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Sea Grant Florida

Dune Restoration and Enhancement

for the Florida Panhandle

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Foreword

The purpose of this manual is to provide an overview of the Florida Panhandle coastal dune systems and specific information on coastal dune restoration and restoration enhancement activities. These restoration techniques have been developed and tested through research and monitoring activities for the northern Gulf of Mexico region.

As with many projects that summarize information and experiences from a variety of disciplines, some sections of this manual will be useful to a broad group of individuals. Other sections may target a specific audience. The authors have worked for many years with homeowners, local government officials, land managers, nurseries, and restoration project managers. Requests from these various audiences for a common resource that would provide both basic and targeted information pertinent to coastal dune restoration inspired us to create this manual.

This manual may serve as a tool to assist managers and homeowners with development of restoration goals, introduce restoration practitioners to required permitting processes, or assist contractors with timelines for implementing restoration activities based on the knowledge of the impacted flora and fauna.

This manual begins with basic information about coastal systems along the western Florida Panhandle and provides a context for the importance of dunes. Readers will find this information useful in understanding how the components of the coastal system are interrelated, learning about the diversity of plant communities that make up our coastal system, and understanding the roles of the flora and fauna found on our coasts.

The second section of the manual focuses on the restoration of coastal dunes within the western Florida Panhandle. This section provides initial contacts for permitting processes and technical information on approaches for dune restoration and explains specific restoration techniques for establishing dunes and planting dune vegetation. Readers will also learn about additional plant species that provide wildlife cover, nectar, and other kinds of food for insects and wildlife. This information is also pertinent to nursery growers, contracting agents, land managers, and local governments who participate in the development of contract specifications that address plant species selection, nursery production systems, and appropriate planting locations, spacing, timing, and transplant size.

The third section of the manual provides detailed information on plant species found in the many plant communities in the western Florida Panhandle. Details on identification, biology, propagation methods, and nursery production methods as well as recommendations for successful out-planting for coastal restoration are provided for each plant. This information is useful for the homeowner to understand the timeline for production or the degree of difficulty involved in the production of these plants. Nursery growers, contracting agents, land managers, and local governments will also find this information useful in development of specifications for contracts or seed-collection permits for projects that will require access to seed or cutting materials in advance of restoration planting.

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Factors Affecting Approaches to Dune Restoration and Enhancement in the Florida Panhandle

This manual provides an overview of the coastal systems located along the Florida Panhandle and outlines specific information regarding dune restoration and enhancement activities for this region of the northern Gulf of Mexico.

The authors have compiled this text on the basis of local experiences with these activities, where more formal research reports are not presently available. This manual represents the work of the authors, and undergraduate and graduate students from the University of Florida, as well as information derived from local professionals, peer-reviewed academic journals, government documents, and various online resources accessed over 20 years of work on this subject area.

Our Coastal Systems

The coastlines along the Florida Panhandle are dynamic and naturally shaped by waves, wind, and sand.

Figure 1. Dune grasses on the frontal zone of the beach of Santa Rosa Island, Florida, showing the initial line of vegetation to capture moving sand. Credit: Josiah Raymer, UF/IFAS

Dune Formation

The Florida Panhandle is a high-energy coast with sufficient availability of offshore sand for wide beach formation. Strong onshore winds carry the sand from the beach landward to allow for dune development.

During spring and summer, beaches gradually grow wider as low-energy waves deposit sand on the shore (Williams 2007). This beach sand is then available for dune formation. Sand moves only when dry and when wind speeds are sufficient to cause individual sand grains to roll and bounce along the surface, or to be carried by wind through the air. Dune formation begins when vegetation is present to slow winds and capture and stabilize blowing sand (Figure 1).

Dune Stability

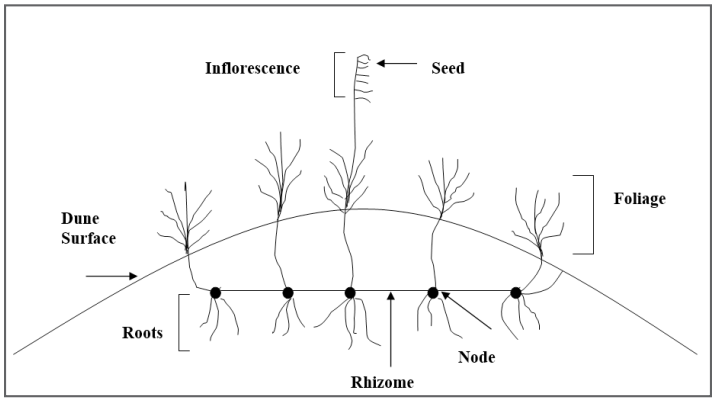


Figure 2. A diagram of sea oats plant parts indicating where each plant part is found in relation to accumulating sand. Credit: Mica Schneider, UF/IFAS

Coastal grasses and shrubs are the biological engineers of our dunes. As windblown sand passes through the stems and leaves of perennial grasses and other types of vegetation located at the edge of the beach, wind speed is dampened and sand is deposited around the base of the plants. This intercepted beach sand remains in place because of the tall stems of the vegetation. It is further stabilized by the three-dimensional latticework of roots and rhizomes (Figure 2).

For dunes to increase in height, vegetation must be able to grow fast enough to keep pace with accumulating sand. This vegetation must also tolerate salt spray, desiccating winds, and low soil moisture.

Figure 3. Beach dunes of Santa Rosa Island showing the herbaceous plant community composed primarily of the perennial grasses sea oats (*Uniola paniculata*) and bitter panicgrass (*Panicum amarum*) with beach elder (*Iva imbricata*) intermixed. Credit: Josiah Raymer, UF/IFAS

Coastal grasses in the Florida Panhandle such as sea oats (*Uniola paniculata*) and bitter panicgrass (*Panicum amarum*) grow fast enough to facilitate rapid beach dune growth. As a result, to promote growth of new beach dunes (foredunes) or to repair damaged dunes, these perennial grasses are often planted after dunes have been eroded, fragmented, or destroyed.

When there are long periods between strong tropical storms, some dunes reach great heights. The dunes reach these heights when they are stabilized by the presence of woody vegetation on the leeward side of developed dunes (Figure 3).

Why Dunes Are Important

Protection from Storms

Dunes are essential for the protection of roads, buildings, and coastal properties. They are resilient, flexible barriers that are the first line of defense against potential damage caused by wind and water from coastal storms. They absorb energy and dissipate the impact of tides, storm surges, and waves, providing protection to homes and businesses as well as our rare coastal ecosystems. Shorelines are protected when waves break on beaches and dunes prevent the full force of water from reaching inland (Figure 4).

Figure 4. Constructed berm with sand fence located in front of coastal development and planted with a mixture of sea oats (*Uniola paniculata*) and bitter panicgrass (*Panicum amarum*) along Navarre Beach, Santa Rosa Island. Credit: Debbie Miller, UF/IFAS

Dunes are also reservoirs of sand. The higher and wider the dunes, the larger the reservoir of sand and the greater the protection from coastal flooding, storm surge, and wave action. The resilience of the beach-dune system relies on the reservoir of sand. When dunes are damaged, sand is released and replenishes our beaches. In a healthy, resilient coastal system, this sand is then available for redevelopment of the dune system. Recognition of the importance of dunes for protection of coastal homes has led local, state, and federal agencies to provide support to preserve and restore dunes to protect coastal communities.

Home to Unique Wildlife and Plants

Dunes are essential for the continued existence of many rare plants and animals. Entire coastal landscapes, including beach dunes, embedded grasslands, wetlands, and scrub provide critical habitat for endangered and rare endemic plant and animal species (a species that is endemic to a particular ecosystem occurs nowhere in the world other than that ecosystem) (Dahl et al. 1975; Dahl and Woodard 1977; Swilling et al.1998).

Beach Mice

Four rare, imperiled subspecies of beach mice occur on the barrier islands and peninsulas of the Florida Panhandle, the Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*), the Santa Rosa beach mouse (*P. p. leucocephalus*), the Choctawhatchee beach mouse (*P. p. allophrys*), and the St. Andrew beach mouse (*P. p. peninsularis*) (Figure 5).

Figure 5. The threatened Santa Rosa beach mouse (*Peromyscus polionotus leucocephalus*). Credit: UF/IFAS file photo

With a single exception, these beach mice are endemic to the beaches of the Florida Panhandle—they occur nowhere else in the world. The one exception is the Perdido Key beach mouse, whose range also extends to a small area in Alabama.

Sea Turtles

Our beaches are nesting habitat for the loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempii*), green sea turtle (*Chelonia mydas*), and sometimes the leatherback sea turtle (*Dermochelys coriacea*). Both nesting female sea turtles and tiny hatchlings can become disoriented by man-made lights. Bright streetlights and houselights can lead sea turtles inland, away from the Gulf of Mexico, where they become prey to dogs, raccoons, and other animals; die of dehydration; or are maimed and killed by vehicles when they crawl into roads or parking lots. Dunes diminish the impact of city lights and provide a barrier between sea turtle nesting habitat and human developments, thereby encouraging adult and hatchling sea turtles to move toward the Gulf of Mexico.

Gopher Tortoises

While sea turtles use the beaches during nesting periods, the gopher tortoise (*Gopherus polyphemus*) finds year-round habitat in dunes. Dunes provide burrowing sites for these land animals. Both dunes and interdunal swales, the low depressions between the dunes in the coastal landscape, provide food resources.

Shorebirds

Our beaches and dunes are critical stopover habitats during migration for many birds and pollinators. Three rare shorebirds, the snowy plover (*Charadrius alexandrinus*), Wilson's plover (*Charadrius wilsonia*), and American oystercatcher (*Haematopus palliates*), nest on the coast of the Florida Panhandle.

Other Beach Dwellers

Figure 6. At left, monarch butterflies (*Danaus plexippus*) resting in tree canopies within backdune trees on Santa Rosa Island. At right, the rare coastal plain hesperapis (*Hesperapis oraria*) known also as the balduina bee mating on the flower of coastalplain honeycombhead (*Balduina angustifolia)*. Credits: Mack Thetford and Jeremy Munn, UF/IFAS

One of the many migratory pollinators that rely on Florida Panhandle coastal ecosystems is the monarch butterfly (*Danaus plexippus*). The monarch uses the milkweed (*Asclepias humistrata*) found on our dunes to deposit eggs and feed larvae for the next generation of butterflies. Rare endemic invertebrates are also found on our coastal landscapes. Three rare beetles, Woodruff's polyphyllan scarab beetle (*Polyphylla woodruffi*), the lobed spiny burrowing beetle (*Gronocarus autumnalis*), and the lobeless spiny burrowing beetle (*Gronocarus inornatus*), live in the dunes. A rare ground-dwelling bee *(Hesperapsis oraria*) is also found on our barrier islands and the immediate coastline (Figure 6).

Endemic Plants

Endemic plants such as the two forms of Godfrey's goldenaster (*Chrysopsis godfreyi* forma *godfreyi* and *Chrysopsis godfreyi* forma *viridis*), Cruise's goldenaster (*Chrysopsis gossypina* subsp. *Cruiseana*), false rosemary (*Conradina canescens*), coastal sand frostweed (*Crocanthemum arenicola*), gulf coast lupine (*Lupinus westianus* var. *westianus*), and squareflower (*Paronychia erecta*) are also associated with coastal landscapes (Figure 7). There are also rare plants such as the largeleaf jointweed (*Polygonella macrophylla*).

Chrysopsis godfreyi forma *godfreyi*, Godfrey's goldenaster Credit: Natalie Hooton, UF/IFAS

Chrysopsis godfreyi forma *viridis*, , Godfrey's goldenaster Credit: Natalie Hooton, UF/IFAS

Chrysopsis gossypina subsp. *Cruiseana*, Cruise's goldenaster Credit: Natalie Hooton, UF/IFAS

Conradina canescens, false rosemary Credit: Mack Thetford, UF/IFAS

Crocanthemum arenicola, coastal sand frostweed Credit: Gabriel Campbell, UF/IFAS

Paronychia erecta, squareflower Credit: Gabriel Campbell, UF/IFAS

Figure 7. Endemic plant species of the Gulf of Mexico coastal dunes plant communities.

Threats to Dunes

Frequent strong weather events such as hurricanes and tropical storms cause dune loss. Big storms erode the shoreline, uproot vegetation, and may breach or completely flatten even well-developed beach dunes, leaving them fragmented and their associated ecosystems damaged or destroyed (Webb et al. 1997; Figure 8). These storms also make beach dunes, their embedded ecosystems, and the coastal mainland more vulnerable to damage from future storms.

Figure 8. Extensive loss of well-developed beach dunes following Hurricane Ivan (2004) resulted in uprooted vegetation and flattened dunes; photo taken from Fort Pickens facing east toward Pensacola Beach. (UF/IFAS photo by either Debbie Miller or Mack Thetford)

With an increased threat of severe storms associated with global climate change and sea-level rise, the loss of dunes means there may be less storm protection available for coastal property owners. Wildlife habitat may also become increasingly fragmented. An increase in severe storms, paired with the compounding effects of human development along our coastlines, makes natural redevelopment of dunes and other coastal habitats difficult.

Extensive residential and commercial development along Florida's Gulf Coast has shrunk and fragmented natural habitat. Development means fewer beach dunes, less important habitat, and less sand available for natural dune reformation. Without human assistance through active restoration, these increased stresses will change coastal dunes and beaches too rapidly and too frequently for them to repair and regrow naturally.

Coastal Landscapes and Associated Plant Communities

The coastal environment is harsh for plants. In addition to periodic large storms, coastal plants must endure salt spray, strong winds, burial and scouring by blowing sand, limited water, and low nutrient availability (Snyder and Boss 2002). Plants that live along our coastline have adapted to survive these harsh conditions and have created unique plant communities.

Dunes nearest the Gulf of Mexico block onshore winds, resulting in a decrease in salt spray and sand movement inland. This causes a greater variety of plants that are less salt and wind tolerant on the leeward side of beach dunes. Starting from the Gulf of Mexico and moving landward,

beach, beach dune, coastal interdunal swale, coastal grassland, and scrub are plant communities that can be found along the coastline of the Florida Panhandle (FNAI 2010) in fairly predictable patterns. Sandy, unvegetated beaches and beach dunes are nearest to the Gulf of Mexico, followed by coastal grasslands with embedded coastal interdunal swales toward the mainland. Coastal scrub typically occurs at the highest elevations on back-barrier and mainland dunes, also known as backdunes. These plant communities blend into an undulating matrix where shifts in vegetation composition can be rapid with very minor changes in elevation (Figure 9; Table 1).

