

A Review of the 1975 Report on the Environment of Kiawah Island

Environmental Science Committee
Kiawah Island Natural Habitat Conservancy
May 2014



TABLE OF CONTENTS

Introduction	3
Coastal Processes and Geomorphology	5
Climatology	8
Mammals	12
Ornithology	18
Loggerhead Turtles	22
Reptiles and Amphibians	26
Dune and Marsh Vegetation	34
Appendix A: Websites Pertinent to This Document and Wildlife on Kiawah Island	37
Appendix B: Videos of <i>Conservation Matters</i> Talks	38
Appendix C: Reports of <i>Conservation Matters</i> Talks and Conservancy-Sponsored Studies	39
Appendix D: Kiawah Conservancy DVDs	40
Appendix E: Introduction to the 1975 Environmental Report	42

Kiawah Island has a long and rich history. The more modern history begins with the Vanderhorst family, who acquired a portion of the island in 1775, and the island was in their hands until the middle of the 20th century. In 1950 C. C. Royal purchased Kiawah from the Vanderhorst estate for the timber rights, and, in 1954, began the development of summer homes. In 1974 the heirs of C. C. Royal sold Kiawah to the Kuwait Investment Corporation, and that group commissioned an extensive environmental inventory of Kiawah Island as the basis for a master plan for development. The environmental inventory was published in 1975, and contains a wealth of information about the state of our island in the latter part of the 20th century. That document is the subject of this review.

THE 1975 ENVIRONMENTAL STUDY

The 1975 Environmental Inventory of Kiawah Island was prepared for Coastal Shores, Inc. by the Environmental Research Center, Inc. of Columbia, SC. The Project Coordinator was W. David Chamberlain, and the Project Directors were William M. Campbell and John Mark Dean.

The introduction to the 1975 report states that "[The] document reflects 16 months of scientific inquiry into Kiawah Island. A broad multidisciplinary approach to the environmental inventory was selected in order to address the complex interrelationships of the existing ecosystems and to provide optimum information necessary for informed decision making. Thirteen disciplines, embracing subject matter from microscopic phytoplankton to prehistoric man, are represented in this report."

There are 13 sections in the 1975 report. In the order in which they appear in the report, they are:

- Geology and Coastal Processes
- Dune and Marsh Vegetation
- Forest Ecology
- Climatology
- Ornithology
- Mammalogy
- Herpetology
- Loggerhead turtles
- Water Quality and Microbiology
- Phytoplankton
- Macrobenthic Community
- Nektonic Community
- Archaeology

A summary of the 1975 report, as given in its introduction, is attached to this document as Appendix I.

Reviewing the 1975 Report

The membership of the Environmental Science Committee of the Kiawah Conservancy includes island residents and employees of both the Town of Kiawah Island (ToKI), and the Community Association (KICA). Committee members read and then reported to the Committee on eight of the 13 sections. Our objectives were to:

- Inform the Conservancy and thereby the Kiawah community about the information in the report.
- Describe the state of the island's environment in 1975 and compare it with today's environment. There are several important, general questions to pursue.
 - What aspects of the Island's habitat have improved? Has there been deterioration?

- Authors of 1975 Report
John Mark Dean
www.baruch.sc.edu/faculty/dean.shtml
W. David Chamberlain
 (deceased) Wrote a well-known birding guide for this part of the U.S.

- What aspects of our development and management practices have worked and where can improvements be made?
- What are the significant problems and challenges for our habitat health (such as climate change)?
- Look for important topics or areas that were not covered or that were only briefly covered in the original report. (One example would be the nearby hummock islands.)
- Identify areas that would profit by research going forward.
- Search for information that would be most worth communicating to island residents through articles in *Naturally Kiawah* or in the *Conservation Matters* forums.
- Bring together in one report information on Kiawah's natural environment with information from other relevant sources.

The eight sections of the 1975 report that have been reviewed, and the reviewers, are:

Section Title	Reviewer
Coastal Processes and Geomorphology	Richard Ames, KIC Board member
Climatology	Richard Ames, KIC Board member
Mammalogy	James Jordan, Town of Kiawah Island
Ornithology	Aaron Given, Town of Kiawah Island
Loggerhead Turtles	Pamela Cohen, KIC Board member
Herpetology	Nick Boehm, Kiawah Island Resort
Dune and Marsh Vegetation	David Achey, KICA
Forest Ecology	David Achey, KICA

In addition, James Chitwood, the former chair of the Environmental Science Committee added information and a number of comments.

The remainder of this document is a summary of those reports.

Preparation of the Report

This report was prepared by the Environmental Science Committee of the Kiawah Island Conservancy. Members of the committee include members of the board of the Conservancy plus wildlife specialists working for the Town of Kiawah Island, the Kiawah Island Community Association, and the Kiawah Island Resort. It is important to note that this was a collaborative effort on the part of a number of people and organizations on the island.

Finally, the report was prepared by John Kotz, chair of the Environmental Science Committee of the Kiawah Conservancy, in March 2014.



COASTAL PROCESSES AND GEOMORPHOLOGY

The 1975 Report

The purposes of the 1975 study in this area were:

- to describe and define basic landforms of the Kiawah coast and principal coastal processes that formed the coast.
- to produce detailed maps of geomorphological environments of the island (dunes, dune ridges, spits, beaches and marshes).
- to determine the history of erosion and deposition of sediments.

To fulfill these objectives, the researchers evaluated historical records from 1661 to 1973 and produced detailed maps and surveys of selected areas.

The main conclusions presented in the report are as follows:

- Kiawah Island is one of a few barrier islands in South Carolina that is presently undergoing rapid deposition.
- During the past century the island built seaward at annual average of tens of feet.
- The southern boundary of Cougar Island was the shoreline during the Civil War. This shoreline has prograded 2500 feet southwards during the last century.
- Most of Kiawah Island was deposited in the last 3000 – 4000 years.
- Neighboring Folly and Morris Islands show extensive erosion during the last 100 years.
- Charleston Harbor changes in the late 1870s were a major contributor to the erosion of Morris and Folly Islands and the deposition of sand on Kiawah Island.
- Sand eroded from Morris and Folly Islands migrated southward, accumulating at Stono Inlet.
 - Coastal processes (waves, currents, storms) transport sand from these shoals to be deposited along the Kiawah coast.
 - It is possible that this source of sediment will be depleted during future years. However, a major reversal in present depositional trend is not expected within the next 50 years (that is, before 2025).

- The east end of Kiawah Island and the west end of Seabrook Island are extremely unstable (subject to rapid changes in erosion and deposition), largely related to adjacent tidal deltas affiliated with the Stono and North Edisto rivers.
- Kiawah River spit (Captain Sam's) was also considered unstable and had over washed several times by storms.
- The middle of Kiawah Island is relatively stable.

Information on the Beach from Other Sources

Following a major beach renourishment program in 2006, the *2006 East End Beach Restoration Report* was issued and has provided additional information.

- Kiawah Island continues to be one of the healthiest barrier islands on the South Carolina coast.
- Two large Stono River shoal bypassing events in 1994 and 1997 attached significant volumes of sand to the eastern end of Kiawah Island. A new beach line and dune system formed 2000 feet seaward of the original shoreline.
- Sand forced to migrate westward by current and wave action formed a new barrier island/marsh/lagoon environment flushed by a channel at the western end.
- Changes to wave action and the migrating flushing channel caused erosion at Ocean Course of 500 feet, leading to the beach restoration plan of 2005.
- Kiawah Island is stable to slightly erosional along West Beach. Other sections of the beach are accretional.

Several *Local Comprehensive Beach Management Plans* for Kiawah Island have been published by the Town of Kiawah Island. The first was in 1996, and the most recent extensive report was in 2012. The important conclusion of the 2012 report was that "Kiawah Island has a very healthy beach that requires very little management or manipulation to maintain. ... Kiawah's main issues are dog management, beach walkover maintenance, and protection of critical wildlife habitat areas."

Many other useful and interesting insights into the Kiawah beach environment can be found in the 2012 report.

- (Page 3) South Carolina beaches and barrier islands differ greatly from North Carolina and Florida beaches. South Carolina's higher tidal range (averaging 5.4 feet in Charleston, but exceeding 8 feet during some new moon periods), lower average wave heights, and finer sand all contribute to our coast's unique character. ... [There] is probably more sand trapped in inlets south of Charleston than exists above the low-tide line of every barrier island in the region.
- (Page 5) Kiawah's consistent seaward growth this century is remarkable, especially considering many of its neighbors to the north and south have eroded. The shoals of Stono Inlet are responsible for this.
- (Page 7) Along the coast of Kiawah Island, wave direction varies with the seasons. In the summer months, waves generally approach the shore from the southwest, while in the winter, waves approach from the northeast. This means that sand generally moves to the east in the summer and to the west in the winter.
- (Section 5.1.2) In general, Kiawah is one of the most stable barrier islands in the state, although the eastern and western ends of the island are more dynamic due to their proximity to inlets. The long term erosion rate at Captain Sam's Inlet shows the shoreline is accreting at 8.5 ft/yr. The erosion rates around the unstabilized erosion zone at Stono Inlet range from 0.92 ft/yr to 19.46 ft/yr. This wide variation is a perfect example of how dynamic these inlets are.
- The Town of Kiawah Island has conducted one beach renourishment project in its history (2006). Due to the healthy nature of Kiawah's beach, there are no plans to renourish the beach at any time, barring a natural disaster.

- 2012 Beach Management Plan. This plan is available from the Town website at: www.wildlifeatkiawah.com/linked/2012beachmanagementplanweb.pdf

The 2012 report should be consulted for detailed information on the beach.

The 2012 Beach Management plan mentions the instability of the beach at the eastern end of the island. Some significant scarping of the beach in that area occurred in the fall of 2013, and this bears watching. (See *Kiawah Island Talk*, Issue No. 236, December 2013/January 2014.)



Beach scarping at the east end of Kiawah.
Photo taken December 3, 2013 at 11 AM on the falling tide.

Recommendation for Potential Research

Based on our reading of the 1975 report, and further information from 2006, the Environmental Science Committee would recommend continued periodic monitoring and study of the coastline, including the sand shoals east of Kiawah (which are the main source of sand for continued deposition along the Kiawah beaches).



CLIMATOLOGY

The 1975 Environmental Report

The weather information in the 1975 report was not collected on Kiawah Island. Interpretations were based on measurements from National Weather Service stations at Charleston and Beaufort, SC.

Temperature

- Mean annual temperature on Kiawah is 66 °F.
- Average high temperature is 81 °F in July.
- Average low temperature is 49 °F in February.
- Standard deviation from average monthly annual mean of 12 °F.
- Nighttime low temperatures fall below 32 °F no more than 19 times during a typical year – usually in December and February.
- Daytime highs exceed 90 °F 31 days each year, primarily in July.
- The growing season averages 295 days.

Humidity

- Kiawah Island experiences high relative humidity (owing to its proximity to the ocean and the number of ponds on the island).
- Annual mean value is 73.5% with a standard deviation of 12.5%

Weather Systems

- Kiawah is influenced greatly by frontal systems propagating across the U. S. from west to east.
- Summertime high pressure along the eastern seaboard dominates Kiawah weather with winds blowing in a southerly direction.

