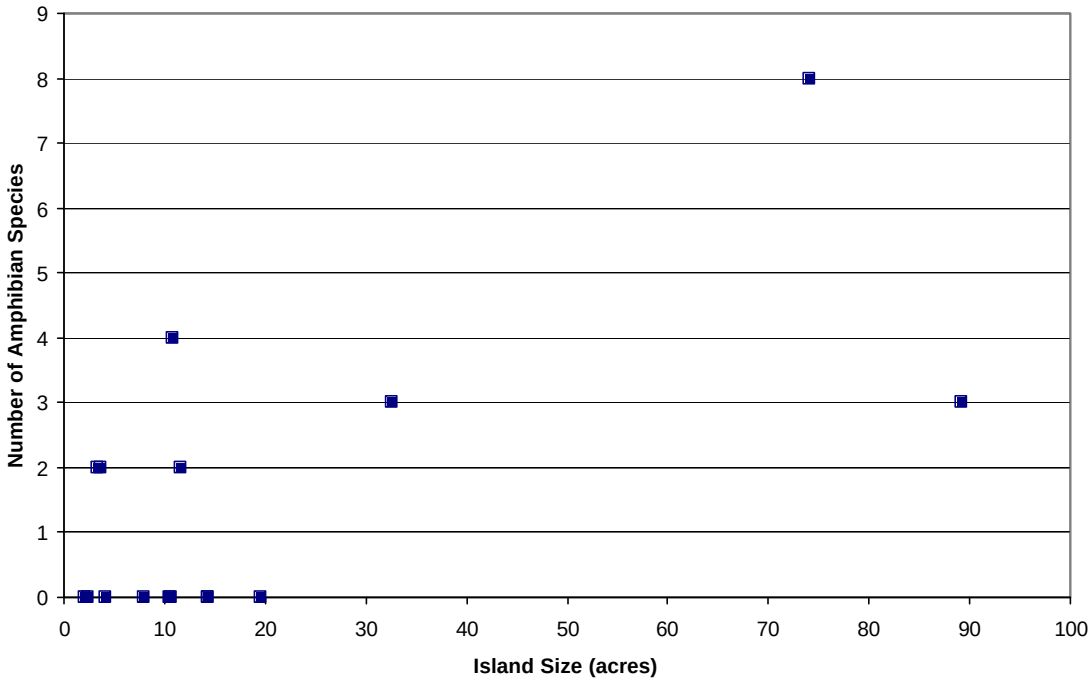

Figure 28. Relationship between the numbers of amphibians observed per island and island size.

A total of 352 amphibians representing nine species was found on the sixteen core islands (Table 5). The frequency of observations of amphibians was relatively low during winter, but increased markedly during spring (Figure 29). The Southern Leopard Frog (*Rana utricularia*) was the most common comprising 40.3% of the total being found primarily during the warm weather seasons. The frogs were observed most commonly near freshwater ponds or wetlands.

Table 5. List and total numbers of amphibians found. Numbers in parentheses indicate number of islands sampled that month. Numbers under months indicate numbers of islands where species was found that month.

Common Name	Scientific Name	Total Obs.	Sept (4)	Oct (12)	Nov (13)	Dec (15)	Jan (16)	Feb (14)	Mar (16)	Apr (16)	May (16)	Jun (16)
Southern Leopard Frog	*Rana utricularia*	142	1	2	4	0	0	1	3	2	3	2
Slimy Salamander	*Plethodon variolatus*	108	0	1	2	2	2	2	2	1	1	1
Green TreeFrog	*Hyla cinerea*	74	0	1	1	1	1	0	2	4	6	5
Narrowmouth Toad	*Gastrophryne carolinensis*	14	0	0	0	0	0	0	0	2	2	0
Southern Toad	*Bufo terrestris*	6	0	1	0	0	0	0	0	1	1	2
Central Newt	*Notophthalmus viridescens*	3	0	1	0	0	1	0	0	1	0	0
Squirrel Treefrog	*Hyla squirella*	3	0	0	0	1	1	0	0	0	0	0
Bullfrog	*Rana catesbeiana*	1	0	0	0	0	0	0	0	0	1	0
Mole Salamander	*Ambystoma talpoideum*	1	0	1	0	0	0	0	0	0	0	0

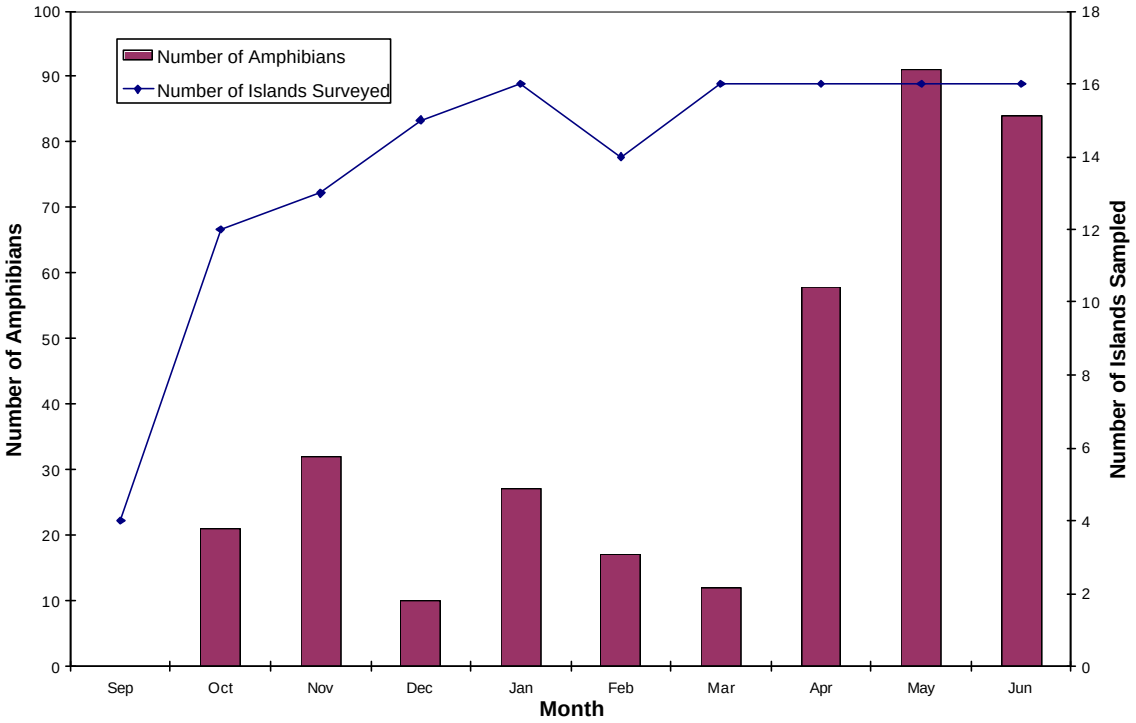

Figure 29. Total numbers of amphibians observed by month. Numbers over bars are numbers of islands sampled that month.

The South Carolina Slimy Salamander (*Plethodon variolatus*), a species found throughout the state, was the second most frequently found amphibian and was observed in all months but September. However, of 108 specimens observed, the majority (100) was found on island ACE 12, which is a relatively large island (74 acres) with several wetlands. The third most commonly found amphibian was the Green Tree Frog (*Hyla cinerea*) of which 74 were found on seven islands. Tree frogs were found during all months except September and February. Green Tree Frogs are found throughout the coastal plain (Martof *et al*., 1980).

The remaining amphibians were relatively rare comprising 28 specimens representing six species including fourteen Eastern Narrowmouth Toads

(*Gastrophryne carolinensis*), six Southern Toads (*Bufo terrestris*), three Central Newts (*Notophthalmus viridescens*), three Squirrel Tree Frogs (*Hyla squirella*), one Bullfrog (*Rana catesbeiana*), and one Mole Salamander (*Ambystoma talpoideum*). Working on the relatively large sea island of Kiawah in 1974 and 1975, Gibbons and Harrison (1975) found six amphibian species: Southern Toad, Green Tree Frog, Squirrel Tree Frog, Leopard Frog, Narrowmouth Toad, Spadefoot Toad, and the Slimy Salamander. Species found in our study, but not in the Kiawah study, were Central Newt, Bullfrog, and Mole Salamander.

The presence of sustainable amphibian populations is generally dependent upon the availability of fresh to low-salinity surface water for an extended period of time. The absence of at least seasonal or semi-permanent pools or depressions severely limits the potential for amphibian populations. Amphibians are diverse with regard to both seasonality of breeding and to duration of larval-stage. Accordingly, the more permanent the source(s) of low-salinity water, the more diversity of amphibians that are likely to be present in a given area.

Some small hummocks have no surface freshwater source other than possibly tree holes and stump holes, and many such islands have xeric soils as well. Amphibians may disperse temporarily to such islands, but are unlikely to become resident. An example of this scenario was the discovery of an overwintering Green Tree Frog beneath a log on Marsh Hawk Island (K51). This low-elevation island is primarily Maritime Grassland with no potential for breeding by any amphibian species. K51 is only a few hundred meters from acceptable Green Tree Frog breeding habitat on Kiawah Island.

Most frogs and toads require the availability of surface fresh to slightly brackish water for a least a month to as long as a year for successful larval development (Martof *et al.*, 1980). Shorter larval stages of only a month or so occur in Eastern Spadefoot Toad (*Scaphiopus holbrookii*) and Eastern Narrowmouth Toad (*Gastrophryne carolinensis*). Eastern Spadefoot was one of the species that seemed better suited for occurrence at least on larger hammocks with seasonal wetlands and pools. However, this species was not encountered on surveyed islands. Eastern Narrowmouth toad was encountered on the two largest islands in the survey, Long Island and South Williman Island, in part, and is rather abundant on the latter. Southern Toad (*Bufo terrestris*) and most frogs require 2-3 months for larval development and are better suited for colonization of most hammocks than are large frogs such as Bullfrog (*Rana catesbeiana*) and Green Frog (*Rana clamitans*) that require about a year for completion f the tadpole stage. Other amphibians have variable surface water and moisture needs for population viability. Larvae of many salamanders are aquatic and require freshwater for a month or longer. Other salamanders lay eggs in moist, protected areas such as under decaying logs or among roots. This is the case for South Carolina Slimy Salamander (*Plethodon variolatus*) that was recorded on two ACE Basin hammocks, ACE 12 in Beaufort County and ACE 52 in Colleton County. The population on ACE 12 is robust, with multiple individuals encountered on all survey trips. These two islands have more widespread mesic and hydric soils than other hammocks in the survey. Soils on both islands have higher organic content than was observed on most islands, and shell within the soil of ACE 52 also bolsters

both the organic content and moisture retention. Sandy, more xeric soils characteristic of most hammocks retain little moisture and apparently will not suport this species, even in association with decaying logs.

Central Newt (*Notophthalmus viridescens*), only encountered on ACE 12, typically has a terrestrial larval stage, and is dependent upon moist micohabitats that occur in association with mesic to hydric soils. Adults generally inhabit permanent freshwater pools or ponds. ACE 12 has no permanent freshwater source, and adult newts have been found beneath logs, both within and some distance from forested freshwater wetlands with seasonal pools. This species, and perhaps additional species of amphibians may be more abundant on larger hammocks (100+ acres) with permanent freshwater pools and ponds similar to those that occur within the North and South Williman Island-complexes. This scenario was indicated by the occurrence of both Bull Frog and Southern Cricket Frog, both species apparently absent from the vast majority of hammocks, on the largest North Williman Island (several hundred acres).

Sources of low-salinity surface water are temporary at best on most hummocks, frequently not retaining water long enough to allow successful breeding of most amphibians. The presence of amphibians on most hammocks is a testimony to the resiliency and flexibility within their life histories. Species such as Narrowmouth Toad, Southern Toad, Green Tree Frog (*Hyla cinerea*) and Southern Leopard Frog (*Rana utricularia*) were found well removed from freshwater sources. Indeed, the latter three species were encountered on hammocks where the occurrence of surface freshwater of sufficient duration for breeding and larval development seems unlikely, except perhaps under extreme and protracted rains of historic proportions. The occurrence of Central Newt and Mole Salamander on ACE 12 is evidence of either variant life histories or the ability to survive as adults for extended periods between anything more than a 2 to 3-month availability of surface freshwater. Such species may survive for perhaps several years as adults between acceptable conditions for successful breeding and larval development.

The distribution of several amphibian species within the 16-core islands is indicative of a nearly phenomenal capability for dispersal across estuarine habitats that would appear to be a major barrier. Green Tree Frog, in particular, shows a high propensity for dispersal even across expanses of Salt Marsh and tidal creeks. This species is highly arboreal, giving it the capability to move across broad expanses of Salt Marsh. Its occurrence on hammocks on the seaward side of tidal creeks, some quite large, may be indicative of an ability to swim across estuarine waterways. It is certainly an excellent swimmer, and is common on the coastal mainland very near salt marshes (J. W. McCord, pers. observation). Green Tree Frog is abundant even in developed areas and frequently takes cover in dark, moist protected areas during daylight. Accordingly, it is occasionally transported by boat, which is another potential distribution method (J. W. McCord, pers. observation). This species was recorded on six of seven core-islands in the ACE Basin and on one (Long Island) of nine Folly-Kiawah core-islands. ACE 9, Buzzard Island, is the only ACE Basin hammock on which this species was not recorded. Both a low-salinity depression wetland with a seasonal pool and permanently-watered ~10-m^2-cistern are present on this island. However, Buzzard Island is the most remotely

isolated hammock in the survey, is located very near the coast, and is surrounded by expansive high-salinity estuarine systems. Three of the six ACE Basin islands on which this species was recorded do not have suitable breeding habitats, and the presence of frogs on these islands is testament to their dispersal capability.

The apparent absence of Green Tree Frog on most of the Folly-Kiawah area hammocks is likely primarily due to an absence of low-salinity wetlands on most of the islands surveyed in this region. Long Island is the only surveyed core-hammock in this region that affords suitable habitat for breeding and larval development. The only non-core island on which Green Tree Frog was found is Marsh Hawk Island (K51). K51 is a low-elevation, primarily Maritime Grassland hammock isolated from Kiawah Island by <200 m of Salt Marsh. There are numerous freshwater ponds associated with a golf course on the adjacent Kiawah Island upland. A single overwintering frog was found beneath a log by the senior biologist on a rare non-core island visit. This frog was the only amphibian recorded for the nine non-core islands in the survey. Marginally appropriate breeding habitat is present on several non-core Kiawah hammocks. Though neither Green Tree Frog nor other amphibians were recorded on the two Stono River hammocks (S1 and D2) or the three Beaufort islands (B1, B2 and B3), it seems probable that at least Green Tree Frog is present on B2, Charlotte Island. Charlotte Island has an enclosed depression wetland with a seasonal pool that should provide sufficient habitat to support at least Green Tree Frog.

Squirrel Tree Frog is also abundant in the lower Coastal Plain but was only encountered on South Williman Island (ACE 12), which is isolated by <1 mi from the mainland and which is even nearer the Combahee River. Squirrel Free Frog is also arboreal and has a similar life cycle to that of Green Tree Frog. Perhaps its relative scarcity on hammocks, even those near the mainland within river deltas, is a function of less effective dispersal capabilities and/or a narrower range of salinity tolerance.

Southern Leopard Frog is seemingly less effective at dispersal and colonization of hammocks than is Green Tree Frog, even to those hammocks with wetlands similar to those on other islands where this species occurs in some abundance. Among the 16 core islands, Southern Leopard was only encountered within the ACE Basin (five of seven islands), and principally on islands nearer the mainland and in close proximity to sources (Combahee and Ashepoo Rivers) of major freshwater input into the lower Basin. This species is a terrestrial, swimming or hopping frog, and may not be well suited for traversing broad estuarine marshlands. It was recorded (one individual at each island) on several hammocks (ACE 5, ACE 52, ACE 54) where there is little to no potential for successful breeding. Two of these three hammocks are in close proximity to larger hammocks with thriving populations, but the smaller islands are separated from potential source islands by saline waterways up to 200-300 m in width. However, ACE 54 is well isolated from other islands with nearly a mile-wide expanse of Salt Marsh and tidal creeks between it and the nearest island or mainland with a viable population. Southern Leopard Frog was only encountered, and only a single specimen, on one non-core island in the Folly Beach-Kiawah Island region. Marsh Island Park (K 53) is very near the “mainland” of Kiawah Island and connected via a causeway and

narrow bridge over a small tidal creek. A small seasonal brackish pool on this island may be capable of sustaining this species, which is not uncommon in association with man-made freshwater ponds on Kiawah Island proper (Norm Shea, pers. comm.). It is present on the adjacent Charleston County mainland in suitable habitats, and is abundant in isolated freshwater wetlands at Ft. Johnson, James Island (J. W. McCord, pers. observation). The poor dispersal capabilities of this species relative to Green Tree Frog are evident in the apparent absence of Southern Leopard Frog on Long Island despite the occurrence there of several fresh to slightly brackish wetlands that present seemingly suitable breeding habitat. In contrast, Green Tree Frog is not uncommon on Long Island.