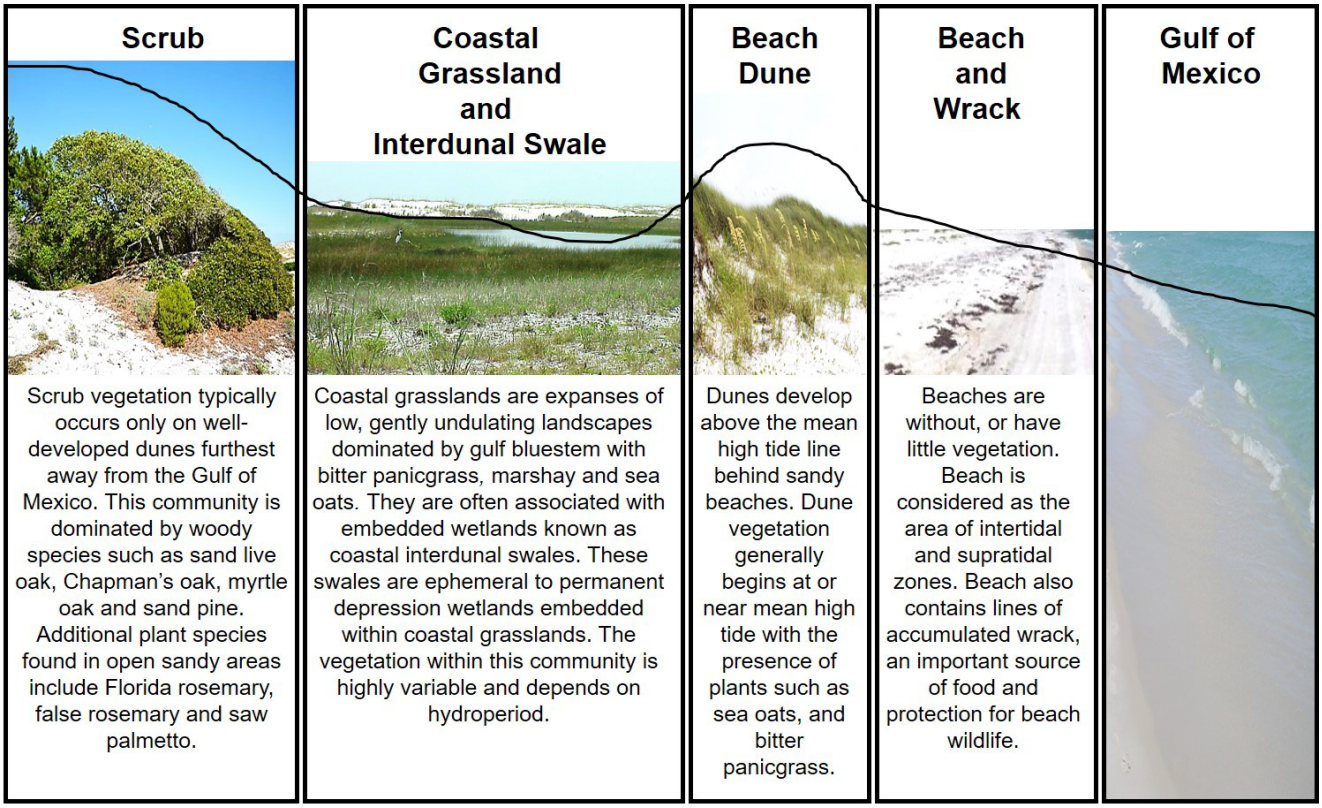


Figure 9. Names, descriptions, and positions of plant communities relative to the Gulf of Mexico found along the coastline of the Florida Panhandle as described by the Florida Natural Areas Inventory (FNAI 2010). Credits: Figure by Ashlynn Smith, UF/IFAS. Photos by Ashlynn Smith, Josiah Raymer, and Mack Thetford, UF/IFAS

Table 1. Definition of plant communities of the Florida Panhandle Coast. (Adapted from Florida Natural Areas Inventory 2010)

Plant community	Definition
Beach and wrack	Landform along the margin of the Gulf extending from the low water line landward to the point where permanent vegetation or a dune is found. Beach litter consisting of "algae, grasses, driftwood, fruits, seeds, and carrion, along with cultural litter" that accumulates at the high tide line (wrack line).
Grass-dominated beach dunes	Well-developed dune dominated by grass cover of primarily *Uniola paniculata*, *Panicum amarum*, *Spartina patens* or *Schizachyrium maritimum.*
Mixed grassy/woody beach dunes	Well-developed dunes with a mix of grass and woody species. Cover of grasses is greater than that of woody species.
Coastal grassland	Expanses of low, gently undulating dunes dominated by *Uniola paniculata*, *Panicum amarum*, *Spartina patens* or *Schizachyrium maritimum* with unvegetated swales and vegetated swales imbedded within.
Coastal interdunal swale	Ephemeral, depression wetlands embedded within coastal grasslands
Scrub	Well-developed dunes dominated by woody species

Beach and Frontal Zone Plant Community

The most dynamic part of our coastline includes the sandy beach and the beach dunes found immediately onshore from the Gulf of Mexico. The sandy beach borders the Gulf and is shaped by wind and tides. The foredunes, or beach dunes closest to shore, are found landward of the highest monthly tides and form when wind-blown sand is captured by plants.

Beach

The beach is a gently sloping landform that extends from the low water line of the Gulf of Mexico to the edge of the first beach dune. Sandy beaches of the Florida Panhandle consist of white, quartz sand. Little or no vegetation is found on the beach.

Along the beach, you can also find wrack—or beach litter consisting of "algae, grasses, driftwood, fruits, seeds, and carrion, along with cultural litter" that accumulates at the high tide line (Behbehani and Croker 1982; Orr et al. 2005; Dugan et al. 2003; Nordstrom et al. 2012). Although wrack is not considered a plant community, it is an important food resource for wildlife such as shorebirds and ghost crabs and should not be removed (Figure 10).

Figure 10. Newly deposited wrack on Pensacola Beach, Florida. Credit: Mack Thetford, UF/IFAS

Plants found on the immediate sandy areas of the beach are sandwiched between the Gulf and the first beach dunes (foredunes) and are usually transient residents, meaning they are only present for short time periods (Table 1). These plants are exposed to the harshest of conditions and exist at the threshold of possible plant survival. One common species often found near or in beach wrack is sea rocket (*Cakile* species). This plant is an important food source for beach mice, but the plants only live a single growing season. Sea rocket seeds are tolerant of salt water, and the species is dependent on waves and wind to spread the seed.

Beach Dune

Beach dunes are herbaceous plant communities that develop above the high tide line behind sandy beaches (Figure 11). They exist in a uniquely harsh microclimate, characterized by salt spray, heavy winds, tidal fluctuations, and large-scale storm surges. Dune vegetation generally begins at or near high tide with the presence of creeping herbs such as beach morning glory (*Ipomea imperati*) (Clewell 1986) or mounding herbaceous plants such as beach elder (*Iva imbricata*). Directly landward are the dune-building rhizomatous grasses, which are essential for the horizontal and lateral growth of dunes. Sea oats (*Uniola paniculata*) is generally the dominant dune-building grass on foredunes along with bitter panicgrass (*Panicum amarum*) (Snyder and Boss 2002; Clewell 1986; FNAI 2010). An additional grass, gulf bluestem (*Schizachyrium maritimum*) is also considered a dune stabilizer and often grows on beach dunes along the Gulf Coast.

Dune-building plants are noted for their ability to grow vertical shoots from their underground modified stems, or rhizomes, in response to sand burial allowing them to tolerate sand accretion. In essence, the dune-building grasses are essential for the formation, growth, and physical stability of beach

Figure 11. Foredune of Santa Rosa Island showing the beach dune plant community with sea oats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*) and beach elder (*Iva imbricata*). Credit: Josiah Raymer, UF/IFAS

dunes. Beach dunes dampen sand movement, wind, and salt spray and therefore alter the environment of plant communities found landward.

Interior Plant Communities

The interior of the barrier islands, from beach dunes to sound/bay-side scrub dunes, consists of a mosaic of landscape elements including coastal grasslands, coastal interdunal swales, and scrub dunes. Bay systems and connecting waterways such as Santa Rosa Sound also influence environmental conditions as well as the local flora and fauna. Nearest these bodies of water are scrub dunes, open pine forest, and fringing marshes. We do not address coastal pine or salt marsh communities in this manual.

Coastal Grassland

Coastal grasslands are herbaceous plant communities that exist between beach dunes and inland woody plant communities, such as coastal scrub (Figure 12).

Figure 12. Coastal grassland of Santa Rosa Island. Credit: Ashlynn Smith, UF/IFAS

Bluestems (*Andropogon* species and *Schizachyrium* species), camphorweed (*Heterotheca subaxillaris*), and earleaf greenbriar (*Smilax auriculata*) are characteristic of coastal grasslands. The dune-building grasses like sea oats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*), and marshhay (*Spartina patens*) are also present on coastal grasslands.

Rare plant species found in coastal grasslands include Godfrey's goldenaster (*Chrysopsis godfreyi*), Cruise's goldenaster (*Chrysopsis gossypina* subsp. Cruiseana), and gulf coast lupine (*Lupinus westianus* subsp. *westianus*). Coastalplain honeycombhead (*Balduina angustifolia*), the sole nectar source for the endemic coastal plain Hesperapis (*Hesperapis oraria*), which is also known as the balduina bee and sandhill milkweed (*Asclepias humistrata*), the food source for monarch butterfly larvae, grow here. Other species that grow in coastal grasslands are spadeleaf (*Centella asiatica*), LeConte's flatsedge (*Cyperus lecontei*), Spanish daisy (*Helenium amarum*), seabeach evening primose (*Oenethera humifusa*), squareflower (*Paronychia erecta*), coastal groundcherry (*Physalis angustifolia*), Walter's groundcherry (*Physalis walteri*), and heartwing dock (*Rumex hastatulus*).

Coastal Interdunal Swale

Interdunal swales are herbaceous wetlands found in depressions embedded within coastal grasslands or between dunes. Ephemeral swales are seasonally wet for shorter periods of time while permanent swales remain wet (Figure 13). They have a highly variable vegetative composition depending on salt content of the soil, length of time standing water is present during the growing season and conditions at the time seeds germinate and plants establish. (FNAI 2010). Coastal interdunal swales may contain low shrubs such as St. John's wort (*Hypericum* species), wax myrtle (*Morella cerifera*), and yaupon (*Ilex vomitoria*) in areas where the soil is not always saturated. Inundated portions or deep swales may contain sawgrass (*Cladium jamaicense*) or black needlerush (*Juncus roemerianus*).

Figure 13. At left, a coastal interdunal swale of Santa Rosa Island following a recent rain with sparse vegetation and bladderwort (*Utricularia* sp.) in peak flower. At right, a coastal interdunal swale of Santa Rosa Island, Gulf Islands National Seashore, with dense herbaceous vegetation and occasional woody dune species occurring in the swale and on the surrounding ridges. Credit: Gabriel Campbell, UF/IFAS

Scrub

Coastal scrub is the most imperiled ecosystem in Florida (FNAI 2010) and is found on older stabilized dunes (Figure 14). It consists of a dense shrubland of stunted sand live oak (*Quercus geminata*), Chapman's oak (*Quercus chapmanii*), myrtle oak (*Quercus myrtifolia*), and sand pine (*Pinus clausa*). Open sandy areas embedded within the oak thickets are an important characteristic, because they provide movement corridors for small mammals and reptiles. Additional plant species found in open sandy areas include Florida rosemary (*Ceratiola ericoides*), false rosemary (*Conradina canescens*), October flower (*Polygonella polygama*), yaupon (*Ilex vomitoria*), and woody goldenrod (*Chrysoma pauciflosculosa*).

Figure 14. Scrub community occurring in the back dunes of the Fort Pickens unit of Gulf Islands National Seashore, Santa Rosa Island. Credit: Ashlynn Smith, UF/IFAS

Restoring Dunes in the Western Florida Panhandle

Before you start any restoration activity, be sure to contact all local, county, state, and federal agencies to ensure appropriate permits for plantings, installation of sand fences, use of wrack, and other activities are in place. Below are contacts and descriptions of federal, state, county, or local regulation resources to assist in initiating contact to determine if your restoration activity will require permits or oversight (Tables 2 and 3). Please note that county or state (DEP) permits related to the Coastal Construction Control Line (CCCL) are each independent requirements and do not suffice for a Federal Endangered Species Permit.

Table 2. Federal and state coastal project review contacts and resources.

US Fish and Wildlife Service Panama City Office https://www.fws.gov/panamacity/
Florida Department of Environmental Protection Coastal Construction Control Line Program http://www.dep.state.fl.us/beaches/programs/ccclprog.htm
Florida Department of Environmental Protection Sand fence guidelines and requirements Building Back the Dunes https://www.dep.state.fl.us/beaches/publications/pdf/BuildingBackSandDunes.pdf Sand Fence Guidelines http://www.dep.state.fl.us/beaches/publications/pdf/sndfncgl04.pdf

Coastal Construction Control Line

In order to protect beach and dune systems in Florida, the Florida Legislature adopted the Florida Beaches and Shores Preservation Act (parts I and II of Chapter 161, Florida Statutes). The Coastal Construction Control Line (CCCL) program was created as a result of this statute.

Any activity south of the CCCL requires a review from the Florida Department of Environmental Protection (FDEP) to determine whether a permit is needed or a waiver can be granted. The landowner should contact the FDEP representative to discuss each project. A local field representative may be contacted for minor activities. Minor activities include dune walkovers, small decks, plantings, and sand fences. This requirement is to help the property owner to ensure success of the project and to maintain the integrity of the beach and dune system.

The CCCL (Figure 15) can be reviewed by using FDEP Map Direct which is available online at: https://ca.dep.state.fl.us/mapdirect/?gallery=beaches

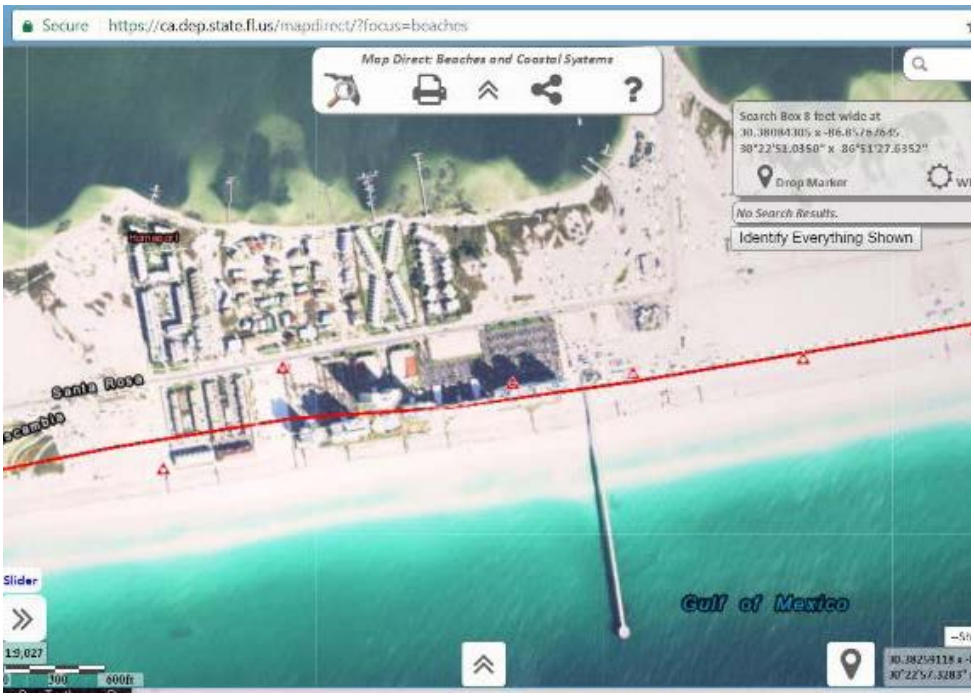


Figure 15. An example Map Direct Image depicting the Coastal Construction Control Line (in red) on Navarre Beach. Credit: FDEP Map Direct

Table 3. County contact information to determine if there is a local permitting process north of the CCCL. Or, contact the US Fish and Wildlife Service (1601 Balboa Avenue, Panama City, FL 32405; 850-769-0552).

