

# A Vegetation Survey of Kiawah Island

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## An Overview of the Ecology of Kiawah Island

Kiawah Island is a barrier island located in Charleston County, SC. Barrier islands of the southeastern coastal plain are largely the product of underlying geological processes and Kiawah Island is no exception. Kiawah's historical ecology may be viewed as the result of succession of a sand bar or spit. Sand deposited by wind and wave action built up into a series of dunes that were then colonized by plants. Overtime new lines of dunes would form and the dune vegetation likely facilitated the capture of windblown sediments. When interpreting the landscape of Kiawah and other regional barrier islands one can see the effects of ancient dunes and swales as well as the local river and creek systems that may cut into the land (Figure 1).

Mature barrier islands will typically exhibit a gradient associated with exposure to



Figure 1: An aerial view of Kiawah Island

saltwater. This gradient may be observed as being perpendicular to the beach such that as one moves further from the mean high tide line of the Atlantic Ocean the effects of salinity on the local ecology are lessened until the effects of salt are encountered again as one approaches the salt marsh that separates the back side of the island from the mainland or other islands (Hosier 1975). This dynamic is observed across most of Kiawah, although at times it may be obscured

by the intricate system of “ponds”. Nonetheless 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 (Nelson 1986). Much of the island is dominated by maritime forest which has become an iconic feature of the Lowcountry, Kiawah included. South Carolina’s 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 under taken 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.

## Objectives

- Survey the flora of Kiawah Island to produce an updated plant species list.
- Identify what invasive species are actively impacting the site today.
- Identify what other invasive species have the potential to alter the site in years to come.
- Identify what portions of the site are most at risk.
- Collect baseline data on the degree of tallow tree (*Triadica sebifera* (L.) Small) infestation on Kiawah Island.
- Suggest management practices that can be implemented to address invasive species at Kiawah Island.
- Provide educational outreach for communicating the problems associated with invasive species on Kiawah Island.

## Methods and Tools

In order to meet the objectives of this study several different types of data were collected. A vegetation survey was used to create an updated species list and to identify invasive species on the island. GIS mapping was used to identify locations of invasive infestations on undeveloped property and public lands with the idea that these locations may be the focus of invasive management in the future. Tallow tree (*Triadica sebifera* (L.) Small) is an invasive known to thrive in maritime forests and coastal areas. To better assess the level of infestation of tallow tree on Kiawah Island, tallow tree density was determined on the undeveloped lots and in permanent plots that were established near the River Course. A more detailed description of the methods and tools used to meet the objectives for this study follows.

### Vegetation Survey

From October 2011 through November 2012 over 30 trips were made to Kiawah Island to conduct the vegetation survey. The primary methodological approach was to conduct a comprehensive survey of the island. While a strong respect for property rights prohibited a complete survey of all lots and holdings, multiple representative areas of the island were covered. This was accomplished through a variety of approaches. The vast system of trails and walkways was used to cover much of the island directly. Every road on Kiawah was surveyed as well, although most lots and home sites were not comprehensively surveyed out of respect for the property owners. Town properties, resort properties and KICA properties were surveyed throughout the island. Observations were made in all seasons and special effort was made to document the Kiawah Island flora as extensively as possible.

While there were likely some plant taxa not encountered during this survey, this is the most complete vegetation survey conducted on Kiawah Island to date. In addition to the overall taxonomic survey, invasive plant species were noted and, in some cases, mapped using GPS – derived location data. The purpose of this survey was not to criticize the individual plantings of Kiawah residents or developers. To this end, developed lots that harbored invasive species were generally not recorded to respect the rights of the property owners and avoid singling out individuals. Invasive species on undeveloped lots or in natural areas are noted where they have naturalized and are considered a threat to the natural environment. An initial list of previously observed plant taxa was developed from the work of Sharitz (1975), Hosier (1975), Aulbach-Smith (1998) and Wendelburger (1998) (Appendix I).

### Plant Taxonomy

All plants observed on Kiawah Island were collected, pressed and vouchered in The Citadel Herbarium (CITA). This survey focused on the native vegetation of Kiawah Island and naturalized non-native taxa. Ornamental plantings and yard plants were not included in this survey except when they had spread to undeveloped lots or common natural areas. Nomenclature follows the USDA PLANTS database while keying of plant specimens was completed using *Flora of Southern and Mid-Atlantic States* (Weakley 2012) and published volumes of the *Flora of North America* series. Invasive plant status follows the guidelines of the South Carolina Exotic Pest Plant Council Terrestrial Exotic Invasive Plant Species List (2011).

## **Mapping**

Mapping of invasive species was accomplished by on-the-ground observations. GPS locations were collected and uploaded in to an ArcGIS project. In general mapped locations of invasive taxa are provided only when the taxa was actively invading a natural area or undeveloped property. Mapped occurrences of invasives are meant to be representative and will not include all occurrences of invasive plants on the island. Mapped habitat uses the GIS layer produced by graduate student Shane Roberts. Newly and previously defined habitats were not mapped individually, but instead were incorporated into the existing mapped units. The majority of the newly described habitats are successional or transitional habitats and are better described as part of a mosaic than as discrete, impermanent units.

## **Tallow Tree Density on Undeveloped Lots**

A survey of tallow trees was conducted on a subset of undeveloped lots on Kiawah Island. The diameter of each tree was measured 1.4 m off the ground to observe the diameter at breast height (dbh) for all tallow trees found in the lot. Trees were categorized into one of three categories: small (< 4 cm dbh), medium (4-15 cm dbh) and large (> 15 dbh). The total number of trees greater than 4 cm in diameter was tallied and divided by the total area covered by the lots to give an approximate tallow tree density for undeveloped portions of Kiawah Island. A cut off of 4 cm (~1.5 inches) was chosen because trees smaller than that are not usually capable of producing seeds. This technique mirrors data that was collected for Dewees Island and allows for direct comparisons between the two South Carolina island communities. A subset of previously sampled lots on Dewees Island was re-surveyed after several years of tallow tree management to assess the effectiveness of their efforts and to provide an example of how such efforts might proceed on Kiawah Island.