Air Stagnation

- Rare

Thunderstorms

- Afternoon thunderstorms particularly in June, July and August cause high winds, rain and, infrequently, tornados.

Winds

- Winter winds primarily blow from the northwest.
- March – August winds are primarily from south.
- September – December winds shift gradually from out of the northeast to blowing from the west.

Rainfall

- Annual average of 49 inches.
- Greatest during summer.
- Locally highly variable.

Tropical Cyclones

- From 1686 to 1972 South Carolina was adversely affected by tropical storms or hurricanes 169 times.
- It is unusual for tropical storms/hurricanes to make landfall along the South Carolina coast.
- Hurricanes approaching the South Carolina coast from the Atlantic side could be a major threat to Kiawah Island.
- A tropical cyclone making landfall to the southwest of Kiawah would cause the greatest damage, particularly if landfall occurred during high tide.

During the 1975 study only limited data was collected (on July 2 – 3, 1975) from three stations on the west side of the island.

Changes Since 1975

Hurricanes and Tropical Storms

Hurricane Hugo struck Charleston as a Category 4 storm on 21 September, 1989. Storm surge and rough tides caused extensive damage, especially in Charleston County. The highest storm surge observation was 20.2 feet (6.2 m) at Seewee Bay near McClellanville.

Weather Stations on Kiawah

There are now three weather stations on Kiawah Island measuring and reporting temperature, dew point, humidity, wind speed, wind gust, pressure and precipitation.

- Cougar Point Golf Course:
www.weather.com/weather/hourbyhour/graph/1036379:5
- KICA Maintenance (from 1 May, 2006):
www.kica.us/weatherstation/Current_Vantage_Pro_PlusKICA.htm

- Mingo Point (from 30 August, 2011):
www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KSCKIAWA3

The Beach, Marshes, and Climate Change

Most people in science agree that we are beginning to see the effects of a profound change in climate that may bring other consequences. Several recent articles point to this problem.

On November 26, 2013, an article titled "This is the impact of your climate change" (by Sammy Fretwell) was published on the front page of *The Post and Courier*.

Chunks of seashore are vanishing from South Carolina's Cape Romain National Wildlife Refuge as rising ocean levels and storms chew up the remote, unspoiled beaches some animals depend on for survival. It's a trend threatening the future of rare sea turtles and birds that frequent the shores of Cape Romain's barrier islands — and there's little indication the erosion will stop anytime soon, federal officials say.

During the past 25 years, erosion has claimed about 1,200 acres from four primary barrier islands in the nature preserve north of Charleston, according to statistics provided last week by the Fish and Wildlife Service.

Those include Bulls Island, the refuge's signature land formation, which drew national attention last week as U.S. Interior Secretary Sally Jewell toured the island's eroding Boneyard Beach.

But even more erosion is on the way as sea levels are expected to rise up to 5 feet in the Southeast by the end of this century.

On November 18, 2013 *The Post and Courier* published another article (by Bo Petersen) titled "Climate change drives plants, animals north."

Plants spread and animals move. They always have. But what's happening now is an entire ecosystem is starting to move. Bit by bit, white shrimp are making up more of the catch than brown shrimp in the Lowcountry, as the browns move farther north. Fewer purple finches are seen. Saw palmetto, which grows berries mostly in Florida, is starting to grow berries more abundantly farther north.

Species after species is moving because the air, land and sea are warming. And the Lowcountry — the farthest north reach of sub-tropical climate on the East Coast — could see changes more quickly and more severe than other areas.

"Right there on the cusp of (species) ranges," said Elizabeth Fly, National Oceanic and Atmospheric Administration biologist who studies changing climate on economically and ecologically important coastal marine species. "We're going to see increasing temperatures and shifting species distribution."

Finally, in August 2013 the premier scientific journal *Science* published an issue on "Natural Systems in Changing Climates." One article is particularly important to us on Kiawah Island: "Can Coastal Marshes Rise Above It All?" (Eli Kintisch; Vol. 341, pages 480-481).

Although they're not the most glamorous biomes, the United Nations estimates that wetlands are one of the world's most valuable providers of "ecosystem services," such as storm protection, water filtering, and seafood production. They also help lock up as much as 450 billion metric tons of carbon globally, absorbing warming compounds that might otherwise leak into the atmosphere.

Recommendations for Possible Research

- Analyze historical weather station data from Kiawah Island and other local sources. The objective is to learn how the climate of Kiawah Island differs from Charleston and Beaufort and surrounding areas where weather has been monitored since 1975.
- Investigate local temperature trends to determine if there is a statistically significant warming trend (possible evidence of global warming).
- Study the effects of climate change on species distribution, migration timing and patterns, coastal habitats and ecology, and so on.



MAMMALS

The 1975 Environmental Report

The purposes of the 1975 study of mammals (titled "Mammalogy") were:

- to inventory mammalian species on Kiawah by habitat.
- to identify potential effects of development on mammals.
- to identify and quantify mammals likely to present management problems in the future.

- For much more current information on mammals at Kiawah, see www.wildlifeatkiawah.com/

Their approach to the study of mammals was first to evaluate the historical records from 1664 to 1965. They also made surveys and observations amounting to 79 field days and 12 nights across five main habitat types. These included:

- Observations of mammals and mammal signs
- Mouse and rat snap traps; Sherman live traps
- Mole traps
- Cage traps
- Mist nets
- Shooting

The results of the 1975 study included the following:

- There were 5996 trapnights with 296 mammals captured.
- The highest trapping success for small mammals was in the Vanderhorst mansion and an old field near Cougar Island.
- There were hundreds of observations of deer, hogs, raccoon, opossum, Eastern mole, gray squirrel, and rabbits (marsh and cottontail).
- The most abundant mammals trapped, *by habitat*, were
 - Dunes: house mouse, cotton rat, raccoon, least shrew, and opossum.
 - Pine-palmetto-oak woodlands: cotton mice, opossum, raccoon, least shrew, wood rat.
 - Dykes and cheniers: rice rat, least shrew, cotton rat, cotton mouse. (*Ed Note: A chenier is a "sandy or shelly beach ridge."*)

- Marsh and pond edges: wood rat, cotton rat, cotton mice, rice rat, least shrew
- Open fields: cotton rat, least shrew, rice rat, house mouse

Conclusions, organized by habitat type

- Dunes
 - House mice were only captured in dune areas (an exotic species).
 - Hogs were causing substantial damage and should be removed.
 - Control of raccoons will likely be necessary to protect sea turtle nests.
- Woodlands
 - Thick overstory has decreased light to the understory and the understory is sparse.
 - Populations of mammals are low with the exception of the gray squirrel and possibly the least shrew and Eastern mole.
- Marsh-pond edges and dyke-chenier
 - This is the most productive habitat for mammals.
 - The east end of the island has the majority of this habitat and is a critical area for management considerations.
- Open fields
 - This was a small percentage of the total habitat.
 - Many small mammals were found in this habitat (and provide food for predators).
 - Fields provide a vital transition zone between woodlands and open areas.

General Conclusions Regarding Mammals

- Deer, hogs, raccoons, gray squirrel, cotton rat, cotton mouse, house mouse, and Eastern mole are considered abundant and will adapt readily to development.
- The primary concern for mammals is adequate cover, both in quality and quantity.
- Raccoons and opossums require travel lanes 10 meters wide as well as pockets of cover for resting and feeding.
- Deer require wider travel lanes (10-30 meters).
- Edge is very important to all mammals but mixing of habitat types is good.
- Bobcats are likely restricted to the woodlands on the western end of the island. (*Ed note: notice the difference with current bobcat range.*)
- Fox populations are listed as very sparse; there were no observations in this study.
- River otter and mink were present but very sparse.
- Wild hogs and goats should be removed from the island.

Changes Since 1975

- Bobcats are now abundant across all habitat types on the island.
- Gray fox populations are abundant at times but very cyclical.
- Coyotes are present and their management has become an issue.
- No fox squirrels are observed.
- Hogs and goats were indeed removed.
- Norway rats, black rats, and white-footed mice (as well as other exotic species) are now present.

List of Mammals Sorted by Abundance (1975)*

Mammal	Abundance	Mammal	Abundance
Gray squirrel	Very abundant	Mexican freetail bat	Common
Cotton mouse	Very abundant	Eastern cottontail	Common
Hispid cotton rat	Very abundant	Marsh rabbit	Common
Eastern mole	Abundant	Eastern woodrat	Common
Raccoon	Abundant	Southern flying squirrel	Probably common
Feral hog*	Abundant	Bobcat	Fairly common
White-tailed deer	Abundant	Fox squirrel	Uncommon
Virginia opossum	Very common	Gray fox	Uncommon
Least shrew	Very common	Mink	Uncommon
House mouse	Very common	River otter	Uncommon
Shorttailed shrew	Common	Rice rat	n/a
Red bat	Common		

* Two mammals (longtailed weasel and pine vol) were likely on Kiawah but there were no confirmed sightings. Other mammals that were possible: Long-nosed shrew, star-nosed mole, Norway rat, Eastern harvest mouse, golden mouse, and black rat. There no feral hogs presently on the island.

Information on Kiawah Mammals from Other Sources

An excellent source of information on mammals on Kiawah Island is on the Town website: www.wildlifeatkiawah.com/mammals.html. There you will find information on

• **Mammals on Kiawah**
www.wildlifeatkiawah.com/mammals.html

Bobcat	White-tailed deer	Gray & red fox	Dolphins
Opossum	Raccoon	River otter	Mink
Coyote	Gray squirrel	Eastern cottontail rabbit	Southern flying squirrel

Bobcats

In August 2008, the Town of Kiawah Island issued a document on *Bobcat Conservation on Kiawah Island*. The following is the introduction to that document:

"Bobcats (*Lynx rufus*) are the top mammalian predator on Kiawah Island and are primarily responsible for the population regulation of many species on Kiawah, including white-tailed deer (*Odocoileus virginianus*). Based on scent station surveys initiated in 1997, the bobcat population on Kiawah Island has remained stable over the last 11 years with population estimates ranging from 26-35 animals. This population likely consists of 8-10 adult females, 4-5 adult males, with the remainder being juveniles of both sexes.

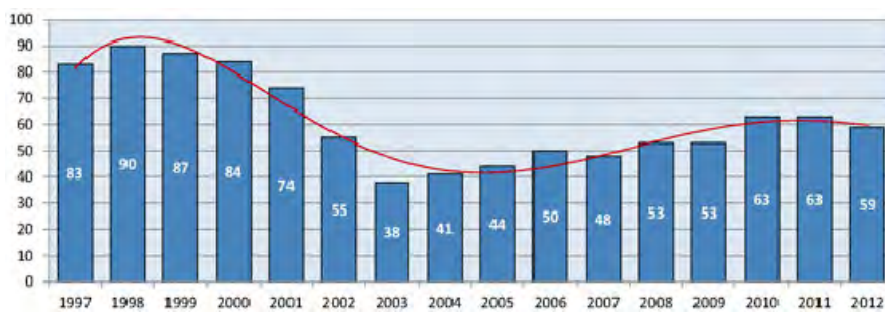
Bobcats serve as an ideal "umbrella species" for Kiawah Island. An umbrella species is a species that typically requires large amounts of habitat and the conservation of this species in turn benefits other species that utilize the same habitat areas. So, if bobcats have enough habitat and resources to survive on Kiawah, then most other island wildlife species will have the necessary space and resources as well. Over the past decade, 3 separate multi-year studies have focused on gaining a better understanding of bobcats and their habitat, as well as their resource requirements on Kiawah Island. Research is ongoing, and we continue

to refine our understanding of the unique relationship between bobcats, habitat, and humans."