County	Phone Number Office Address	Department, Division or Office Website
Bay	850-248-8250 840 West 11th Street Panama City, FL 32401	Bay County Planning and Zoning Department http://www.co.bay.fl.us/planning.php
Escambia	850-595-4988 223 Palafox Place Pensacola, FL 32502	Escambia County Natural Resources Management https://myescambia.com/our-services/natural-resources-management
Franklin	850-653-9783 34 Forbes Street, Suite 1 Apalachicola, FL 32320	Franklin County Planning and Building Department http://www.franklincountyflorida.com/county-government/planning-building/
Gulf	850-248-8350 840 West 11th St. Panama City, FL 32401	Gulf County Builders Services http://www.co.bay.fl.us/builders.php
Okaloosa	850-651-7180 1250 Eglin Parkway N, Suite 301 Shalimar, FL 32579 812 East James Lee Boulevard Crestview, FL 32539	Okaloosa County Growth Management, Building Division Inspections - Permitting http://www.co.okaloosa.fl.us/gm/building/permitting Jim Trifilio, Coastal Management Coordinator 850-609-5382, 1540 Miracle Strip Parkway SE
Santa Rosa	850-981-7000 6051 Old Bagdad Hwy, Suite 202 Milton, FL 32583	Santa Rosa County Development Services http://www.santarosa.fl.gov/development-building/index.cfm?Menu=167
Walton	850-892-8108 117 Montgomery Circle DeFuniak Springs 32435	Walton County Environmental Department http://www.co.walton.fl.us/96/Environmental

Preservation and Use of Existing Resources

One of the first considerations following storm-related or other damage to existing dunes is to determine the potential for natural dune development with minimal to no assistance. Sea oats and other beach plants are naturally resilient to storm damage. If not buried too deeply by sand or left exposed for too long, sea oats will regrow. Removing and discarding uprooted sea oats during clean up after storms hinders the ability of the dunes to recover naturally. Do not remove uprooted sea oats from the beach after a storm unless to use nearby for restoration purposes.

Wrack

Beach wrack is an additional resource that is important to the resilience of beaches and beach dunes. Beach litter consisting of "algae, grasses, driftwood, fruits, seeds, and carrion, along with cultural litter" that accumulates at the high tide line or wrack line after storms is referred to as wrack. Wrack contains resources important to wildlife and aids in the development of beach dunes (Behbehani and Croker 1982; Orr et al. 2005; Dugan et al. 2003; Nordstrom et al. 2012) (Figure 9).

The rough surface of the mixture of materials that make up the wrack catches seeds of dune plants and sand carried by the wind. Trapped seeds germinate and grow with the help of wrack. As wrack decays, it supplies nutrients, protection, and moisture to the plants, potentially increasing the survival and growth of these plants. Seagrasses and algae commonly found in wrack are nitrogen and phosphorous sources for dunes (Williams and Feagin 2010). For these reasons, wrack has an important function in

beach ecology and should be left in place (Hooton et al. 2014).

Despite the benefits of wrack, the Florida Fish and Wildlife Conservation Commission (FWC) allows mechanical beach cleaning at some times of the year, which leads to the removal of wrack. Disposal of wrack collected during beach cleaning could squander a valuable resource. Wrack removed by raking can be collected and placed around newly planted sea oats or native dune plants as a natural supplement to enhance growth of dune vegetation. Guidelines for mechanical beach cleaning (http://myfwc.com/wildlifehabitats/managed/sea-turtles/beach-activities/beach-cleaning-guidelines) are available from FWC and include beach cleaning permit conditions and contact information. It is important to note that beach raking also results in loss of new seedlings of sea oats and should be avoided, particularly after storm events.

Uprooted Sea Oats

Uprooted sea oats can be a good source of restoration material. Part of what makes sea oats resilient to the harsh coastal environment is their long underground stems (rhizomes). When these stems are uncovered via erosion, they are often found scattered on the beach or piled up against buildings, remaining trees, and other structures. These scattered stems can be replanted and used for restoration. (Figure 16). Beach homeowners have found, and research has shown, that uprooted sea oats can be used to restore dunes. If immediate action is taken to bury these stems in sand 6–12 in deep, sea oats stems and leaves will likely sprout the following summer (Miller et al. 2003). Typically, with good weather, sea oats must be replanted within 3 to 11 days after they are uprooted to be successful. Additional planting may be necessary to supplement the re-planted sea oats.

Figure 16. Sea oats rhizomes following uprooting from a storm event with new growth initiating from nodes. This material can be used for restoration following storms. Credit: Mack Thetford, UF/IFAS

Active Restoration Applications

In this section we'll look at restoration techniques that include installing sand fence and planting nursery-produced native plants. In some situations, state and federal permits may be required for these activities.

Sand Fence

Installation of sand fence in combination with planting vegetation has been a successful method for dune restoration, but the length and arrangement of sand fencing may be regulated in your area. This is because the use of sand fencing in the Florida Panhandle must follow federal and state regulations enacted to protect nesting sea turtles. Contact your local FDEP field representative (http://www.dep.state.fl.us/beaches/programs/ccclprog.htm) for more information and to ensure use of sea-turtle-friendly fencing techniques. If the intended dune restoration area does not allow for the combination of sand fencing and planting, planting alone is preferred.

Where sea turtle nesting is not a concern, many configurations of fencing have been used, but no one fencing configuration has proven to be more successful than another at collecting sand (Miller et al. 2001). The easiest to install, straight fencing parallel to the Gulf, performs as well as several other configurations tested on the Florida Panhandle. It is actually the length of the fence that is the most important characteristic when it comes to sand accumulation. The longer the fence, the greater the sand accumulation. Sand fencing can also provide an additional benefit by deterring people from disrupting planting sites. Consult DEP's publication, *Sand Fence Guidelines,* https://floridadep.gov/sites/default/files/SandFencingGuidelines_0.pdf. To repeat, before designing a dune restoration project that incorporates sand fence installation, be sure to check with a DEP field representative.

This will ensure your project does not conflict with sea turtle nesting.

Generally, plants can be transplanted adjacent to sand fences at the time of fence installation. Between buildings and the Gulf of Mexico or gulfward of large dunes, northerly winds are diminished, and sand movement is moderate. In this case, plants can be transplanted near fences. However, in open areas with large amounts of unconsolidated quartz sand and high wind speed, sand movement is rapid, and fences may fill quickly with loose sand. This was seen in areas of complete dune and vegetation loss in the Florida Panhandle after Hurricanes Opal and Ivan. The loose sand should be allowed to settle before plants are installed. Once sand accumulation has slowed, plants may be transplanted on the newly stabilized sand adjacent to the sand fence. An alternative in this situation would be to place plants 15 ft landward and gulfward of fences at time of fence installation (Miller et al. 2001). In this situation, planting further away from fencing allows for both plants and fencing to effectively accumulate sand.

Planting Beach Dune Species

Plants alone are often as effective at accumulating sand as planting in combination with sand fences. Planting on a stabilized beach is preferred.

Sand berms are artificial dunes resulting from dune re-nourishment activities and are often an unstable substrate for establishing plants. It is best after sand placement to allow the sand to stabilize before planting into a berm.

Sea oats are the dominant—but not the only—beach dune species in Florida's natural dunes. For dunes to provide their many natural benefits, including habitat for wildlife and ecosystem services such as protection for coastal homeowners, it is best if we reestablish dunes that resemble natural, nearby dunes by including the many plants that are found on them.

As a best practice, at least three to four species of herbaceous plants should be considered when restoring beach dunes. After dunes have had several years to grow and the initial plants are established, additional plant species can be added.

Obtaining appropriate plant material can be difficult, especially when using sea oats. Sea oats are protected by various regulations and have genetic and phenotypic variations specific to local populations. Fortunately, sea oats are available at commercial nurseries, but be sure to ask if your stock originates from the Gulf Coast. Sea oats from a population outside of your local area may not grow or flower well. These plants may also interfere with future generations of local sea oats if they do intermix with the local populations through seed production.

The transplant size of grasses and small herbaceous species can vary considerably based on the nursery source. These plants may be grown in a variety of production systems resulting in long, narrow rootballs to short, broad rootballs depending on the dimensions of the production containers.

A common practice among producers is to remove the plants from the production containers and pack only the plants without their production containers in a box for shipping.

When plants remain in their original production systems, the restoration manager has the option to hold the plants for a longer period of time between delivery to the restoration site and planting. These plants may be easily watered and have good air movement between the leaves. A quick review of the terms of sale and shipping options in addition to the plant materials available from a grower before ordering will provide much of this information. Otherwise, plants combined in a shipping box without pots must be planted quickly. Also, the heat the plants generate from within the shipping containers can be detrimental.

Plantings for the establishment of new dunes should be as far landward as possible. The most successful restoration along the Florida Panhandle has taken place where vegetation was planted at least about 300 ft inland of the mean high tide line. This may not be possible in areas of coastal development. When possible, new dunes should fill large gaps between fragmented dunes. This will increase plant survival and allow for natural redevelopment toward the Gulf of Mexico.

What, where, and when to plant are the most commonly asked questions in regard to beach plantings to establish dunes. For the Florida Panhandle, sea oats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*), beach elder (*Iva imbricata*), and sometimes gulf bluestem (*Schizachyrium maritimum*) are the most commonly planted species when planting beach dunes nearest the Gulf.

Figure 17. Suggested pattern for creating planting zones when conducting restoration plantings on beach dunes along the northern coast of the Gulf of Mexico. Specific planting order will vary based on the intent of the project. Credit: Byron S. Claypool, UF/IFAS

A diversity of plants is preferred for many reasons, including food and habitat for wildlife. However, these plants should not be intermixed within the same row or zone. Sea oats will completely replace bitter panicgrass within one to two years if planted immediately adjacent to each other. Instead, planting in blocks or rows of each species maintains the diversity of the planting for a longer period of time (Figure 17).

We are recommending four planting zonation patterns because these patterns have resulted in greater survival, plant growth, and sand accumulation in recent studies (Stoddard et al. 2014). The first two suggested planting schematics include (beginning nearest to the Gulf of Mexico) several rows of bitter panicgrass. The first recommendation is then to follow the planting of bitter panicgrass with beach elder immediately landward, sea oats landward of beach elder, and gulf bluestem behind all other species (Figure 18).

Another combination is to plant bitter panicgrass followed by sea oats, gulf bluestem, then beach elder as the most landward.

Two other patterns of planting beach dune vegetation have proven successful. Both include sea oats as the plant species closest to the Gulf of Mexico and beach elder as the furthest from the Gulf of Mexico.

One suggestion is to plant the first several rows (three or more) with sea oats nearest to the Gulf of Mexico, rows of bitter panicgrass landward of sea oats, followed by gulf bluestem, then beach elder.

The second suggestion is to plant gulf bluestem landward of sea oats, bitter panicgrass landward of gulf bluestem, and beach elder on the back row or back several rows. Beach elder can also be planted in a large block well out in front of all other species, but it does not do as well when planted as the first row of plants with other species immediately landward.

If the objective of the restoration project is to build sand quickly, these planting combinations accumulate sand at a similar rate to monocultures of sea oats or bitter panicgrass. It should be noted that gulf bluestem and beach elder both have higher survival when planted behind either sea oats or bitter panicgrass, or when planted alone. Any of these planting patterns promote plant survival and dune growth.

Figure 18. Specific planting-order configuration recommendations when conducting restoration plantings on beach dunes along the northern coast of the Gulf of Mexico using four distinct planting zones. Credit: Ashlynn Smith, UF/IFAS

Recommended Planting Dates

Plant survival is highest when rainfall is consistent and temperatures are moderate. In the Florida Panhandle, sea oats, bitter panicgrass, and beach elder should be planted into moist soil from the months of December through April, with optimal results from March to April.

Planting during summer can be successful if summer rains are consistent. However, if summer rainfall is limited, plantings will need supplemental water. Early fall plantings have also been successful but, on average, October and May are typically the driest months in the Florida Panhandle, and plants should be established before these dry periods (Miller et al. 2001).

Gulf bluestem is an exception (Miller et al. 2014). Planting in June, July, and August is best because these are the only months of high survival for this species. June appears to be the best planting date, but with consistent rainfall, planting can also be successful in July and August. Survival of gulf bluestem varies widely from 50 to 100 percent, and planting outside of the recommended months can dramatically limit survival. If planting gulf bluestem in one of the previously suggested zonation patterns, leave space for the planting of gulf bluestem later in the season.

Recommended Plant Spacing

Recommendations for spacing of beach plants vary. For sea oats, place plants from 1 to 5 ft apart depending on plant size and the restoration objective. One strategy is to have a lower density closer to the water and higher density as the planting extends landward (Figure 19). The example shown here places plants about 36 in apart nearest the Gulf and then decreases spacing to 18 in, finally decreasing spacing to 12 in apart at the most landward portion of the planting as the rows of plants move away from the Gulf of Mexico.

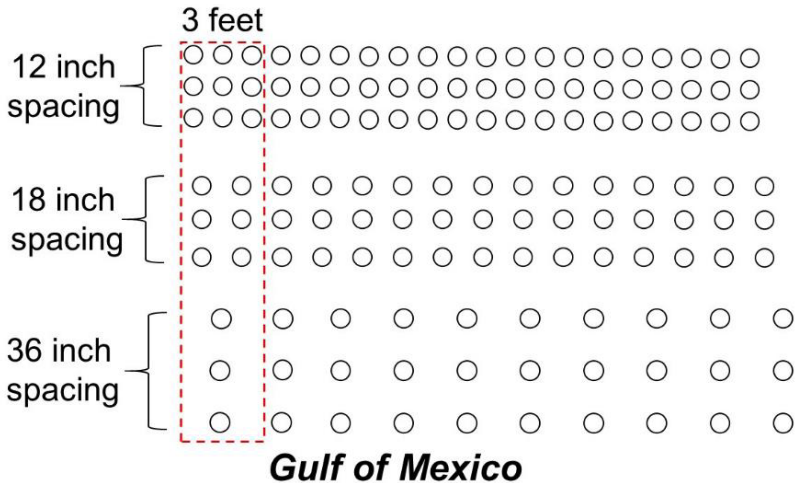


Figure 19. An example strategy for spacing of dune restoration plantings. Begin with a lower density and wider spacing closer to the water; end with a higher density and closer spacing as the planting extends landward. Credit: Ashlynn Smith, UF/IFAS

This allows for wider dune development because sand can then move into all parts of the project area. If the plants nearest the Gulf of Mexico are planted too densely, sand moving from the beach landward will be trapped in the first few rows, preventing the back of the planting from receiving sand. Larger plants, such as 4-inch pots, can be spaced farther apart than smaller ones.