## **Plot Data**

Plots were established in low lying areas near the River Course to quantify tallow tree density in a common area that had not been managed to remove tallow tree. Each plot was laid out as a 10 m by 10 m square for a total area of 100 m<sup>2</sup>. Individual trees had their diameter

at breast height measured in centimeters. These measurements were converted to basal area ( $m^2$ ) and then summed across the plot. The conversion to basal area and summation at the plot level were achieved using the following formula:

$$Plot\ basal\ area = \sum(0.00007854 \times (DBH)^2)$$

## Results

### The Flora of Kiawah Island

The flora of Kiawah Island has been assessed several times in the last 40 years, but never in a comprehensive manner. Sharitz (1975) established plots along two transects across the upland portion of the site to assess the maritime forest community prior to development of the island. Similarly, Hosier (1975) focused on the marsh and dunes vegetation along 9 transects traversing the island from the beach to the marsh. These studies included in the initial environmental inventory of the island (Campbell et al. 1975) provide a useful reference for the species that composed the natural communities of Kiawah Island prior to development. Any restoration projects undertaken at Kiawah would be well advised to review these early studies of the island flora.

In 1998, Aulbach-Smith investigated the natural plant communities of Kiawah Island for the Town. Her treatment of the natural plant communities identified 16 United States Vegetation Classification (USNVC) community types on Kiawah Island. As a result of this survey, seven additional plant assemblages were recognized and assigned to the corresponding United States Vegetation Classification associations as a result of this survey. Table 1 summarizes the specific vegetation associations identified in this survey and explains how these community types relate to “The Natural Communities of South Carolina” (used by SC Dept. of Natural Resources) and the mapped units of Kiawah Island Habitat produced by Shane Roberts. Of particular interest are the “Southern Hairgrass - Saltmeadow Cordgrass - Dune Fingergrass Herbaceous Vegetation” and the “Saltmeadow Cordgrass - Marsh Bristlegrass - Beach Marsh-pennywort Herbaceous Vegetation” communities. These two plant associations are ecologically valuable to a variety of bird species by providing sustenance from warm season grasses (which fruit in the Fall) and areas for foraging for insects. Both of these communities are also adjacent to maritime shrub thickets, maritime forest or salt shrub thickets which provide the birds with cover. These groupings make up some of Kiawah’s more elusive maritime grassland habitats occurring sparsely on the eastern and western edges of the island. In general the habitat that was most vulnerable to tallow tree invasive appears to have been seasonal wetlands and other shallow fresh water habitat. Plot observations were later targeted toward quantifying the level of invasion in these habitats. Maritime forest areas exhibited some degree of tallow tree invasion, but this was likely driven by proximity to dense tallow populations in moister environments.

In addition to the community classifications, an initial species list was developed from the previous surveys (Appendix I). During the course of this survey over 70 new plant species were identified on Kiawah Island. With these new species added to the existing list they push the

total number of observed plant species up to 308 (Appendix II). This is a 30% increase in the total plant diversity attributed to the island and a significant increase in our knowledge of this site. Of these 308 species only 17 species are on the South Carolina Exotic Pest Plant Council’s list of “invasive plant pest species”. The real and potential threats of these taxa are addressed in the following section.

### The Invasive Plant Problem on Kiawah Island

While tallow tree (*Triadica sebifera* (L.) Small) is the most obvious invasive plant impacting Kiawah Island, 17 non-native species known to pose an ecological threat were observed to be naturalized somewhere on the island. Eleven of these invasive species fall into the “severe threat” category according to the South Carolina Exotic Pest Plant Council (SC-EPPC). The two trees in the severe threat category are: tallow tree, tree-of-heaven (*Ailanthus altissima* (Mill.) Swingle). Tallow tree is clearly a significant threat (Figure 2), while tree-of-heaven was only observed at one location (Figure 3).