The observed highest diversity and abundance of amphibians in the heart of the ACE Basin, and particularly nearest the mainland and freshwater source rivers, suggests potential dispersal by flood events that may carry a diversity of amphibian species seaward where they were deposited on various hammocks, surviving and sustaining where suitable habitats occur. Such dispersal would not occur in coastal marshlands removed from river deltas, as is the case for the Folly Beach-Kiawah Island region. In addition to Green Tree Frog, the presence of Southern Toad and Eastern Narrowmouth toad on Long island indicates an alternate dispersal scenario for these species. Certainly, southern Toad and even Eastern Narrowmouth toad have thicker, more impervious skin than do Hylid and Ranid frogs, possibly allowing these species to move across at least narrow estuarine systems onto hammocks. Another potential method of dispersal for these and other pool breeding species may be via wading birds. It seems conceivable that amphibian eggs could adhere to the legs, feet, etc of wading birds and be transported from mainland wetlands into wetlands on hammocks.

Questions regarding genetic drift and genetic isolation seem relevant to the occurrence of amphibians on hammocks, particularly for those species that are seemly less suited for dispersal except under extraordinary circumstances. Species that are widespread on hammocks, like Green Tree Frog and perhaps Southern Leopard Frog would appear to have reasonable potential for gene flow with mainland populations and/or with other hammock populations in a given area. Species that are more limited in occurrence and distribution because of life history requirements that are less suited to habitats available on most hammocks may occur in more isolated populations in which gene flow would likely be very limited. Unfortunately, many amphibians display a general lack of genetic variability either within or between sub-populations (J. Quattro, pers. comm.).

Highton *et al*. (1989) conducted an evaluation of genetic variation throughout the range of Slimy Salamander (*Plethodon glutinosus*) using acrylamide and starch-gel electrophoresis and immunological techniques. As a result, the species was split into 13 genetically distinct populations (Conant and Collins, 1998). However, there remains disagreement among herpetologists as to the validity of the results. Tissue samples were taken from specimens of South Carolina Slimy Salamander (*Plethodon variolatus*) captured on ACE 12 and ACE 52 and from the mainland in Beaufort County within 10 miles of ACE 12. Preliminary mitochondrial DNA tests revealed no significant detectable levels of genetic variability, but potential remains that more detailed and significantly more

expensive microsatellite tests could show variability, if such exists (J. Quattro, pers. comm.). Many interesting questions arise relative to genetic characteristics of various species, particularly of herptiles, on the hammocks as compared to mainland populations because of probable differences in colonization mechanisms between species (J. Quattro, pers. comm.).

The presence of amphibians is generally tied to ephemeral, isolated wetlands and the absence of predatory fish (Russell *et al*., 2002). Although isolated wetlands, particularly small ephemeral wetlands, are at great risk though out the Southeast, amphibians on the mainland may have the option to readily migrate to nearby wetlands. However, if isolated wetlands on coastal hammocks are lost, the amphibians have no alternatives and will be extirpated, potentially losing unique genotypes and affecting the ecology of the island. Because of the vulnerability and importance to these isolated herpetofaunal populations, consideration should be given to protecting all isolated wetlands, regardless of size, on coastal hammocks.

Reptiles

Sixteen species and 1,146 reptiles were observed on the 16 core islands. Reptiles were, by far, more commonly observed during spring compared to other seasons sampled (Figure 30). Number of reptile species ranged from two per island to eleven, with number of species being positively related to island size. (Figure 31).

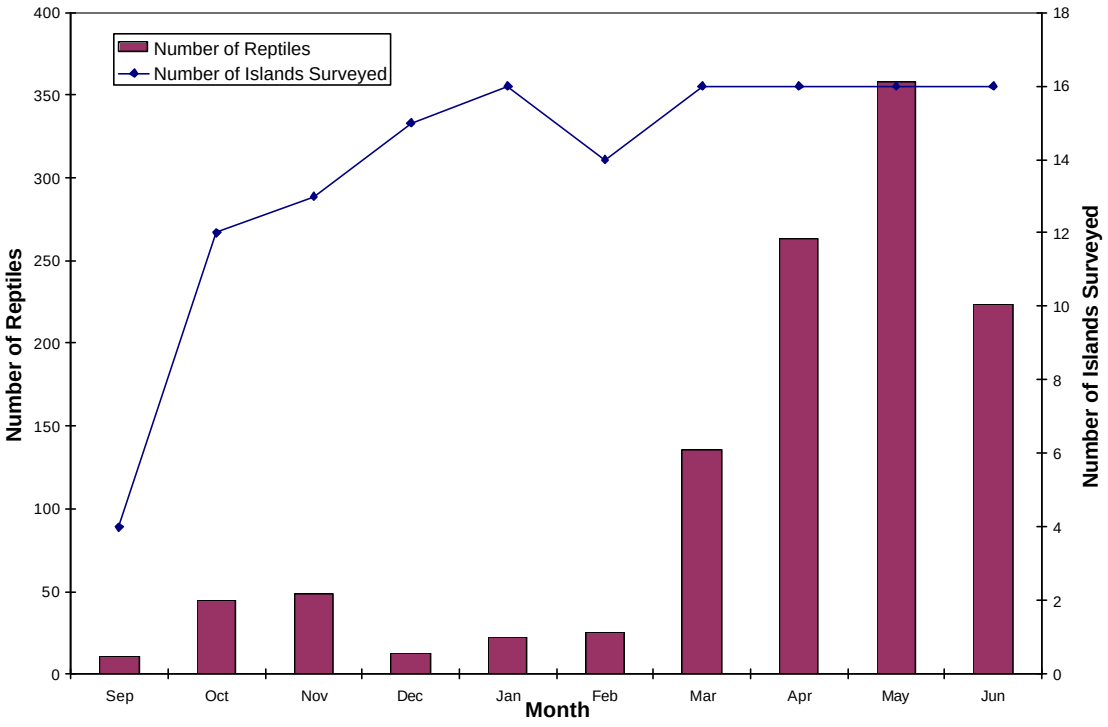

Figure 30. Numbers of reptiles collected on 16 core islands and number of core islands sampled each month.

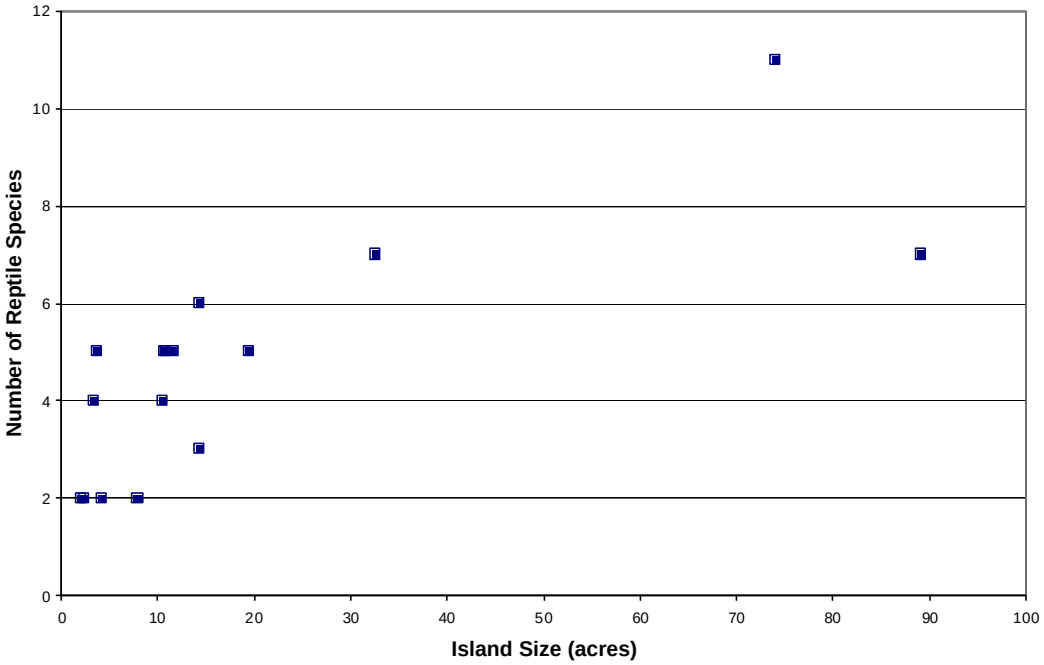

Figure 31. Number or reptile species compared with island size.

The most abundant reptile was the Carolina Anole (*Anolis carolinesis*) of which 579 were found on all islands (Table 6). This species is ubiquitous in South Carolina (Martof *et al*., 1980). Unlike most other reptiles, anoles were found during winter, although not as frequently as during other seasons.

The second most abundant reptile was the Southeastern Five-line Skink (*Eumeces inexpectatus*) with 304 being observed. The species was rare during winter, but was observed frequently during spring and early summer.

The surveys produced 142 Ground Skinks (*Scincella lateralis*). Ground Skink, like the Five-line Skink, was uncommon during the colder months, but was relatively common during spring and early summer.

The legless Eastern Glass Lizard (*Ophisaurus ventralis*) was observed 30 times on the sixteen core islands. The species was not observed at all from December through March, but was found on three to five islands per month during spring. This species is relatively common in South Carolina's coastal plain. The congeneric, the Island Glass Lizard (*Ophisaurus compressus*), is an endangered species that is most often found in xeric habitats in coastal pine and Maritime Forest. This species was not found during our study. Martof *et al*. (1980) note that the island glass lizard is most often found under tidal wrack on sandy beaches, a habitat that is not common on hammocks.

The only American Alligators (*Alligator mississippiensis*) observed were juveniles found on ACE 1. These alligators were found in a central, permanent low-salinity pond within a *Spartina bakeri* Wetland. Although alligators are relatively common in impoundments and lagoons on the larger barrier islands, they are apparently rare on the hammocks because of the rarity of year-round, freshwater bodies large enough to sustain adequate prey.

Nineteen Eastern Cottonmouths (*Akistrodon piscivorus*) were found on four ACE basin islands (ACE 1, ACE 5, ACE 12, and ACE 52). However, most (15) were found on ACE 52, a relatively small island of 9 acres. It is likely that some individuals were observed more than once, but on one sampling date in May, seven separate individuals were observed. This island has a few small, ephemeral wetlands, but no standing water. Cottonmouths were not routinely handled and measured, but appeared to range in size from about 36 to 110 cm in total length. These snakes were not found from December through February.

All thirteen Broad-Headed Skinks observed were found on ACE 12, the largest island surveyed in the ACE basin. Broad-headed skinks (*Eumeces laticeps*) were observed beginning in January with the largest numbers recorded in June.

Eastern Mud Turtle (*Kinosternon subrubrum subrubrum*) was found 13 times, but on only three islands (ACE12, F51, and F7). Martof *et al*. (1980) note that this species tolerates brackish waters, however salinities in waters surrounding islands in the Folly Beach area were relatively high, often exceeding 25 ppt. Mud Turtles were not observed from November through February.

Diamondback Terrapins (*Malaclemys terrapin centrata*) were not directly observed on the hammocks, but were seen in tidal creeks near the islands. The presence of the species on some islands was confirmed by the presence of robbed nests on three islands (one on ACE54, five on F7, and three on K1). Nests were most often found on relict dune ridges that were near the island edges, close to small creeks. The hammocks may provide a critical nesting habitat for diamondback terrapins. It is presumed that nests are typically destroyed by raccoons, although other mammals may have also been responsible. Zimmerman (1992) observed terrapin nest on Kiawah Island beaches and noted that predation by raccoons was high. However, he also noted that "bobcats, foxes, and ghost crabs all contributed to nest destruction."

Eastern Diamondback Rattlesnake (*Crotalus adamanteus*) was observed on ACE6 and ACE9. The snake observed on ACE6 was about 90 cm in total length and the one observed on ACE 9 was about 110 cm. The presence of these relatively small snakes suggests that the species is reproducing in the area. Bennett (1995) notes that Diamondback Rattlesnake is common in Longleaf Pine and barrier island/maritime forests. He further notes that the Gopher Tortiose Council may petition to have the species declared as federally threatened or endangered. In South Carolina, the diamondback is already listed as a Species of Concern. The species' range appears to have been reduced, although Martin and Means (1999-2000) report that a few are reported from the coastal terraces of North Carolina at Camp Lejeune and Croatan National Forest. In coastal South Carolina the species is found from the Georgia border to Edisto Island, although Martin and Means speculate that a small, disjunct population may be present in the Francis Marion National Forest in Berkeley County.

Other reptiles observed on the marsh hammocks were seven Southern Black Racers, (*Coluber constrictor priapus*), seven Yellow Rat Snakes (*Elaphe obsoleta quadrivittata*), two Six-line Race Runners (*Cnemidophorus sexlineatus sexlineatus*), two Rough Green Snakes (*Opheodrys aestivus*), two southeastern Crown Snakes

(*Tantilla coronata*), one Eastern King Snake (L*ampropeltis getula getula*), and one Scarlet Snake (*Cemophora coccinea copei*).

Gibbons and Harrison (1975) working on a Kiawah Island inventory, found four species of turtle: Box Turtle, Diamondback Terrapin, Yellow-bellied Turtle, Eastern Mud Turtle, and the marine Loggerhead Sea Turtle. Among the lizards, they found the same six species found in our study, but found 14 snake species compared to our six. Species found in the Kiawah study, but not our study were: Banded Water Snake, Ribbon Snake, Garter Snake, Coachwhip, Corn Snake, Copperhead, and Canebrake Rattlesnake. The only species we observed that was not found on Kiawah was Diamondback Rattlesnake.

Table 6. List of reptiles found on the 16 core islands. Number in parentheses indicate number of islands sampled during each month.

Common Name	Scientific Name	Number of islands where species was found										
		Total Obs.	Sep (4)	Oct (12)	Nov (13)	Dec (15)	Jan (16)	Feb (14)	Mar (16)	Apr (16)	May (16)	Jun (16)
Carolina Anole	*Anolis carolinensis*	579	4	8	8	6	5	9	14	13	15	14
Southeastern Five-lined Skink	*Eumeces inexpectatus*	304	1	3	0	1	2	0	6	14	14	12
Ground Skink	*Scincella lateralis*	142	1	2	3	2	1	3	6	8	3	6
Eastern Glass Lizard	*Ophisaurus ventralis*	30	0	2	2	0	0	0	0	4	3	5
American Alligator	*Alligator mississippiensis*	22	0	0	0	0	0	0	0	1	1	1
Eastern Cottonmouth	*Agkistrodon piscivorus*	19	0	2	2	0	0	0	1	1	2	1
Broad-headed Skink	*Eumeces laticeps*	13	0	0	0	0	1	1	0	1	1	1
Eastern Mud Turtle	*Kinosternon subrubrum subrubrum*	13	2	1	0	0	0	0	1	1	1	0
Southern Black Racer	*Coluber constrictor priapus*	7	0	0	1	0	0	0	2	2	2	0
Yellow Rat Snake	*Elaphe obsoleta quadrivittata*	7	0	0	0	0	0	0	3	1	1	2
Six-lined Racerunner	*Cnemidophorous sexlineatus sexlineatus*	2	0	0	0	0	0	0	0	0	1	1
Eastern Diamondback Rattlesnake	*Crotalus adamanteus*	2	0	0	0	0	0	0	1	0	0	1
Rough green snake	*Opheodrys aestivus*	2	0	0	0	0	0	0	1	0	1	0
Southeastern Crown Snake	*Tantilla coronata*	2	0	0	1	0	0	0	0	0	1	0
Scarlet Snake	*Cemophora coccinea*	1	0	0	0	0	0	0	0	1	0	0
Eastern Kingsnake	*Lampropeltis getula getula*	1	0	0	0	0	0	0	0	1	0	0

Mammals

While sign of mammals was present on all islands, direct observations were rare, and several species were not seen at all. Survey crews actually observed 55 mammals on the sixteen core islands while recording 368 signs of mammals. The total number of sign, however, is a minimal number because multiple sign on an island on a given day were counted as only one observation (*e.g.*, dozens of raccoon sign could be found on a single island on one day, but was recorded as only present or absent).