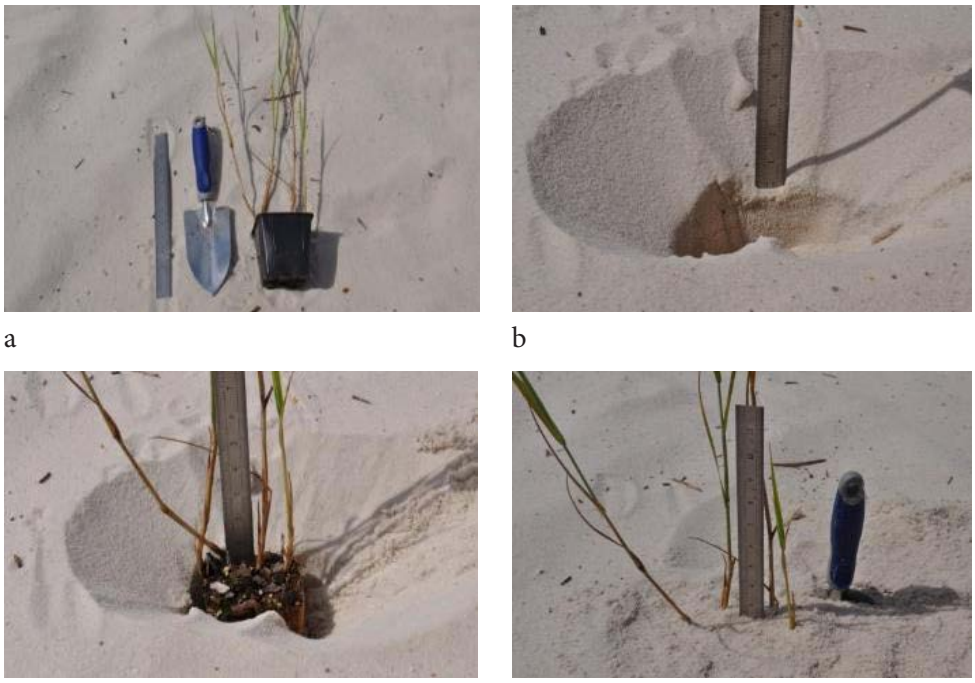
Recommended Planting Depth

Dune plants are quite tolerant of deeper burial in the sandy beach soil. In fact, planting too shallow is the most common cause of plant death. The top layer of the quartz sand of the Florida Panhandle dries very quickly after rain. Moisture increases with depth, and deep planting allows the roots to stay in contact with the moisture as they grow into the sand. Sea oats and bitter panicgrass should be planted so that the top of the rootball is at least 6 in below the beach surface. If transplants have short leaves, plant to a depth where at least 3 in of the foliage is above the beach surface.

For other beach grasses and herbaceous and woody plants, place the rootball deep enough to access the available soil moisture (Figures 20 and 21). Note how the dry sand above the moist sand can easily be identified. This demonstrates how dry the upper 4–6 in of sand can be only 12 hours after a heavy rain.

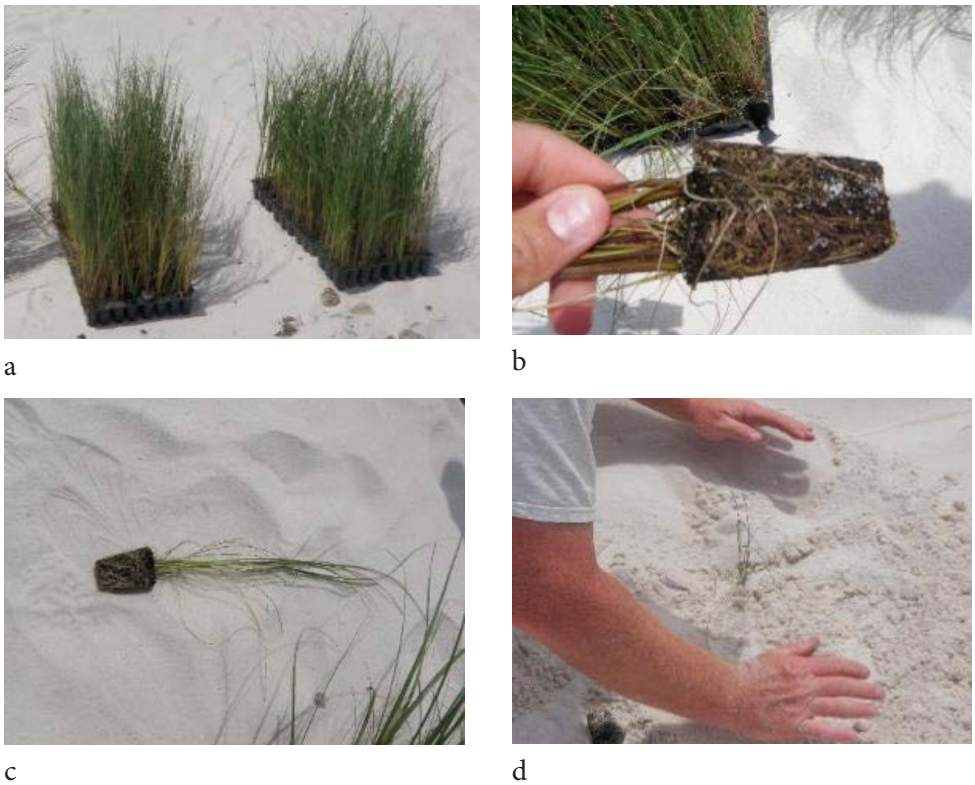
The planting depth may differ based on the species and the size of the production container (Figure 22). Each of these plants grown and marketed as a 4-inch transplant represent differing container dimensions.

Container depth may have a direct impact on the rooting depth of the transplant. Deeper pots provide a deeper rooting profile for the transplants. As a general rule, try to place a few inches of beach sand above the rootball at planting. Many production



a b c d

Figure 20. Beach planting of bitter panicgrass (*Panicum amarum*) grown in a shallow 4-inch nursery pot (a). Note the depth to moist sand (b). Planting depth may be estimated on the basis of the 6-inch length of the planting trowel. Approximately 4–6 in of sand is placed over the top of the rootball (c, d). Credit: Emily Bagby, UF/IFAS



a b c d

Figure 21. Beach planting of sea oats (*Uniola paniculata*) grown in a shallow, 96-cell nursery flat (a). Note the depth of the rootball (b) and the proportion of foliage (c). Planting depth is 6 in or more with only a small proportion of the foliage showing above the surface (d). Credit: Mack Thetford, UF/IFAS

substrates are coarser in texture than the beach sand, and the wind will cause these substrates to dry very quickly if they are not covered. Be sure to completely fill the hole around the plants with sand. Air trapped in the planting hole will prevent the roots from growing into the native sand and decrease the chance the plant will survive.

Figure 22. Two styles of 4-inch pots produce a deep rooting profile for *Chrysopsis gossypina* subsp. *Cruiseana,* or Cruise's goldenaster, at left and a shallow rooting profile for *Conradina canescens,* false rosemary, right. Credit: Emily Bagby, UF/IFAS

Planting Amendments

Wheat Straw

The potential of using organic substances similar to beach wrack to enhance growth of dune vegetation has been tested in the Florida Panhandle. A layer of wheat straw approximately 8 in deep around transplanted sea oats will increase sea oats growth and sand accumulation (Figures 23 and 24). If sea oats are transplanted during dryer months, survival may also increase with the use of wheat straw. (Hooton et al. 2014). Wheat straw has been tested with sea oats, but further research is needed before this procedure can be recommended for other species.

Figure 23. Foredune restoration site of sea oats (*Uniola paniculata*) planted approximately 12 in apart, the right half with an 8-inch layer of wheat straw two weeks after planting to serve as an artificial wrack. Below, the close-up view.

Figure 24. Two years later, the right half of the plot shows the sea oats with wrack are larger, are flowering, and have collected more sand compared to the left half of the plot where sea oats without artificial wrack are smaller, have no flowers, and have collected less sand. Credit: Natalie Hooton, UF/IFAS

Fertilizer

A variety of fertilization protocols exist for newly transplanted and established sea oats, but there has been little information available to verify the need or effectiveness of fertilizer additions.

Slow-release fertilizer can initially be added to new plantings, but continuous fertilization is not necessary due to adaptation of sea oats to extreme nutrient-deficient sites. Florida DEP specifications for restoration projects in Walton County include the addition of ½ teaspoon of Osmocote® 18-6-12 at the time of planting, which releases nutrients over a period of 90 days.

Water Adsorbing Gel Products

Water adsorbing polymer gel products such as Terrasorb®and Stock-osorb®, used at a rate between 8 and 12 ounces of hydrated gel per transplant have also been recommended at the time of planting (USDA-NRCS) to assist with water availability. Recent investigations using woody plants with and without the addition of an adsorbing polymer gel product did not demonstrate a significant improvement in plant survival or growth (Miller et al. 2013). Further work is needed to determine if these products are indeed beneficial to the establishment and growth of beach plants.

Irrigation

Irrigation, or immediate watering at the time of transplant, is not imperative, but can increase the success of plant establishment. What is critical is that plants are placed into 6 in of moist soil in a location that can depend on 1 to 2 in of water per month, either through rainfall or irrigation. In drier years, watering may be necessary for survival of shrubs or woody species. Most herbaceous or grass transplants will be established within a few months and should be well-established within the first year. For woody species, establishment may take from one to two years, which allows plants to be tolerant of dry periods, including extended drought, without additional inputs.

Planting Woody Species after Beach Dune Establishment

Scrub vegetation, including sand live oak (*Quercus geminata*), myrtle oak (*Quercus myrtifolia*), yaupon (*Ilex vomitoria*), and Florida rosemary (*Ceratiola ericoides*), frequently grows on the leeward side of large, well-developed beach dunes, scattered in association with coastal grasslands and coastal interdunal swales, and on back-barrier dunes (Figure 25). These woody plants have been found to further stabilize dunes. Dunes with woody plants are more likely to survive strong storms (Pries et al. 2009).

Additional woody species such as wax myrtle, yaupon, and salt bush (*Iva frutescens*) are found in swales within coastal grasslands (Figure 26). The fruits of these woody plants are also critical to beach mice and other coastal wildlife, particularly in the winter and spring following strong storms. Thus, replacement of these species to our coastal landscapes is important.

Woody species should not be placed too close to the Gulf of Mexico in order to reduce exposure to salt spray. A good rule of thumb is to wait until at least two to three small beach dunes have redeveloped before incorporating woody species into a dune restoration project. Generally, these woody species should be planted at least 560 to 670 ft landward of the Gulf of Mexico or behind well-developed beach dunes (Thetford et al. 2005; Thetford et al. 2015).

Figure 25. Scrub vegetation, including sand live oak (*Quercus geminata*), myrtle oak (*Quercus myrtifolia*), yaupon (*Ilex vomitoria*), and Florida rosemary (*Ceratiola ericoides*) on a large, well-developed beach dune. Credit: Ashlynn Smith, UF/IFAS

Figure 26. Woody species grow among wetland species in this interdunal swale and associated dune ridge. Back dunes with associated scrub species can be seen in the background. Credit: Hannah Hunsburger, UF/IFAS

Herbaceous and woody plants grown for restoration purposes may be produced in a variety of containers using a variety of production substrates. The appropriate size of transplant for a given site will depend upon factors such as the size of the shoot and root and the relationship of both components. The production system may vary based on the restoration site soil characteristics, relative soil moisture, and the tolerances of a given species to conditions such as drought or salt stress. Nursery-grown plants are exposed to minor water and heat stress at the end of the production period to assist with the transition from a nursery setting to the harsh conditions of a restoration site. Examples of container systems we have used to produce plants for coastal restoration trials include 3-gallon and 1-gallon tall pots, and standard gallon or quart nursery containers (Figure 27).

Figure 27. Examples of container systems used for production of plants for coastal restoration include 3-gallon and 1-gallon treepots (top row), and standard 1-gallon or quart nursery containers (bottom row). Credit: Mack Thetford, UF/IFAS

Woody plants grown in proportionally tall pots, or treepots, with well-developed root systems do the best (Figure 28). Planting should be conducted during the spring or fall. Two years after planting, survival of inkberry holly (*Ilex glabra*) produced in standard 1-gallon pots was 32 percent, while survival of inkberry holly produced in 1-gallon tree pots was 65 percent (Thetford et al. 2005). Unless the location has exceptionally high winds and sand accumulation, deep planting should be used. This means the top of pot will be 6–8 in below the surface of the sand.

If high winds and sand erosion are a problem at a site, deep planting will help prevent the uprooting of plants. Additionally, placing a portion of the roots in soil with a higher moisture content may aid plant establishment.

Figure 28. Yaupon (*Ilex vomitoria*) seedlings grown in 1-gallon treepots and 1-gallon standard nursery containers demonstrating the deeper (14-inch) rootball of the treepot. Credit: Mack Thetford, UF/IFAS

Planting of Herbaceous Plants for Wildlife Cover, Food, and Nectar

Grasses and shrubs are not the only plants that are important to coastal landscapes. Flowers, fruits, and leaves of many broad-leaved herbaceous plants are excellent sources of food and nectar for wildlife species. These plants should be added to a restoration planting several years after the establishment of dune-building species or to enhance existing well-developed dune systems. Detailed plant descriptions and outplanting recommendations are provided within this manual.

References

Behbehani, M.I., and R.A. Croker. 1982. "Ecology of beach wrack in northern New England with special reference to Orchestia platensis." *Estuarine, Coastal and Shelf Science*. 15(6):611–620. https://doi.org/10.1016/0272-7714(82)90075-0

Clewell, A.F. 1986. "Natural setting and vegetation of the Florida Panhandle: An account of the environments and plant communities of northern Florida, west of the Suwannee River." Mobile District, Alabama: U.S. Army Corps of Engineers, Final Report COESAM/PDEI-86/001.

Dahl, B.E., B.A. Fall, A. Lohse, and S.G. Appan. 1975. "Construction and stabilization of coastal foredunes with vegetation: Padre Island, Texas." United States Army Corps of Engineers, Coastal Engineering Research Center. Miscellaneous Paper No. 9–75.