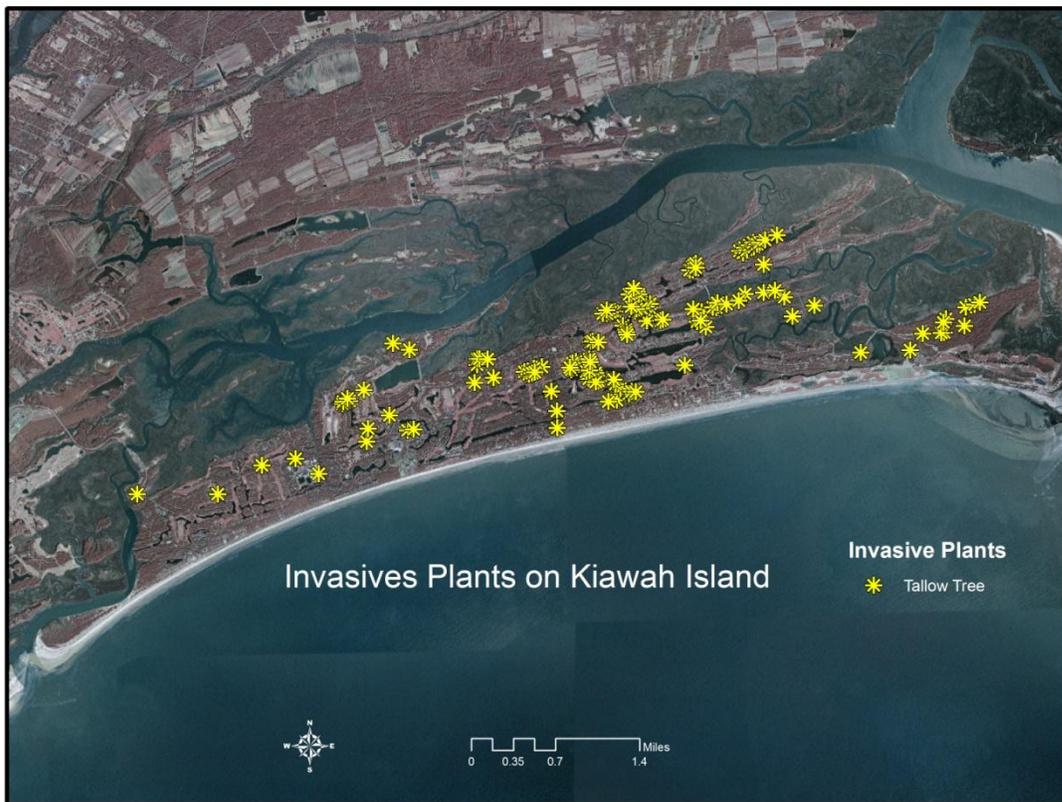


Figure 2: Tallow Tree on Kiawah Island

Table 1: USVCS Plant Associations observed on Kiawah Island by Aulbach-Smith (1998) and Gramling (2012: in bold text)

United States Vegetation Classification System	CEGL Reference	Mapped Units	Nelson 1986 Classifications
Live Oak- Cabbage Palmetto - Coastal Red Cedar/ Red Bay Forest	CEGL007032	Forest	Maritime Forest
Live Oak - Sand Laurel Oak - Slash Pine / Beauty-berry Forest	CEGL007030	Forest	Maritime Forest
Slash Pine / Sand Live Oak - Saw Palmetto Woodland	CEGL004658	Forest	Maritime Forest
Live Oak - Cabbage Palmetto - Coastal Red-cedar - Toothache-tree / Tough Bumelia Woodland	CEGL003525	Forest	Maritime Forest
Southern Cattail - Giant Foxtail Greass Seasonally Flodded Herbaceous Vegetation	CEGL004138	Marsh Edge	Brackish Marsh / Interdune Pond
Cabbage Palm - Live Oak Saturated Forest	CEGL007040	Forest	Maritime Forest
Carolina Willow Seasonally Flooded Forest	CEGL004222	Marsh Edge	Interdune Pond
Yaupon - Morella cerifera Shrubland	CEGL003813	Shrub	Maritime Shrub Thicket
Wax Myrtle - Groundsel-tree / Saltmeadow Cordgrass Shrubland	CEGL003809	Shrub	Maritime Shrub Thicket
Sand Live Oak Dune Shrub Thicket	CEGL003833	Shrub	Maritime Shrub Thicket
Saltmarsh Cordgrass Carolinian Zone Herbaceous Vegetation	CEGL004191	Marsh	Salt Marsh
Black Needlersuh Herbaceous Vegetation	CEGL004168	Marsh	Brackish Marsh
Saltmeadow Cordgrass - Salt Grass - Seaside Ox-eye Herbaceous Vegetation	CEGL004197	Marsh	Brackish Marsh
Woody-glasswort - Saltmarsh Cordgrass - Saltwort - SaltGrass Herbaceous Vegetation	CEGL002278	Marsh	Salt Flat
Seaside Oxeye / Saltmeadow Cordgrass - Black Needlerush Shrubland	CEGL003924	Shrub	Salt Shrub Thicket
Groundsel-tree - Maritime Marsh-elder - Wax Myrtle - (Yaupon) Shrubland	CEGL003920	Shrub	Salt Shrub Thicket
<b>Southern Hairgrass - Saltmeadow Cordgrass - Dune Fingergrass Herbaceous Vegetation</b>	CEGL004051	<b>Marsh / Marsh Edge</b>	<b>Maritime Grassland</b>
<b>Sea-oats - Beach Marsh-pennywort Herbaceous Vegetation</b>	CEGL004040	<b>Open_Dunes</b>	<b>Maritime Grassland</b>
<b>Seaside Greenbrier / Camphorweed - Trailing Wild Bean - (Sea-oats) Herbaceous Vegetation</b>	CEGL004234	<b>Open_Dunes</b>	<b>Maritime Grassland</b>
<b>Harper's Searocket Sparse Vegetation</b>	CEGL004401	<b>Open_Dunes</b>	<b>Intertidal Beach</b>
<b>Saltmeadow Cordgrass - Marsh Bristlegrass - Beach Marsh-pennywort Herbaceous Vegetation</b>	CEGL004257	<b>Marsh Edge</b>	<b>Maritime Grassland</b>
<b>Wax-myrtle / Saltmeadow Cordgrass Shrubland</b>	CEGL003839	<b>Shrub</b>	<b>Maritime Shrub Thicket</b>
<b>Cabbage Palmetto - (Southern Red-cedar) Woodland</b>	CEGL003526	<b>Forest</b>	<b>Maritime Forest</b>

The lone population of tree-of-heaven was establishing on Cougar Island (Figure 3) and should be considered a management priority. This portion of Cougar Island may have been affected by contaminated machinery. In this same cleared area the invasive rattlebox (*Sebania punicea* (Cav.) Benth.) and closely related *Sesbania herbacea* (Mill.) McVaugh are found (Figure 3). *S. herbacea* often referred to as just “sesbania” or peatree is a plant whose native range is undetermined. Originally thought to be an invasive species, *S. herbacea* may be native to Florida and perhaps even the coastal Carolinas (Weakley 2012). Nonetheless, *S. herbacea* can be weedy, especially along disturbed roadsides and construction areas.