There is also extensive information on the bobcats now on Kiawah at the Town of Kiawah Island website: www.wildlifeatkiawah.com/bobcats.html. At the end of 2013 there were approximately 30 bobcats on the island. (This is more than double the typical density in mainland South Carolina.) Six of these have GPS collars that are reporting their position (which can be observed on the website above). (Three others were captured but not collared as they were too small to wear a GPS collar.)

Deer

As in so many suburban areas, the deer population is high. (The density in 2013 is 54 per square mile.) However, their population (currently about 500) has become more stable through a combination of factors: (a) bobcats take a large number of fawns in the summer months, (b) about 20 a year are killed after being hit by an automobile, and (c) alligators occasionally feed on fawns and adult deer.



Deer density (deer per square mile) on Kiawah Island
(from www.wildlifeatkiawah.com)

Coyotes

Coyotes have spread eastward in the U. S., and there are now sightings on Kiawah. In 2013, one coyote was trapped and fitted with a GPS collar. Locations of sightings can be seen on the website www.wildlifeatkiawah.com/coyotesightings.html. Also in 2013, at least one coyote was the cause of serious sea turtle nest predation.

In February 2014, Jim Jordan, Town of Kiawah Island biologist, wrote the following:

Coyotes on Kiawah Island

Coyotes first appeared on Kiawah Island more than 5 years ago and numbers have slowly increased since that time. Coyotes are not native to South Carolina and historically were found only west of the Mississippi River. Coyotes were first reported in the Upstate of South Carolina in 1978 and can now be found in all 46 South Carolina counties. Although some coyotes were brought to our state by fox hunters, most of our coyotes arrived here on their own as they expanded their range eastward. Historically, the native red wolf (now endangered) roamed the entire southeast, but habitat change and persecution eliminated red wolves from our state by the early 1900's. This created a void for a medium-sized canid to exploit, and coyotes have done just that.

Coyotes are typically grayish or reddish-brown in color and have the general appearance of a small shepherd-type dog. They have slim muzzles, erect pointed ears, and a bushy tail. They stand 23-26 inches high at the shoulder and weigh between 25-40 pounds. Contrary to popular belief, coyotes do not typically form packs. They are usually solitary or can be found in pairs. A group of coyotes, larger than 2, is likely a family group in which the

- For websites that describe coyote management, see
 - a) Coyotes in an urban environment: coyotecoexistence.com
 - b) South Carolina Department of Natural Resources site that emphasizes more the control of coyotes: www.dnr.sc.gov/wildlife/coyote/

See also the excellent book on management of coyotes in the urban environment: *Suburban Howls*, J. G. Way, Dog Ear Publishing, 2012.

young have not yet dispersed. Coyotes are omnivorous and will eat a wide variety of prey items, including: muscadine grapes, acorns, persimmons, rodents, rabbits, and deer fawns.

Coyotes and People

Coyotes are not a threat to people. Coyotes have a natural fear of people and will not approach people unless they have been accustomed to being fed. Residents should never feed coyotes or leave pet food outdoors after dark.

Coyotes and Pets

On rare occasions, coyotes will prey on unattended domestic pets. Pet predation is usually due to the territorial nature of the coyote or a lack of available prey. Keep unattended pets indoors after dark. In the unlikely event that you encounter a coyote while walking your dog, you should make plenty of noise and raise your arms to be sure the coyote is aware of your presence. You should also keep your leashed pet as close to you as possible or pick up your pet if it is small enough to easily do so.

Coyote Monitoring

Town Biologists have been monitoring the island's coyote population since 2009. Efforts are focused in 3 main areas as detailed below.

1. Monitor abundance and distribution on the island using sightings from residents and visitors. Please report all coyote sightings by sending an email to coyote@wildlifeatkiawah.com.
2. Monitor any and all human/coyote or pet/coyote conflicts that may arise.
3. Monitor any negative impacts to other wildlife species (bobcats, sea turtles, nesting shorebirds, etc.)

Coyote Research

Town Biologists are currently monitoring habitat use and behavior of coyotes using GPS collars. This research provides detailed data on the type of habitat coyotes are using, movement patterns, food sources, and much more. Learning as much as we can about this new arrival is vital to developing a long-term management program for the species if and when it becomes necessary. One male coyote was collared during 2013 and he spent the majority of his time in undeveloped areas on the eastern end of the island. Biologists hope to collar 2 more coyotes in early 2014.

Coyote Management

In a perfect world, we would remove all the coyotes from the island. Unfortunately, this is not a viable option. Coyotes are very intelligent and difficult to trap or shoot and it would be impossible to eradicate them from the island. In addition, the wholesale killing of coyotes simply causes them to produce more offspring and voids are quickly filled by coyotes from adjacent areas.

The current management strategy is to monitor problems and respond specifically to these problems if and when they arise. For example, if coyotes begin to depredate lots of sea turtle nests, we would develop a program to mitigate the issue. This program might include special screens for nests, night patrols to locate and protect nests before depredation occurs, and even shooting or trapping (in specific problem areas).

On February 24, 2014, the Charleston *Post & Courier* posted on its website an article titled "Sullivan's weighs state advice on managing coyotes." The first few lines of the article were:

"Attempting to get rid of all the coyotes here by trapping or shooting them is not a practical solution, a state wildlife official said. Even if such measures were successful, it wouldn't be long before more coyotes moved onto the island from elsewhere, said Emily Cope, deputy director for the Wildlife and Freshwater Fisheries Division of the state Department of Natural Resources. Instead of widespread trapping or shooting, she suggested focusing on coyote problems as they arise at specific island locations. 'I think from the town's perspective, targeting only the problem areas will be more desirable,' she said."

- For the *Post & Courier* article, see <http://www.postandcourier.com/article/20140224/PC16/140229680/1009/sullivans-weighs-state-advice-on-managing-coyotes&source=RSS>

Recommendations and Possible Research

The following are areas for future research:

- Monitor the presence and activities of coyotes. Develop a management plan.
- Be vigilant about the introduction (or reintroduction) of invasive species such as the armadillo and feral hogs.
- There is very little information on bats in the 1975 survey, and it is likely that there are species other than the ones listed in that survey.
- Consider the reintroduction of the fox squirrel.
- A study of small mammals in general was done as part of Bobcat Research in 2003-2004. This study should be continued and expanded.



ORNITHOLOGY

According to Aaron Given, the ornithologist employed by the Town, over 250 species of birds visit Kiawah over the period of a year. We are very fortunate in having an environment that is unique in supporting shorebirds, wading birds, and birds that frequent forests and grasslands.

• For much more current information on birds at Kiawah, see www.wildlifeatkiawah.com/

The 1975 Environmental Report

The purpose of the study was to determine the status and distribution of birdlife on Kiawah Island.

METHODOLOGY

- The time period was 13 months (June 1974 – July 1975).
- A literature review consisted of a search of records relevant to Kiawah.
- The team conducted a sample survey early in the morning in each habitat.
- No formal survey method was mentioned in the report.
- No quantitative data were obtained (with the exception to some waterfowl numbers).
- Special attention was devoted to critical areas and rare, endangered, and unique species.

Results and Conclusions

For purposes of organization, six major habitats were identified, and the results are given for those habitats.

- I. *Front Beach (not included in the acreage total)*
 - i. 47 species recorded.
 - ii. Stono River Inlet and Captain Sam's Inlet are major resting areas for large numbers of terns, gulls, and pelicans.
 - iii. Kiawah's location in relation to Deveaux Bank and Bird Key is a major contributing factor to the high use.
 - iv. We should limit human disturbance.

2. *Sand Dunes (2% of the area covered)*
 - i. 28 species recorded.
 - ii. Least Tern, American Oystercatcher, and Wilson's Plover nest here.
 - a) Majority of nesting occurred on Captain Sam's Spit.
 - b) 1 pair of Oystercatchers, 3 pairs of Wilson's Plovers, 2 colonies of Least Terns were observed.
 - c) Wash-over, wind, and predation cause poor reproductive success.
 - iii. Other breeding birds included common ground-dove, willet, Eastern meadowlark (no longer seen on Kiawah), redwinged blackbird, and painted bunting.
 - iv. Ipswich sparrow (rare subspecies of the savannah sparrow) winters in the dunes.
 - v. Human disturbance is a critical factor that can have an adverse impact for bird species.

3. *Maritime Forest (34% of the area covered)*
 - i. 65 species recorded.
 - ii. A tendency to overlook the importance of undisturbed maritime forest.
 - iii. This is the most desirable property for development, so population declines can be expected.
 - iv. Most damaging practice is the reduction of understory and is linked to the declines of several songbird species (i.e. Carolina Wren and White-eyed Vireo).

4. *Brackish ponds*

The list of ponds surveyed in 1975 is as follows:

1. Ibis	7. Sparrow
2. Pintail	8. Bass
3. Egret	9. Rookery
4. Bufflehead	10. Heron
5. Canvasback	11. Falcon
6. Willet	12. Blue Heron

 - i. 69 species recorded
 - ii. Drawdowns in water levels concentrated birdlife.
 - iii. Rookery Pond (2.4 acre). (*Ed note: we are not certain where this pond is or if it still exists.*)
 - a) Nesting confined to swamp willows
 - b) Seven species nested:
 1. Cattle Egret (50 nests)
 2. Great Egret (7 nests)
 3. Little Blue Heron (LBHE), tri-colored heron (TCHE), and snowy egret (SNEG).
(~50 nests total between SNEG, TCHE, and LBHE)
 4. Green Heron (5 nests)
 5. Anhinga (5 nests)
 - c) Need to protect the rookery from human disturbance.
 - iv. Waterfowl Usage
 - a) Reported heavy use of waterfowl in winter.
 - b) Waterfowl usage depends on pond size, salinity, cover, and disturbance.
 - c) Development of Kiawah will result in the creation of adverse conditions for the majority of the wintering waterfowl population.
 - d) Maintain marginal vegetation around ponds.
 - e) Seasonal water level control at Ibis and Bass Pond

5. *Seral Area*
 - i. Old fields, pastures, road edges, etc.
 - ii. 32 species recorded
6. *Tidal marsh and creeks*
 - i. Biologically, the most productive area
 - ii. 70 species recorded

Birds Encountered During the Study

- See the extensive annotated list in the 1975 report.
- 165 species were encountered during the study.
- Rare birds observed: Fulvous Whistling Duck (1), Black Rail (1), Roseate Spoonbill, Osprey (1 pair?), Peregrine Falcon (1), Sooty Tern (1), Great Black-back Gull (2), Wood Stork (several)

CHANGES SINCE 1975

- We believe Rookery Pond no longer exists (or at least is not in the state it was in 1975).
- The pond system has changed dramatically since 1975.
- Cattle egrets were once common and nested in the Rookery Pond.
- Ducks were much more common than they are now and there was a greater diversity of species including Black Duck, Mallard, Northern Shoveler, and Wood Duck.
- Cooper's Hawk was rare on Kiawah. It is now fairly common.
- Northern Bobwhite used to be common. No longer observed on Kiawah.
- Wilson's Plovers numbers have increased since 1975.
- Red Knots: Flocks of several hundred are commonly observed during migration in March-May.
- Black-necked Stilt was rare, but now a fairly common but localized breeder.
- Yellow-billed Cuckoo: breeding numbers appear to have declined.
- Belted Kingfishers used to nest in the dead palmettos trees lining the ponds.
- Yellow-bellied Sapsucker was not recorded during the study, but is now a common winter resident.
- Loggerhead Shrike was only found once during the 1975 study. There are now at least several nesting pairs.
- Red-eyed Vireo used to be a common breeding bird. Probably does not breed here anymore.
- The Prairie Warbler used to breed in the seral areas and myrtle thickets around Sandy Point. No longer considered a breeder.
- Yellow-breasted Chat was fairly common breeder. No longer considered a breeder.
- Hooded Warbler was a fairly common breeder in the maritime forest. Does not breed here anymore.
- Eastern Meadowlark used to breed in the seral areas and grassland areas of Captain Sam's Spit. No longer breeds here.