Dahl, B.E., and D.W. Woodard. 1977. "Construction of Texas coastal foredunes with sea oats (*Uniola paniculata*) and bitter panicum (*Panicum amarum*)." *International Journal of Biometeorology*. 21:267-275.

Dugan, J.E., D.M. Hubbard, M.D. McCrary, and M.O. Pierson. 2003. "The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California." *Estuarine, Coastal and Shelf Science*. 58(10):25–40. https://doi.org/10.1016/S0272-7714(03)00045-3

Florida Natural Areas Inventory (FNAI). 2010. "Guide to the natural communities of Florida." http://fnai.org/PDF/FNAI-Natural-Community-Classification-Guide-2010_20150218.pdf

Hooton, N. 2011. "Restoration strategies for improving survival and composition of plant species native to coastal dunes in the Florida Panhandle." Master's Thesis. University of Florida. 81p.

Hooton, N., D.L. Miller, M. Thetford, and B.S. Claypool. 2014. "Survival and growth of planted *Uniola paniculata* in dune building using surrogate wrack on Perdido Key Florida, U.S.A." *Restoration Ecology*. 22(5):701–707. http://onlinelibrary.wiley.com/doi/10.1111/rec.12129/

Miller D.L., L. Yager, M. Thetford, and M. Schneider. 2003. "Potential use of *Uniola paniculata* rhizome fragments for dune restoration." *Restoration Ecology*. 11(3):359–369.

Miller, D.L., M. Thetford, and L. Yager. 2001. "Evaluation of sand fence and vegetation for dune building following overwash by Hurricane Opal on Santa Rosa Island, Florida." *Journal of Coastal Research*. 17(4):936–948. http://www.jstor.org/stable/4300253

Miller D.L., M. Thetford, and L.W. Atwood. 2013. "Effect of polyacrylamide gel on woody plant establishment in barrier island swales." *Natural Areas Journal*. 33:500–508. doi:10.3375/043.033.0402.

Miller, D.L., M. Thetford, J. Dupree, and L.W. Atwood. 2014. "Influence of seasonal changes and shifting substrate on survival of restoration plantings of *Schizachyrium maritimum* (Gulf bluestem) on Santa Rosa Island, Florida." *Journal of Coastal Research*. 30(2):237–247.

Nordstrom, K.F., N.L. Jackson, A.L. Freestone, K.H. Korotky, and J.A. Puleo. 2012. "Effects of beach raking and sand fences on dune dimensions and morphology." *Geomorphology*. 179:106–115. http://dx.doi.org/10.1016/j.geomorph.2012.07.032

Orr, M., M. Zimmer, D.E. Jelinski, and M. Mews. 2005. "Wrack deposition on different beach types: Spatial and temporal variation in the pattern of subsidy." *Ecology*. 86(6):1496–1507.

Pries, A., L.C. Branch, and D.L. Miller. 2009. "Impact of hurricanes on habitat occupancy and spatial distribution of beach mice." *Journal of Mammalogy*. 90(4):841–850.

Snyder, R.A., and C.L. Boss. 2002. "Recovery and stability in barrier island plant communities." *Journal of Coastal Research*. 18(3):530–536. http://www.jstor.org/stable/4299100

Stoddard, M., D.L. Miller, L.C. Branch, and M. Thetford. 2014. "Endangered beach mouse: Linking population studies/habitat restoration to predict sea level rise." Final Report submitted to Gulf Islands National Seashore, Gulf Coast Cooperative Ecosystems Studies Unit Project H5000 02 A271. 130p.

Swilling, W.R., M.C. Wooten, N.R. Holler, and W.J. Lynn. 1998. "Population dynamics of Alabama beach mice (Peromyscus polionotus ammobates) following Hurricane Opal." *The American Midland Naturalist*. 140(2):287–298. https://doi.org/10.1674/0003-0031(1998)140[0287:PDOABM]2.0.CO;2

Thetford, M., D.L. Miller, K. Smith, and M. Schneider. 2005. "Container size and planting zone influence on transplant survival and growth of two coastal plants." *HortTechnology.* 15(3):554–559.

Thetford, M., D.L. Miller, L.W. Atwood, and B.O. Ballard. 2015. "Microsite and rooting depth are more important than water-holding gel for establishment of restoration plantings of *Ilex vomitoria* on barrier islands in the Gulf of Mexico." *Native Plants.* 16(2):77–86.

Webb, C.A., D.M. Bush, and R.S. Young. 1995. "Property damage mitigation lessons from Hurricane Opal: The Florida Panhandle coast." *Journal of Coastal Research*. 13(1):246–252. http://www.jstor.org/stable/4298613

Williams, A., and R. Feagin. 2010. "Sargassum as a natural solution to enhance dune plant growth." *Environmental Management*. 46(5):738–747. doi:10.1007/s00267-010-9558-3

Williams, M.J. 2007. "Native plants for coastal restoration: What, when, and how for Florida." USDA, NRCS, Brooksville Plant Materials Center, Brooksville, Fla. http://www.fl.nrcs.usda.gov/programs/pmc/flplantmaterials.html

General Description, Propagation, and Outplanting of Northwest Florida Coastal Plants

The coastal plant communities of the Gulf Coast support a plethora of individual plant species that may be very broadly or quite narrowly distributed along the Gulf of Mexico in northwest Florida.

A subset of these plant species includes plants broadly recognized as the primary components of most coastal plant communities within this region. The biology, propagation, production, and outplanting for many of these key plants have not been studied or described. Much of the information for those that have been studied remains narrowly distributed. This portion of the manual has been drafted to provide resources for the propagation, production, and outplanting of a broad range of plant species found within coastal plant communities along the Panhandle of Florida that may be used for various aspects of coastal dune restoration.

For each of the plants included, the authors have compiled brief descriptive identification characteristics, propagation (including both seeds and stem cuttings where available), nursery production, and outplanting protocols when known. When more formal research reports are not available, this manual will also provide a brief summary of local experiences.

These summaries represent the work and experiences of the authors and undergraduate and graduate students as well as information they have derived from dichotomous keys, field guides, textbooks, peer-reviewed academic journals, government documents, and various online resources accessed over 20 years of working on this subject area.

For plant species where information or experiences are limited, the authors have provided information from published literature on closely related species. This information on related species is provided as a starting point for further investigation. Relevant literature citations for resources related to each species are associated with each species.

Appendices provide a brief and likely incomplete summary of characteristics for each of the plants presented such as the plant form (herbaceous and woody), contribution of the species to coastal structure (builder or stabilizer), most common landscape position(s) (foredune, dune field, backdune), and potential to serve as a food source for beach mice, or serve as a pollen or nectar source. Additionally, conversions and equivalents and a glossary of terms are provided for the identification, propagation, production, and outplanting of these species.

Before initiating any seed or cutting collection from either private or public lands, contact the landowner or manager for permission to access the site. Additionally, public lands generally will have restrictions on the collection of plants or seed. State or federal regulations may also restrict the collection or marketing of some plants, so it is always advisable to contact the landowner for permission or to inquire about permitting processes before collecting.

Plant Identification and Nomenclature Resources

Plant taxonomy and descriptions of vegetative and reproductive characteristics for the plants of this manual are developed primarily from first-hand experiences of the authors and are informed from review of the following resources:

Clewell, A.F. 1985. *Guide to the Vascular Plants of the Florida Panhandle*. University Presses of Florida.

Hall, D.W. 1993. *Illustrated Plants of Florida and the Coastal Plain*. Maupin House.

Nelson, G. 1994. *The Trees of Florida: A Reference and Field Guide*. Pineapple Press Inc.

Nelson G. 1996. *The Shrubs and Woody Vines of Florida. A Reference and Field Guide*. Pineapple Press, Inc.

Taylor, W.K. 2009. *A Field Guide to Florida Grasses*. University Press of Florida.

Taylor, W.K. 2013. *Florida Wildflowers: A Comprehensive Guide*. University Press of Florida.

Wunderlin, R.P, and B.F. Hans. 2011. *Guide to the Vascular Plants of Florida, 3rd Edition*. University Press of Florida.

The following websites and search engines may be useful for expanding the information reported herein.

Atlas of Florida Plants: Wunderlin, R.P., B.F. Hansen, A.R. Franck, and F.B. Essig. 2017. Atlas of Florida Plants http://florida.plantatlas.usf.edu/ [S.M. Landry and K.N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa.

Butterflies and Moths of North America:` Lotts, Kelly and Thomas Naberhaus, coordinators. 2017. Butterflies and Moths of North America. (http://www.butterfliesandmoths.org/)

USDA Plant Materials Database - USDA, NRCS. 2017. The PLANTS Database http://plants.usda.gov (19 July 2017). National Plant Data Team, Greensboro, NC 27401-4901.

List of Species by Scientific Name

List of Species by Common Name

Sand Dune Plant Species

Fact Sheets

Asclepias humistrata

sandhill milkweed

Apocynaceae

Credit: Gabriel Campbell, UF/IFAS

Sandhill milkweed is scattered on backdunes, in sandhills, and often in disturbed areas, such as mowed roadsides. It has a range in Florida south to Lake Okeechobee and also occurs in coastal southeast states west to Louisiana and northeast to North Carolina.

The larvae of monarch butterflies are entirely dependent on native milkweeds as a food source for survival, and several studies have identified sandhill milkweed as a monarch butterfly sustainer. Monarchs feed on the leaves of sandhill milkweed, which contain a steroid toxic to predators of milkweeds. Milkweed bugs (*Oncopeltus*) are also dependent on milkweeds, stalking and feeding almost entirely on milkweed seeds. Several other pollinators, including bees and other butterflies, visit this plant.

General Description

Sandhill milkweed is a deciduous perennial usually less than 3 ft tall. Plants form tuberous (thickened) roots and may become dormant at varied times during the warmer months as well as during the winter. *Stems* are prostrate to ascending.

Leaves are simple and oppositely arranged. They are "sessile," which means that they lack stalks, and the leaf bases clasp the stem. Leaves are green to green with purple and 2 to 5 in long. Leaves have a glabrous (smooth) surface and prominent pink to maroon veins.

Inflorescences (flower groups) are umbels (attached at a single point like the frame of an umbrella) with white to pink to lavender flowers on pedicels (stalk of a single flower) and occur terminally or in leaf axils during spring to summer with sporadic flowering through fall. *Flowers* are typical of the genus with calyces and corollas having 5 reflexed lobes; corollas can be up to 7 mm long. Within each flower, pollen is produced and the many grains of pollen fuse together in a special, sack-like structure called a pollinium that is transferred by pollinators as a single unit.

Fruits are follicles 3 to 6 in long containing brown seeds with an attached coma (white, floss-like fiber) that facilitates wind dispersal. All seeds from a single follicle are likely pollinated with pollen from the same pollonium. This plant exudes a milky sap when tissue is punctured.

Credit: Gabriel Campbell, UF/IFAS

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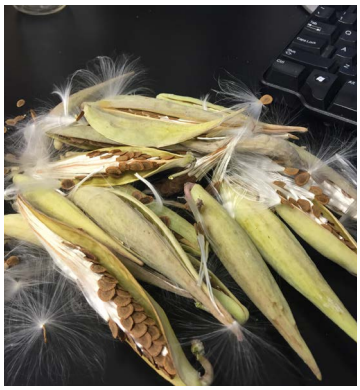


Credit: Gabriel Campbell, UF/IFAS

Propagation

Campbell (2016) describes sandhill milkweed seed collection, storage, and germination as follows. Seeds should be collected when the follicle is dehisced (splits open) or when it dehisces upon the slight application of pressure, typically with a large seed crop in late May and continuing sporadically throughout the summer. If seeds are not immediately germinated, they should be allowed to air dry for 2 weeks before storage in airtight containers at room temperature. Seeds remain viable for at least 18 months in storage.

Seeds are non-dormant at time of collection with optimal germination temperatures between 24 and 28°C.

Seeds germinate in light but may prefer dark. Viability of seeds is variable but can reach near 100%. Seeds can be germinated with high success in seedling flats. Seedlings have been grown with limited success in 40-cell plug flats, 4-in pots, and 1-gal pots in a greenhouse and outdoors with a standard fertilizer and overhead irrigation. This plant is vulnerable to damping off, aphids, and thrips during greenhouse production and aphids and monarch butterfly larvae during outdoor production. Greenhouse growers report diminishing plant quality after seedlings achieve growth of a few to several nodes.

Though no published cutting propagation protocols are available for *Asclepias humistrata*, other milkweeds are known for their ability to be propagated from root cuttings (Landis 2014; Luna and Dumroese 2014). Use a well-drained substrate and natural photoperiod to grow this plant. Cutting propagation results in a clonal population and is not recommended for this species.

Outplanting

Sandhill milkweed is an obligate outcrosser, and, therefore, monocultures (clonal populations resulting from vegetative propagation) for restoration projects are discouraged. Clonal populations may eliminate the potential for outcrossing necessary for seed production. Seedlings (12 months) from 40-cell flats were successfully planted in an outdoor research plot on a historic sandhill pine plant community with over 50% survival. Plant survival was similar after 1 year with or without supplemental fertilizer or irrigation.

Literature Cited

Campbell, G. 2016. "Dormancy and germination characteristics of two Florida native forbs, *Asclepias humistrata* and *Lupinus diffusus*." Masters thesis. University of Florida.

Landis, T.D. 2014. "Monarch waystations: propagating native plants to create travel corridors for migrating monarch butterflies." *Native Plants Journal.* 15(1):5–16.

Luna, T., and R.K. Dumroese. 2013. "Monarchs (*Danaus plexippus*) and milkweeds (*Asclepias* species): the current situation and methods for propagating milkweeds." *Native Plants Journal.* 14(1):5–15.

Balduina angustifolia

coastalplain honeycombhead

Asteraceae

Credit: Gabriel Campbell, UF/IFAS

Coastalplain honeycombhead is found in beach dunes, coastal grasslands, and scrub throughout Florida and into Alabama and Mississippi. It is a prolific flower and seed producer that attracts numerous pollinators, including the gulf fritillary butterfly. Interestingly, the endemic, solitary, and ground-dwelling coastal plain Hesperapis (*Hesperapis oraria*), also known as Balduina bee, is completely dependent on the coastalplain honeycombhead for survival, only emerging from the ground a few weeks each year in September to October to collect pollen and nectar (Hunsburger 2013). This bee only occurs on barrier islands and peninsulas in the northern Gulf of Mexico (Hunsburger 2013) and is particularly vulnerable to climate-change-driven sea-level rise and habitat fragmentation.