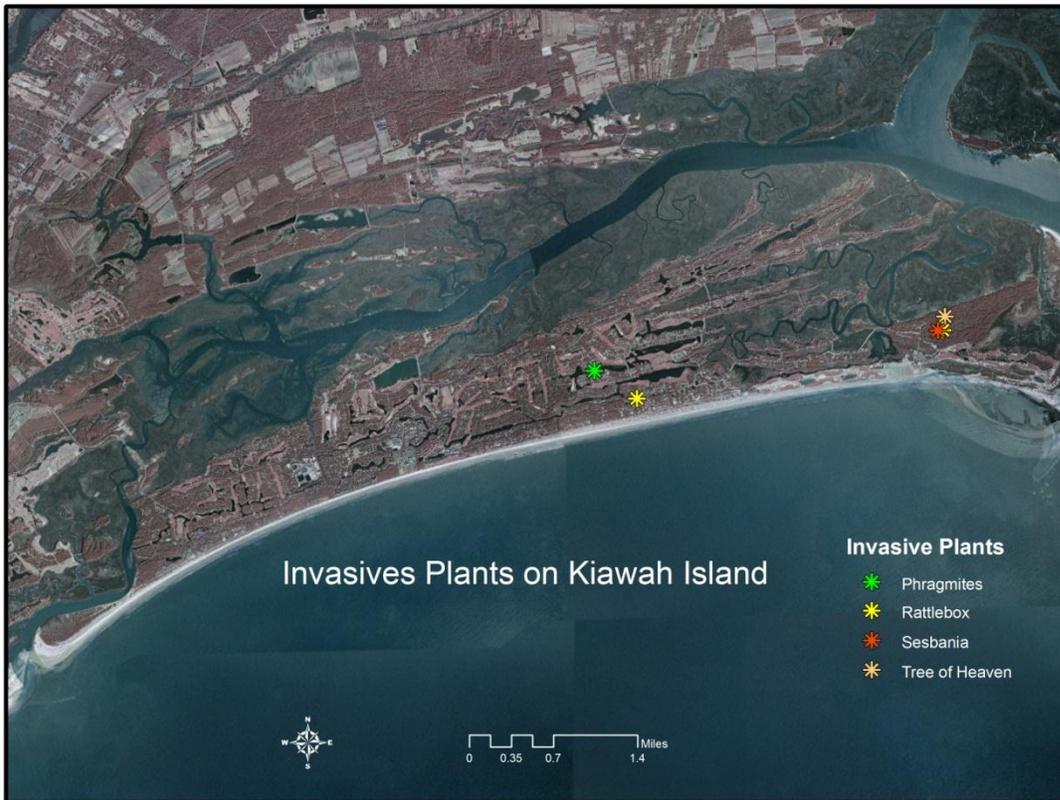


Figure 3: Phragmites, rattlebox, sesbania and tree-of-heaven on Kiawah Island

*Phragmites australis* (Cav.) Trin. ex Steud. is another taxon whose origin story has changed over the years. Originally it was thought that *P. australis* was native to Europe and introduced to N. America early on during colonization. More recent studies suggest that a native genotype of phragmites exists, but the non-native European genotype appears to be aggressively invading brackish to freshwater habitats throughout the Eastern U.S. At Kiawah Island phragmites was only observed along the edge of Bufflehead Pond. The lightweight seeds of this wetland grass are easily spread and it will be surprising if more phragmites is not found elsewhere on the island. Phragmites is a SC-EPPC severe threat and should be considered a

management priority. The only other grass observed at Kiawah falling into the severe threat category is bahiagrass (*Paspalum notatum* Fluegge). Bahiagrass is a common weed throughout the Southeast and is most noticeable along roadsides and in lawns. The maritime grasslands of Kiawah are not as threatened by bahiagrass as other places, because the sandy soils and salt spray provide less than ideal conditions for this invader. In general these maritime stresses are likely to reduce the habitat for bahiagrass to sodded yards and mown roadsides.

Invasive vines found on Kiawah that have been identified as a severe threat to the local ecology include English ivy (*Hedera helix* L.), Chinese wisteria (*Wisteria sinensis* (Sims.) DC.) and Japanese Honeysuckle (*Lonicera japonica* Thunb.) (Figure 4). While English ivy and Chinese wisteria are likely escapees from landscape plantings, Japanese honeysuckle is frequently spread by birds and constitutes a greater problem regionally. Many people are so used to the site of Japanese honeysuckle they fail to recognize it as an invasive species. These three species should be managed as they exhibit a clear threat. Chinese wisteria can easily strangle a tree if left untended and its lightweight seeds are often carried well beyond its original planting site. English Ivy often spreads vegetatively, but may become a problem as it reaches areas with more light and begins to flower. Common periwinkle (*Vinca minor* L.) is similar to English ivy in