Information on Birds of Kiawah Island from Other Sources

The *2012 Local Comprehensive Beach Management Plan* for Kiawah Island was noted in the section on the beach. This report also included significant comments on threatened or endangered birds.

Species	Federal Status	State Status	Habitat
Brown pelican	—	Species of concern	Beach
Wilson's plover	—	Threatened	Beach, dunes
Piping plover	Threatened	Threatened	Beach, dunes
Red knot	Candidate for listing	—	Beach
Least tern	—	Threatened	Beach

- 2012 Beach Management Plan. This plan is available from the Town website at: www.wildlifeatkiawah.com/linked/2012beachmanagementplanweb.pdf

Potential Research

Suggestions from the authors of the 1975 report:

- A study of the effect of development on wintering densities of waterfowl.
- A study of the effect of development on the density of songbirds.
- A thorough examination of Rookery Pond. (*Ed note: we believe this pond no longer exists.*)
- A study of the reproductive success, predation rates, and colony structure of Least Terns.

Suggestions from Aaron Given, Biologist, Town of Kiawah Island:

The authors noted that the *common ground dove* is a “Prime example of what happens when habitat is eliminated,” and that the “ground dove should serve as a good example of the level of awareness needed in development”. Therefore, it is recommended that we need a study of the bird's breeding ecology. There is generally a lack of information on the eastern population of this species. A study like this would transcend Kiawah and would be applicable to all barrier islands with similar habitat. Specifically, we need to study its reproductive success, home range, and habitat use.

Additional recommended studies are:

1. Least Tern Nesting: Provide nesting platforms in ponds, and fence off east end nesting area to exclude predators.
2. Wilson's Plover nesting biology.
3. Red Knot stopover ecology.
4. Expand the Marsh Sparrow project to include habitat analysis.
5. Continue fall migration bird banding.
6. Use hydrogen isotopes to study origins of migrating birds.



LOGGERHEAD TURTLES

1975 Environmental Report

Purpose of Study

- Study and collect data on loggerhead turtles (*Caretta caretta*) from 1972-1975.
- Confirm and document Kiawah Island as an established rookery.
- Determine geographic locations of nesting sites.
- Evaluate factors that influence nesting.

Methods of Study

- Total emergences of adult females were recorded daily during four nesting seasons (1972-1975).
- Topographical conditions, and meteorological events were noted.
- Females were tagged and documented during egg deposition, dry runs, and in-season returns.
- The beach was divided into 7 zones, and nesting concentrations were compared annually.
- Time of day and tidal conditions of emergences were graphed for 1974-1975.

Conclusions

- Kiawah beach is an important nesting location for the threatened species *Caretta caretta*.
- Two hundred adult females were estimated to be present each year of the study.
- Concentration and egg deposition is subject to sand structure, artificial lighting, and human activity.
- Most nesting occurs after dark from 9 PM to 1 AM.
- Nesting season begins in May and continues until mid August with highest concentrations in June and July.
- Most active emergences are recorded after a new or full moon with prevalent flood tides.

- The Loggerhead Sea Turtle, *Caretta Caretta*, was designated as the official reptile of the State of South Carolina by the General Assembly on June 1, 1988, by Act No. 588.

- Information on sea turtle conservation is at:
 - seaturtle.org
 - www.wildlifeatkiawah.com/loggerhead.html

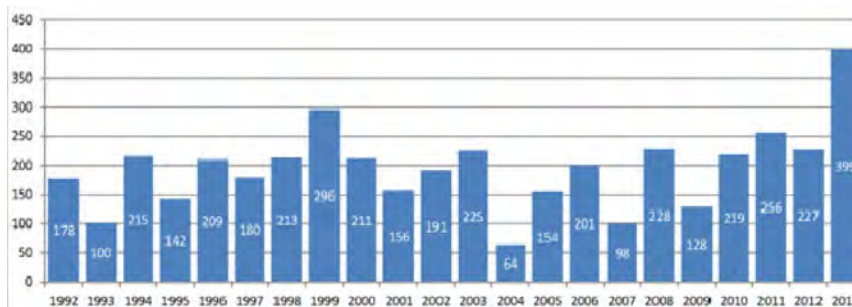
- Preservation of beach habitat is necessary for successful nesting.
- Excessive rainfall causes destruction of nests.
- Serious predation by raccoons is detrimental and requires attention.
- Highest density of nests was located on beach zones with densely vegetated dunes, conducive topography, and areas devoid of human presence
- Lowest density of nests exists in areas with beachfront homes.

Suggestions and Assumptions of the Report's Authors

- Methods for increasing viable hatchlings in the future:
 - a) Control the raccoon population
 - b) Provide an indoor hatchery
- Problems exist that may interfere with Kiawah's population of loggerheads. It is postulated that loss of nesting habitat, predation, and off-shore adult mortality may cause a great decline of future populations.

Information on Turtles of Kiawah Island from Other Sources

The loggerhead sea turtle is listed as a threatened species by the U. S. Fish and Wildlife Service and by the South Carolina Department of Natural Resources. Nonetheless, Kiawah Island had an excellent nesting season in 2013, with 403 nests on the beach. A plot of nests by year (www.wildlifeatkiawah.com/loggerhead.html) shows there is a trend toward more nests in the last decade. We average about 150 nests per season.



Loggerhead turtle nesting on Kiawah Island

Information about Kiawah Island and the loggerhead turtle is also found in the 2012 Beach Management document:

A program to protect the nests of loggerhead turtles on the beach of Kiawah Island has been in operation since 1973. In the early years, support came from the Kiawah Island Community Association (KICA) and the island developers, but since 1990, the Town of Kiawah Island has provided funding for the program. Beginning in 1998, the turtle program has operated under a permit from the South Carolina Department of Natural Resources under authority granted through Cooperative Agreements with the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) under Section 6 of the Endangered Species Act.

Historic records show that the Kiawah beach is an important site for loggerhead turtle nesting, with a density of eighteen to twenty nests per mile. This rate is among the highest in the state for developed areas. Nesting turtles showed some preference for the undeveloped east end of the island before 1990, but that preference has diminished since then.

Another useful website for information on Kiawah loggerhead turtle is seaturtle.org. (See specifically: www.seaturtle.org/nestdb/index.shtml?view_beach=54). As of October 26, 2013, the following information is given for Kiawah:

Loggerhead Turtle Data (2013)*

Topic	Number
Unique females	143
Nests	399
Estimated eggs	42930
Hatched eggs	31421
Emerged hatchlings	28544
Mean incubation duration	57.4 days
Mean hatch success	72.8%
Mean emergence success	65.1%
Nest success	92.6%
Beach success	66.9%

* www.seaturtle.org/nestdb/index.shtml?view_beach=54

One very interesting feature of the 2013 data is that the most significant reason for nest and egg loss was thought to be coyote predation.

The *leatherback sea turtle* is the only federally "endangered" species that occurs on the Kiawah Island beach. According to the *2012 Beach Management Plan*, "South Carolina has had 20 nests in the last 10 years (2003-2012), two of which were on Kiawah Island. Leatherback nests that occur on Kiawah's beach are marked and monitored by the Kiawah Island Turtle Patrol, following the same general protocol used for loggerheads."

Reviewer Comments on the 1975 Report:

- Some of the conclusions are not based on efficient quantitative biological data.
- The study is devoid of predator counts, egg counts in nests, and hatchling release data.
- An accurate sampling of rainfall in August 1974 was not gathered. This caused 100% mortality to nests that did not hatch before the copious rainfall.
- Although tagging of nests began in 1973, it was admitted that there was an improvement in turtle patrol techniques in 1974 & 1975. This resulted in a higher number of emergences recorded.
- The authors mention that nests were transported to a hatchery. However, no information as to the location of a hatchery or any further history of the hatchlings was given.

Reviewer Suggestions for Future Research:

- Kiawah's all-volunteer Turtle Patrol is an important asset for turtle conservation and the acquisition of data. Their work needs continuing support from the Town and other island organizations.
- Habitat preservation must be a priority to preserve Kiawah's beach as a significant turtle rookery.

- Establishing an indoor turtle hatchery could benefit the Kiawah Island turtle population as well as provide a unique learning facility for residents and guests.
- To our knowledge there has not previously been a coyote population on Kiawah Island. However, they arrived a few years ago and there are now more sightings (see page 16 above). With their arrival turtle nest predation has occurred. (Significant turtle nest predation occurred in other parts of low country as coyotes moved onto the barrier islands.) A great deal now needs to be done to manage this problem. Among them the following:
 - a) More research into coyote behavior in an area that has not seen these predators before.
 - b) Turtle nest protection.



REPTILES AND AMPHIBIANS

The 1975 Environmental Report

- The purpose of the study was to obtain information on the abundance, distribution, population, and general ecology of reptiles and amphibians on Kiawah.
- According to historical records, most barrier islands such as Kiawah have about half the number of species of reptiles and amphibians as does the mainland.
- The collection period was from June 1974 to July 1975.

- Information on reptiles is at: www.wildlifeatkiawah.com/reptiles.html

Methods

- Researchers used baited hoop nets, minnow traps, pitfall traps, trot lines, tarpaper ground cover, seining, road collecting, and field collecting.
 - Each method came up with different results.
 - Hoop nets proved not to be useful because alligators kept trying to eat the bait and destroyed the traps.
- Seining was very successful, capturing everything including alligators.
- Drift fences and pitfall traps.
 - These were generally more successful for amphibians than reptiles.
 - High rain levels reduced the overall effectiveness of this method.
- Tarpaper sheets
 - Act as a ground cover, which many species of reptiles and amphibians use for hiding and cover.
- Hand/incidental collecting was the most effective method, yielding more species than any other method.