White-tailed deer (*Odocoileus virginianus*) and raccoon (*Procyon lotor*) were common, with some evidence of their presence being seen on most islands during every trip. Deer scat, rubs, antlers, and skeletons were among the sign observed.

A total of seven Raccoon was directly observed on five islands, while sign was observed on all islands. Raccoon sign included scat, tracks, skeletal remains, and damaged turtle nests.

The most frequently directly observed mammal was the Marsh Rice Rat (*Oryzomys palustris*). A total of 22 rats was observed on eight islands along with 22 nests. Seven rice rats were observed on ACE 1 in association with the brackish

water wetland. When disturbed the rats were observed jumping into the water. Golley (1962) noted that this species is often found in dense cover near freshwater and saltwater marshes, and builds a loosely constructed nest with *Spartina* stems and leaves. Rice Rats are known to eat Fiddler Crabs, *Spartina* and young Marsh Wrens. Nests were found under coverboards on ACE 1, K52, F53, and K6, and rats were observed under boards on ACE1, ACE52, F53, and K6.

Hispid Cotton Rat (*Sigmodon hispidus*) was observed only four times and on only two islands. Andre (1981) conducted a trapping study of small mammals on Bull Island, SC and found that cotton rats were usually most abundant in old rice fields where Marsh Rice Rat was relatively rare. Though few animals were seen, this species was apparently abundant on F52, Large Truluck Island. "Runs" were obvious, particularily in Ruderal Gardens. Hispid Cotton Rat was likely the primary food for Gray Fox, Bobcat, and Red-tailed Hawk recorded on the island.

Numerous burrows, believed to have been dug by the Nine-banded Armadillo (*Dasypus novemcinctus*), were observed on three islands in the ACE basin (ACE 12, ACE 54, and ACE 9. During the past century, the species expanded its range from Texas into the Florida panhandle. From 1920 to about 1970, there were several introductions of armadillos into the Atlantic coast region of Florida. The panhandle and peninsular populations expanded until they eventually merged. Armadillos are now found in uplands throughout Florida, except in the Keys and parts of the Everglades and Big Cypress swamp (Schaefer and Hostetler, 2004). The species is continuing to expand its range into the southeastern part of South Carolina, and it is now common to see them in Beaufort County (Yarrow, 1999). Their diet is comprised largely of insects, earthworms, scorpions, spiders, and other invertebrates. Assuming they may be slow to repopulate hammocks, managers may want to examine the impacts of this invasive species to determine if depredation is warranted.

A curious find was two American Beaver (*Castor canadensis*) skulls – one on ACE 9 and one on ACE 12. Though of interest, and despite the continuing expansion of this species' range into the lower Coastal Plain, this and most other hammocks do not afford suitable habitat to sustain beavers. Beavers do occur in the Coastal Plain within freshwater bottomlands of the ACE Basin rivers, and there are several large marsh islands, with permanent freshwater ponds and substantial palustrine acreage that could potentially support beavers. Perhaps a major flood in the ACE Basin caused the displacement of some animals that later died on the islands because of the lack of sustainable habitat.

Mink (*Mustela vison*) are found throughout the state and populations are highest in coastal marshes. However only one was observed on F51, and tracks were observed twice on F51 and once on ACE 1. Mink are typically found near water (saltwater marshes, river swamps, and small wooded streams; Baker and Carmichael, 1989). Although no long-term population trend data exist for the species, anecdotal information from trappers in South Carolina and Georgia suggest that mink populations are declining (Baker, 1999). Coastal Mink are rarely targeted by trapping because the fur of ranch-reared animals is far superior.

Because coastal mink can be observed at night sitting on floating *Spartina* wrack, surveys were begun in South Carolina in 1990 (Baker, 1999). Researchers

found that while mink appeared relatively common south of Charleston Harbor, relatively few were found to the north. The apparent decline in mink populations may be related to declining habitat or environmental contaminants (DDE, PCBs and mercury). Contaminants are of particular concern because much of the mink's diet (40%) is fish, and PCBs and mercury are known to be relatively high in some fish species throughout the coastal plain. Osowski *et al*. (1995) examined mink tissues from coastal specimens from North Carolina, South Carolina, and Georgia and found mercury concentrations known to negatively affect reproduction, growth, and behavior. Mink have adapted relatively well to encroachment on their habitat by humans, occasionally using man-made rock piles and bridge crossings for dens. It is reasonable to expect that some dens may be found on marsh hammocks under tree roots next to tidal creeks, and removal of these trees could reduce available habitat. Although we found evidence of mink on hammocks, their importance to the species remains unknown.

Sign of Northern River Otter (*Lutra canadensis*) were relatively common, being observed on ten of the sixteen core islands. Only two otter were directly observed; one was a relatively old-appearing animal that was found sleeping on its back at an otter camp (=latrine) on ACE 52. On the larger islands, more than one of these camps was often found. The camps are typically, although not always, located at the tips of islands immediately adjacent to small tidal creeks. These locations often have a low canopy of small pine, cedar, or live oak, and the ground is often matted with pine needles, leaves, grasses, *Spartina* sps. wrack, or Spanish Moss. Otter scat, recognizable by the preponderance of fish bones and scales, was common at these locations. Newman and Griffin (1994) summarized the use of latrines (camps) by otters as locations to defecate, urinate, scent mark and groom. They also note that latrines are typically located under coniferous trees where the needle litter may serve as a soft, absorbent substrate for grooming. Although the camps observed in our study were commonly located on the tips of islands, these locations may have also been selected because of nearness to creeks. No dens were found in association with these camps, but camps may be used to mark territories for males (O.E Baker, SCDNR, Pers. Comm. 2004). Presumably, these camps are also resting and sunning stations for otter that offer quick escape when they are disturbed or threatened. Otter camps may be particularly vulnerable to development of marsh hammocks because their location is ideal for docks and houses.

Bobcat (*Lynx rufus*) was not directly observed in this study, but sign of bobcat (scat, prey remains) were relatively common. Bobcat sign was recorded 25 times on 11 of the 16 islands examined. They were most frequently observed on K55 and ACE 1 where sign were observed on five dates each. Bobcat was found throughout the range of the study from the ACE basin to Kiawah/Folly and the Stono River. The species is relatively common on Kiawah Island where radio-transmitter collars have be placed on several during recent years (Norm Shea, Pers. Comm., 2003). The bobcat population appears stable and they are co-existing relatively well with humans. Given their ability to move easily from island to island, they are likely to use marsh hammocks for hunting and other purposes.

Although the Eastern Gray Squirrel (*Sciurus carolinensis)* is a very common mammal throughout the state, they were relatively rare on coastal hammocks. Nests were seen on an ACE islands, but no squirrels were observed on any ACE islands. A total of only 3 squirrels was recorded on core islands. However, several were observed on non-core Kiawah Islands (K2, K53, and K57), all of which are connected to larger Kiawah Island by bridges or causeways. We believe that squirrels are rare on most islands because the surrounding waters provide effective barriers, and that the smaller islands probably do not have enough hardwood tree habitat to support them. The other Gray Squirrel observed were on a Beaufort Island that has extensive hardwood trees and is separated from a much larger island by about 150m of high marsh flat that could be easily crossed by a squirrel. In addition, a possible sign of Southern Flying Squirrel (Glaucomys volans) was observed on ACE 12, where halved hickory nuts were observed.

Birds

As noted in the Methods, this study was largely qualitative rather than quantitative. However, to provide us with some indication of species relative abundance, seasonality, and distribution among the islands, we recorded numbers of birds to the best of our ability. Total numbers of birds observed were often the sum of estimates taken of passing individuals or flocks. We, no doubt, recorded the same individuals on different visits to hammocks, and probably in a few cases, counted some individuals multiple times on the same visit. Total numbers of birds should be used only as an index of relative abundance. The reader should also be advised that total numbers alone should not be used to assess the relative importance of various habitats, communities, or islands to specific species. Observations of large flocks of a single species may have been somewhat fortuitous and not truly indicative of the typical avian fauna for an island or community. Along with numbers of birds observed, the reader should be mindful of frequency of occurrence, distribution (percentage of islands with that species), seasonality, the habits of a species (e.g., using hammocks for nesting, feeding, resting, flocking, etc), and rarity of that species.

A total of approximately 9,925 birds representing 111 species was observed over the course of the surveys on all 25 islands. For the 16 core islands, 7,496 birds representing 108 species were observed (Table 7). For the core islands, the average number of birds per island was 469. For the nine non-core islands, 2,429 birds representing 73 species were observed with an overall average of 270 birds per island. Differences in numbers of species and individuals per island reflect the much greater sampling effort on the core islands, and the timing of visits. Four species observed on the non-core islands were not observed on the core islands (one yellow warbler, one merlin, three red-headed woodpeckers, and six chipping sparrows). Thirty-nine species observed on the core islands were not observed on the non-core islands.

Early in the study, several islands were visited once for evaluation as potential survey islands. These islands were not included in the official final list of islands because they were similar to nearby islands already in the survey, they were logistically difficult to sample, owners would not allow routine access, or other

reasons. Despite visiting these islands only once, the Northern Water Thrush, which was not encountered elsewhere, was observed. Additionally, some birds were observed flying over core islands including Peregrine Falcon, Barn Swallow, Purple Finch, Purple Martin, and Chimney Swift.

For the species in common on core and non-core islands, the differences in total numbers of individuals observed generally reflected the relative amount of sampling effort for each group of islands. The five most abundant species in terms of total number observed on the 16 core islands were Yellow-rumped Warbler (1,410), American Robin (794), Cedar Waxwing (627), Northern Cardinal (525), and the Carolina Chickadee (409). The robins and waxwings were present as migratory flocks over a relatively brief period of time during spring.

The bird species were separated into four groups based upon characterizations from the avian literature (Forsyth, 2001). These four designations were Permanent Resident (PR), Winter Visitor (WV), Summer Resident (SR), and Transient (T).

Considering only the data from the 16 core islands, 56 species were permanent residents, 24 winter visitors, 14 summer residents, and 13 transients.

A total of 3,583 birds representing 56 permanent residence species was observed representing 45.6 percent of the total birds on the 16 core islands. The five most abundant permanent residents were the Northern Cardinal, Carolina Chickadee, Blue-Gray Gnatcatcher, Carolina Wren, and Red-winged Blackbird. Of permanent resident species for which at least a total of 20 individuals were observed for the entire study, six species were seen only seasonally on the islands. These were Blue-gray Gnatcatcher (seen Mar.-June), Common Grackle (seen Jan. -June), Yellow-throated Warbler (one seen in Sept., and Dec., and otherwise seen Mar.-June), Brown-Headed Cowbird (seen in Oct-Nov, Apr-June), Fish Crow (Nov., Mar.- June) and White Ibis (seen only in Oct. and Nov.). Populations of some of these species, including the blue-gray gnatcatcher, swell during the warmer portion of the year (Chamberlain and Chamberlain (1975). The remaining 50 permanent resident species were seen on the islands in a majority of the months surveyed.

Twenty-four species that are characterized as winter visitors contributed 3532 birds or 47.1 percent of the total. While winter visitors represented only 22.2 percent of the species, they represented the largest number of birds among the categories. This was primarily because the three most abundant species (Yellow-rumped Warbler, American Robin and Cedar Waxwing) were in this group, and these species individually accounted for 18.8 percent, 10.6 percent, and 8.4 percent of all birds observed in the survey. Mixed flocks of American Robins and Cedar Waxwings were observed in large numbers feeding on red cedar fruit. Red cedars, which are common on the marsh hammocks, are undoubtedly important for these seasonally abundant birds. The Yellow-rumped Warbler were observed on all 16 islands from October through May, but were most common from November through March. They were observed on only one island in October, nine in April, and two in May. Similar patterns of abundance were observed for six other winter visitors including Ruby-crowned Kinglet, Palm Warbler, Swamp Sparrow, Gray Catbird and Belted Kingfisher. Conversely, the American Robins and Cedar

Waxwings were seen only during a few months - December through March for the American Robin and February through April for the Cedar Waxwing.

Fourteen species were characterized as summer residents, contributing 281 birds or 3.7 percent of all birds on the 16 core islands, despite this group making up 13.0 percent of the overall number of avian species found in the study. The five most abundant summer residents were the Great Crested Flycatcher, Painted Bunting, Northern Parula Warbler, Orchard Oriole and Acadian Flycatcher. Unlike the winter visitors species, these species are present during relatively narrow windows of time, being observed from April through June, although an extension of the study into July and August or September would have likely shown these species to be present throughout the warm-weather season.

We observed thirteen species characterized as transients. This accounted for only 100 birds or 1.3 percent of all birds observed on the core islands. In order of abundance these species were Common Yellowthroat (34), Prairie Warbler (21), American Redstart (15), Black and White Warbler (7), Ovenbird (7), Spotted Sandpiper (7), Black-throated Blue Warbler (3), Baltimore Oriole (1), Cape May Warbler (1), Hooded Warbler (1), Magnolia Warbler (1), Prothonotary Warbler (1), and Wood Thrush (1). The Common Yellowthroat was seen in all months surveyed except June.

Relationships with Island Size

When numbers of bird species per island were compared to island size, it was clear that the larger islands had greater species richness, but the relationship did not appear to be linear (Figure 32). Number of species per island appears to increase rapidly as island size increases from less than five to greater than five to twenty acres. Thereafter, species richness appears to increase slowly, although additional large islands need to be sampled to confirm this. Total numbers of birds (all species combined) is also positively correlated with island size. It appears that bird number increases rapidly with increasing island size up to about 50 acres, and more slowly thereafter (Figure 32).

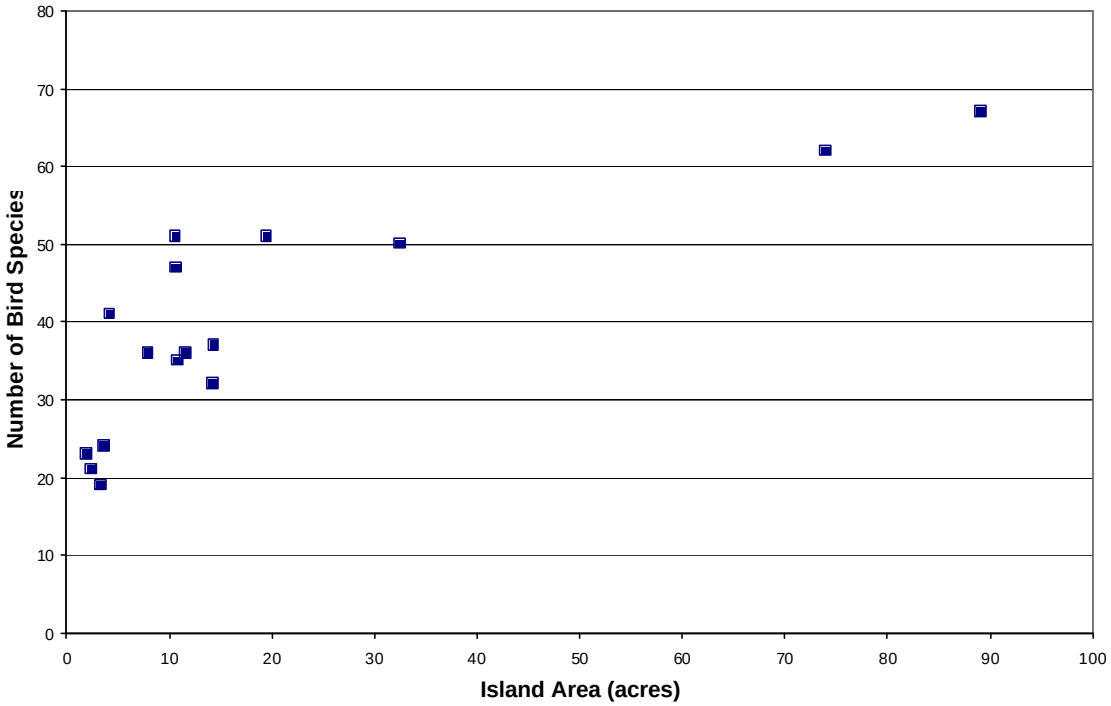

Figure 32. Number of bird species compared to island size.