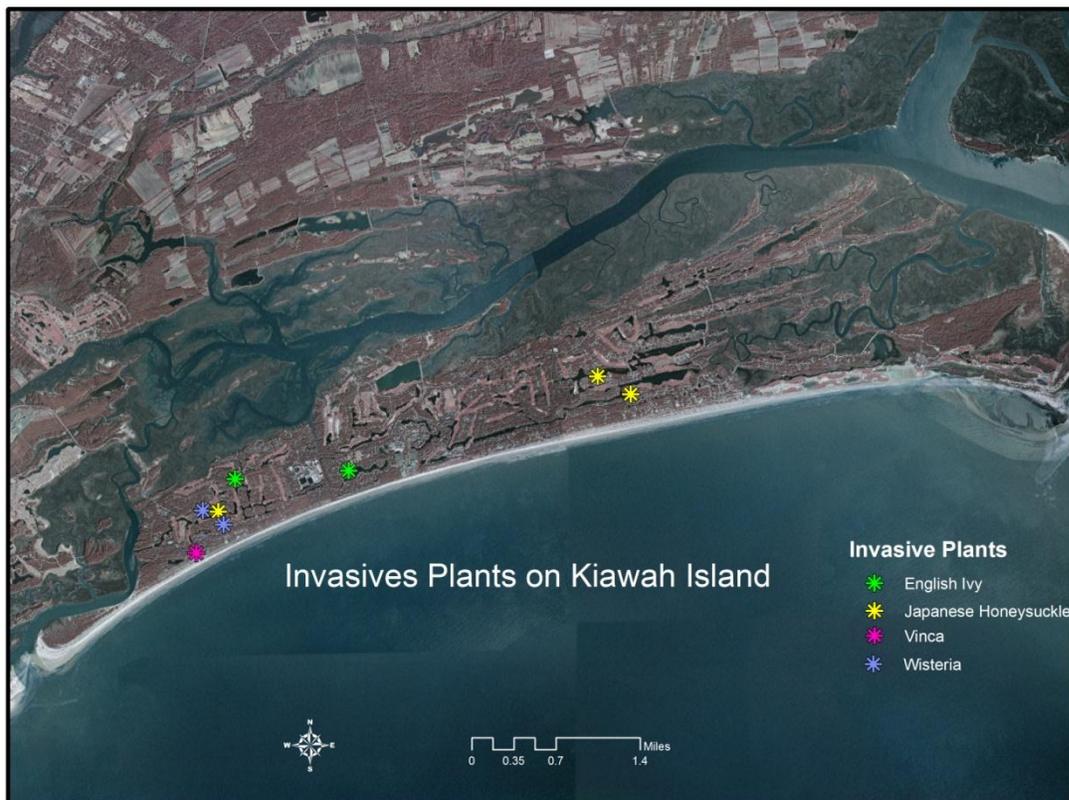


Figure 4: Invasive vines on Kiawah Island

that it often creeps along as a ground cover and invades other areas through encroachment. While common periwinkle is only a significant (rather than severe) threat, it is a common landscape plant that requires regular maintenance to keep it from escaping into adjacent natural areas.

The invasive shrubs privet (*Ligustrum sinense* Lour. and *Ligustrum japonicum* Thunb.) and thorny olive (*Elaeagnus pungens*) are also common landscape plants and have been labeled a severe threat by SC-EPPC (Figure 5). Both of these shrubs, along with the significantly threatening bamboo (*Phyllostachys aurea* Carrière ex A. Rivière & C. Rivière), are commonly placed as border plants along one's property line. Unfortunately the same aggressive growth rates that allow these plants to quickly obscure a line of sight, contribute to their invasive nature. Plants such as these may prove to be the most significant challenge to dealing with invasives on Kiawah Island. These commonly sold and broadly used plants are ubiquitous in the current landscape trade and are planted as ornamentals all across the island.