General Description

Coastalplain honeycombhead is an herbaceous, widely branched annual to biennial that can reach heights of 1 meter but often is much shorter in coastal plant communities. *Leaves* are entire, simple, narrowly linear, up to 2 in long, and alternate. Inflorescences occur *en masse* during the summer. Inflorescences are branched corymbs when not solitary. Heads contain ray flowers up to 0.8 in long with yellow rays and disk flowers up to 4 to 5 mm long, also yellow. When dry, mature heads are viewed from above, chambers in the head take on the appearance of cells in a honeycomb. Chambers appear white and contain easily identifiable fruits. *Fruits* are achenes typically no longer than 2 millimeters. *Seeds* are black with an attached whitish grey 2-mm-long pappus with round scales.

Propagation

Cutting propagation of coastalplain honeycombhead is possible with an application of 5,000 ppm IBA (Indole-3-butyric acid) recommended for optimal rooting response. Apical stem cuttings taken during June to July should achieve at least 80% rooting and produce about 15 roots per cutting (Wilson et al. 2010).

Credit: Gabriel Campbell, UF/IFAS

Propagation from seed has also been studied. Seeds of coastalplain honeycombhead are physiologically dormant and

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need a period of cold stratification for germination (Pérez 2007; Wilson et al. 2010). Seeds possess a non-deep physiological dormancy and have up to 80% germination with exposure to alternating day/night winter temperatures of 22/11°C for about 4 to 5 weeks. Natural germination should occur in the spring.

Seedlings can be grown in greenhouses. The following is adapted from Smith et al. (2014) for the production of plants in 1-gal pots for ornamental plantings. Transplants may be placed in smaller containers for a shorter production period if used for reestablishment of this species for restoration purposes.

Plant seeds in germination media within 6-cell packs where they can remain for 4 weeks or until they form cohesive rootballs. Plants may be transitioned to outdoor, full sun culture and moved up to 1-gal pots within a well-drained media, such as Atlas 7000, for an additional 16 weeks of production. Production in smaller containers or production of smaller vegetative transplants for restoration plantings will shorten the production period.

Outplanting

This species has successfully been transplanted (20-week-old seedlings) from a container (1-gal pot) when grown in a well-drained substrate (Atlas 7000), and performed well in a trial garden as a native wildflower producer for several months (Smith et al. 2014). This species is an annual and needs to be transplanted early in the growing season so it is established before floral initiation. The species is also known to be an obligate outcrosser. Multiple plants will need to be established in close proximity to ensure pollination among container-grown plants to encourage seed production and natural recruitment the following season in the restoration area where planted.

Literature Cited

Hunsburger, H. 2013. "Distribution and habitat use of Florida endemic solitary bee Hesperapis oraria and host plant Balduina angustifolia." Master's thesis. University of Florida.

Pérez, H.E. 2007. Final Report FWAC Grant #R-006-06. 3 p.

Smith, A.M., S.B. Wilson, M. Thetford, K.L. Nolan, and C. Reinhardt Adams. 2014. "Performance of nine Florida native wildflower species grown in varying container substrates." *Native Plants Journal*. 15(1):75–86.

Wilson, S.B., H. Perez, and M. Thetford. 2010. *Propagation, Production, and Landscape Evaluation of Native Wildflowers in West, Central and South Florida.* Condensed Progress Report for the Florida Wildflower Foundation. http://flawildflowers.org/resources/pdfs/pdf2012/Wildflower year-end progress report-Wilson et al.pdf

Ceratiola ericoides

Florida rosemary

Ericaceae

Credit: Ashlynn Smith, UF/IFAS

Credit: Gabriel Campbell, UF/IFAS

Florida rosemary is important in maintaining back dune structures and is found inland in scrub communities. This plant is found throughout scrub plant communities in Florida, and more broadly is found west to Mississippi and east to South Carolina in xeric soils and in communities with fire return intervals of 20 to 40 years. Plants are killed by fire and storm surge events, but seeds germinate readily post-disturbance. Its fruit is an important food source for wildlife but is not produced until plants are at least 12 years old.

General Description

Florida rosemary is a monotypic evergreen shrub that can reach heights of 6 ft. The shrub has a rounded form and is densely branched. Stems have shredding, gray bark with rough leaf scars when several years old while young stems are pubescent. Leaves are simple, dark green, so strongly revolute they appear needle-like, linear, 8 to 12 mm long by 1 mm wide. They grow in whorls of 4 or 6 in distinct rows when viewed from the stem apex but are opposite. They smell like rosemary when crushed. Inflorescences occur from spring to fall and individual plants have very small male or female flowers clustered at leaf axils. Flowers are yellow to brown, and the plants are dioecious (male and female flowers occurring on separate plants). *Fruits* are round, fleshy drupes with a 3-mm diameter. They are yellow to green and contain 2 seeds.

Credit: Mack Thetford, UF/IFAS

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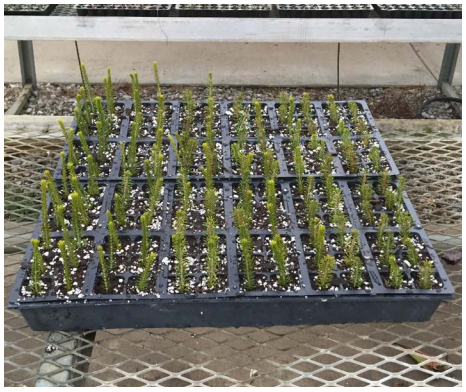
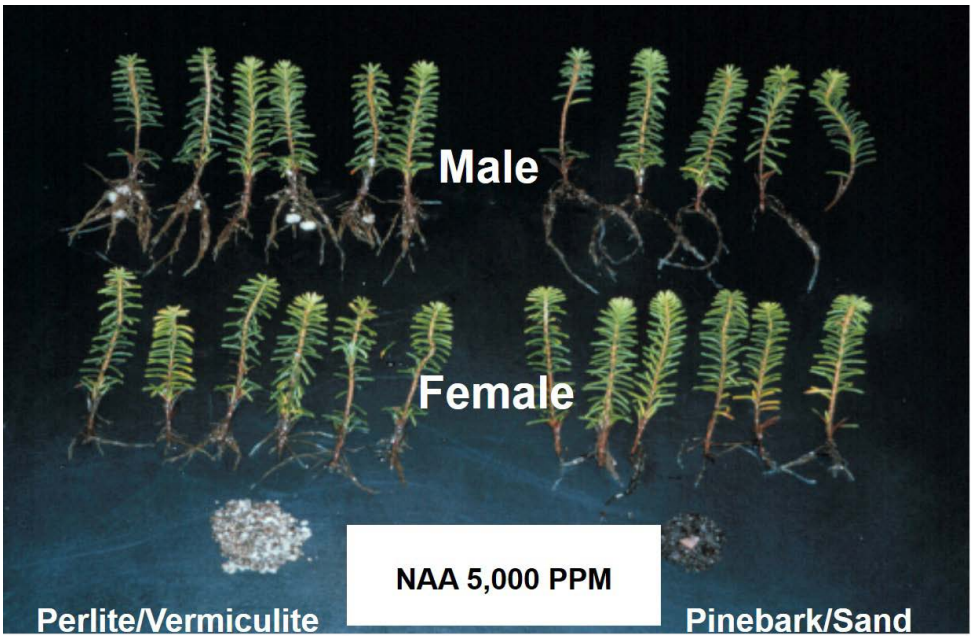
Propagation

The following cutting propagation protocol is adapted from Thetford et al. (2001). Softwood stem cuttings produce roots in course propagation substrates such as perlite:vermiculite (1:1) or pinebark:sand (6:1). Cuttings taken from stem tips should be around 3.5 in long with the bottom ½ inch of foliage removed. The base of the cutting should be exposed to auxin treatments below 5,000 ppm to improve root qualities such as root number and root length. Cuttings take several (8 to 12) weeks to initiate roots under intermittent mist; hence this xeric plant may require fungicide applications (drenches) to reduce root zone pathogens that may cause root rots. Cuttings should be propagated in flats with multiple cells such as 72-cell flats to allow transfer outdoors for production.



Credit: Gabriel Campbell, UF/IFAS

Florida rosemary has roots with a very small diameter and adventitious roots of cuttings may be weakly attached to cuttings. Retaining rooted cuttings in the initial propagation flats and allowing several months of outdoor production before attempting to transplant them to production containers will improve retention of the newly formed root systems.



Credit: Mack Thetford, UF/IFAS

Cuttings can be transferred to production containers such as 4-in, 1-qt or 1-gal pots with an amended 100% pine bark substrate and grown outside with overhead irrigation (Miller et al. 2008).

Propagation from seed is slow but can be done. Johnson (1986) developed the following technique. Collect fruits from December through March and let them air dry for at least a week. Scarifying seed with sandpaper speeds up germination to 6 months rather than 8 or 12 months. Plant the seeds in a large pot (at least 6 in) with a well-draining substrate, and water them as needed. Seedlings are very small at germination and will require a very long production period to reach transplant size.

Outplanting

This species should be restricted to areas with minimal disturbances similar to the areas where it occurs naturally. One-and-a-half-year-old plants grown in 1-gal pots from stem cuttings have been planted with success behind two to three embryo dunes (1.6 to 3.3 ft in height) at least 560 ft from the Gulf of Mexico (Miller et al. 2008). This species was sensitive to higher levels of salt spray and higher wind speeds when placed closer to the Gulf. Do not use seedlings that are less than one year old (Johnson 1986).

Literature cited

Johnson, A.F. 1986. "Recipe for growing Florida rosemary, Main Ingredient: Patience!" *Palmetto Spring*. 5.

Miller, D.L., M. Thetford, and M. Schneider. 2008. "Distance from the gulf influences survival and growth of three barrier island dune plants." *Journal of Coastal Research*. 24(3):261–266.

Thetford, M., D.L. Miller, and P. Penniman. 2001. "Vegetative propagation and production of *Ceratiola ericoides* Michx. for use in restoration." *Native Plants Journal*. 2(1):116–125.

Chrysoma pauciflosculosa

woody goldenrod

Asteraceae

Credit: Mack Thetford, UF/IFAS

Woody goldenrod is found in beach dunes, scrub, and sandhill plant communities. It occurs in the Panhandle of Florida and more broadly in the southeastern United States west to Mississippi and northeast to North Carolina. This plant may leach chemicals into the soil that inhibit seed germination of gulf bluestem (*Schizachyrium scoparium* var. *scoparium*) (Fischer et al. 1994). Woody goldenrod is an underused landscape plant with a prolific fall color from flowers that attract numerous pollinators.

General Description

Woody goldenrod is a multibranched, evergreen sub-shrub that can reach heights of 3.3 ft or more. *Stems* are glabrous, numerous, ascending, and round in cross section. Stems bearing flowers and fruits extend far beyond vegetative stems. *Leaves* are sessile (without stalks), simple, 0.75 to 2.5 in long, alternate, elliptic to oblong, and grayish green with an entire margin. Inflorescences are heads that are sticky, borne in clusters, and numerous, with a single outer row of yellow ray florets. They occur from late summer to fall. *Fruits* are hard, dry, pale, bristled achenes.

Propagation

Cutting propagation of woody goldenrod is easily accomplished with terminal stem cuttings. Nonbranched, vegetative apical stem cuttings from summer softwood or winter hardwood root without auxin, but a 5,000 ppm IBA (Indole-3-butyric acid) application will increase root numbers and root length (Wilson et al. 2010). Propagation from seed for woody goldenrod has been accomplished with wild-collected seed. Seeds prefer cooler temperatures (20/10°C alternating day/night temperatures) to warmer ones (Wilson et al. 2010).

Outplanting

Rooted cuttings or seedlings may be grown in a variety of coarse production substrates and a variety of container sizes. Smith et al. (2014) produced woody goldenrod in substrates such as Atlas 3000, Atlas 7000, Fafard 3B, and Metro Mix 300 while the authors have grown them in a 100% pine-bark substrate amended with lime and slow-release fertilizer. Plants grown in 1-gal containers were evaluated for potential use in home landscapes with high transplant success (Smith et al. 2014). Peak flowering for the trial plants occurred in November.

Literature Cited

Fischer, N.H., G.B. Williamson, J.D. Weidenhamer, and D.R. Richardson. 1994. "In search of allelopathy in the Florida scrub: the role of terpenoids." *Journal of Chemical Ecology*. 20(6)1355–1380.

Smith, A.M., S.B. Wilson, M. Thetford, K.L. Nolan, and C. Reinhardt Adams. 2014. "Performance of nine Florida native wildflower species grown in varying container substrates." *Native Plants Journal.* 15(1):75–86.

Wilson, S.B., H. Perez, and M. Thetford. 2010. "Propagation, Production, and Landscape Evaluation of Native Wildflowers in West, Central and South Florida, 2010 Condensed Progress Report." http://flawildflowers.org/resources/pdfs/pdf2012/Wildflower year-end progress report-Wilson et al.pdf

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Chrysopsis
goldenaster

Asteraceae

Credit: Mack Thetford, UF/IFAS

Two species of goldenaster are found on beach dunes within the western Panhandle of Florida (FNAI 2000). *Chrysopsis gossypina* subsp. *Cruiseana* (Cruise's goldenaster) and *Chrysopsis godfreyi* (Godfrey's goldenaster), which is further differentiated into two morphologically distinct forms, *Chrysopsis godfreyi* f. *godfreyi* (pictured below right) and *Chrysopsis godfreyi* f. *viridis* (pictured below left).

Credit: Mack Thetford, UF/IFAS

Both forms of *Chrysopsis godfreyi* and *Chrysopsis gossypina* subsp. *Cruiseana* share many morphological similarities and co-occur in coastal plant communities. They are presented together to provide distinguishing characteristics among the these species. A summary table of vegetative characteristics and photos is also provided.

General Descriptions

Chrysopsis godfreyi
Godfrey's goldenaster

Godfrey's goldenaster is a perennial to biennial basal rosette-forming plant that occurs in two distinct forms, forma *godfreyi* and forma *viridis.* Stems of the rosette portions of the plants branch near the base on robust plants or are solitary. While in the rosette form the stems are 0.75 to 2 in long, are wooly basally becoming arachnoid (f. *godfreyi*) or glabrous (f. *viridis*) or remaining wooly towards the tip as stems elongate to form inflorescences. Inflorescences typically are slightly ascending, though they may be upright in sheltered areas away from salt spray. *Rosette leaves* are up to 4 in long, oblanceolate, and wooly on both surfaces (f. *godfreyi*) or glandular pubescent (f. *viridis*). They are obtuse and have sparse serrations on the apex. Cauline leaves are linear to ovate and entire with an acute apex. They are sometimes clasping and reduce either abruptly or gradually from top to bottom. Leaves are wooly for f. *godfreyi* while for f. *viridis* they are glandular pubescent and they always bear densely stalked glands on both sides. *Inflorescences* are yellow heads arranged in corymbs to panicles. They occur in the fall, are nodding when in bud, and have densely stalked glands on peduncles. *Ray flowers* number 25 to 35 per head and are 10 to 15 mm long. *Disc flowers* number 50 to 100 per head and are 7 mm long. The involucre is 9 to 12 mm with 4 to 5 imbricate series of phyllaries that are densely covered with trichomes. *Fruits* are achenes 2 to 2.5 mm long, and pale with ridges. They are covered with hairs appressed to the seed coat and have an attached 2-whorled pappus consisting of a 7-mm bristled whorl and an outer whorl of short scales.