The number of birds observed on an island would obviously be expected to increase as island size increases providing more space and a greater diversity of habitats. However, as island size increases (assuming that islands are essentially circular), the internal area of the island increases much faster than perimeter. If one assumes that more perimeter equals more "edge habitat" where bird density is probably higher, then larger islands offer proportionately less "edge" and, correspondingly, the number of birds may not increase substantially in a linear manner for larger islands.

Sommershoe (2000) working on small hammocks in the Savannah National Wildlife Refuge examined seasonal abundance of Neotropical migrants. He found that both the number of species and the number of birds was positively related to island size for islands ranging in size from 0.32 ha (0.79 acres) to 3.08 ha (7.61 acres). This observation is consistent with data from the present study (Figure 32, Figure 33). He noted that density of birds declined with increasing size of the islands and this may be related to the fact that smaller islands are, in effect, all "edge" with little interior forest, and densities of birds are likely to be greater in edge habitats.

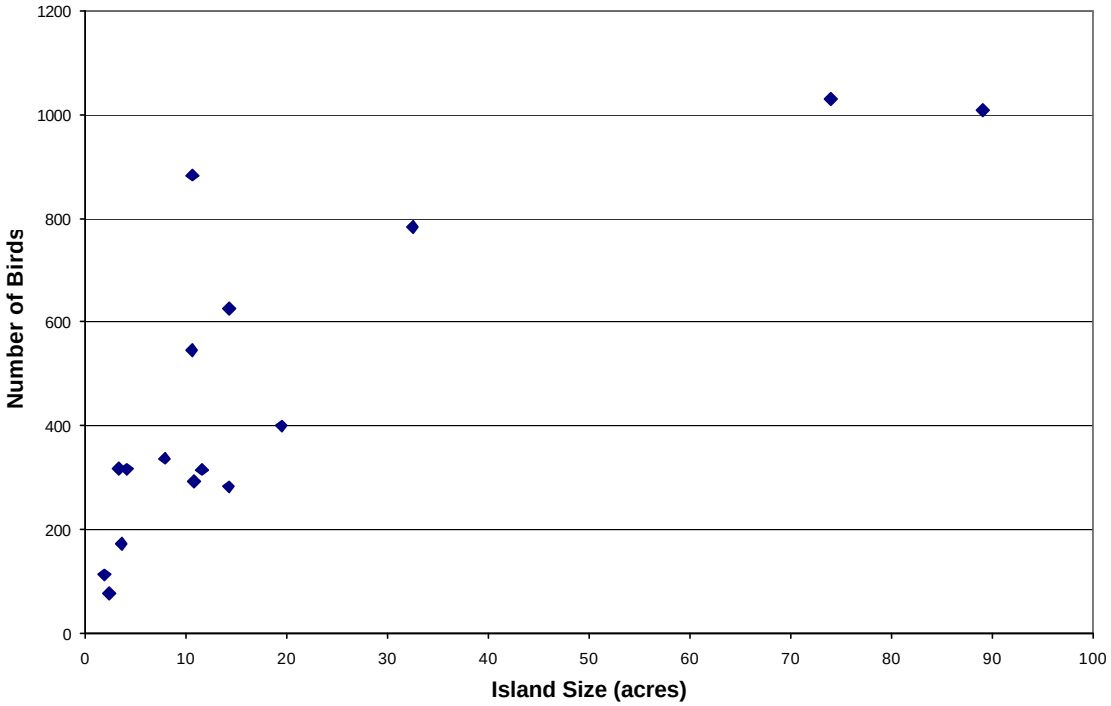

Figure 33. Relationship between total number of birds and island size.

Table 7. Birds observed on the 16 core islands from September through June. Species are ranked in order of overall abundance. Numbers in parentheses are numbers of islands sampled each month. Bird designations are from Forsyth (2001) for birds of coastal South Carolina. The bird designation is divided into two parts: the first portion indicates the relative abundance (C= common, FC= fairly common, U= uncommon, and LU= limited habitat and uncommon) and the second part indicates seasonal occurrence (PR=permanent resident, WV=winter visitor, SR=summer/spring resident, and T=transient).

				Number of islands where species was found										
Common Name	**Species Name**	**Bird Desig.**	**Total Obs.**	**Sep (4)**	**Oct (12)**	**Nov (13)**	**Dec (15)**	**Jan (16)**	**Feb (14)**	**Mar (16)**	**Apr (16)**	**May (16)**	**Jun (16)**	**Months with Birds**
Yellow-rumped Warbler	*Dendroica coronata*	C-WV	1410		2	10	12	13	13	14	9	2		8
American Robin	*Turdus migratorius*	C-WV	794				1	4	8	2				4
Cedar waxwing	*Bombycilla cedrorum*	C-WV	627						5	4	6			3
Northern Cardinal	*Cardinalis cardinalis*	C-PR	525	4	10	7	8	13	11	15	15	16	16	10
Carolina Chickadee	*Poecile carolinensis*	C-PR	409	2	6	9	8	11	9	11	10	11	13	10
Blue-gray Gnatcatcher	*Polioptila caerulea*	C-SR	323							12	16	14	12	4
Carolina Wren	*Thryothorus ludovicianus*	C-PR	287	4	9	10	8	11	10	13	10	14	14	10
Red-winged Blackbird	*Agelaius phoeniceus*	C-PR	234		3		4	6	4	2	4	10	8	8
Tufted Titmouse	*Baeolophus bicolor*	C-PR	227	2	4	8	3	7	7	8	8	10	7	10
White-throated Sparrow	*Zonotrichia albicollis*	C-WV	185			2	4	7	4	8	7			6
Eastern Towhee	*Pipilo erythrophthalmus*	C-PR	173		3	4	3	5	4	5	6	5	4	9
Pine Warbler	*Dendroica pinus*	C-PR	148		1	2	1	3	2	5	4	7	5	9
Red-bellied Woodpecker	*Melanerpes carolinus*	C-PR	137	1	5	4	6	10	8	8	7	8	10	10
Blue Jay	*Cyanocitta cristata*	C-PR	132	4	7	2		2	6	4	5	8	8	9
Song Sparrow	*Melospiza melodia*	C-WV	128		2	4	8	8	5	7				6
Ruby-crowned Kinglet	*Regulus calendula*	C-WV	91		2	8	8	8	7	5	1	1		8
Great Crested Flycatcher	*Myiarchus crinitus*	C-SR	88								6	8	9	3
Painted Bunting	*Passerina ciris*	FC-SR	83								7	15	11	3
Boat-tailed Grackle	*Quiscalus major*	C-PR	80	2	1		1	1	1	2	4	9	3	9
American Crow	*Corvus brachyrhyncos*	C-PR	78			2	1	5	4	4	7	1	1	8
Mourning Dove	*Zenaida macroura*	C-PR	75		2	1	1	2	3	2	5	5	6	9
Palm Warbler	*Dendroica palmarum*	FC-WV	65		3	2	5	6	4	6	5			7
Yellow-throated Warbler	*Dendroica dominica*	FC-PR	52	1			1			2	7	5	2	6
Common Grackle	*Quiscalus quiscula*	C-PR	52					1	5		1	1	4	5
House Finch	*Carpodacus mexicanus*	FC-PR	46		2	2		1		2	2	2	2	7
Black Vulture	*Coragyps atratus*	C-PR	46		1		3	2	3	3	3	1	1	8
Northern Mockingbird	*Mimus polyglottos*	C-PR	42		4	2	6	3	7	4	1	1	1	9
Brown-headed Cowbird	*Molothrus ater*	C-PR	42		1	1					5	3	1	5
Brown Thrasher	*Toxostoma rufum*	C-PR	40	1	1	3		4	2	2	2	3	4	9
Swamp Sparrow	*Melospiza georgiana*	C-WV	39		1	1	5	4	3	3	1			7
Downy Woodpecker	*Picoides pubescens*	C-PR	39	1	2	2	4	4	3		2	1	5	9
Gray Catbird	*Dumetella carolinensis*	U-SR	36	1	6	2	4	2	4	3	2	2		9
Common Yellowthroat	*Geothlypis trichas*	C-PR	34	2	5	4	1	1	2	1	4	6		9
Northern Parula Warbler	*Parula americana*	C-SR	34	1	1	1				1	3	2	2	7
White-eyed Vireo	*Vireo griseus*	FC-SR	34	1	2			1	1	2	2	1	2	8

Northern Flicker	*Colaptes auratus*	C-PR	32		5	3	2	3	3	2	3	2		8
Fish Crow	*Corvus ossifragus*	C-PR	30			1				1	3	5	3	5
Red-tailed Hawk	*Buteo jamaicensis*	C-PR	26		1	2	3	6	3	3		2	1	8
White Ibis	*Eudocimus albus*	FC-PR	25		1	2								2
Orchard Oriole	*Icterus spurius*	FC-SR	25								2	4	2	3
Great Blue Heron	*Ardea herodias*	C-PR	24	2	1	2	3	3	2	1	2		2	9
Eastern Bluebird	*Sialia sialis*	C-PR	24					1	3		1			3
Prairie Warbler	*Dendroica discolor*	FC-SR	21	2	3	1					3	1		5
Hermit Thrush	*Catharus guttatus*	FC-WV	20				4	2	1	5	1			5
Belted Kingfisher	*Ceryle alcyon*	FC-PR	20	1	4	5	1	1	1	2	2			8
Yellow-bellied Sapsucker	*Sphyrapicus varius*	FC-WV	20		2	4	5	2	2	2				6
Lesser Yellowlegs	*Tringa flavipes*	C-WV	18						1		1	1		3
Great Horned Owl	*Bubo virginianus*	C-PR	17		2	2	2	3	2	2	2	1		8
Pileated Woodpecker	*Dryocopus pileatus*	C-PR	17		1	1	2			3	3	1		6
Bald Eagle	*Haliaeetus leucocephalus*	FC-PR	17			1	2	4	2	3	1	2	1	8
Great Egret	*Ardea alba*	C-PR	16		3	3		1			1	2	2	6
Green Heron	*Butorides virescens*	C-SR	16	1							2	3	7	4
American Redstart	*Setophaga ruticilla*	C-T	15	1	1							3		3
Saltmarsh Sharp-tailed Sparrow	*Ammodramus caudacutus*	FC-WV	14		1									1
Seaside Sparrow	*Ammodramus maritimus*	FC-PR	14		1									1
Wood Stork	*Mycteria americana*	FC-SR	13	1	2	1					1		1	5
House Wren	*Troglodytes aedon*	FC-WV	13		2	3	2	2	2					5
Whimbrel	*Numenius phaeopus*	C-T	12									1		1
Osprey	*Pandion haliaetus*	C-SR	12			1	1	1		2	1	1	3	7
Eastern Screech-Owl	*Otus asio*	C-PR	10	1	4					1		2		4
Acadian Flycatcher	*Empidonax virescens*	FC-SR	9									1	2	2
Loggerhead Shrike	*Lanius ludovicianus*	FC-PR	8	1					2	1	1	1	1	6
Eastern Phoebe	*Sayornis phoebe*	C-WV	8	1	1	4	1		1	1				6
American Woodcock	*Scolopax minor*	FC-WV	8				1	3	2					3
Red-eyed Vireo	*Vireo olivaceus*	C-SR	8		1						1	2	1	4
Spotted Sandpiper	*Actitis macularia*	FC-T	7	1						1	1	1		4
Yellow-billed Cuckoo	*Coccyzus americanus*	FC-SR	7								3	2	1	3
Dark-eyed Junco	*Junco hyemalis*	C-WV	7				1	1						2
Black-and-White Warbler	*Mniotilta varia*	FC-WV	7		2	1					1	1		4
Savannah Sparrow	*Passerculus sandwichensis*	C-WV	7		1	1				2	1			4
Summer tanager	*Piranga rubra*	C-SR	7								1	2	1	3
Ovenbird	*Seiurus aurocapillus*	FC*-T	7		1	1					1	4		4
Blue-headed Vireo	*Vireo solitarius*	FC-WV	7				1		1	3				3
American Goldfinch	*Carduelis tristis*	C-WV	6				1	1	1					3
Little Blue Heron	*Egretta caerulea*	C-PR	6	1		1					1		3	4
Tricolored Heron	*Egretta tricolor*	C-PR	6	1	1	2							1	4
Snowy Egret	*Egretta thula*	C-PR	5	1		1		1	1					4
Clapper Rail	*Rallus longirostris*	C-PR	5			2			1			1	1	4
Cooper's Hawk	*Accipiter cooperii*	U-WV	4		1		1			2				3
Sharp-shinned Hawk	*Accipiter striatus*	FC-WV	4		2			1	1					3
Chuck-will's-widow	*Caprimulgus carolinensis*	C-SR	4									2	1	2
Semipalmated Plover	*Charadrius semipalmatus*	C-WV	4				1					1		2
Sedge Wren	*Cistothorus platensis*	U-WV	4					1		2				2
Eastern Wood-Pewee	*Contopus virens*	FC-SR	4		1							3		2

Laughing Gull	*Larus atricilla*	C-SR	4								1		1	2
Black-crowned Night Heron	*Nycticorax nycticorax*	C-PR	4			1						1	1	3
Eastern Kingbird	*Tyrannus tyrannus*	C-SR	4									1	1	2
Ruby-throated hummingbird	*Archilochus colubris*	C-SR	3									2	1	2
Black-throated Blue Warbler	*Dendroica caerulescens*	FC-T	3	1								1		2
Yellow-crowned Night-Heron	*Nyctanassa violacea*	FC-SR	3										2	1
Brown-headed Nuthatch	*Sitta pusilla*	C-PR	2									1		1
Eurasian Collared Dove	*Streptopelia decaocto*	LU-PR	2									1	1	2
Barn Owl	*Tyto alba*	U-PR	2					1	1					2
Red-shouldered hawk	*Buteo lineatus*	FC-PR	1									1		1
Killdeer	*Charadrius vociferus*	C-PR	1				1							1
Marsh Wren	*Cistothorus palustris*	C-PR	1								1			1
Northern Bobwhite	*Colinus virginianus*	U-PR	1								1			1
Magnolia Warbler	*Dendroica magnolia*	U-T	1		1									1
Cape May Warbler	*Dendroica tigrina*	FC-T	1	1										1
Wood thrush	*Hylocichla mustelina*	FC-SR	1									1		1
Baltimore Oriole	*Icterus galbula*	U-WV	1									1		1
Indigo Bunting	*Passerina cyanea*	C-SR	1									1		1
Prothonotary Warbler	*Protonotaria citrea*	FC-SR	1								1			1
Golden-crowned Kinglet	*Regulus satrapa*	U-WV	1							1				1
European starling	*Sturnus vulgaris*	C-PR	1								1			1
Hooded Warbler	*Wilsonia citrina*	FC-SR	1								1			1
Black-throated green warbler	*Dendroica virens*	LU-SR	1			1								1

Developed Region vs. Undeveloped Region

Fourteen of the sixteen core islands of this study can be split into two groups of seven islands each – one group representing a developed region (Folly/Kiawah area) and the other representing an undeveloped region (ACE Basin). The remaining two core islands have been substantially "disturbed" by human building and activities and, as such, were not suitable for inclusion in the comparison. Islands in the two groups are of comparable size, with the overall average size being 19.4 acres for the developed region and 21.5 acres for the undeveloped region.

Total number of bird species is presented for island in Figure 34. Though some of the small islands in the developed region appeared to have more species present, there is no significant difference between the number of bird species seen in the developed and undeveloped regions (P=0.303, ANCOVA).