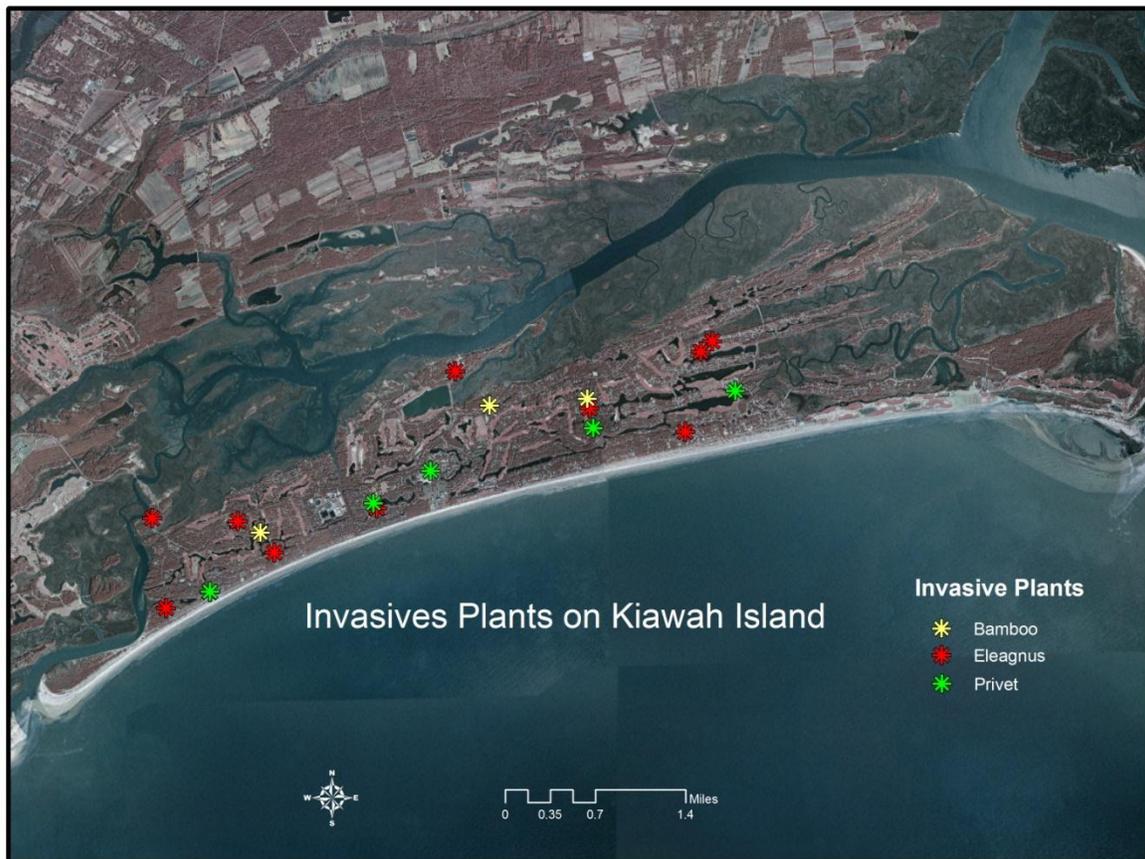


Figure 5: Bamboo, elaeagnus and privet on Kiawah Island

## Management Guidelines for Kiawah Island

In order to address the problem of invasives on Kiawah Island one must first identify the problem species, determine the severity of the threat it poses and determine where it is likely to be a problem. This survey provides information pertinent to achieving such perspective on invasive species. In this section I will address the threat posed by various invasive taxa and suggest some possible management actions to deal with the threat. There are also some common steps that can be taken when dealing with any invasive plant species. In general the most important tool for dealing with invasive species is communication. As I worked on this project and others, I encountered an information gap between stakeholders and the literature with respect to what plants are invasive and why they are problem. Education at various levels and outreach efforts are essential to an invasive plant management plan when there are multiple stakeholders. Regardless of how aggressively or subtly the Town of Kiawah or other entities move forward with invasive species management or removal, there must be a corresponding education campaign. When working with other groups I have heard this time and again. Public education is essential when carrying out activities that affect the natural environment in a community, especially at a place like Kiawah where the natural environment is a significant part of the community's identity.

### The Watch List

Several species on Kiawah Island should be noted for their potential to threaten the local environment. These species are characterized by the potential to invade natural areas because they have done so elsewhere and are already located on Kiawah Island as ornamental plantings. While most of these species have not naturalized they should be made a management priority if they are observed to naturalize. The basic idea is that it is easier to stop a few individuals than wait until you have to confront a critical mass. This will require some vigilance. Giant reed and Chinese silvergrass are plants that should be watched to make certain that they don't invade open areas. They require lots of light and could occupy any nutrient rich grassland habitat. Sacred bamboo or nandina is another common landscape shrub that is easily spread by its red berries. If nandina begins to pop up in partially shaded woodland areas, it would be advisable to begin eradicating it immediately. Elephant ear is known to invade moist wetland margins or drainage areas. This showy plant is

Recommended Kiawah Watch List		
<i>Arundo</i>	<i>donax</i>	giant reed
<i>Colocasia</i>	<i>escuelenta</i>	elephant ear
<i>Cycas</i>	<i>revolutas</i>	sago palm
<i>Miscanthus</i>	<i>sinensis</i>	Chinese silvergrass
<i>Nandina</i>	<i>domestica</i>	sacred bamboo
<i>Vitex</i>	<i>rotundifolia</i>	beach vitex

very obvious when it establishes, but can be a serious problem if it blocks drainage ditches. To my knowledge sago palm has never been reported as invasive in South Carolina, but numerous seedlings of sago palm were observed to have naturalized in undeveloped lots on Kiawah Island. Going forward these seedlings may die out due to frost or freezing, but it is recommended that any further signs of invasive activity in this species be reported. Finally, 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.

### Problem Species

The next threat level includes species that are invasive and have naturalized on Kiawah Island. These species are becoming a nuisance and should be considered for removal or control measures in natural areas where they have invaded. Pampas grass (*Cortaderia selloana*) provides an interesting example of a species on the cusp between the watch list and a problem species. As one drives on to Kiawah Island from the mainland a tuft of pampas grass sits out along the edge of the marsh on the opposite side on the road from the entrance to Cassique. This nearby invader is a reminder that this common landscape species can escape. Similar escapees can be found naturalized on James Island and Folly Beach. More problematic are the elaeagnus and privets that have invaded many parts of the island already. These hedge species have been spread by birds to a variety of natural habitats with noticeable effects. Privet and elaeagnus are crowding out native shrubs and herbs. Elaeagnus has a particularly aggressive

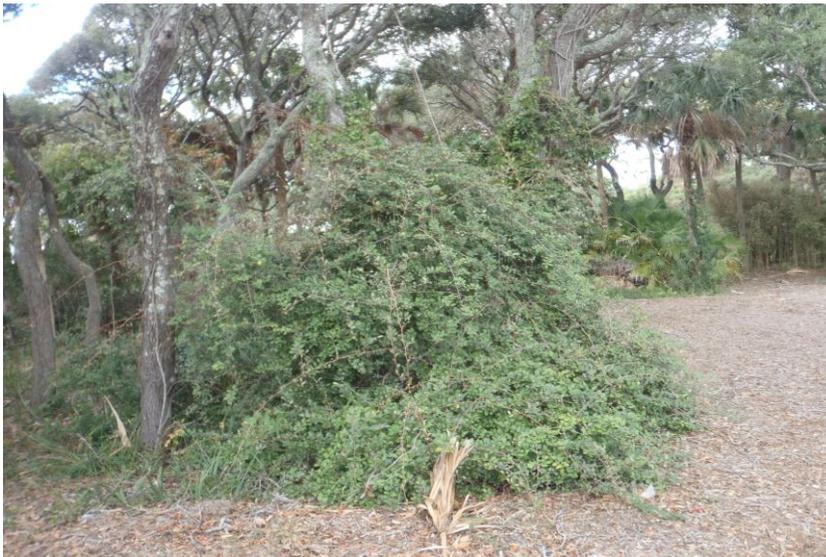


Figure 6: Elaeagnus growing near the Straw Market

growth pattern as seen in this photo. It is recommended that elaeagnus and privets be removed when found in natural areas or when undeveloped lots are being cleared to build upon. Yeamans Hall plantation has worked extensively to remove elaeagnus and privet from portions of maritime forest on their property. While not as easily spread to new

locations, bamboo may be worse to deal with. Bamboo plants that are encroaching upon natural habitats should be removed or at least cut back. Bamboo is one of the toughest plants

to remove from a landscape, but it generally does not seed in to new locations. To prevent future problems with bamboo it may be best to discourage its planting in the first place.