Individual and Species Results

Individual animals sampled:

- 1000 amphibians
- 200 snakes
- 100 lizards

- 50 freshwater turtles
- 200 alligators

Species Sampled

Of 100 known coastal mainland reptiles and amphibians, 30 were found.

- Frogs: 6 of 24 species
- Amphibians: 1 of 19 species of amphibians
- Lizards/skinks: 6 of 10 species of lizards
- Turtles: 2 of 10 species of turtles
 - Yellow bellied sliders have the only established population.
 - Shells of box and mud turtles were also found. (These have recently been seen on Kiawah.)
 - No snapping turtles were found on Kiawah, although they are common on the mainland.
 - Loggerhead turtles nest on the beach.
- Only one species of alligators exists on Kiawah. Over 100 were estimated to be on the island in 1975.
- Snakes: 14 of 35 species of snakes
 - The most common terrestrial snakes were the yellow rat snake and black racer.
 - The most common snake species overall were found near or around water: ribbon snakes, water moccasins, banded water snakes. Copperheads and canebrake rattle snakes were found but much less frequently than water moccasins.
 - Several species were found that were represented by only a few individuals: coachwhip, chain king (eastern king), corn snake, crown snake, garter snake, and scarlet king snake.

Occurrence by Habitat

The fact that Kiawah is relatively small provides easy mobilization between different habitats. Excess rain fall also plays a major roll in where species are found

- Open beach: none to speak of other than sea turtles.
- Salt marsh, tidal creeks, and brackish areas: Diamondback terrapin.
- Exposed dunes: Coachwhip snakes observed but not frequently seen.
- Maritime forests:
 - 5 amphibians and more than a dozen reptiles are commonly found in these forested areas. (Slimy salamanders are restricted to the moist forested areas.)
 - Skinks (braid-headed, five-lined, and ground) are found exclusively in these areas.
 - Many of the snake species are associated with the forested areas. These include king snakes, rat snakes, crown snakes, blackracers, copperheads, and canebrakes.
 - Due to the proximity of the forested areas to the ponds the following aquatic species were frequently encountered: ribbon snakes, banded water snakes, water moccasins, and American alligators.
- Freshwater ponds
 - Approximately 12 freshwater ponds exist on Kiawah.
 - Green tree frogs and leopard frogs are frequent, along with alligators and aquatic snakes (banded water snakes and water moccasins).

Ecology of species

Yellow bellied sliders

- Probably intolerant of higher salinities.

- Their enormous size was noteworthy. The North American record for a slider was found on Kiawah in 1975 having a plastron length of 284 mm.
 - The juveniles were even larger than average.
- The abnormally large size of the sliders raises two questions:
 - Is this "Island Gigantism"?
 - In most such cases it is associated with pollution, but Kiawah is very natural.
- Dr. Whit Gibbons later did some research on these turtles and found that their large size was due to an increase in food and a decrease in competition compared with mainland turtles.

American Alligator

- ~ 100 on the island based on periodic counts. (The number is now in the range of 400. See below.)
- They do occur in high salinity areas.
- Some of the 12 ponds had 50 or more individuals.
- Blue Heron Pond had a clutch of about 25.
- There is a rapid growth rate and successful reproduction throughout island.

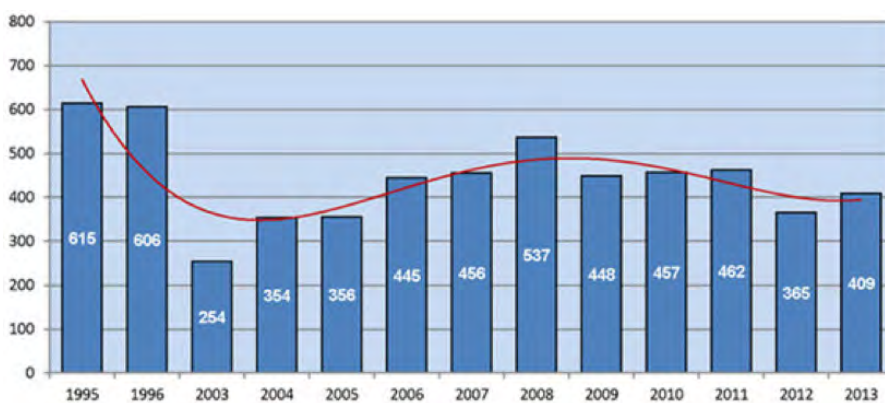
Development Consideration

- Alterations in the water level, salinity, and removal of buffer zones could lead to significant population effects.
- Land clearing and removal of essential organic litter and ground cover could have detrimental impacts to some species.

Information on Reptiles and Amphibians of Kiawah Island from Other Sources

The Town website (www.wildlifeatkiawah.com/alligator.html) has excellent information on our resident alligators:

Alligator spotlight surveys are conducted by Town biologists and KICA Lake Management staff each summer. Surveys are conducted for 2 nights along a predetermined route that includes most island ponds. The graph below shows the estimated number of alligators along the route each year. The red line shows the population trend.



Estimate of alligator population on Kiawah Island

In June 2012 Keith Hanson, a graduate student at the College of Charleston, issued a report on his research on glass lizards on Kiawah and included detailed recommendations for conserving herpetofaunal diversity. Among these were to:

- Hanson's report (Management Guidelines and Recommendations for Conserving Herpetofaunal Diversity) is available from the Kiawah Conservancy.

- Protect natural habitats/leave natural habitats undisturbed.
- Maintain and landscape with native plants.
- Reduce direct mortality (by, among other things, controlling pets, educating tourists and residents).
- Limit pesticide and fertilizer use.

Loggerhead and leatherback turtles are found in the ocean or the tidal rivers, but our brackish rivers and creeks support another turtle, the diamondback terrapin. This turtle has been internationally designated as a threatened species. According to the website wildlifeatkiawah.com,

The diamondback terrapin is Kiawah's only brackish water turtle. Terrapins are 5-8 inches long (females are twice as big as males) and weigh between 0.5 lbs and 1.5 lbs. These turtles get their name from the striking diamond-shaped pattern on their top shell. They are typically light brown or gray on top and yellow to olive on the bottom. Their whitish-gray skin is covered with unique black spots and wavy markings. Terrapins can live more than 20 years.

They feed primarily on snails, worms, fish, and crabs. In the marshes of Kiawah, terrapins eat mostly periwinkle snails and fiddler crabs.

Unfortunately, as reported by B. Petersen in the *Post & Courier* on October 7, 2013, there are declining numbers of these turtles in the creeks leading to the Kiawah River. One possible consequence of this decline could be an increase in the population of the marsh periwinkle snail, a prime food source for the diamondback terrapin.

- Summary of KI research on diamondback terrapins, ongoing since 1983. Includes links to several journal articles. www.bio.davidson.edu/dorcas/research/Terrapins/Malaclemysterrapin.htm
Also: <http://www.wildlifeatkiawah.com/terrapins.html>

Questions and Suggested Research

- Why are many of the mainland species not present despite having suitable habitat?
- What are the effects of competition and its removal?
- Population studies on the American Alligator
 - The alligator population has significantly increased from an estimated 200 individuals in 1975 to about 400 today.
 - Is this due to the increase in the number of ponds (from 10-15 ponds in 1975 to about 130 today)?
- What happened to all the cottonmouth moccasins and ribbon snakes?
 - Moccasins are a common food source for the American alligator. As the alligator population has increased, this could have an effect on the moccasin population.
 - Has there been a significant change in the freshwater systems?
 - In general, how has development affected the snake population?
- Continue observation of the diamondback terrapin and efforts for its preservation.

Reptiles and Amphibians on Kiawah Island

REPTILE		REPTILE	
TURTLES	Diamond back terrapin	SNAKES - non-venomous	Banded water
	Yellow bellied sliders		Ribbon
	Mud turtle		Black racer
	Box turtle		Coachwhip
	Loggerhead		Chain king
			Rough green
			Yellow rat
LIZARDS	Common glass lizards		Corn
	Carolina anole		Crowned
	Ground skink		Scarlet
	Broad-headed skink		
	Southeastern five-lined skink	SNAKES - venomous	Copperhead
	Six-lined race runner		Cottonmouth moccasin
			Canebrake rattle
CROCIDILIANS	American alligator		
FROGS	Southern toad		
	Green tree frog		
	Squirrel tree frog		
	Narrow-mouth toad		
	Spadefoot toad		
	Leopard frog		
SALAMANDER	Slimy		



FOREST COMMUNITIES OF KIAWAH ISLAND

Overview of the 1975 Report

At the center of Kiawah Island is a 3200 acre tract of high ground supporting maritime thickets and forests. The maritime forest is the most stable ecosystem on the island and frequently the community most conducive to habitation by both people and wildlife. Because of the extreme importance of these areas to the stability of the entire island, an analysis of the woody flora was conducted.

The 1975 study examined the species composition and distribution of the forests on Kiawah Island. Dissections of forest sections due to construction, roadways and clearing of understory plantings could cause a severe change in habitats. This report gave the condition of forests in 1975 and some management advice for the future.

Two transects of each forest type were set up based on aerial pictures. Each area was evaluated as to plant type, canopy configuration and size density.

The forests were divided into four groups: Oak/Pine Forests, Mixed Oak Hardwood Forests, Palmetto Forests, Oak Thicket and miscellaneous wooded areas. Soil types were anglicized and vegetation lists were created. The most critical community was listed as Low Oak Woods and Thicket. These are extremely important to erosion control and wind breaks to heavily salt-laden air, which effects forest communities further inland. Relationships between these communities were also discussed.

Information on Forest Communities from Other Sources

In 2012 Professor J. Gramling of The Citadel completed *A Vegetation Survey of Kiawah Island*. The introduction to this survey is useful in this section on dune and marsh vegetation (as well as in the section on forest communities).

... the basic template for vegetation on a South Carolina barrier island holds up well for Kiawah. From sea to salt marsh the following natural communities are easily observed: intertidal beach; maritime grassland; maritime shrub thicket; maritime forest; salt shrub thicket; salt marsh. Much of the island is dominated by maritime forest which has become an iconic feature of the Lowcountry, Kiawah included. South Carolina's

- **2012 Vegetation Survey Report**

www.wildlifeatkiawah.com/linked/vegetation_survey_of_kiawah_island.pdf

- **Updated Plant List**

The Gramling report has an updated species list that includes 30% more taxa than has been previously identified for the island.

maritime forests are dominated by live oak (*Quercus virginiana*), palmetto (*Sabal palmetto*), yaupon holly (*Ilex vomitoria*) and wax myrtle (*Morella cerifera*). Intertidal mud/salt flats occur on the back side of the island and may intergrade into salt marsh or salt shrub thicket communities. These flats are characterized by high salinity and irregular tidal flooding which limits vegetation to a few, low-growing species able to tolerate hyper-saline conditions. Tidal freshwater marsh and interdune pond communities have mostly been augmented on Kiawah Island to create the system of managed ponds that are found throughout. Brackish marsh communities are found on the edges of ponds as well as along portions of interior creeks replacing salt marsh communities as salinity declines. Maritime grasslands dominate the dune systems for Kiawah and occur as pockets of habitat intermixed within larger areas of maritime forest, maritime shrub thicket and/or salt shrub thicket near the eastern and western ends of the island.