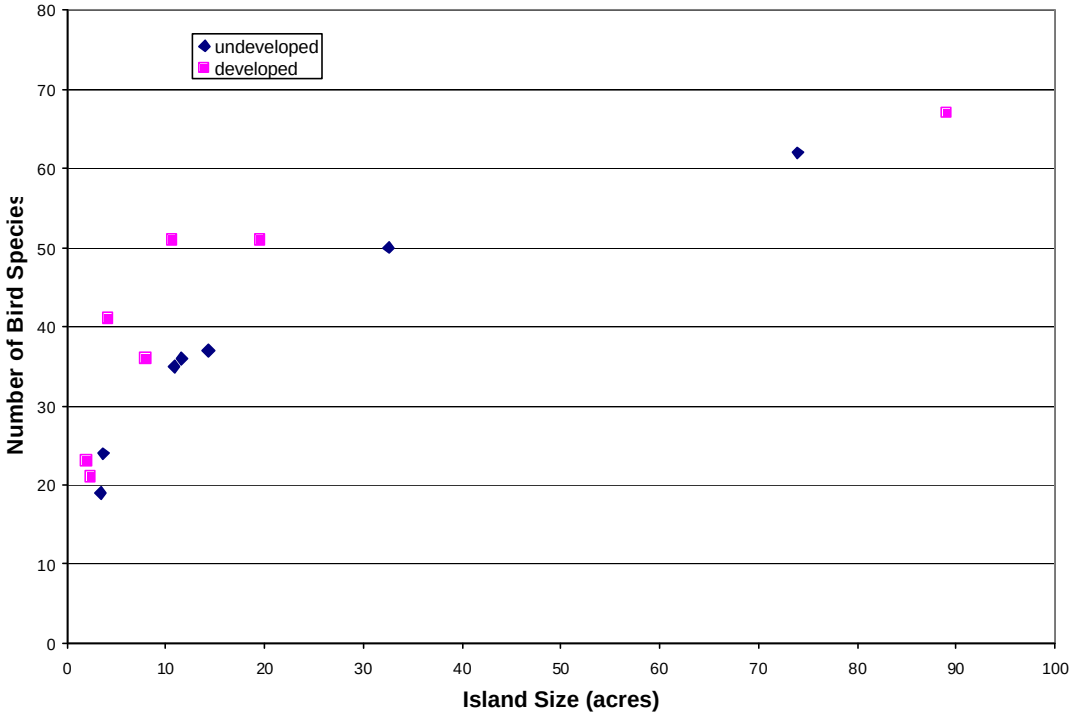

Figure 34. Total number of bird species observed for each island as related to island size (acres). Islands in the developed region are those located in the Folly/Kiawah region and those in the undeveloped region are those in the ACE Basin.

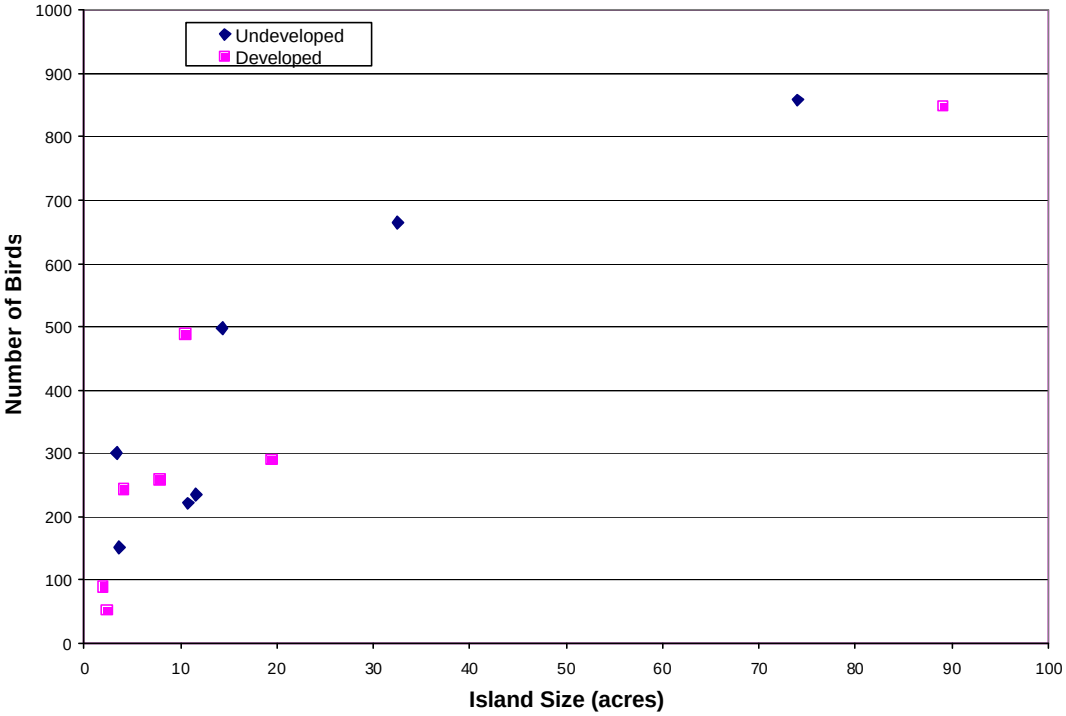

Figure 35. Total number of birds observed for each island as related to island size (acres). Islands in the developed region are those located in the Folly/Kiawah region and those in the undeveloped region are those in the ACE Basin.

To further analyze bird abundance between the developed vs. undeveloped regions, the birds were examined with respect to migratory categories (Permanent Resident, Summer Resident, Winter Visitor and Transient) (Table 8). A simple comparison of mean number of bird species for the regions indicates that only the Permanent Resident species were more abundant on the developed islands (24.0 to 20.9). The other four groups were nearly identical in terms of number of species present. However, scatterplot figures indicate size of the island could have had an overriding influence on numbers of species and simple summary statistics may be misleading. In Figure 36 and Figure 37, it appears that the islands in the developed region generally had more Permanent Resident and Winter Visitors species than those in the undeveloped region. No discernable trend can be seen with the summer residents and the transients (Figure 38, Figure 39).

Table 8. Numbers of species and total numbers of birds found on islands in the developed and undeveloped regions. PR=Permanent Resident, SR=Summer Resident, WR= Winter Visitors, and T= Transient.

		Number of Species				Number of Birds			
Island	**Region**	**PR**	**SR**	**T**	**WV**	**PR**	**SR**	**T**	**WV**
ACE1	undeveloped	27	6	1	16	235	23	3	404
ACE12	undeveloped	28	10	8	16	497	78	18	265
ACE5	undeveloped	9	1		9	51	6		243
ACE52	undeveloped	19	4	3	9	93	10	5	113
ACE54	undeveloped	24	4	2	6	159	10	2	64
ACE6	undeveloped	12	2	2	8	79	3	2	67
ACE9	undeveloped	22	2	2	11	138	16	4	339
F51	developed	38	9	5	15	468	58	17	305
F53	developed	14		1	8	58		2	28
F7	developed	26	4	8	13	170	12	17	90
K1	developed	22	3	2	9	102	3	4	148
K52	developed	23	3	3	11	112	6	3	122
K55	developed	33	4	2	12	152	7	8	320
K6	developed	12	1	1	7	40	1	1	10

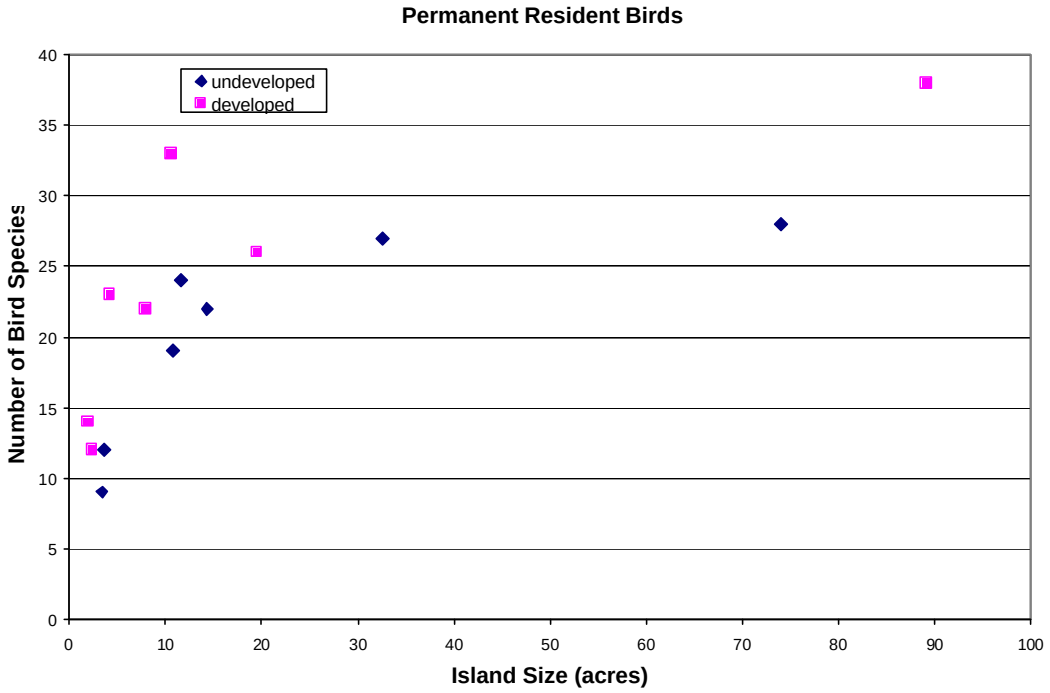

Figure 36. Total number of bird species classified as Permanent Residents that were observed on each island, as related to island size (acres). Islands in the developed region are those located in the Folly/Kiawah region and those in the undeveloped region are in the ACE basin.

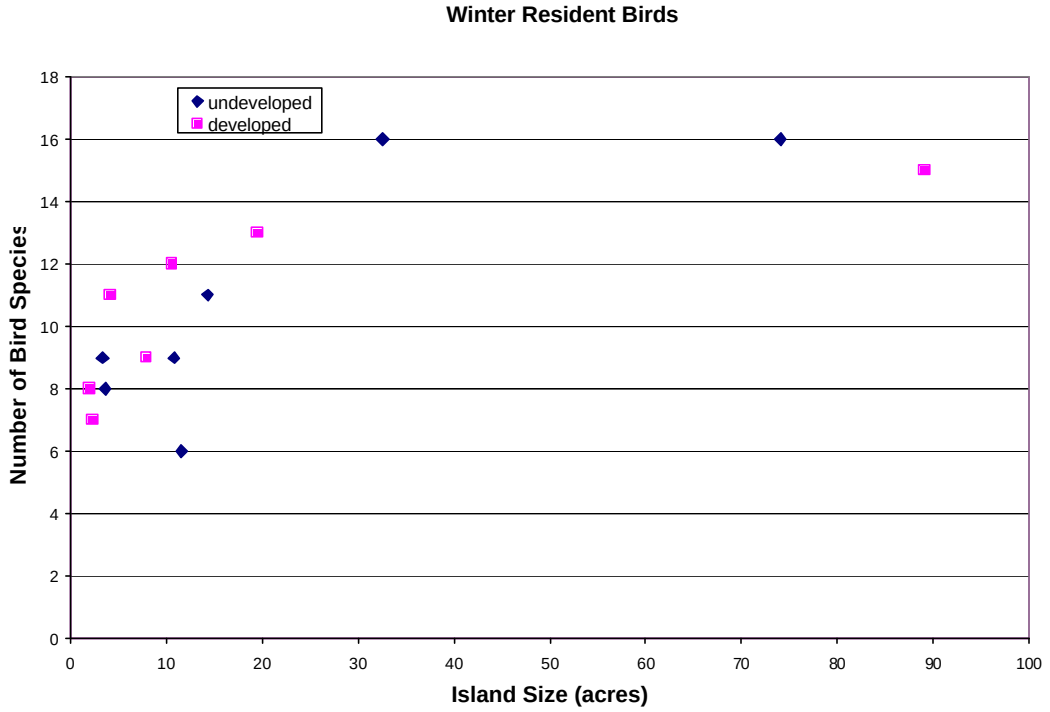

Figure 37. Total number of bird species classified as Winter Visitors that were observed on each island, as related to island size (acres). Islands in the developed region are those located in the Folly/Kiawah region and those in the undeveloped region are those in the ACE Basin.

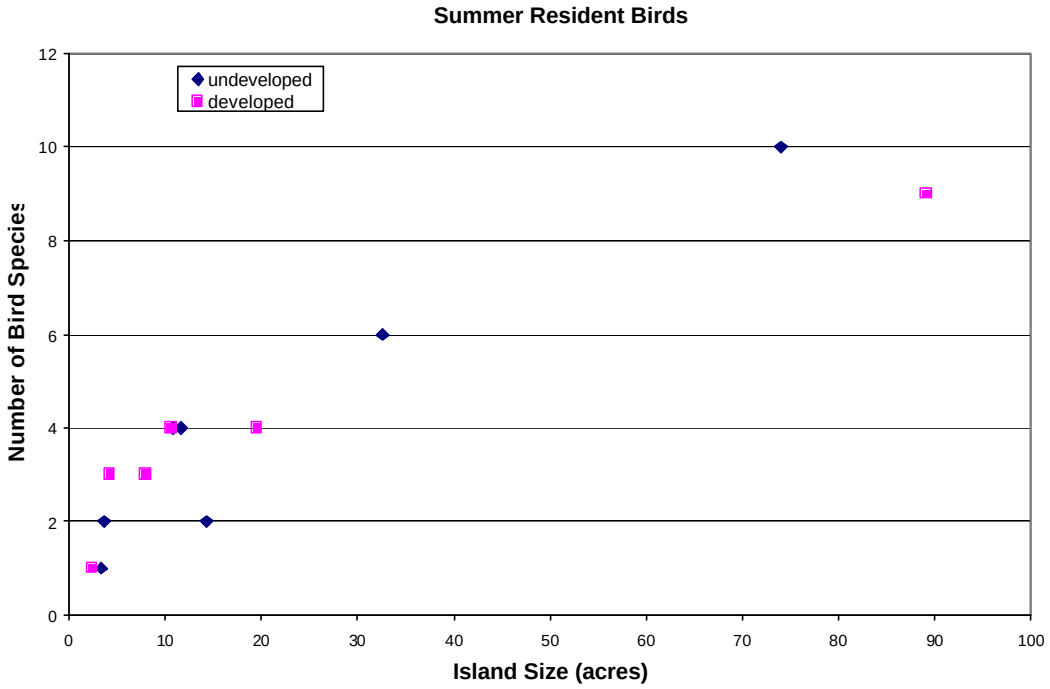

Figure 38. Total number of bird species classified as Summer Residents that were observed on each island, as related to island size (acres). Islands in the developed region are those located in the Folly/Kiawah region.

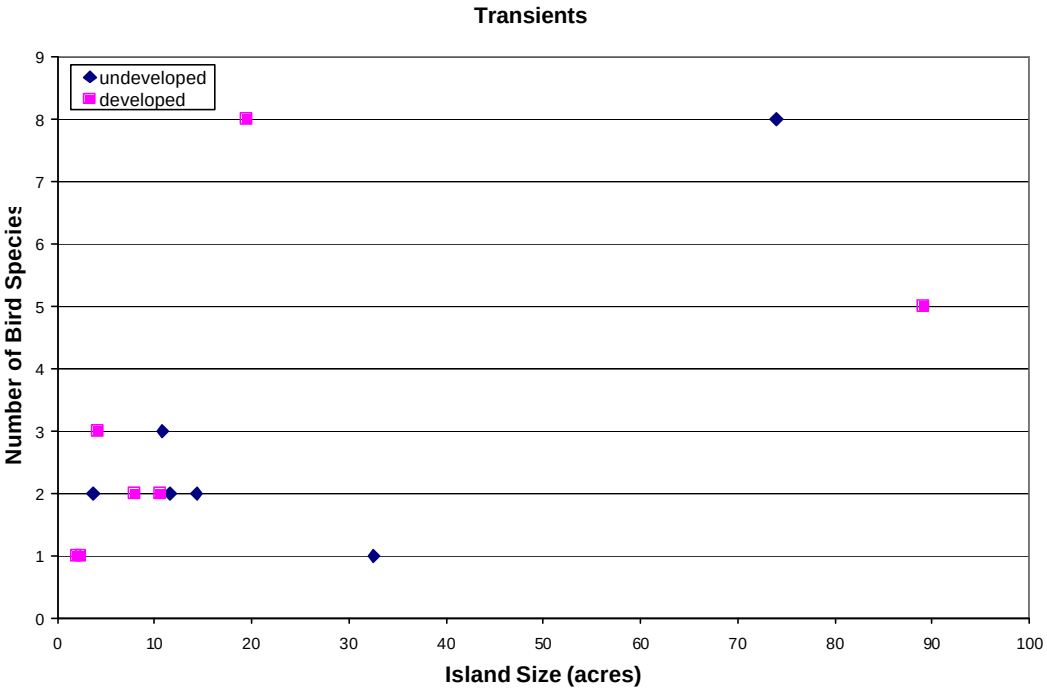

Figure 39. Total number of bird species classified as Transients that were observed on each island, as related to island size (acres). Islands in the developed region are those located in the Folly/Kiawah region and those in the undeveloped region are those in the ACE Basin.