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Credit: Gabriel Campbell, UF/IFAS

The two forms of Godfrey's goldenaster, forma *viridis* and forma *godfreyi,* are essentially distinguished by the type and density of leaf pubescence. Forma *viridis* lacks wooly pubescence on cauline leaves and all inflorescences, having principally green, sticky, glandular trichomes, while forma *godfreyi* consistently has long wooly (silver to white) pubescence on the cauline leaves, inflorescence bracts, and bracteoles.

Godfrey's goldenaster is a Florida state endangered endemic plant that only occurs in the coastal western half of the Florida Panhandle and one county in eastern coastal Alabama. This plant is found in coastal disturbed areas and within beach dune and scrub communities. Godfrey's goldenaster often occurs in large colonies on stable beach dunes and dune ridges.

Chrysopsis gossypina subsp. *Cruiseana*

Cruise's goldenaster

The cottony goldenaster (*Chrysopsis gossypina*) is a short-lived perennial herbaceous forb native to the coastal plain from Louisiana to Virginia. The subspecies Cruise's goldenaster (*Chrysopsis gossypina* subsp. *Cruiseana*) is restricted to coastal sand dunes in Florida and a portion of Alabama and is classified as endangered by the state of Florida. Cruise's goldenaster co-occurs with both forms of Godfrey's goldenaster.

Vegetative and floral characteristics are similar among these two species. Basal foliage of rosette leaves is pubescent, but the density of trichomes is not sufficient for leaf surfaces to appear white or silver as described for *Chrysopsis godfreyi* f. *godfreyi,* and there are no glandular trichomes as described for *Chrysopsis godfreyi* f. *viridis*. A distinguishing characteristic among these three goldenasters is the lack of pubescence on cauline leaves of *Chrysopsis gossypina* subsp. *Cruiseana*. Cauline leaves of elongated inflorescences are distinctively glabrous, entire, and reduced in size in comparison to Godfrey's goldenaster. *Fruits* are achenes with 1 to several yellow to red gland-like ridges.

Propagation

Reproduction from seed was studied by Hooton (2011) to characterize seed production and germination requirements for these *Chrysopsis* from native populations in Escambia County, Florida. From mature flowers collected in a native setting, a range of 6,000 to 8,000 seeds was recorded per plant. In growth chamber studies, seed were shown to need light to germinate, and all three could be successfully germinated at alternating day/night temperatures of 30/20, 25/15, and 20/10°C to achieve 50 to 70% germination. Wild-collected seed may be thrashed from dried heads and sown directly in open flats without grading or further cleaning. Seedlings emerge within 3 weeks and can be transplanted to liner production flats or small pots and grown outdoors. Smith et al. (2014) produced landscape-quality transplants from seed in a variety of production substrates.

Vegetative propagation is also possible for *Chrysopsis* if terminal stem cuttings are collected during short days while plants remain vegetative.

Credit: Mack Thetford, UF/IFAS

Credit: Mack Thetford, UF/IFAS

However, once critical day length triggers floral development, the cuttings may root but will only produce inflorescences that have no ability to form subsequent vegetative growth. Cuttings will root readily within 7 days without supplemental auxin and should be removed from overhead mist as soon as roots are detected. The resulting rooted cuttings may be potted in standard, well-drained potting mix in 4-in pots and will be ready for outplanting within 4 to 6 weeks when rootballs have grown sufficiently to hold together.

Outplanting

Credit: Emily Bagby, UF/IFAS

The authors have successfully planted all of these *Chrysopsis* from plants that filled 4-in pots that were propagated from either seedlings or rooted cuttings. Greatest outplanting success was achieved in late January with near 100% survival 4 months after planting. Plants were outplanted on backdunes midslope at least 12 in from each other and existing perennial grasses. Fertilizer (½ tsp Osmocote 18-6-12) application at the time of planting improved the aesthetic and increased biomass for these plants but was not necessary for survival.

Literature Cited

Hooton, N. 2011. "Restoration strategies for improving survival and composition of plant species native to coastal dunes in the Florida Panhandle." Master's Thesis, University of Florida.

Smith, A.M., S.B. Wilson, M. Thetford, K.L. Nolan, and C. Reinhardt Adams. 2014. "Performance of nine Florida native wildflower species grown in varying container substrates." *Native Plants Journal*. 15(1):75–86. doi:10.3368/npj.15.1.75

Florida Natural Areas Inventory (FNAI), 2000. Field Guide. Godfrey's goldenaster. http://www.fnai.org/FieldGuide/pdf/Chrysopsis_godfreyi.pdf

General characteristics and descriptions for field identification of *Chrysopsis* including photos of vegetative rosettes (basal leaves) or scans of upper (cauline) leaves of elongated inflorescences.

Chrysopsis godfreyi forma *godfreyi*	*Chrysopsis godfreyi* forma *viridis*	*Chrysopsis gossypina* subsp. *Cruiseana*
Godfrey's goldenaster	Godfrey's goldenaster	Cruise's goldenaster
		
Heavy pubescence ("long wooly hairs") on stems and leaves throughout the plant including inflorescence leaves gives it a silvery-white appearance.	Moderate to minimal pubescence on lower leaves, which may be wooly, though all leaves including middle and upper inflorescence leaves with sticky, glandular trichomes.	Moderate pubescence with higher amounts on basal rosette leaves but stem and inflorescence leaves becoming glabrous with entire margins.
		

Credits: Rosettes, Natalie Hooton, UF/IFAS; cauline and basal leaves, Mack Thetford, UF/IFAS

Conradina canescens

false rosemary

Lamiaceae

Credit: Gabriel Campbell, UF/IFAS

False rosemary is found on the backsides of foredunes, on all sides of backdunes, and inland in scrub communities. False rosemary is killed by fires but will reseed to an area in the absence of further disturbance. It is endemic to west Florida and Alabama, contributes to beach mouse habitat, and attracts many pollinators.

General Description

False rosemary is an evergreen sprawling sub-shrub that can reach heights and widths of 3 ft.

Credit: Gabriel Campbell, UF/IFAS

Stems are pubescent and spreading or erect. *Leaves* are simple, linear, pubescent, oppositely arranged, and gray. They grow up to ½-inch long, and they smell like mint when crushed. Inflorescences are solitary, axillary, and zygomorphic (two-lipped) with 4 stamens. They have lavender to white corollas with dark spots on the lower lip occurring from March to November. *Fruits* contain 4 nutlets.

Propagation

Softwood cuttings can be used for asexual propagation. The following protocol is adapted from Thetford and Miller (2002 and 2004). Four-inch nonbranched terminal shoots should be taken during the growing season. Auxin application improves root number and root length of cuttings. Remove the basal ½ in of foliage and quick dip in liquid auxin for one second or stick the basal ½ to ¾ in of the cutting into auxin talc powder. Root cuttings in 72-cell flats under mist for 3 to 4 weeks followed by hand watering for another 2 to 3 weeks in a well-draining substrate such as 100% pine bark. Cuttings will benefit from fertigation with a complete fertilizer solution providing nitrogen at a rate of 150 ppm 1 to 2 times a week before transplanting to larger containers.

Plants can be pruned to stimulate branching starting week 4 before or after transplanting to larger pots. Plants perform well in 4-in and 1-qt pots and require 4 to 6 weeks to develop a full rootball and a canopy of 6 to 8 in.

Credit: Gabriel Campbell, UF/IFAS

No published information on germination of false rosemary is available. A related species that grows in colder climates, *Conradina verticillata*, has been shown to require cold stratification (12 weeks at 5°C) to alleviate seed dormancy and light to germinate (Albrecht and Penagos 2012). The authors have noted frequent occurrence of *Conradina canescens* seedlings in the bare soils and neighboring pots of the nursery production area,

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suggesting the species will recruit readily from seeds once introduced to an area.

Outplanting

Credit: Gabriel Campbell, UF/IFAS

The authors have transplanted false rosemary from 4-in pots to protected back dune and scrub areas with high success. However, tender plants from nursery production areas are very sensitive to high winds and salt spray, suggesting transplants from nursery stock may need to be restricted to areas with less wind and salt spray.

Literature Cited

Albrecht, A.A., and J. C. Penagos Z. 2012. "Seed germination ecology of three imperiled plants of rock outcrops in the southeastern United States." *The Journal of the Torrey Botanical Society.* 139(1):86–95.

Thetford, M., and D.L. Miller. 2002. "Propagation of four Florida coastal dune species." *Native Plants Journal.* 3(2):112–120.

Thetford, M., and D.L. Miller. 2004. *Propagation and production of Gulf bluestem*. ENH973. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ep230

Williamson, G.B., N.H. Fischer, D.R. Richardson, and A. Peña. 1989. "Chemical inhibition of fire-prone grasses by fire-sensitive shrub, *Conradina canescens*." *Journal of Chemical Ecology.* 15(5):1567–577.

Credit: Mack Thetford, UF/IFAS

Crocanthemum arenicola

Synonym: *Helianthemum arenicola*

coastal sand frostweed

Cistaceae

Credit: Gabriel Campbell, UF/IFAS

Coastal sand frostweed is found on beach dunes, scrub, and sandhills. It is endemic to the Florida Panhandle, Mississippi, and Alabama coastal counties. After Hurricane Katrina, coastal sand frostweed became the plant with highest frequency on stable dunes on Horn Island, Mississippi (Lucas and Carter 2013).

General Description

Coastal sand frostweed is an herbaceous, perennial groundcover species. Leaves are alternate and simple, and have pubescence that conceals the leaf surface. Inflorescences are terminal umbellate clusters that occur during spring. Flowers have radial symmetry and are 10 to 20 mm wide with 5 bright yellow petals. Fruits are pubescent two-valved capsules.

Propagation

Apical stem cuttings (6–8 cm) collected in early April from Santa Rosa Island rooted readily under intermittent mist within two weeks in a climate-controlled greenhouse. Rooted cuttings formed complete rootballs in 72-cell flats in less than 7 weeks.

Credit: Gabriel Campbell, UF/IFAS

Mature plants may be divided and potted in a coarse potting mix, but survival with this method has only been 50%. Larger divisions have survived in container production with more success than smaller divisions.

Seed germination information is presently not available for coastal sand frostweed, although the authors found non-scarified seeds don't imbibe water (i.e., seeds are physically dormant). Other *Helianthemum* species have been reported to have physical dormancy as well (Pérez-García and González- Benito 2006; Thanos 1992).

Outplanting

No published outplanting information is presently available for coastal sand frostweed.

Literature Cited

Lucas, K.L., and G.A. Carter. 2013. "Change in distribution and composition of vegetated habitats on Horn Island, Mississippi, northern Gulf of Mexico, in the initial five years following Hurricane Katrina." *Geomorphology.* 199:129–137.

Pérez-García, F., and M.E. González-Benito. 2006. "Seed germination of five *Helianthemum* species: Effect of temperature and presowing treatments." *Journal of Arid Environments.* 65:688–693.

Thanos, C.A., K. Georghiou, C. Kadis, and C. Pantazi.1992. "Cistaceae: a plant family with hard seeds." *Israel Journal of Botany.* 41(4–6):251–263.

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Geobalanus oblongifolius

Synonym: *Licania michauxii*

gopher apple

Chrysobalanaceae

Credit: Gabriel Campbell, UF/IFAS

Gopher apple occurs from the lower Florida peninsula northward to South Carolina westward to Louisiana in coastal dunes, sandhills, and disturbed areas such as roadsides. Gopher apple gets its name because gopher tortoises, along with other small mammals, eat their fruit. Gopher apple is an ideal groundcover for a coastal landscape with well-draining soil and a low pH (Gilman 2014).

General Description

Credit: Mack Thetford, UF/IFAS

Gopher apple is a low-growing, clonal, evergreen shrub reaching heights of less than 1.6 ft that spreads via stout underground stems. *Leaves* are alternate, simple, elliptic to spatulate, and grow from 0.8 to 4 in long by 0.4 to 1.6 in wide. They are largest at midstem compared to upper and lower stem, glabrous or pubescent below, with shallowly undulate to entire margins. Leaves superficially resemble the leaves of oaks. *Stems* are stout, woody, underground, and give rise to aerial shoots. *Flowers* are white, borne in terminal clusters, and commonly extend past the leaves. They are inconspicuous and appear from April to summer.

Fruits are single-seeded drupes. They are fleshy, ellipsoid, dark purple to yellow (rarely white), and 0.4 to 1.6 in in diameter. Plants with reddish new growth typically produce purple fruits while plants with greenish-white new growth typically produce yellow to white fruits.

Propagation

Gopher apple seeds are not dormant and can be easily used for propagation with nearly 100% germination of viable seed (Wilson et al. 2010). Gopher apple prefers warmer alternating temperatures (30/20 and 35/25°C vs 25/15 and 20/10°C) when exposed to a 12-hour photoperiod (Wilson et al. 2010). Seedlings have performed well in a peat-based potting mix (Fafard 3B) when grown in a greenhouse (Smith et al. 2014).

Credit: Mack Thetford, UF/IFAS

Cutting propagation (softwood cuttings) of gopher apple is possible without the application of auxins, but auxins may increase rooting percentage to near 100% (Wilson, Pérez and Thetford, 2010). Cuttings may be taken in May or June before stems become woody. Place cuttings under intermittent mist with natural photoperiods.

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Rooted cuttings failed to overwinter when new growth was not present before winter dormancy. More information on subsequent growth of rooting cuttings is needed.

Outplanting

Transplanting gopher apple is known to be difficult in the wild, but it should establish from nursery-grown plants (Gilman, 2014). Greenhouse-grown plants have been successfully grown in field plots in western and south Florida during a 10-month research trial (Smith et al. 2014).

Literature Cited

Gilman, E.F. 2014. Licania michauxii *Gopher apple*. FPS-342. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fp342

Smith, A.M., S.B. Wilson, M. Thetford, K.L. Nolan, and C. Reinhardt Adams. 2014. "Performance of nine Florida native wildflower species grown in varying container substrates." *Native Plants Journal.* 15(1):75–86.