The various ecological communities of Kiawah Island are constrained by the underlying geology and current proximity to saltwater. Soils on barrier islands reflect their sandy origins and are generally nutrient poor. Freshwater is generally limited, while salt spray may inhibit plant growth. Trees and shrubs nearest to the dunes will exhibit retarded growth and height limits much lower than the same species occurring on the interior of the island. These dwarfed individuals comprise parts of the maritime shrub thicket. Similarly the combined effects of sandy, nutrient-poor soils, salt spray and occasional strong offshore winds tend to produce a shorter, mature maritime forest on a barrier island than on the mainland.

In general the maritime habitat is stressful to plants; limiting the height and diversity of forests found on narrow barrier islands. Environmental stresses that impact the native flora will also be expected to impact non-native species as well. Invasive species are defined as non-native plants that establish outside of where they are planted or naturalize. A vegetation survey of Kiawah Island was undertaken to establish a plant species list for the island, assess the plant communities on the island, identify invasive or potentially invasive plant species, and develop management guidelines for invasive plant species.

A major part of the 2012 report was devoted to problem species. Gramling identified the following non-native species to watch for their potential to threaten the local environment:

Giant reed	Chinese silvergrass
Elephant ear	Sacred bamboo
Sago palm	Beach vitex

Gramling particularly noted that "**beach vitex** is a real threat to Kiawah Island. This plant has a track record for invading dunes and encroaching upon turtle nesting sites. A population of beach vitex was removed from the island (to my knowledge it was the only population), but the threat is real."

Gramling also listed some "problem species." Among these are plants that are already wide-spread: **pampas grass**, **elaegnus**, and **bamboo**.

The final category Gramling refers to as "red alert species," and his section on these is useful to repeat here:

There are some species that must be dealt with sooner rather than later because they have significant ecological impacts in the short term. Non-native wisteria can have detrimental effects on a tree by crowding out its leaves or even by strangling younger trees. **Escaped wisteria** should be eradicated as soon as it is found to prevent damage to other plants and inhibit the further spread of this plant. **Tree-of-heaven** grows rapidly and spreads its

seeds prolifically. The tree-of-heaven population on Cougar Island should be an eradication priority before it starts to pop-up elsewhere on Kiawah Island. Finally **tallow tree** is affecting various portions of the island. *Tallow tree is far and away the most common invasive species on the island and has the potential to permanently alter the remaining freshwater and temporary wetlands on Kiawah.* On Kiawah Island, these wet habitats are even rarer than on a typical barrier island because of the system of ponds that sequester much of the run-off. Temporary or seasonal freshwater wetlands provide habitat for amphibians and possibly turtles. These moist habitats provide drinking water to a variety of animals and support a diversity of plant species when unaffected by tallow tree. Once invaded by tallow tree these wetlands begin to convert into drier habitats. ***Tallow tree is truly more than just a minor problem; it is a serious threat to the long term ecological integrity of Kiawah Island.***

Fortunately, Gramling's report spurred an effort to eradicate the tallow tree, and significant work on this was done in the fall of 2013

Recommendations for Future Work

This would be an excellent time to conduct a post development survey based on the 1975 results. Because we had such an extensive study prior to large scale development, we have an excellent opportunity to gauge the effect of construction on the island.

Numerous specific problems should be examined during development in the following years.

- The impact of construction related changes in the level of the water table on sabal palmetto and other pond margin species.
- The effects of understory removal and clearing of major portions of the forest on regeneration of forest species, such as the oaks, would be very important.
- A plant collection of our forest type would be a valuable educational tool.



DUNE AND MARSH VEGETATION

Overview of 1975 Report

The beach along Kiawah Island is growing in places. It is due to the natural development and stability of the vegetation in these areas. However, there are areas that are going through rapid changes that could be considered detrimental to these ecosystems. Vegetation groups change in a particular site as a result of environmental changes which may be brought about by changes in the physical and/or biotic environments. Thus, the vegetation on Kiawah is not static but is continually changing.

The 1975 study examined the “mosaic” of community types, each the product of the interaction of many environmental factors that contribute to the make up of the dunes and the stability of more inland ecosystems.

Nine transects were set up from the salt marsh thicket to the beach (page 36). A survey was done of the vegetation in these transects and grouped to particular plants communities present. Relationships within each transect were examined in depth as to plant types etc. Transects were set up along pond systems as well.

A very extensive plant list was created of the plant communities. Flowering and fruiting times for each of the plants were listed in the inventories. A plant collection was also created as a part of the study, but the location of this collection is not known.

Information on Dune and Marsh Vegetation from Other Sources

In 2012 Professor J. Gramling of The Citadel completed *A Vegetation Survey of Kiawah Island*. That report, with information also applicable to this section, is described in the preceding section on Forest Communities.

Because Kiawah Island is also surrounded to such an extent by salt marshes, we were very interested in a report in *Science* magazine in September 2013 titled “Can Coastal Marshes Rise Above It All?”. The opening paragraph of the article was the following: “As climate change causes sea level to rise, wetland scientists are struggling to predict which salt marshes will drown—and which might climb out of danger.” The article went on to say that “Although they’re not the most glamorous biomes, the United Nations estimates that wetlands are one of the world’s most

- 2012 Vegetation Survey Report
www.wildlifeatkiawah.com/linked/vegetation_survey_of_kiawah_island.pdf

The location of transects for the study of dune and marsh vegetation. From the 1975 report, Section D, page 46.

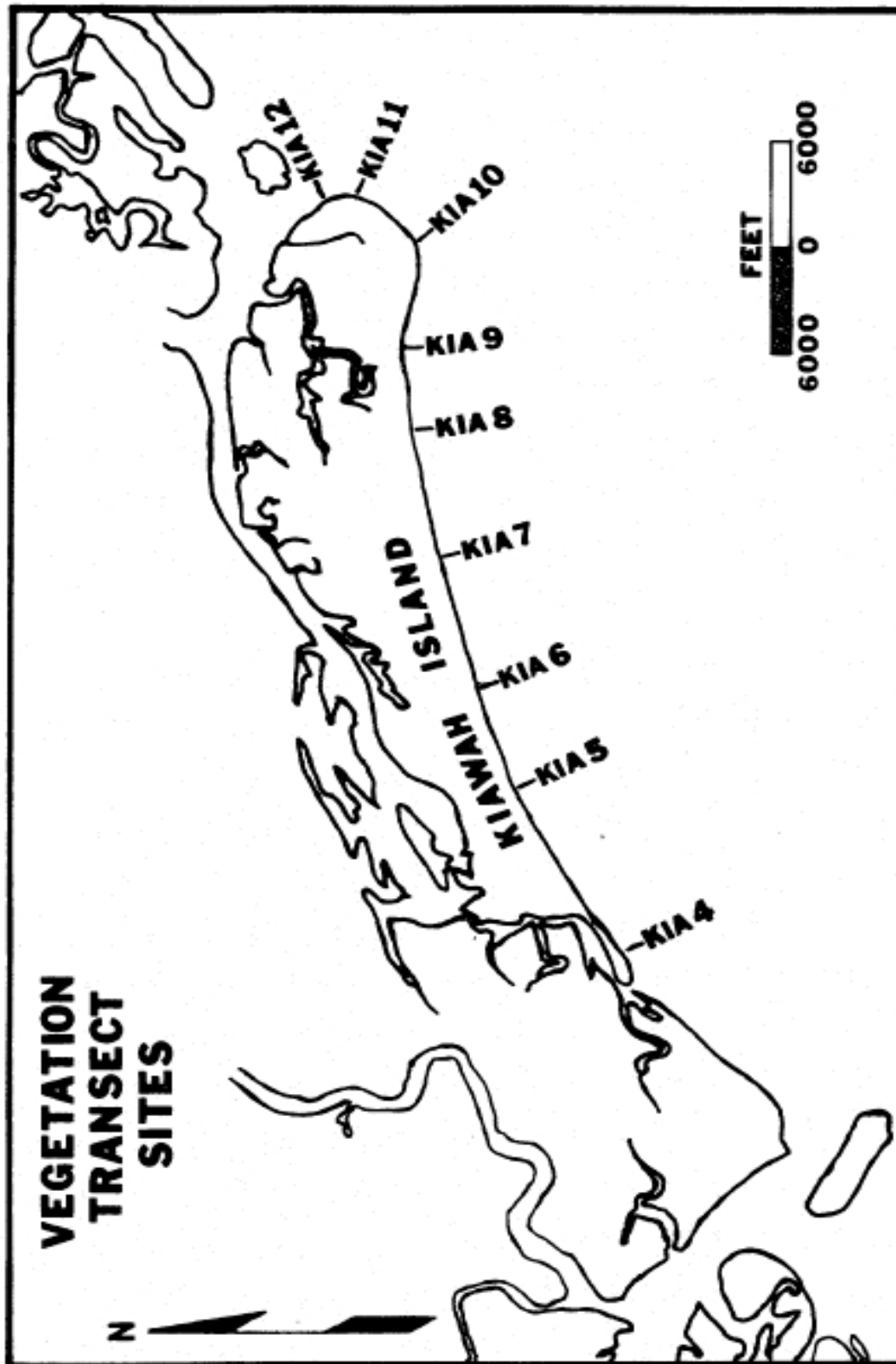


Figure 22. Location of vegetation transects. Each transect was located to show the variation in physiography and vegetation along the island.

valuable providers of “ecosystem services,” such as storm protection, water filtering, and seafood production. They also help lock up as much as 450 billion metric tons of carbon globally, absorbing warming compounds that might otherwise leak into the atmosphere. ... Marshes have already experienced centuries of insults—such as pollution, overfishing, and draining for farming and development—that have disrupted the ecological systems that help keep them healthy. Now, rising temperatures are causing landbased ice sheets to melt and seawater to expand.”

The 2012 Beach Management Plan also mentions dune vegetation. One species particularly mentioned is seabeach amaranth:

Seabeach amaranth is an annual plant that is typically found on barrier islands. Its primary habitat includes overwashed sand flats at accreting ends of barrier islands and lower foredunes and upper strands of noneroding beaches. While the ends of Kiawah Island appear to be suitable habitat for this species, there are no known plants in existence at the present time. Attempts were made to reintroduce this plant to Kiawah Island in the late 1990s but no evidence of survival of the plants is currently available. Monitoring of the island for the presence of this plant is ongoing and involves personnel from SCDNR and USFWS. In cooperation with these entities, plans could be formulated to monitor and maintain populations of this plant if it is documented.

- **Report on the health of marshes**

E. Kintisch, *Science*, Volume 341, page 480, 2013.

- 2012 Beach Management Plan. This plan is available from the Town website at: www.wildlifeatkiawah.com/linked/2012beachmanagementplanweb.pdf

Recommendations for Future Work

It has been almost 40 years since the survey was performed in these transects. The beach and dune system is always in a state of change, and the plant community composition can be indicative of environmental stress. The island has gone through an extensive development period since 1975. It may be time to recreate the transects and plant surveys and compare results to 1975. Also, a new plant collection should be created to be kept on the island and possibly be maintained by the Conservancy.