Disturbed vs. Undisturbed Islands

One of the secondary objectives in this study was to directly compare disturbed and undisturbed islands with respect to bird abundance. This portion of the study was built into the larger study, although manpower and time limitations resulted in this comparison being relatively small in scale. We chose six islands in the Folly/Kiawah Area that were roughly equal in size and vegetation type. Three of these were considered disturbed by humans, meaning they had buildings and roadways. The undisturbed islands had no significant modifications. To further complicate this comparison, one of the undisturbed islands became disturbed in the middle of the study when understories were cleared. Also, one of the disturbed islands was not one of the 16 core islands and although we feel that island was surveyed well, it was surveyed by biologists other than those who surveyed the other five islands.

Overall, the undisturbed islands had slightly more bird species than did the disturbed islands (48.3 to 43.0 species). However, average numbers of birds were much higher on the disturbed island relative to the undisturbed (554.6 to 344.3 birds). This difference was due, at least partially, to large flocks of birds (Cedar Waxwing, Yellow-rumped Warbler, Robin, or Tree Swallow) encountered on 5 trips during the winter and early spring. Four of these trips were to disturbed islands. It is unclear whether large flocks of transient birds preferred the disturbed

islands or if disproportional sampling of disturbed habitats during this period made encounter more likely.

Separating the birds into seasonal migratory groups indicates there was little difference between the disturbed and undisturbed islands by category (Figure 40).

However, examination of the numbers of birds on the islands indicates that the disturbed islands had substantially larger average numbers of permanent resident (261 vs. 141) and winter visitor species (283 vs. 186; Figure 41). There was little difference between the numbers of summer resident and transient birds.

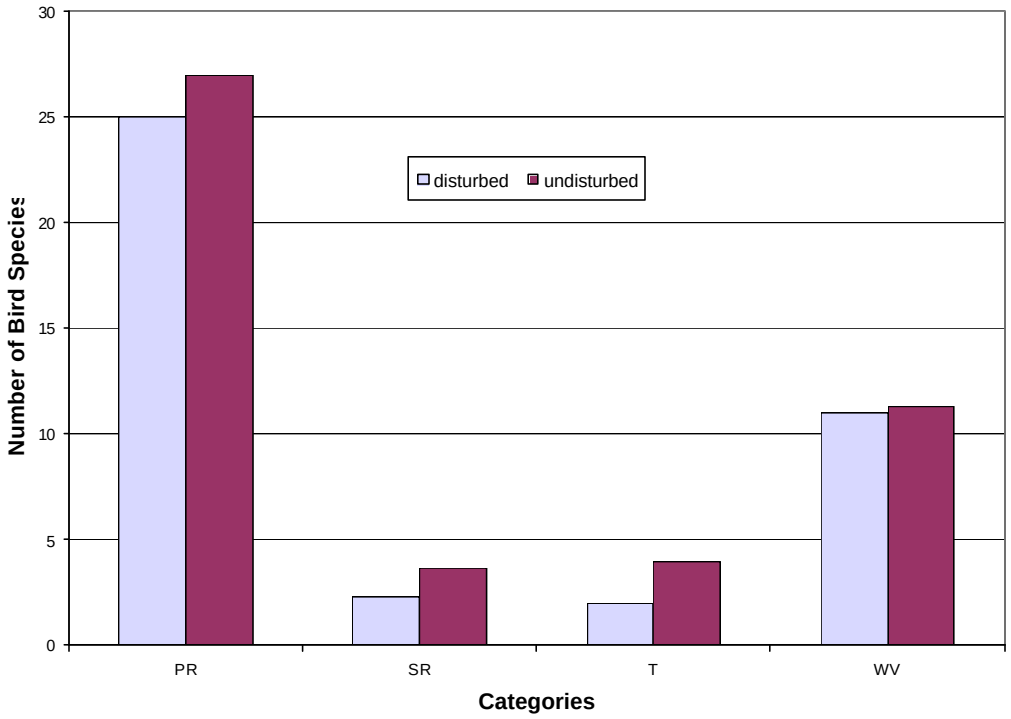

Figure 40. Comparison of average numbers of bird species on the three disturbed and three undisturbed islands. PR= Permanent Residents, SR=Summer Residents, T=Transients, WR=Winter Visitor.

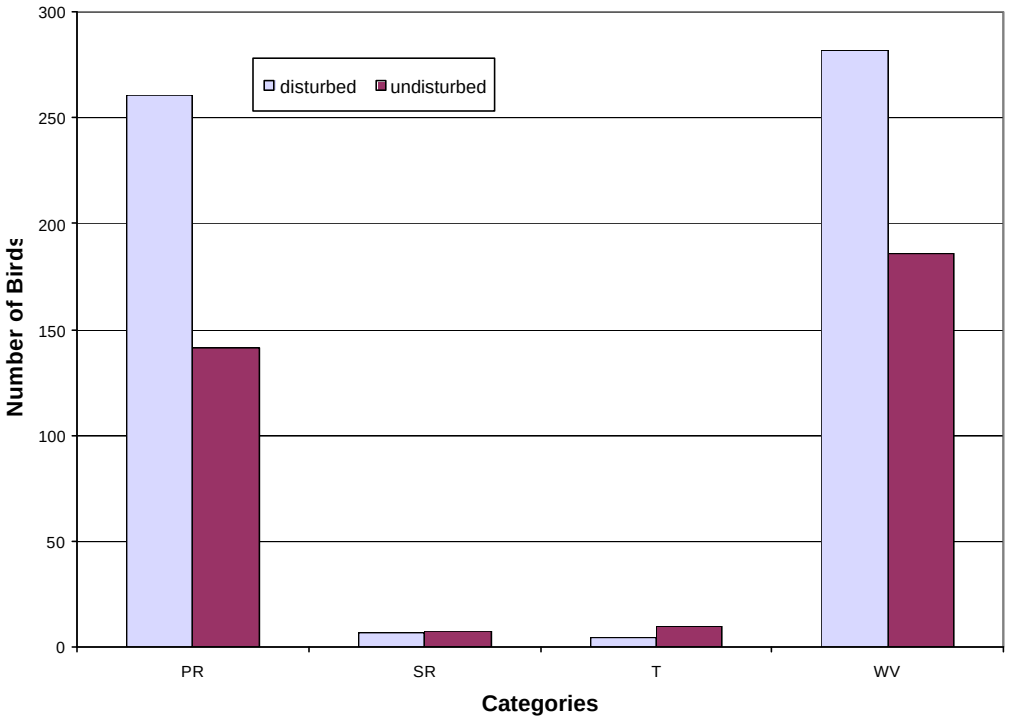

Figure 41. Comparison of average numbers of birds on the three disturbed and three undisturbed islands. PR= Permanent Residents, SR=Summer Residents, T=Transients, WR=Winter Visitor

Effects of Development on Bird Abundance

This study does not provide strong evidence of a difference in bird diversity between developed and undeveloped regions. However, the overall average number of birds per island was considerably higher on the islands in the undeveloped region. A more rigorous study is required to conclusively determine this. Although islands were of roughly the same size in each area, island morphology was variable. Islands with more reticulated uplands had greater "surface area" or edge, and presuming that bird and insect abundance is positively correlated with increase edge, this could have had an over-riding effect on the results (Hutto, 1985;Somershoe, 2000). Also, bird diversity and abundance may have been related to the presence of permanent and ephemeral wetlands (more common in the ACE Basin), or a higher degree of habitat diversity on the ACE islands. The ACE Basin islands are associated with rivers and relatively low salinities, and some of the islands were considerably farther from the ocean than those in the Folly/Kiawah area. As a result, the ACE Basin islands were more similar to inland forest communities, and this probably strongly influenced bird species composition and abundance.

The examination of disturbed and undisturbed islands, acknowledging the limitations of the study design and small sample size, suggests relatively minor differences in numbers of bird species between the two categories. However, numbers of permanent resident and winter visitor birds on the disturbed islands was higher than on the undisturbed islands. Bird density may typically be higher on disturbed islands because the overall diversity of habitat may be greater. In

addition to typical Maritime Forest communities, disturbed islands provide much more open space, which is highly attractive to some species. Open space, however, can promote the occurrence of non-desirable species like Brown-headed Cowbird at the detriment of more desirable species such as painted buntings and warblers.

Comparisons with Other Studies

A study was conducted similarly to our study on Kiawah Island in 1974-75 (Chamberlain and Chamberlain, 1975). That study found 65 avian species in the "Maritime Woodlands." Two species were found that were not recorded in our study (Yellow-breasted Chat, and Winter Wren). They also observed 70 species in searches concentrated in the marsh and creeks, of which fifteen were in common with our study, and largely included wading birds that were resting on the marsh hammocks.

A study in coastal Georgia using the "Bioblast technique" (two to four-day concentrated surveys in spring and fall by teams of biologists) examined 23 marsh hammocks (Fabrizio and Calvi, 2003). They reported 113 species, which is similar to the 111 species found in our study. Five species were numerically ranked in the top ten of both studies: Northern Cardinal, Carolina Wren, Blue-gray Gnatcatcher, Carolina Chickadee, and Red-winged Blackbird. The American Robin, Cedar Waxwing, and White-throated Sparrow were in the top ten of our study, but were not seen in the Georgia Study probably because these species are migratory, and were not present at the time of the Georgia study. Interestingly, the Painted Bunting ranked 18th in South Carolina, but was not seen in Georgia. Again this was probably because the Georgia study was conducted during seasons when the Painted Bunting was absent. The Indigo Bunting, however, ranked number 5 in Georgia and number 100 in South Carolina. The abundance of the Indigo in Georgia may be related to the fact that several very large islands were included in that study, probably providing more open area and wetlands that would have favored this species. The South Carolina study noted 37 species that were not observed in Georgia, and at least 31 species were observed in the Georgia study, but not in South Carolina. These included many seabirds such as Brown Pelican, Ruddy Turnstone, Black-bellied Plover, Double-crested Commorant, and others known to occur in South Carolina. Combining the two studies, at least 138 species of birds were recorded on or in association with hammocks.

Male Painted Buntings were observed and heard calling on fifteen of sixteen islands during the spring months. Fledglings and juveniles were also observed on several islands, further indicating the usefulness of these islands as nesting sites. Expert ornithologists in the region were consulted and responded that marsh hammocks may be critical for the survival of a significant population of painted buntings (D. Forsyth, J. Cely, Pers. Comm. 2004). Hunter *et al*. (2001) noted that the Eastern Painted Bunting is associated with maritime scrub-shrub habitat mixed with a woodland setting. They note, however, that the species is often not present when no understory is present or if scrub-shrub patches are separated from woodlands. Partners in Flight have rated this bunting as a high priority species (Hunter *et al*., 2003). Breeding bird counts suggest a steep population decline for the species and this decline may be related to increased nest parasitism by Brown-

headed Cowbird, which is likely linked to increased coastal development. Brown-headed Cowbird are found primarily associated with open, cleared areas and will not usually penetrate woodlands. Thus, development or clearing of woodlands promotes the population of this species, even if portions of a developed tract are retained in natural condition.

Conclusions

This is the largest survey of its kind that we are aware of. Yet, we observed only 0.6 percent of the coastal hammocks in South Carolina. Other studies have examined multiple islands, but not over an extended time period, and not including all fauna and flora.

Our study has shown us that coastal hammocks are unique ecosystems with greater species diversity than was expected for both flora and fauna. Hundreds of plant species were found in at least 24 different plant communities. These habitats contribute to a mosaic that is much more complex than the simple descriptions of Maritime Forest that have historically been ascribed to hammocks. Although we sampled on a small portion of the islands, several rare or even endangered plants were found. We believe that a larger effort on more islands will undoubtedly produce many more rare and perhaps undescribed plants. Not only are the various habitats important for plant diversity, but some, such as the calcareous habitats created by Native Americans, are unique in the coastal plain and offer cultural value.

Numbers of animals and species diversity were also greater than was anticipated. Of particular note was the surprisingly large number of amphibians. Because amphibians must have access to freshwater resources to reproduce, and because the surrounding saltwater is an effective recruitment barrier, salamanders, frogs and newts are dependent upon the relatively small wetlands that dot some of the hammocks. A loss of these wetlands, regardless of size, would undoubtedly lead to extirpation of the species from these coastal habitats.

The hammocks provide refuges and perhaps essential habitats for reptiles including the Diamondback rattlesnake – a species that may be destined for the endangered or threatened species list. The relict sand dunes on hammocks also provide nesting habitat for both Diamondback Terrapins and Mud Turtles. Coastal populations of terrapins are known to be in decline because of multiple reasons, but the of nesting habitat will undoubtedly become a major factor as more of the coastal zone is developed.

Mammals were very common on hammocks, utilizing the habitats for nesting, feeding, mating and resting. Evidence of deer, raccoon, bobcat, otter and mink was common on all islands regardless of size or location. These isolated habitats probably provide a degree of security that is lacking on the mainland. Otter camps were relatively common and appeared to be used frequently for grooming, resting, and marking territory. Many of these camps had similar attributes – on a tip of land, access to deep water, low-hanging understory, and a mat of vegetation. Unfortunately, the preferred locations for homesites often include otter camps, virtually ensuring a conflict between otters and development.

It is clear from this study that birds utilize marsh hammocks for a number of purposes. Migratory birds use hammocks as stopover sites where they rest and refuel. Important species such as the Painted Buntings utilize hammocks for nesting, feeding, and rearing of young, and wading birds rest on remote hammocks as they wait for the tide to drop. The relative importance of the hammocks compared to coastal Maritime Forest on the mainland is to be determined, but it is likely that they provide a relatively isolated refuge, particularly in developed regions such as the Folly Beach/Kiawah Island area.

Given that edge habitat is very important to birds, and that small islands are essentially all edge, these hammocks may be particularly important habitats.

There are likely numerous factors that can affect species richness, diversity, and abundance of animals on hammocks. Factors that may influence the populations include island size; morphology (reticulated vs. round); vegetation density and type; presence of primary forest canopies; understories and bordering scrub/shrub habitats; degree of development (human activity and buildings); location (nearness to undeveloped or developed islands or the mainland); regional location (undeveloped vs. developed watersheds); nearness to migratory corridors for birds; amount of food (seeds, fruit, insects, etc); amount of open space; presence of ephemeral or permanent wetlands; accessibility by humans and frequency of human visitation; presence of feral animals (such as goats and pigs); and presence of free-roaming dogs and cats. Although our study was the largest of its kind, it was not comprehensive enough to tease out the relative importance of these various factors in a statistically rigorous manner. The relative importance of islands in developed and undeveloped areas should be examined more rigorously.

Recommendations

Management

- Islands should not be exempted from protection based upon size; Size alone should not be used to characterize the relative biological importance of marsh hammocks.
- Consideration should be give to declaring Otter camps (latrines) as Geographical Areas of Particular Concern (GAPC)
- Certain island and nesting habitats (notably relict dunes near tidal creeks) for diamondback terrapins should be preserved
- Isolated wetlands, regardless of size, need protection on hammocks for the survival of wildlife, particularly amphibians
- Along with preservation of isolated wetlands, adequate wooded buffers adjacent to the wetlands should be preserved
- Woodlands with understories and associated scrub-shrub habitats need to be maintained for migratory birds, including the Eastern Painted Bunting and migratory warblers
- Goats and pigs that are damaging the understory and are predators of native wildlife, should be removed from islands.
- Consideration should be made to designating many of the Native American shell mounds as GAPC
- Rare or uncommon plant species on hammocks should be protected, and considerations should be made to listing these on the State's threatened and endangered species list.
- Best Management Practices for sustaining native plants and animals should be developed for use in the event hammocks are developed.

Research

- Migratory routes and hammock utilization by birds should be quantitatively compared to the mainland and the larger Sea Islands.
- Utilization of truly isolated hammocks by wading birds and mammals should be compared to the more "accessible" hammocks (i.e., those providing easy access by boat or foot) to determine relative importance
- Examine importance of woodland edge for birds; compare bird use of hammocks with reticulated upland margins vs. hammocks that are round; examine the influence of island size on bird utilization in a controlled study with islands of similar morphology.
- Examine movement patterns and range of Diamondback Rattlesnakes on and between hammocks
- The trophic structure of the hammock island communities should be examined

- Collect more quantifiable data on abundance and species composition of amphibians and reptiles though use of drift fences, pitfall traps, seasoned coverboards, and other techniques.
- Document nocturnal activity of animals on hammocks including deer, raccoon, mink, armadillos, frogs, and others
- Examine the habits of amphibians on the hammocks with emphasis on use of ephemeral wetlands
- Define the distribution of South Carolina Slimy Salamanders throughout the coastal zone including hammocks, and utilize microsatellite DNA to examine the genetics of the species.
- Investigate the diversity of biota on the larger hammock islands, particularly those with permanent freshwater impoundments or wetlands
- Examine the relative importance of hammocks to diamondback terrapins and mud turtles; examine predation rates and identify predators to determine if depredation is required
- Conduct more concentrated searching on more hammocks to determine presence and distribution of the endangered Island Glass Lizard
- Develop a GIS database for sites of cultural significance including Native American shell mounds, middens, and rings

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Appendices

Appendix 1. List of individuals who provided information on fauna and flora of hammock islands.