### **Red Alert Species**

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 runoff. 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 serious threat to the long term ecological integrity of Kiawah Island.

### **Dealing with Tallow Tree: The Dewees Island Example**

To better understand the full extent of tallow tree invasive on Kiawah Island data was collected using several approaches. The first approach was to collect tallow tree location information to provide insight into how tallow tree is distributed across Kiawah Island. Tallow tree was found to be more frequent on the less developed eastern side of Kiawah Island (Figure 2). In addition to point observations, more detailed data was collected on tallow tree as well. Data on tallow tree density was collected in 100 m<sup>2</sup> plots to provide reference information for any future tallow management. Plots were located in currently unmanaged tallow



Figure 7: Tallow Tree Plot 1

infestations. These plots likely represent some of the highest concentrations of tallow tree on Kiawah Island. A wetland area near the River Course between the end of Kiawah Island Club Drive and the end of River Course Lane was selected for these plots. In each plot the DBH data was collected for all tallow trees in the 100 m<sup>2</sup> area (Figure 6). This stem data was converted into basal area and summed across each of the three plots: the average basal area for a 100 m<sup>2</sup> sampling area was .2357 m<sup>2</sup> which comes to an average of 23.57 m<sup>2</sup> / ha. Additional tallow tree data was collected using a novel approach.

The tallow tree problem on Kiawah Island is similar to what many other communities in the region are facing. Dewees Island is a similar community to Kiawah in that it is a barrier island vacation destination with a strong ecological component to its identity. Over the past four years Dewees Island has been combatting tallow tree through a large scale effort. While Dewees Island is smaller than Kiawah Island and has more limited access, the results from Dewees Island should be informative for the Town of Kiawah Island and other stakeholders in the Kiawah community. Dewees Island began treating invaded portions of the common property in 2006 & 2007. In 2009 they began a large scale effort to remove tallow tree from untreated common areas and private lots. Through a combination of grant funds and budgeting of funds for environmental management on the island they were able to keep the per owner cost down to \$100 per lot. Owners had to “opt in” to have tallow tree removed from their property and only 52 of the 150 lots were treated. Participation was low due to concerns over the effects of the herbicide being used and the visual impact of the tree removal. The results of the 2009 treatment were greeted by the other lot owners with a new found commitment to tallow tree removal. A second effort was undertaken in 2011 to retreat persistent infestations and to treat new lots and home sites. In 2011, 88 additional lots were included in the tallow tree treatment. As of Summer 2012 only 8 lots on Dewees Island had not been treated for tallow and a third year of tallow treatment is in the works.

The Dewees Island example provides several useful lessons for how Kiawah may approach a concerted effort to remove tallow tree. The first lesson is that public buy-in is essential. Once that was achieved, Dewees Island could fully address the tallow tree problem. The second lesson is that tallow tree removal is a multi-year, multi-step process and as such requires foresight and commitment. Prior to large scale tallow tree treatment, Ryan Bollinger, a graduate student at the College of Charleston, collected data on the presence of tallow tree in lots on Dewees Island (Bollinger 2009). Having advised Ryan on his project and working closely with Lori Sheridan-Wilson, the environmental manager at Dewees Island, I suggested that we re-sample several lots on Dewees to assess the success of their tallow tree removal efforts. In the summer of 2012 a 10% subsample of the Dewees lots was resampled in the same manner that Bollinger had used. Trees were identified as mature (>~4 cm dbh) or large (>~15 cm dbh). Smaller trees had been ignored in Bollinger’s study since the purpose was to focus on mature

seed-producing individuals. In my resample I also noted the trees that were less than 4 cm dbh. Between 2009 and 2012, 94% of the mature tallow trees had been successfully eliminated from

Year	Total Mature Trees	Mature trees / acre
2009	1025	37.4
2012	58	2.1

the resampled lots on Dewees Island (Table 2). The entire sampled portion on Dewees had 25.6 mature trees per acre in early 2009. The resampled subset of lots actually had a higher tallow density of 37.4 mature trees per acre prior to treatment, which plummeted to 2.1 mature trees per acre by 2012. Half of these resampled plots had been treated twice, while the other half received only a single treatment for tallow in 2011.

In June 2012 I led a group of school teachers to Kiawah Island to sample undeveloped lots using Bollinger’s method, but also noting the presence of immature trees (defined as >1.4 m in height but < 4 cm dbh). Sampled lots at Kiawah had 26.9 mature trees per acre. This is very close to the 25.6 trees per acre observed across nearly all of Dewees Island. Since the numbers of immature stems were counted on Kiawah Island and tallow trees mature in three years, the total number of mature trees on sampled lots can be estimated for two years from now. Assuming that no treatment of tallow takes place, the density of tallow trees is expected to jump from 26.9 mature trees in 2012 to 34.1 mature trees per acre in 2014. This would be a 26.7% increase in the next two years without factoring in tallow seedlings less than 1.4 m in height.