APPENDIX A

Websites Pertinent to This Document and to Wildlife on Kiawah Island

Kiawah Conservancy

www.kiawahconservancy.org

This website is the repository for many of the documents mentioned in this report or provides links to those documents.

Current information on mammals at Kiawah:

www.wildlifeatkiawah.com/

Bobcats:

www.wildlifeatkiawah.com/bobcats.html

Bobcat management guidelines:

www.wildlifeatkiawah.com/linked/2011_bobcat_management_guidelines.pdf

Coyotes:

www.wildlifeatkiawah.com/coyotesightings.html

coyotecoexistence.com (This is a site that explores the behavior and management of coyotes in an urban environment.)

www.dnr.sc.gov/wildlife/coyote/ (Download from this site a more complete discussion of coyote behavior and management.)

2012 Beach Management Plan:

www.wildlifeatkiawah.com/linked/2012beachmanagementplanweb.pdf

Weather Stations:

Cougar Point Golf Course:

www.weather.com/weather/hourbyhour/graph/1036379:5

KICA Maintenance (from 1 May, 2006):

www.kica.us/weatherstation/Current_Vantage_Pro_PlusKICA.htm

Mingo Point (from 30 August, 2011):

www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KSCKIAWA3

Sea turtles:

seaturtle.org

www.wildlifeatkiawah.com/loggerhead.html

www.wildlifeatkiawah.com/2013turtlenestmap.html

www.seaturtle.org/nestdb/index.shtml?view_beach=54

Diamondback terrapins:

Summary of Kiawah Island research on diamondback terrapins, ongoing since 1983. Includes links to several journal articles.

www.bio.davidson.edu/dorcas/research/Terrapins/Malaclemysterrapin.htm

See also: www.wildlifeatkiawah.com/terrapins.html

2012 Vegetation Survey Report:

www.wildlifeatkiawah.com/linked/vegetation_survey_of_kiawah_island.pdf

APPENDIX B

Videos of *Conservation Matters* Talks

Note: These will be available on the Kiawah Conservancy website when the new site is online.

**Tidal Creek Habitats- Dr Denise Sanger.mp4**

Uploaded Apr 12, 2014 · 226.8 MB

**Research Updates 12-10-2009.m4v**

Uploaded Apr 12, 2014 · 159.5 MB

**Painted Bunting & Bobcat GPS 4-2-2008.m4v**

Uploaded Apr 12, 2014 · 150.4 MB

**Loggerhead Turtles-Melissa Bimbi.mp4**

Uploaded Apr 12, 2014 · 58.0 MB

**Kiawah Bobcats & Other Wildlife- Dr. Roberts 5-2007.m4v**

Uploaded Apr 12, 2014 · 70.8 MB

**Hummock Islands- Billy McCord.m4v**

Uploaded Apr 12, 2014 · 168.0 MB

**Human Impacts on Costal Wildlife-AI Seagars 11:3:2010.mp4**

Uploaded Apr 12, 2014 · 217.4 MB

**Dr Shane Roberts-Bobcat & Deer Ecology 12-5-2007.m4v**

Uploaded Apr 12, 2014 · 224.5 MB

**Diamondback Terrapins-Dr Whit Gibbons.m4v**

Uploaded Apr 12, 2014 · 162.8 MB

**Diamondback Terrapins-Dr Mike Dorcas.m4v**

Uploaded Apr 12, 2014 · 62.9 MB

**Alligators- Norm Shea copy.m4v**

Uploaded Apr 12, 2014 · 192.5 MB

**Conservancy DVD's Highlighted.doc**

Uploaded Apr 12, 2014 · 37.5 KB

**Butterflies- Billy McCord.m4v**

Uploaded Apr 12, 2014 · 171.7 MB

APPENDIX C

Reports of *Conservation Matters* Talks and Conservancy-Sponsored Studies

*Note: These will be available on the Kiawah Conservancy website
when the new site is online.*



Hammock Islands.pdf

Uploaded Apr 16, 2014 · 2.5 MB



sataloff_thesis_rev copy.pdf

Uploaded Apr 11, 2014 · 3.4 MB



roberts_shane_b_200705_phd.pdf

Uploaded Apr 11, 2014 · 3.8 MB



Painted Bunting Radio Telemetry 2007.pdf

Uploaded Apr 11, 2014 · 2.8 MB



Bobcat Research Summary 1997-2007.doc

Uploaded Apr 11, 2014 · 31.5 KB



Bobcat Habitat Use to Prioritize Preservation-Abstract.pdf

Uploaded Apr 11, 2014 · 680.3 KB



Bobcat GPS Pilot Study.pdf

Uploaded Apr 11, 2014 · 2.4 MB

APPENDIX D

Kiawah Conservancy DVDs

Note: These are available from the Kiawah Conservancy.

- 1a. *The Legacy of Kiawah* (Description of development of Kiawah—"building with balance" with Mark Pamar and others)
- 1b. *The Legacy of Kiawah—Professional* (Shorter version of 1A with some comments directed to landscape professionals)
2. *The Magic of Kiawah* (Scenes only and music)
3. *Kiawah—The Wild Side* (Bob Cogill dedication with narrators, including the Nature Center)
4. *Bobcat and Deer Ecology on Kiawah Island: Implications for Habitat Preservation*. Dr. Shane Roberts (A 1 hr presentation ending with Q&A followed by 40 min of additional voice over detail. Searchable with 17 chapters. December 5, 2007.)
5. *Kiawah Bobcats and Other Wildlife: Ecology, Habitat Preservation and Backyard Habitat*. Dr. Shane Roberts (Details of PhD research and habitat implications. Most detail of any presentations. Predator/prey details, backyard habitat, HIS tool and early gps in four chapters. December 5, 2007.)
6. *2007 GPS Bobcat Program* (Used at Bobcat Ball. No sound. Some words beyond TV field).
7. *Conservation Matters*, April 2, 2008: *Painted Bunting Telemetry & Bobcat GPS* (Live presentations of the two pilot projects by Sarah Latshaw and Eric Rice. Not miked. April 3, 2008.)
8. *Conservation Matters — Birds of Kiawah*. Presentation by Dr. Paul Roberts (Voice over with good quality photos. Extensive chapters, generally by category and by individual bird. May 5, 2008.)
9. *Conservation Matters — Butterflies of Kiawah*. Billy McCord of SCDNR (Voice over with good quality photos. Extensive chapters by butterfly type. May 5, 2008.)
10. *South Carolina Hammock Islands: Oases in the Marsh*. Billy McCord (KPOG presentation, November, 2008.)
11. *Diamondback Terrapins*. Dr. Mike Dorcas at Night Heron Nature Center on November 4, 2008.
12. *Conservation Matters: Habitat Improvement Initiative and Sweetgrass Awards*. Justin Core on November 5, 2008.
13. *Rhett's Bluff Area Trapping: bobcat gps collar trapping and painted bunting trapping in 2008*. No sound (except some painted bunting). April 2, 2008.
14. *Conservation Matters: Diamondback Terrapins*. Dr. Whit Gibbons on February 4, 2009.
15. *Painted Buntings & Bobcats: Research Update* (February 19, 2009, by Sarah Latshaw and Jim Jordan at a KING meeting. Excellent summary of all work to date.)
16. *Painted Buntings and Bobcats: 2009 Bobcat Ball Special Edition*. Same content as (15) plus slide show of attendees and "Hip to be Square".

17. *Conservation Matters — Working Toward a Sustainable Kiawah*. Scott Fister on March 4, 2009.
18. *Conservation Matters — Alligators on Kiawah*. Norm Shea on April 1, 2009. Good quality and energetic voice over with Q&A.
19. *Conservation Matters — Native Landscaping*. Karl Ohlandt on May 6, 2009.
20. *Conservation Matters — Native Landscaping Panel*. Speakers were: Justin Core (Conservancy), Dave Achey (KICA), Norm Shea (KICA), Clint Weimann (Good Natured Gardening), John Tarkany (John Tarkany Associates), Hayward Townsend (Sunnyside Farms), Kevin Whalley (Dolphin Builders), and Mitch LaPlante (LaPlante Associates).
21. *Meet Some Kiawah Experts Available To Help You!* November 11, 2009 Presentations of the first three speakers from (20) above. Good way to introduce three key people that can help those going for the Gold. Another good resource is Peter Nelson of the Sanctuary staff.
22. *Conservation Matters — Wildlife Research Update*. December 2, 2009. Updates on bird monitoring (Aaron Given), Bobcats (Jim Jordan), and painted bunting (Sarah Latshaw).
23. *Conservation Matters — Tom Blagdon, Nature Photography*. February 10, 2010. Three versions available: (a) Sandy Island, Acadia, Kiawah Island—Poor quality for internal archive only. (b) Acadia and Kiawah—fairly good quality. (c) Kiawah (about 20 min)—fairly good quality and of greatest local interest.
24. *Conservation Matters — Loggerhead Turtles*. Melissa Bimbi. March 3, 2010.
25. *Conservation Matters — Life Cycle of the American Oystercatcher*. Pam Cohen. May 5, 2010. Good Quality, excellent photography.
26. *Close Ups and Wide Angles: Kiawah in the Movies*. Cynthia Neal. September 23, 2010. Sponsored by the Conservancy, Photo Club and Our World.
27. *Conservation Matters — Human Impacts on Coastal Wildlife*. Al Segars (SCDNR). November 3, 2010.
28. *Conservation Matters — Wildlife Research Update: 2010*. Sarah Latshaw (College of Charleston), Jim Jordan (Town of Kiawah), Aaron Given (Town of Kiawah). December, 2010.
29. *Conservation Matters — Tidal Creek Habitats*. Dr Denise Sanger (Sea Grant Consortium). February 2, 2011.
30. *Conservation Matters — Wood Storks*. Pamela Cohen. March 2, 2011.
31. *Conservation Matters — Marine Mammals in South Carolina*. Wayne McFee (NOAA).

APPENDIX E: Introduction to the 1975 Report.

INTRODUCTION

This document reflects 16 months of scientific inquiry into Kiawah Island. A broad multidisciplinary approach to the environmental inventory was selected in order to address the complex interrelationships of the existing ecosystems and to provide optimum information necessary for informed decision making. Thirteen disciplines, embracing subject matter from microscopic phytoplankton to prehistoric man, are represented in this report.

The study of the geology of the island is an examination of landform through the use of sequential aerial photographs, maps, soil borings, grain size analysis, and beach profiles. Beach profiles were established along the island's length and surveyed monthly to measure changes in beach configuration. All of these methods produced information relating to Kiawah's genesis. From an origin over 50,000 years ago to the present, Kiawah's landforms were traced as they shifted in response to long shore drift, sediment loads, and storm stresses. The coastal processes that are continually changing the interface between ocean and land are explained by the island's unique geomorphological character. The dunes, dune ridges, beaches and marsh all combine to provide a composite of the island's growth. It was discovered that Kiawah is today one of the few islands on the South Carolina coast that is prograding with the gradual seaward growth of the island being made at the expense of landforms to the north. Unlike its neighboring barrier islands, Kiawah is stable and generally free of erosional problems.