Name	Affiliation	Occupation
Clark Alexander	UGA	College Professor
Reed Armstrong	SCCCL	Professional biologist
Buddy Baker	DNR	Professional biologist
Steve Bennett	DNR	Professional biologist
Dave Bushek	USC Baruch	College Professor
Robin Coller-Socha	DNR	Professional biologist
Susan Davis	DNR	Professional biologist
Jean Everett	CofC	College Professor
Bob Feller	USC Baruch	College Professor
Whit Gibbons	SREL	Professional biologist
Jimmy Hadden	US ACE	Professional Biologist
Ray Haggerty	DNR	Professional biologist
Don Hammond	DNR	Professional biologist
Anthony Harold	CofC	College Professor
Julian Harrison	CofC	College Professor
Brenda Hockensmith	DNR	Professional biologist
Fred Holland	DNR/NOAA	Professional biologist
Bob Martore	DNR	Professional biologist
Charles Moore	DNR	Professional biologist
Tom Murphy	DNR	Professional biologist
Ginger Ogburn-Mathews	USC Baruch	College Professor
David Owens	CofC	College Professor
Amy Ringwood	DNR	Professional biologist
Bill Roumillat	DNR	Professional biologist
Craig Sasser	USFWS	Professional biologist
Geoff Scott	NOAA	Professional biologist
Al Segars	DNR	Veterinarian
John Taggart	UNC Wilmington	College Professor
Wayne Waltz	DNR	Professional biologist
David Webster	UNC Wilmington	College Professor
Elizabeth Wenner	DNR	Professional biologist

Appendix 2. List of plants encountered on hammock islands.

Plant Division	Family	Species Name
Psilophyta	Psilotaceae -- Whisk-fern family	*Psilotum nudum*
Pteridophyta	Aspleniaceae -- Spleenwort family	*Asplenium platyneuron*
Pteridophyta	Blechnaceae -- Chain Fern family	*Woodwardia areolata*
Pteridophyta	Blechnaceae -- Chain Fern family	*Woodwardia virginica*
Pteridophyta	Dennstaedtiaceae -- Bracken Fern family	*Pteridium aquilinum var. pseudocaudatum*
Pteridophyta	Osmundaceae -- Royal Fern family	*Osmunda cinnamomea*
Pteridophyta	Polypodiaceae -- Polypody family	*Pleopeltis polypodioides michauxiana*
Pinophyta	Cupressaceae -- Cypress family	*Juniperus virginiana var. silicicola*
Pinophyta	Pinaceae -- Pine family	*Pinus echinata*
Pinophyta	Pinaceae -- Pine family	*Pinus elliottii*
Pinophyta	Pinaceae -- Pine family	*Pinus palustris*
Pinophyta	Pinaceae -- Pine family	*Pinus serotina*
Pinophyta	Pinaceae -- Pine family	*Pinus taeda*
Magnoliophyta: Liliopsida	Agavaceae -- Century-plant family	*Yucca aloifolia*
Magnoliophyta: Liliopsida	Agavaceae -- Century-plant family	*Yucca filamentosa*
Magnoliophyta: Liliopsida	Agavaceae -- Century-plant family	*Yucca gloriosa*
Magnoliophyta: Liliopsida	Arecaceae -- Palm family	*Sabal minor*
Magnoliophyta: Liliopsida	Arecaceae -- Palm family	*Sabal palmetto*
Magnoliophyta: Liliopsida	Arecaceae -- Palm family	*Serenoa repens*
Magnoliophyta: Liliopsida	Cannaceae -- Canna family	*Canna flaccida*
Magnoliophyta: Liliopsida	Cyperaceae - Sedge family	*Scirpus lineatus*
Magnoliophyta: Liliopsida	Cyperaceae - Sedge family	*Scleria ciliata var. ciliata*
Magnoliophyta: Liliopsida	Cyperaceae - Sedge family	*Scleria oligantha*
Magnoliophyta: Liliopsida	Cyperaceae - Sedge family	*Scleria triglomerata*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex alata*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex cephalophora*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex complanata*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex dasycarpa*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex debilis*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex floridana*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex longii*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex lupulina*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex muhlenbergii*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Carex striatula*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cladium jamaicense*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cyperus croceus*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cyperus erythrorhizos*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cyperus esculentus*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cyperus retrorsus var. deeringianus*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cyperus rotundus*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cyperus tetragonus*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Cyperus virens*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Dichromena colorata*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Eleocharis albida*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Fimbristylis castanea*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Rhynchospora caduca*

Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Rhynchospora corniculata*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Rhynchospora fascicularis*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Rhynchospora inexpansa*
Magnoliophyta: Liliopsida	Cyperaceae -- Sedge family	*Rhynchospora mixta*
Magnoliophyta: Liliopsida	Dioscoreaceae -- Yam family	*Dioscorea floridana*
Magnoliophyta: Liliopsida	Hydrocharitaceae -- Tape-grass family	*Limnobium spongia*
Magnoliophyta: Liliopsida	Iridaceae -- Iris family	*Hypoxis leptocarpa (Hypoxis curtissii)*
Magnoliophyta: Liliopsida	Iridaceae -- Iris family	*Iris virginica*
Magnoliophyta: Liliopsida	Iridaceae -- Iris family	*Sisyrinchium atlanticum*
Magnoliophyta: Liliopsida	Iridaceae -- Iris family	*Sisyrinchium rosulatum*
Magnoliophyta: Liliopsida	Juncaceae -- Rush family	*Juncus biflorus*
Magnoliophyta: Liliopsida	Juncaceae -- Rush family	*Juncus bufonius*
Magnoliophyta: Liliopsida	Juncaceae -- Rush family	*Juncus dichotomus*
Magnoliophyta: Liliopsida	Juncaceae -- Rush family	*Juncus effusus var. solutus*
Magnoliophyta: Liliopsida	Juncaceae -- Rush family	*Juncus marginatus*
Magnoliophyta: Liliopsida	Juncaceae -- Rush family	*Juncus roemerianus*
Magnoliophyta: Liliopsida	Lemnaceae -- Duckweed family	*Lemna valdiviana*
Magnoliophyta: Liliopsida	Liliaceae -- Lily family	*Allium canadense*
Magnoliophyta: Liliopsida	Liliaceae -- Lily family	*Trillium maculatum*
Magnoliophyta: Liliopsida	Liliaceae -- Lily family	*Zephyranthes atamasco*
Magnoliophyta: Liliopsida	Linaceae -- Flax family	*Linum sps.*
Magnoliophyta: Liliopsida	Orchidaceae -- Orchid family	*Spiranthes vernalis*
Magnoliophyta: Liliopsida	Orchidaceae -- Orchid family	*Tipularia discolor*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Andropogon tenuispatheus*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Andropogon ternarius*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Andropogon virginicus*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Aristida longispica*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Aristida purpurascens*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Arundinaria gigantea*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Briza minor*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Bromus tectorum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Cenchrus longispinus*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Cenchrus tribuloides*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Chasmanthium cf. sessiliflorum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Chasmanthium laxum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Chasmanthium sessiliflorum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Chloris petraea*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Cortaderia selloana*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Cynodon dactylon*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium aciculare*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium angustifolium*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium chamaelonche*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium commutatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium depauperatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium dichotomum var. dichotomum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium dichotomum var. ramulosum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium lancearium*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium laxiflorum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium oligosanthes*

Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium scoparium*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium sphaerocarpon var. sphaerocarpon*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Dichanthelium tenue*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Distichlis spicata*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Elymus glabriflorus*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Elymus virginicus*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Eragrostis sps.*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Eremochloa ophiuroides*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Hordeum pusillum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Lolium perenne var. aristatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Lolium perenne var.multiflorum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Luziola fluitans*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Melica mutica*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Microstegium vimineum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Muhlenbergia filipes*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Oplismenus hirtellus*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Panicum anceps var. rhizomatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Panicum dichotomum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Panicum virgatum var. virgatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Paspalum dilatatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Paspalum notatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Paspalum setaceum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Paspalum urvillei*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Phalaris canariensis*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Piptochaetium avenaceum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Poa annua*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Poa chapmanii*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Polypogon monspilensis*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Saccharum giganteum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Setaria glauca*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Setaria magna*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Setaria parviflora*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Setaria viridis*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Sorghum halepense*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Spartina alterniflora*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Spartina bakeri*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Spartina cynosuroides*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Spartina patens*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Sporobolus virginicus*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Stenotaphrum secundatum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Vulpia octoflora*
Magnoliophyta: Liliopsida	Pontederiaceae -- Water-Hyacinth family	*Pontederia cordata*
Magnoliophyta: Liliopsida	Smilacaceae -- Catbrier family	*Smilax auriculata*
Magnoliophyta: Liliopsida	Smilacaceae -- Catbrier family	*Smilax bona-nox*
Magnoliophyta: Liliopsida	Smilacaceae -- Catbrier family	*Smilax pumila*
Magnoliophyta: Liliopsida	Smilacaceae -- Catbrier family	*Smilax rotundifolia*
Magnoliophyta: Liliopsida	Smilacaceae -- Catbrier family	*Smilax smallii*
Magnoliophyta: Liliopsida	Typhaceae -- Cat-tail family	*Typha latifolia*
Magnoliophyta: Magnoliopsida	Acanthaceae -- Acanthus family	*Ruellia carolinensis*

Magnoliophyta: Magnoliopsida Aceraceae -- Maple family	*Acer barbatum*
Magnoliophyta: Magnoliopsida Aceraceae -- Maple family	*Acer rubrum*
Magnoliophyta: Magnoliopsida Aizoaceae -- Fig-marigold family	*Sesuvium portulacastrum*
Magnoliophyta: Magnoliopsida Amaranthaceae -- Amaranth family	*Alternanthera philoxeroides*
Magnoliophyta: Magnoliopsida Amaranthaceae -- Amaranth family	*Amaranthus sps.*
Magnoliophyta: Magnoliopsida Amaranthaceae -- Amaranth family	*Iresine rhizomatosa*
Magnoliophyta: Magnoliopsida Anacardiaceae -- Sumac family	*Rhus copallina*
Magnoliophyta: Magnoliopsida Anacardiaceae -- Sumac family	*Toxicodendron pubescens*
Magnoliophyta: Magnoliopsida Anacardiaceae -- Sumac family	*Toxicodendron radicans*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Centella erecta*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Chaerophyllum tainturieri*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Daucus pusillus*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Hydrocotyle bonariensis*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Hydrocotyle umbellata*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Hydrocotyle verticillata*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Sanicula canadensis*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Sanicula smallii*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Sium suave*
Magnoliophyta: Magnoliopsida Apiaceae -- Carrot family	*Spermolepis divaricata*
Magnoliophyta: Magnoliopsida Apocynaceae -- Dogbane family	*Apocynum cannabinum*
Magnoliophyta: Magnoliopsida Aquifoliaceae -- Holly family	*Ilex cassine*
Magnoliophyta: Magnoliopsida Aquifoliaceae -- Holly family	*Ilex glabra*
Magnoliophyta: Magnoliopsida Aquifoliaceae -- Holly family	*Ilex opaca*
Magnoliophyta: Magnoliopsida Aquifoliaceae -- Holly family	*Ilex vomitoria*
Magnoliophyta: Magnoliopsida Araliaceae -- Ginseng family	*Aralia spinosa*
Magnoliophyta: Magnoliopsida Araliaceae -- Ginseng family	*Hedera helix*
Magnoliophyta: Magnoliopsida Aristolochiaceae -- Birthwort family	*Aristolochia serpentaria*
Magnoliophyta: Magnoliopsida Aristolochiaceae -- Birthwort family	*Hexastylis arifolia*
Magnoliophyta: Magnoliopsida Asclepiadaceae -- Milkweed family	*Cynanchum angustifolium*
Magnoliophyta: Magnoliopsida Asclepiadaceae -- Milkweed family	*Gonolobus suberosa*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Ambrosia artemisiifolia*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Baccharis angustifolia*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Baccharis halimifolia*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Borrichia frutescens*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Chrysopsis mariana*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Cirsium nuttallii*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Conyza bonariensis*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Conyza parva*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Coreopsis tinctoria*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Elephantopus tomentosus*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Erechtites hieracifolia*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Erigeron philadelphicus*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Erigeron quercifolius*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Erigeron strigosus var. beyrichii*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Eupatorium capillifolium*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Eupatorium coelestinum*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Eupatorium mohrii*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Eupatorium rotundifolia*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Eupatorium serotinum*

Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Euthamia hirtipes*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Euthamia tenuifolia*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Gamochaeta falcata*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Gamochaeta pensylvanica*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Heterotheca subaxillaris*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Hypochoeris radicata*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Iva frutescens*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Krigia virginica*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Liatris pilosa*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Melanthera nivea*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Mikania scandens*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Pityopsis graminifolia var. latifolia*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Pluchea camphorata*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Pluchea foetida*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Pluchea odorata*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Pyrrhopappus carolinianus*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Sericocarpus tortifolius*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Smallanthus uvedalius*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Solidago odora*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Solidago sempervirens*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Sonchus asper*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Sonchus oleraceus*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Symphyotrichum dumosum*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Symphyotrichum pilosum*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Symphyotrichum subulatum*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Symphyotrichum tenuifolium*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Taraxacum officinale*
Magnoliophyta: Magnoliopsida Asteraceae -- Aster family	*Pseudognaphalium obtusifolium*
Magnoliophyta: Magnoliopsida Bataceae -- Saltwort family	*Batis maritima*
Magnoliophyta: Magnoliopsida Bignoniaceae -- Trumpet-creeper family	*Bignonia capreolata*
Magnoliophyta: Magnoliopsida Bignoniaceae -- Trumpet-creeper family	*Campsis radicans*
Magnoliophyta: Magnoliopsida Brassicaceae -- Mustard family	*Barbarea verna*
Magnoliophyta: Magnoliopsida Brassicaceae -- Mustard family	*Capsella bursa-pastoris*
Magnoliophyta: Magnoliopsida Brassicaceae -- Mustard family	*Cardamine hirsuta*
Magnoliophyta: Magnoliopsida Brassicaceae -- Mustard family	*Coronopus didymus*
Magnoliophyta: Magnoliopsida Brassicaceae -- Mustard family	*Descurainia pinnata*
Magnoliophyta: Magnoliopsida Brassicaceae -- Mustard family	*Lepidium virginicum*
Magnoliophyta: Magnoliopsida Brassicaceae -- Mustard family	*Raphanus raphanistrum*
Magnoliophyta: Magnoliopsida Bromeliaceae -- Bromeliad family	*Tillandsia usneoides*
Magnoliophyta: Magnoliopsida Buddlejaceae -- Butterfly-bush family	*Polypremum procumbens*
Magnoliophyta: Magnoliopsida Cactaceae -- Cactus family	*Opuntia humifusa var. australis*
Magnoliophyta: Magnoliopsida Cactaceae -- Cactus family	*Opuntia pusilla*
Magnoliophyta: Magnoliopsida Cactaceae -- Cactus family	*Opuntia stricta var. stricta*
Magnoliophyta: Magnoliopsida Callitrichaceae -- Water-starwort family	*Callitriche terrestris*
Magnoliophyta: Magnoliopsida Campanulaceae -- Bellflower family	*Triodanis perfoliata*
Magnoliophyta: Magnoliopsida Caprifoliaceae -- Honeysuckle family	*Lonicera japonica*
Magnoliophyta: Magnoliopsida Caprifoliaceae -- Honeysuckle family	*Lonicera sempervirens*
Magnoliophyta: Magnoliopsida Caprifoliaceae -- Honeysuckle family	*Sambucus canadensis*
Magnoliophyta: Magnoliopsida Caryophyllaceae -- Pink family	*Arenaria lanuginosa*