### **Developing a Long-term Invasive Plant Management Plan**

This report has highlighted the presence of invasive plants on Kiawah Island and documented their naturalization in various areas. The invasive plant location data (Appendix III) and invasive plant maps (Figures 2-5 & Appendix IV) included in this study are a conservative interpretation of the overall invasive problem because they exclude developed lots and areas with limited access. That aside, the maps provide a useful comparison of how the various invasive species are distributed across the island and the relative abundance of each.

An invasive plant management plan will require a discussion between the various stakeholders on Kiawah Island to formalize their commitment and approach. It is recommended that the following steps be taken to maintain the ecological integrity of Kiawah Island in the future:

- Create a system by which undeveloped lots have invasive plants removed when they are developed.

- Review policies for planting invasive species on Kiawah Island
- Coordinate tallow tree removal across the entire island through a broad partnership of the various stakeholders
- Carry out an information campaign to inform residents and visitors about the steps Kiawah Island is taking to protect the local ecological communities

To achieve these goals a long term perspective will be essential. Invasive plant management requires years of commitment and it is important that all participants are aware of this aspect in the beginning. Several additional resources have been included with this report to facilitate the development of a long term invasive plant strategy on Kiawah Island. *A management guide for invasive plants in southern forests* by Miller et al. provides updated information on invasive plant management techniques and the web version may be updated periodically to include recent changes in invasive plant management. *Best management practices for wildlife in maritime forest developments* by Whitaker et al. highlights native and invasive plants associated with maritime forest communities like Kiawah.

Tallow tree removal will need to be the primary focus of invasive plant management on Kiawah Island. The baseline data collected on Kiawah Island provide estimates of tallow tree densities in wetland common areas and on undeveloped lots. This data should be used in the future to assess the success of tallow tree management activities. The Dewees Island example provides useful insight into how tallow tree management can be implemented. Additional invasive species should be addressed according to the threat they pose. Problem species have been highlighted as an immediate threat to Kiawah Island. Watch list species are taxa that have the potential to be invasive at Kiawah Island. Ultimately a multi-tiered approach is recommended to deal with invasive species is a variety of ways. This survey should provide the basis for such an approach.

### **Educational Outreach**

An additional component of this survey was to support activities that educate the public on the effects of invasive plants on Kiawah Island. Throughout the spring of 2012 a series of public walks was conducted in which various residents joined me as I explored portions of Kiawah Island. These walks not only provided additional observers for the plant survey, but they allowed for open discussion of the invasive plant problem at Kiawah and afforded residents and employees the opportunity to see the effects firsthand. Similarly, I participated in the Conservation Matters Flora and Fauna Event at The Sandcastle which provided me the opportunity to discuss this survey and the invasive plant problem on Kiawah with a variety of participants. An article in the *Island Connection* was published highlighting this survey and providing information about the public walks. Preliminary findings of this survey were presented to the Kiawah Island Natural Habitat Conservancy in September 2012.

Several graduate students from both The Citadel and the College of Charleston provided brief assistance with this survey. Graduate student activities included: gathering invasive plant locations with a GPS; collecting data on tallow tree density; collecting, pressing and labeling plant specimens for The Citadel (CITA) Herbarium. These educational opportunities provided students a chance to develop additional skills in botanical research.

The Island Invaders teacher's Workshop was conducted at The Citadel, Kiawah Island and Dewees Island in June 2012. This workshop was funded by an Improving Teacher Quality Grant from the South Carolina Commission on Higher Education and coordinated by The Citadel. This unique research project introduced school teachers from across the Lowcountry to GPS and GIS research techniques and used the invasive tallow tree problem as its primary focus. Over the course of a week, the teachers were educated about tallow tree, spent a morning collecting data at Kiawah, spent a morning collecting data at Dewees and then spent the next two days analyzing the data and sharing their results. The workshop was a great success and the cooperation of the Town of Kiawah and owners of undeveloped lots made a significant contribution to this educational event.

Additional materials in support of invasive plant awareness are included as a digital supplement to this report. The weblinks for these educational materials are:

<http://plants.ifas.ufl.edu/node/683> - Recognition Cards: Invasive and Non-native Plants You Should Know (UF/IFAS Publication # SP 431) from the Center for Aquatic and Invasive Plants, University of Florida, IFAS.

- A set of educational materials to facilitate invasive plant identification

<http://www.srs.fs.usda.gov/pubs/35292> - A field guide for the identification of invasive plants in southern forests.

- A comprehensive guide to facilitate invasive plant identification

<http://www.dnr.sc.gov/marine/pub/BMPSforCoastWeb.pdf> - Best management practices for wildlife in maritime forest developments.

- Includes lists of native plant species to benefit wildlife as well as lists of invasives that are detrimental to maritime forest communities

## Conclusions

This survey was successful in meeting its objectives. An updated species list was produced for Kiawah Island that includes 30% more taxa than had been previously identified for the island (Appendix II). A community assessment attributed seven new plant communities, as described by USVCS, to Kiawah Island (Table 1). Over 175 observations of invasive species were collected to study the patterns of invasives on Kiawah and to facilitate their eradication (Appendix III). Invasive species were assessed and categorized to aid in invasive plant management. Tallow tree infestation was quantified using two different approaches to provide an abundance of baseline data so that stakeholders can assess the results of any tallow tree eradication efforts. General management practices were suggested based upon the severity of the threat an invasive plant poses to the ecological integrity of Kiawah Island. Digital references have been included to facilitate invasive plant identification and invasive plant management. Educational outreach efforts were successful in engaging various segments of the public with respect to the threat of invasive plant species on Kiawah Island. While these goals have been met, the ultimate success of this project will lie in how this information is used.

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