Dune and marsh vegetation mirror Kiawah's geologic stability and are

important to the maintenance of a stable strand line. During the inventory, vegetation associations along the beach, through the dune field, and in the salt marsh were classified and analyzed. Through the use of a system of transects, quantitative techniques were applied to determine successional relationships of dune vegetation. Monochromatic and color infrared aerial photographs were employed to create a mosaic of vegetation patterns. Plant systems were found to correspond quite closely with landform history. The successional relationships represented in the critical contact area between the forest, ocean, and marsh point to the importance of this fragile buffer. Much of Kiawah's stability and protection from adverse weather conditions is dependent on the vegetation of the dunes and salt marsh.

On Kiawah, maritime forest covers the core of the island. Detailed analyses of each forest association included species composition, areal distribution, and understory conditions. Aerial photo-interpretation supported by ground truths allowed the division of the island into five major stand types; Oak-Pine, mixed Oak-Hardwood, Palmetto, Oak thicket, and Wax Myrtle thicket. During the field study transect lines were established across the island where random 10 m² and 2 m² plots were intensively analyzed for species composition.

The forest is the most stable ecosystem on Kiawah. Forest vegetation modifies climatic conditions and supports the abundant terrestrial fauna. The most important forest type on Kiawah is the wind pruned maritime thicket. This zone of secondary dune vegetation protects the interior forest from damaging salt laden aerosols, and is also the final defense against erosional forces. Forest patterns are controlled by physiographic considerations and, to a large extent, by climatic conditions. The maritime forest and its

understory play a vital role in the distribution and support of Kiawah's reptile, amphibian, mammal, and bird populations.

Methodology employed during the climatological study included the use of available weather data from Charleston and Beaufort to extrapolate values for the island. The majority of the information was synthesized since no site specific data had been collected in previous years. Field observations were limited to a short period and focused on microclimatological features. Valuable general information was developed and, combined with microclimatic data, an overall weather picture of the island was obtained.

The maritime subtropical climate of Kiawah is influenced primarily by the Atlantic Ocean. Temperatures are generally moderate, with very humid conditions existing on the island's interior where air flow is restricted by heavy vegetation. Warm sea breezes, high humidities, and frequent precipitation contribute to a lengthy growing season. Onshore winds propel salt aerosols over the island where the effects can be observed most apparently in the wind pruned maritime thicket. Although adverse weather other than thundershowers is infrequent, Kiawah is within the area subject to tropical cyclone landfall. Accompanied by extremely high winds, heavy rains, erosive surf, and storm tides, hurricanes are the most damaging and most common natural disasters. The most destructive of these forces are the storm tides which, in combination with the other aforementioned factors, produce tidal flooding and highly erosive storm surge conditions.

Birdlife on the island is controlled by the distribution of plant communities and the close proximity of major breeding areas for marine species.

Field work consisted of survey sample censuses conducted weekly with specific attention devoted to specialized habitat. Over 150 species were observed during the course of the study including eight rare or endangered species. Such birds as the Peregrine Falcon and Roseate Spoonbill are included in this group. For avifauna, the most important island habitat is the brackish ponds. These impoundments exhibit high species diversity and support an impressive wintering waterfowl population. A critical habitat is the highly specialized rookery area where six species of egrets and herons nest colonially and produce a striking display during the late spring and early summer months. Another specialized nesting habitat was discovered on the beach of the re-curved spit. In the harsh environment of the open beach, a colony of Least terns, Wilson's Plovers, and American Oystercatchers made their nests directly on the sand. Species and populations of maritime passerines were typical of South Carolina barrier islands.

Intensive trapping revealed the presence of 23 species of terrestrial mammals on the island including three introduced species. Systematic line transects were employed for both trap location and the recording of sign. Night lighting and general observation were conducted throughout the study area with emphasis on specialized habitats. Five basic habitats were identified: dunes, pine-palmetto-oak-woodlands, dykes and cheniers, marsh and pond edges, and open fields.

Although not native species, the House mouse, feral goat, and feral hog have become established residents. The House mouse is found primarily in the dunes, the feral goat is highly restricted to specific cheniers, and the feral hog is unrestricted in its choice of habitat. The Bobcat is the top predator in the food chain, but is, unfortunately, very limited in abundance. Habitat

for this cat is confined to portions of the island's woodlands. With populations concentrated in old fields and on pond dykes, the ubiquitous Cotton rat was found to be the base of the predation pyramid. The most critical habitat for mammals is the pond and salt marsh margins. Since a significant number of Kiawah's mammals are dependent on aquatic systems, these areas were judged to be essential for movement, food supply, and cover.

Kiawah's dense vegetation and excellent ponds are a haven for reptiles and amphibians. The thirty species recorded during the study contribute to the store of information on barrier island populations. Sampling techniques included the employment of terrestrial drift fences, seines, minnow traps, aquatic hoop nets, and tarpaper cover. Hand collecting - particularly night lighting - and incidental collection along roads produced more species than any other method. The study also revealed that habitat types are not strictly observed by most reptiles and amphibians on the island. Fourteen different snakes were found including the three venomous species common to the Low-country. Frogs are the basic unit in this animal assemblage since they inhabit virtually every moist area. Highly vocal tree frogs are the most abundant amphibian, found even in the more saline brackish areas. Although only one turtle is common in the ponds of the island, it reaches record proportions. A Yellow-bellied turtle from Kiawah currently holds the world record for the size of this species. The largest and most apparent reptile is the American alligator. On Kiawah the alligator is abundant and often exceeds 10 feet in length. Found in every sizeable body of water, it even ventures occasionally into salt creeks.

The Loggerhead turtle is perhaps the single most important animal

frequenting Kiawah. This giant marine reptile is an endangered species whose critical nesting habitat is rapidly decreasing. Monitoring of Loggerhead nesting activity has been underway on Kiawah for four years with impressive results. During the study period, nightly patrols of the beach were conducted from mid-May to late August to locate gravid female turtles and their nests. Detailed notes were made on each turtle's size, egg clutch, and nest location, after which the animals were tagged and released. In 1975, forty-seven nests were moved to the safety of a hatchery where the eggs were allowed to incubate without the danger of natural disaster or predation. Without this protective measure, 97% of the eggs would normally be destroyed by predators with less than 1% of the hatchling turtles living to their first year. The results to date have been encouraging; more than 1600 hatchlings have successfully been reared and released in the sea. The hatchling release will continue through October 1975, with approximately 3500 young turtles scheduled for release. Kiawah's stable strand line contributes much to the maintenance of South Carolina's Loggerhead population, but continued monitoring and research will hopefully assure this ancient animal a future.

Water quality involved analysis of Kiawah's water at three levels. Inorganic nutrients, microbial biomass, and sanitary bacteriology were examined on a monthly basis. Twenty-two stations representing the front beach, ponds, and estuarine areas were sampled. Inorganic nutrients are important since they act as fertilizer to the microflora in the water column. The two most important elements in this function are nitrogen and phosphorous. Analysis of the amounts of chlorophyll in the water reveals the activity level

of the phytoplankton, as does the measurement of adenosine triphosphate (ATP). These two compounds allow the computation of the water's biomass. The accepted approach to sanitary bacteriology is to count the level of coliform bacteria: indicators of fecal contamination. On Kiawah it was found that the ponds are generally high in coliforms although these are not typically human. The one increase in human contamination of Sparrow Pond was directly related to the beginning of the Inn construction. Creek stations also revealed coliform presence, but much of this was also non-human in origin, and the creeks were therefore judged to be of high quality. Inorganic nutrient levels were average for estuarine and ocean locations, but were much higher in the ponds. This is thought to be a by-product of heavy use by birdlife. Ponds also showed a similar response at the biomass level for the same reason. As expected, estuarine biomass was well within the normal parameters.

Phytoplankton are the microscopic plants borne by the water column of ponds, estuaries, and the ocean. These seemingly insignificant organisms are the vital link that supports higher life forms. Phytoplankton, primary producers capable of converting radiant energy from the sun into chemical energy via photosynthesis, are the base of the aquatic food chain. Since these small plants are such a fundamental unit, it is important to identify the species present in Kiawah's waters and their seasonal abundance. Once this baseline data has been formulated, careful monitoring of the phytoplanktonic community can reveal changes in the aquatic systems quality that may have negative results at higher trophic levels.

Fifteen sampling stations covering the ocean, tidal creeks, and ponds were established on Kiawah and monthly samples were taken by trolling an

ultrafine mesh net. A total of 240 taxa were discovered. Phytoplankton in the tidal creeks were found to be typical of the Atlantic coastal region. Fresh and salt water species regularly fluctuated in the ponds as spring tides introduced saline species and runoff promoted freshwater types.

The community of bottom dwelling animals is referred to as the benthos. Living in the sand and mud of creek bottoms, amphipods, copepods, and polychaetes are important to the food chain and act as indicators of water quality. Benthic samples were taken from the creeks near the island at five locations four times a year. Species diversity and biomass for these macroinvertebrates were computed resulting in numbers that are well within the range of non-polluted estuarine systems. Since benthic organisms respond quickly to changes in sediment load and the introduction of residual chemical compounds, they serve as an effective warning system if monitored on a regular basis.

The nektonic component of Kiawah's waters are the highly mobile animals such as fish and crabs. Four creek stations and eight ponds were sampled during the study. The creeks were sampled seasonally using a 20 foot trawl net and cast nets, while the ponds were examined during the summer of 1974 with a 30 foot seine and cast nets. Kiawah's creeks yielded crabs, shrimp, squid, and 36 species of fish: a typical assemblage found in high quality estuarine areas. Diversity was dramatically reduced under the eutrophic conditions of the ponds. In these systems, dissolved oxygen was often totally absent, so only those species capable of adaptation to such stress were found. The most common fish in the ponds is the Mosquito fish, followed by the Mummichog,

Sheepshead minnow, and the Striped mullet. Estuarine organisms were found to be highly dependent on the marsh detrital cycle as the basis of their food chain while at the same time they were highly influenced by seasonal shifts in water temperature. Pond communities are by nature much more static with minor changes being made in conjunction with spring tide overwash. New species introduced by the tide are, however, quickly eliminated through their adaptive failure.

The archaeology of the island covers human activity from prehistoric times, roughly 3900 B. C., to the post Civil War period. A systematic reconnaissance was conducted on foot to establish site locations. Surface collections were made at each site, as were test excavations. Of the 22 sites identified, five are important, high priority areas. Two of the most important sites are found in the 'back' area of the pastures and Charlie Scott's. The locale is significant since it is probable that it has been occupied continually for approximately 4,000 years. The Bass Pond site (38-CH-124) is highly significant because it is an undisturbed stratified site rare in coastal South Carolina. The West Pasture site (38-CH-123), quite probably the location of the Kiawah Indian Village, has the greatest interpretive potential since many varied aspects of history are represented. The Vanderhorst House is an impressive site consisting of substantially more than that which is visible. The foundations of outbuildings located indicate the presence of a highly structured plantation complex worthy of detailed examination. The Vanderhorst site displays exciting interpretive potential provided proper investigation is employed.