Magnoliophyta: Magnoliopsida Caryophyllaceae -- Pink family	*Arenaria serpyllifolia*
Magnoliophyta: Magnoliopsida Caryophyllaceae -- Pink family	*Cerastium sps.*
Magnoliophyta: Magnoliopsida Caryophyllaceae -- Pink family	*Stellaria media*
Magnoliophyta: Magnoliopsida Chenopodiaceae -- Goosefoot family	*Atriplex patula*
Magnoliophyta: Magnoliopsida Chenopodiaceae -- Goosefoot family	*Chenopodium album*
Magnoliophyta: Magnoliopsida Chenopodiaceae -- Goosefoot family	*Chenopodium ambrosioides*
Magnoliophyta: Magnoliopsida Chenopodiaceae -- Goosefoot family	*Salicornia bigelovii*
Magnoliophyta: Magnoliopsida Chenopodiaceae -- Goosefoot family	*Salicornia virginica*
Magnoliophyta: Magnoliopsida Chenopodiaceae -- Goosefoot family	*Suaeda linearis*
Magnoliophyta: Magnoliopsida Cistaceae -- Rock-rose family	*Helianthemum corymbosum*
Magnoliophyta: Magnoliopsida Cistaceae -- Rock-rose family	*Lechea mucronata*
Magnoliophyta: Magnoliopsida Cistaceae -- Rock-rose family	*Lechea sessiliflora*
Magnoliophyta: Magnoliopsida Clusiaceae -- Mangosteen family	*Hypericum hypericoides*
Magnoliophyta: Magnoliopsida Convolvulaceae -- Morning-glory family	*Calystegia sepium*
Magnoliophyta: Magnoliopsida Convolvulaceae -- Morning-glory family	*Dichondra carolinensis*
Magnoliophyta: Magnoliopsida Convolvulaceae -- Morning-glory family	*Ipomoea pandurata*
Magnoliophyta: Magnoliopsida Convolvulaceae -- Morning-glory family	*Ipomoea purpurea*
Magnoliophyta: Magnoliopsida Convolvulaceae -- Morning-glory family	*Ipomoea sagittata*
Magnoliophyta: Magnoliopsida Cucurbitaceae -- Cucumber family	*Melothria pendula*
Magnoliophyta: Magnoliopsida Ebenaceae -- Ebony family	*Diospyros virginiana*
Magnoliophyta: Magnoliopsida Eleagnaceae -- Silverberry family	*Eleagnus pungens*
Magnoliophyta: Magnoliopsida Ericaceae -- Heath family	*Vaccinium arboreum*
Magnoliophyta: Magnoliopsida Ericaceae -- Heath family	*Vaccinium corymbosum*
Magnoliophyta: Magnoliopsida Ericaceae -- Heath family	*Vaccinium tenellum*
Magnoliophyta: Magnoliopsida Ericaceae -- Heath family	*Vaccinium virgatum*
Magnoliophyta: Magnoliopsida Euphorbiaceae -- Spurge family	*Acalypha sps.*
Magnoliophyta: Magnoliopsida Euphorbiaceae -- Spurge family	*Chamaesyce hirta*
Magnoliophyta: Magnoliopsida Euphorbiaceae -- Spurge family	*Chamaesyce maculata*
Magnoliophyta: Magnoliopsida Euphorbiaceae -- Spurge family	*Cnidoscolus stimulosus*
Magnoliophyta: Magnoliopsida Euphorbiaceae -- Spurge family	*Euphorbia heterophylla*
Magnoliophyta: Magnoliopsida Euphorbiaceae -- Spurge family	*Opuntia stricta*
Magnoliophyta: Magnoliopsida Euphorbiaceae -- Spurge family	*Triadica sebiferum*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Albizia julibrissin*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Amphicarpaea bracteata*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Cassia sps.*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Centrosema virginianum*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Cercis canadensis*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Chamaecrista fasciculata*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Chamaecrista nictitans*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Clitoria mariana*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Crotalaria angulata var. vulgaris*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Crotalaria spectabilis*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Desmodium ciliare*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Desmodium lineatum*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Desmodium nuttallii*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Desmodium paniculatum*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Erythrina herbacea*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Galactia regularis*
Magnoliophyta: Magnoliopsida Fabaceae -- Pea family	*Galactia volubilis*

Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Glottidium vesicarium*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Indigofera caroliniana*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Lespedeza cuneata*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Lespedeza virginica*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Medicago lupulina*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Melilotus alba*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Phaseolus polystachios*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Pueraria lobata*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Senna obtusifolia*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Sesbania herbacea*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Strophostyles helvola*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Trifolium campestre*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Trifolium dubium*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Trifolium repens*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Vicia acutifolia*
Magnoliophyta: Magnoliopsida	Fabaceae -- Pea family	*Vicia hirsuta*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus alba*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus geminata*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus laurifolia*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus michauxii*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus nigra*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus pagoda*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus phellos*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus stellata*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus velutina*
Magnoliophyta: Magnoliopsida	Fagaceae -- Beech family	*Quercus virginiana*
Magnoliophyta: Magnoliopsida	Fumariaceae -- Fumitory family	*Corydalis micranthera*
Magnoliophyta: Magnoliopsida	Gentianaceae -- Gentian family	*Sabatia stellaris*
Magnoliophyta: Magnoliopsida	Geraniaceae -- Geranium family	*Geranium carolinianum*
Magnoliophyta: Magnoliopsida	Hamamelidaceae -- Witch-hazel family	*Liquidambar styraciflua*
Magnoliophyta: Magnoliopsida	Hippocastanaceae -- Horse-chestnut family	*Aesculus pavia*
Magnoliophyta: Magnoliopsida	Juglandaceae -- Walnut family	*Carya alba*
Magnoliophyta: Magnoliopsida	Juglandaceae -- Walnut family	*Carya glabra var. megacarpa*
Magnoliophyta: Magnoliopsida	Juglandaceae -- Walnut family	*Carya illinoensis*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Lamium amplexicaule*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Prunella lanceolata*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Pycnanthemum pycnanthemoides*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Salvia lyrata*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Scutellaria elliptica*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Scutellaria integrifolia*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Stachys floridana*
Magnoliophyta: Magnoliopsida	Lamiaceae -- Mint family	*Trichostema dichotomum*
Magnoliophyta: Magnoliopsida	Lauraceae -- Laurel family	*Cinnamomum camphora*
Magnoliophyta: Magnoliopsida	Lauraceae -- Laurel family	*Persea borbonia*
Magnoliophyta: Magnoliopsida	Lauraceae -- Laurel family	*Sassafras albidum*
Magnoliophyta: Magnoliopsida	Loganiaceae -- Logania family	*Gelsimium sempervirens*
Magnoliophyta: Magnoliopsida	Lythraceae -- Loosestrife family	*Lagerstroemia indica*
Magnoliophyta: Magnoliopsida	Magnoliaceae -- Magnolia family	*Magnolia grandiflora*
Magnoliophyta: Magnoliopsida	Malvaceae -- Mallow family	*Kosteletzkya virginica*

Magnoliophyta: Magnoliopsida	Malvaceae -- Mallow family	*Modiola caroliniana*
Magnoliophyta: Magnoliopsida	Malvaceae -- Mallow family	*Sida rhombifolia*
Magnoliophyta: Magnoliopsida	Meliaceae -- Mahogany family	*Melia azedarach*
Magnoliophyta: Magnoliopsida	Menispermaceae -- Moonseed family	*Cocculus carolinus*
Magnoliophyta: Magnoliopsida	Moraceae -- Mulberry family	*Morus alba*
Magnoliophyta: Magnoliopsida	Moraceae -- Mulberry family	*Morus rubra*
Magnoliophyta: Magnoliopsida	Myricaceae -- Bayberry family	*Morella cerifera*
Magnoliophyta: Magnoliopsida	Nyssaceae -- Sour Gum family	*Nyssa biflora*
Magnoliophyta: Magnoliopsida	Nyssaceae -- Sour Gum family	*Nyssa sylvatica*
Magnoliophyta: Magnoliopsida	Oleaceae -- Olive family	*Forestiera godfreyi*
Magnoliophyta: Magnoliopsida	Oleaceae -- Olive family	*Ligustrum japonicum*
Magnoliophyta: Magnoliopsida	Oleaceae -- Olive family	*Ligustrum sinense*
Magnoliophyta: Magnoliopsida	Oleaceae -- Olive family	*Osmanthus americana*
Magnoliophyta: Magnoliopsida	Onagraceae -- Evening Primrose family	*Gaura sps.*
Magnoliophyta: Magnoliopsida	Onagraceae -- Evening Primrose family	*Ludwigia alata*
Magnoliophyta: Magnoliopsida	Onagraceae -- Evening Primrose family	*Ludwigia palustris*
Magnoliophyta: Magnoliopsida	Onagraceae -- Evening Primrose family	*Ludwigia repens*
Magnoliophyta: Magnoliopsida	Onagraceae -- Evening Primrose family	*Oenothera biennis*
Magnoliophyta: Magnoliopsida	Onagraceae -- Evening Primrose family	*Oenothera laciniata*
Magnoliophyta: Magnoliopsida	Oxalidaceae -- Wood-Sorrel family	*Oxalis corniculata*
Magnoliophyta: Magnoliopsida	Oxalidaceae -- Wood-Sorrel family	*Oxalis filipes*
Magnoliophyta: Magnoliopsida	Oxalidaceae -- Wood-Sorrel family	*Oxalis rubra*
Magnoliophyta: Magnoliopsida	Oxalidaceae -- Wood-Sorrel family	*Oxalis stricta*
Magnoliophyta: Magnoliopsida	Passifloraceae -- Passion-flower family	*Passiflora incarnata*
Magnoliophyta: Magnoliopsida	Passifloraceae -- Passion-flower family	*Passiflora lutea*
Magnoliophyta: Magnoliopsida	Phytolaccaceae -- Pokeweed family	*Phytolacca americana*
Magnoliophyta: Magnoliopsida	Phytolaccaceae -- Pokeweed family	*Phytolacca rigida*
Magnoliophyta: Magnoliopsida	Plantaginaceae -- Plantain family	*Plantago lanceolata*
Magnoliophyta: Magnoliopsida	Platanaceae -- Plane-tree family	*Platanus occidentalis*
Magnoliophyta: Magnoliopsida	Plumbaginaceae -- Leadwort family	*Limonium carolinianum*
Magnoliophyta: Liliopsida	Poaceae -- Grass family	*Andropogon gyrans*
Magnoliophyta: Magnoliopsida	Polygonaceae -- Buckwheat family	*Polygonum punctatum*
Magnoliophyta: Magnoliopsida	Polygonaceae -- Buckwheat family	*Rumex sps.*
Magnoliophyta: Magnoliopsida	Primulaceae -- Primrose family	*Samolus parviflorus*
Magnoliophyta: Magnoliopsida	Pyrolaceae -- Shinleaf family	*Chimaphila maculata*
Magnoliophyta: Magnoliopsida	Ranunculaceae -- Buttercup family	*Clematis catesbyana*
Magnoliophyta: Magnoliopsida	Rhamnaceae -- Buckthorn family	*Berchemia scandens*
Magnoliophyta: Magnoliopsida	Rhamnaceae -- Buckthorn family	*Frangula caroliniana*
Magnoliophyta: Magnoliopsida	Rhamnaceae -- Buckthorn family	*Sageretia minutiflora*
Magnoliophyta: Magnoliopsida	Rosaceae -- Rose family	*Alchemilla microcarpa*
Magnoliophyta: Magnoliopsida	Rosaceae -- Rose family	*Duchesnea indica*
Magnoliophyta: Magnoliopsida	Rosaceae -- Rose family	*Potentilla simplex*
Magnoliophyta: Magnoliopsida	Rosaceae -- Rose family	*Prunus caroliniana*
Magnoliophyta: Magnoliopsida	Rosaceae -- Rose family	*Prunus serotina*
Magnoliophyta: Magnoliopsida	Rosaceae -- Rose family	*Rubus argutus (=betulifolius)*
Magnoliophyta: Magnoliopsida	Rosaceae -- Rose family	*Rubus trivialis*
Magnoliophyta: Magnoliopsida	Rubiaceae -- Madder family	*Cephalanthus occidentalis*
Magnoliophyta: Magnoliopsida	Rubiaceae -- Madder family	*Diodia virginiana*
Magnoliophyta: Magnoliopsida	Rubiaceae -- Madder family	*Galium aparine*

Magnoliophyta: Magnoliopsida Rubiaceae -- Madder family	*Galium hispidulum*
Magnoliophyta: Magnoliopsida Rubiaceae -- Madder family	*Galium pilosum*
Magnoliophyta: Magnoliopsida Rubiaceae -- Madder family	*Galium tinctorum*
Magnoliophyta: Magnoliopsida Rubiaceae -- Madder family	*Galium uniflorum*
Magnoliophyta: Magnoliopsida Rubiaceae -- Madder family	*Houstonia procumbens*
Magnoliophyta: Magnoliopsida Rubiaceae -- Madder family	*Mitchella repens*
Magnoliophyta: Magnoliopsida Rubiaceae -- Madder family	*Richardia scabra*
Magnoliophyta: Magnoliopsida Rutaceae -- Rue family	*Zanthoxylum clava-herculis*
Magnoliophyta: Magnoliopsida Salicaceae -- Willow family	*Salix nigra*
Magnoliophyta: Magnoliopsida Sapotaceae -- Sapodilla family	*Sideroxylon tenax*
Magnoliophyta: Magnoliopsida Saururaceae -- Lizard's-tail family	*Saururus cernuus*
Magnoliophyta: Magnoliopsida Scrophulariaceae -- Figwort family	*Agalinis fasciculata*
Magnoliophyta: Magnoliopsida Scrophulariaceae -- Figwort family	*Agalinis purpurea*
Magnoliophyta: Magnoliopsida Scrophulariaceae -- Figwort family	*Aureolaria sp.*
Magnoliophyta: Magnoliopsida Scrophulariaceae -- Figwort family	*Nuttallanthus canadensis*
Magnoliophyta: Magnoliopsida Scrophulariaceae -- Figwort family	*Veronica arvensis*
Magnoliophyta: Magnoliopsida Scropulariaceae --Figwort Family	*Bacopa monnieri*
Magnoliophyta: Magnoliopsida Solanaceae -- Potato family	*Physalis angulata*
Magnoliophyta: Magnoliopsida Solanaceae -- Potato family	*Physalis heterophylla*
Magnoliophyta: Magnoliopsida Solanaceae -- Potato family	*Physalis virginiana*
Magnoliophyta: Magnoliopsida Solanaceae -- Potato family	*Physalis walteri*
Magnoliophyta: Magnoliopsida Solanaceae -- Potato family	*Solanum americanum*
Magnoliophyta: Magnoliopsida Solanaceae -- Potato family	*Solanum carolinense*
Magnoliophyta: Magnoliopsida Sterculiaceae -- Cacao family	*Melochia corchorifolia*
Magnoliophyta: Magnoliopsida Symplocaceae -- Sweetleaf family	*Symplocos tinctoria*
Magnoliophyta: Magnoliopsida Tiliaceae -- Linden family	*Tilia americana var. caroliniana*
Magnoliophyta: Magnoliopsida Ulmaceae -- Elm family	*Celtis laevigata*
Magnoliophyta: Magnoliopsida Urticaceae -- Nettle family	*Parietaria floridana*
Magnoliophyta: Magnoliopsida Verbenaceae -- Verbena family	*Callicarpa americana*
Magnoliophyta: Magnoliopsida Verbenaceae -- Verbena family	*Lantana camara*
Magnoliophyta: Magnoliopsida Verbenaceae -- Verbena family	*Phyla nodiflora*
Magnoliophyta: Magnoliopsida Verbenaceae -- Verbena family	*Verbena brasiliensis*
Magnoliophyta: Magnoliopsida Verbenaceae -- Verbena family	*Verbena urticifolia*
Magnoliophyta: Magnoliopsida Vitaceae -- Grape family	*Ampelopsis arborea*
Magnoliophyta: Magnoliopsida Vitaceae -- Grape family	*Parthenocissus quinquefolia*
Magnoliophyta: Magnoliopsida Vitaceae -- Grape family	*Vitis aestivalis*
Magnoliophyta: Magnoliopsida Vitaceae -- Grape family	*Vitis labrusca*
Magnoliophyta: Magnoliopsida Vitaceae -- Grape family	*Vitis rotundifolia*
Magnoliophyta: Magnoliopsida Vitaceae -- Grape family	*Vitis vulpina*