Wilson, S.B., H. Perez, and M. Thetford. 2010. *Propagation, Production, and Landscape Evaluation of Native Wildflowers in West, Central and South Florida*. Condensed Progress Report for the Florida Wildflower Foundation. http://flawildflowers.org/resources/pdfs/pdf2012/Wildflower%20year-end%20progress%20report-Wilson%20et%20al.pdf

Hypericum tenuifolium

Synonym: *Hypericum reductum*

Atlantic St. John's wort

Hypericaceae

Credit: Gabriel Campbell, UF/IFAS

Credit: Mack Thetford, UF/IFAS

Atlantic St. John's wort occurs throughout Florida and more broadly west to Alabama and northeast to North Carolina on beach dunes and scrub plant communities frequently associated with wet depression areas. *Hypericum* is a large genus of plants with 31 species in Florida alone (Wunderlin et al. 2017). This plant is a prolific flower producer that attracts numerous pollinators

General Description

Atlantic St. John's wort is a semi-woody to herbaceous perennial subshrub with a decumbent growth habit; forming a small rounded shrub to a low mat that rarely reaches above 1.5 ft. *Leaves* are simple, opposite, and needlelike. *Stems* are often decumbent and matted and are 6-angled in cross-section when young. *Flowers* have 5 persistent sepals, 5 yellow petals, and bear numerous stamens. They are 0.4 to 01.8 in wide, are axillary and terminal, are solitary or grow in small clusters called cymules or dichasia, and flower from June to September. *Fruits* are capsules 6 to 10 mm long and turn brown when ripe.

Propagation

Atlantic St. John's wort can be propagated from stem cuttings. The following is adopted from Thetford and Miller (2004). Collect 4-in terminal stem cuttings during the growing season. Remove leaves of bottom ½ in of cutting and quick dip in auxin [NAA (1-Naphthaleneacetic acid) 500 to 1000 ppm, or IBA (Indole-3-butyric acid) 1000 to 5000 ppm, or Dip 'N Grow] for 1 second (Thetford and Miller 2002). Root cuttings in 72-cell flats with a well-drained substrate under intermittent mist and natural photoperiod. Roots initiate within 2 to 3 weeks. By week 4, rooted cuttings may be removed from mist, and by week 6, transplants can be moved into larger pots (4-in, 1-qt or 1-gal). Rooted cuttings benefit from fertigation with a complete fertilizer solution providing nitrogen at a rate of 150 ppm 1 to 2 times a week before transplanting to larger containers. An additional 4 to 6 weeks of outdoor production with supplemental irrigation is required to develop a full rootball.

No published information on germination requirements of *Hypericum tenuifolium* is available. Germination

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requirements for the related species, *H. perforatum* are variable across populations but need light to germinate with constant (15 and 25°C) or fluctuating (25/15°C) day/night temperatures and are non-dormant (Pérez-García et al. 2006). Light has been reported as necessary for germination of other *Hypericum* sp. with similar optimal germination temperatures, but physiological or physical dormancies have also been reported (Çırak et al. 2007; Çırak 2007.)

Outplanting

No published information on outplanting information is presently available for Atlantic St. John's wort. The authors have successfully transplanted this species in home landscape situations with minimal supplemental irrigation. In Florida, *H. tenuifolium* is considered a facultative wetland species (occurs in wetlands 67% to 99% in the wild) (Wunderlin et al. 2017) and in coastal communities this species is associated with coastal interdunal swales and adjacent low ridges.

Literature Cited

Campbell, M.H. 1985. "Germination, emergence and seedling growth of *Hypericum perforatum* L." *Weed Research.* 25(4):259–266.

Çırak C., K. Kevseroğlu, and A.K. Ayan. 2007. "Break seed dormancy in a Turkish endemic *Hypericum* species: *Hypericum aviculariifolium* subsp. *depilatum* var. *depilatum* by light and some pre-soaking treatments." *Journal of Arid Environments.* 68(1):159–164.

Çırak, C. 2007. "Seed germination protocols for *Ex situ* conservation of some *Hypericum* species from Turkey." *American Journal of Plant Physiology.* 2(5):287–294.

Pérez-García, F., M. Huertas, E. Mora, B. Peña, F. Varela, and M.E. González-Benito. 2006. "*Hypericum perforatum* L. seed germination: interpopulation variation and effect of light, temperature, presowing treatments and seed desiccation." *Genetic Resources and Crop Evolution.* 53:1187–1198.

Thetford, M., and D.L. Miller. 2002. "Propagation of 4 Florida coastal dune species." *Native Plants Journal.* 3(2):112–120.

Thetford, M., and D.L. Miller. 2004. *Propagation and production of Atlantic St. John's wort*. ENH972. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ep229

Wunderlin, R.P., B.F. Hansen, A.R. Franck, and F.B. Essig. 2017. *Atlas of Florida Plants*. [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa. http://florida.plantatlas.usf.edu/

Ilex glabra
inkberry

Aquifoliaceae

Credit: Mack Thetford, UF/IFAS

Inkberry is found throughout Florida and more broadly west to Texas and northeast to the Canadian border. Fruits attract birds and other wildlife but are not edible to humans. Flowers attract pollinators, including honey bees. Plant male and female plants in order to sustain fruit production.

General Description

Inkberry is a colonial, evergreen shrub that can reach heights of 3 to 6 ft. *Leaves* are alternate and simple, growing from 0.75 to 3 in long. They have dark green upper surfaces and powdery pubescent petioles. Leaf margins are entire or they may have up to 6 rounded serrations or notches toward the apices and the apices will have a tiny point. *Inflorescences* are borne in the leaf axils and appear in spring. They are clusters of white flowers that grow 5 to 8 mm in diameter. The species is dioecious with pistillate and staminate flowers occurring on separate plants. *Fruits* contain 5 to 8 nutlets. They are shiny black spherical drupes 5 to 8 mm in diameter. Fruits often persist through winter.

Propagation

The authors have had much success producing inkberry from seed of wild-collected fruits. Fruit can be harvested in January and cleaned seed sown in open flats or in 72-cell flats after moist, cool stratification (40 days at 4.5° C) to overcome seed dormancy associated with immature embryos. Germination may occur over an extended period; seedlings are grown for 4 months before they are transplanted to larger pots.

Outplanting

Plants grown in 3-gal treepots with ½-inch screened composted pinebark had 2 to 6 times greater outplanting survival and were 1.5 times larger after 15 months than plants grown in 1-gal pots (Thetford et al. 2005). Outplanting should be done with protection of a foredune ridge above a meter or at least 466 ft from the Gulf mean high tide line.

Literature Cited

Thetford, M., D. Miller, K. Smith, and M. Schneider. 2005. "Container size and planting zone influence on transplant survival and growth of two coastal plants." *HortTechnology.* 15(3):554–549.

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Ilex vomitoria

yaupon

Aquifoliaceae

Credit: Gina Duke, UF/IFAS

Yaupon is found throughout Florida south to Lake Okeechobee and more broadly throughout the southeast west to Texas and east to North Carolina.

The leaves and small twigs of yaupon contain caffeine, and yaupon teas have been consumed by humans for centuries. The fruits and flowers of yaupon attract wildlife, especially birds and pollinators, and it is a larval host plant for Henry's elfin butterfly (*Callophrys henrici*) (Lotts and Naberhaus 2017). Yaupon is used in landscaping and can tolerate a wide range of environmental conditions. Several cultivars are available in the horticultural industry.

General Description

Yaupon is a dioecious evergreen shrub to small bushy tree that can reach heights of 25 ft. *Leaves* are alternate, simple, and dark green on the upper surface. They are elliptical to ovate, 0.2 to 2 in long by 0.2 to 0.5 in wide, and have a crenate margin, an obtuse apex, and a rounded base. *Flowers* are small and white and occur in leaf axils. The species is dioecious with pistillate and staminate flowers occurring on separate plants. *Fruits* are bright red spherical drupes that grow 5 to 7 mm wide and occur in fall and persist throughout the winter.

Propagation

The authors have had much success growing yaupon from seed of wild-collected fruits. Fruit harvested in winter months (January) are placed in water and pressed to clean flesh from seed. Cleaned seeds are sown in open flats or in 72-cell liners after moist, cool stratification (40 days at 4.5° C) to overcome seed dormancy associated with immature embryos. Germination may occur over an extended period; seedlings are grown for 2 to 4 months before they are transplanted to larger pots.

Yaupon is a common nursery crop, and vegetative propagation methods are numerous for yaupon cultivars. Generally, semihardwood (fall) cuttings can be treated with 3,000 ppm IBA (Indole-3-butyric acid) solution while hardwood (dormant winter cuttings) can be treated with 5,000 ppm IBA solution. Craig (1991) suggests using NAA (1-Naphthaleneacetic acid) on hardwood cuttings. Cuttings are rooted under intermittent mist in a well-drained substrate. Wild-collected cuttings should be collected from a broad range of plants to ensure a broad genetic diversity and a mixture of male and female plants.

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Credit: Mack Thetford, UF/IFAS

Outplanting

Plants have higher outplanting survival in 14-in-deep tree pots (versus the standard 1-gal pots) and in interdunal swales (versus ridges) (Thetford et al. 2015). Outplant yaupon in the proximity of shallow swales for optimal transplant survival.

Literature Cited

Craig, R.M. 1991. "Plants for coastal dunes of the Gulf and south Atlantic coasts and Puerto Rico." USDA SCS. Agriculture Information Bulletin 460.

Lotts, K., and T. Naberhaus. 2017. *Butterflies and Moths of North America.* http://www.butterfliesandmoths.org/

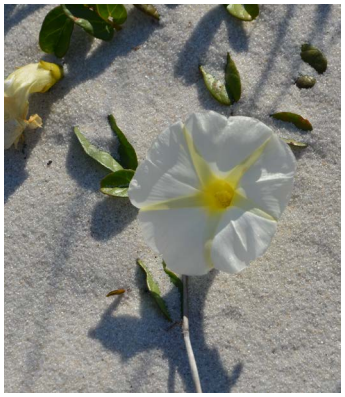
Thetford, M, D.L. Miller, L.W. Atwood, and B.O. Ballard. 2015. "Microsite and rooting depth are more important than water-holding gel for establishment of restoration plantings of *Ilex vomitoria* on barrier islands in the Gulf of Mexico." *Native Plants Journal.* 16(2):77–86.

Ipomoea imperati beach morning-glory
Ipomoea pes-caprae subsp. *brasiliensis* railroad vine

Convolvulaceae

Credit: Gabriel Campbell, UF/IFAS

Two species of *Ipomoea* are found in coastal beach plant communities of the Florida Panhandle; beach morning-glory (*Ipomoea imperati*) and railroad vine (*Ipomoea pes-caprae* subsp. *brasiliensis*). Beach morning-glory and railroad vine are distinguished by the colors of their corollas and the shapes of their leaves. Beach morning-glory flowers are white with yellow and purple in the throat and leaves are elliptical and notched; whereas railroad vine has a pink to purple flower and kidney-shaped leaves. Beach morning-glory flowers occur from spring to fall, while railroad vine flowers are present year-round.



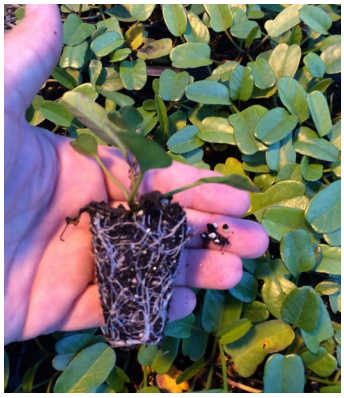
Credit: Gabriel Campbell, UF/IFAS

Both plants occur throughout coastal Florida, however railroad vine has been documented in more counties. More broadly, these plants are found in coastal states west to Texas and northeast to North Carolina. Disjunct populations may exist in Pennsylvania as well. Both species have been reported to occur there. These plants occur in beach dunes and are important sand stabilizers and colonizers after disturbances. The seeds are important forage for several types of wildlife, including endangered beach mice.

General Description

Both species are stoloniferous, scrambling, creeping perennial vines that reach extreme lengths, upward of 30 ft or more. *Leaves* are simple and alternately arranged, with or without lobes. They have elongated petioles. *Stems* are trailing, fleshy, and glabrous, forming roots at nodes. Inflorescences are solitary and axillary. Sepals are coriaceous, glabrous, or pubescent, and corollas are funnelform to campanulate (funnel to bell shaped) with 5 stamens and the style included in the corolla. Interestingly, railroad vine flowers only last one day. *Fruits* are dry, dehiscent capsules with 4 large seeds.

Propagation



Credit: Mack Thetford, UF/IFAS

The authors propagate beach morning-glory stem cuttings without the application of auxins. Single- or multiple-node stem cuttings can be taken along any portion of the stem. Place at least one node into the rooting substrate and place under intermittent mist with natural photoperiod until roots form. Cuttings root within 7 to 10 days and should be removed from mist at the first sign of rooting, or they will quickly deteriorate. Hand water until plants form sufficient roots to hold the propagation substrate when removed from the propagation cell.

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Credit: Gabriel Campbell, UF/IFAS

Plants grow quickly once transferred to production containers with a well-draining substrate in either greenhouse or nursery conditions. Railroad vine can also be propagated from cuttings in a similar manner. Seeds of railroad vine are physically dormant and must be scarified in order to germinate (Devall and Thien 1989). In the wild, seeds germinate during all seasons except for winter (Devall 1992).

Germination for beach morning-glory requires scarification because seeds are physically dormant (Martínez et al. 1992). Seeds germinate with both constant (90% at 35° C) and fluctuating day/night temperatures (60 to 85% at 40/20° C) in dark or light. Seeds retain germinability when buried up to 0.75 in and inundated with 25% seawater.

Outplanting

No published outplanting information is available. The authors have transplanted beach morning-glory in spring and early summer months with high success. Transplants may experience an initial foliar salt burn when transferred from the nursery to high salt and wind conditions. However, transplants will quickly regrow from existing stems or from the base of the plant because of the stoloniferous characteristics of the species.

Credit: Mack Thetford, UF/IFAS

Literature Cited

Devall, M.S. 1992. "The biological flora of coastal dunes and wetlands 2. *Ipomea pes-caprae* (L.) Roth." *Journal of Coastal Research.* 8(2)442–456.

Devall, M.S., and L.B. Thien. 1989. "Factors influencing the reproductive success of *Ipomoea pes-caprae* (Convolvulaceae) around the Gulf of Mexico." *American Journal of Botany*. 76(12):1821–1831.

Martínez, M.L., T. Valverder, and P. Moreno-Casasola. 1992. "Germination response to temperature, salinity, light and depth of sowing of ten tropical dune species." *Oecologia.* 92:343–353.

Iva imbricata

seacoast marshelder

Asteraceae

Credit: Josiah Raymer, UF/IFAS

Seacoast marshelder is an important plant for dune restoration, stabilization, and formation because of its ability to trap sand. It grows on foredunes and forms low, rounded dunes as sand accumulates (Craig 1991). As the aboveground portions of the plant become buried by sand, rooting is stimulated in stem tissue (Craig 1975). This gives the appearance that the plant is rhizomatous when in fact it is the sand burial resulting in the presence of below-ground stems. This plant occurs throughout coastal Florida (except for the Big Bend coast) and in coastal southeastern states west to Texas and northeast to Virginia.

General Description

Seacoast marshelder is a sparsely branched, succulent, shrub-like perennial herb that can reach heights of 1 to 4 ft and widths up to 6 ft. *Leaves* are without stalks, succulent, lance shaped, and mostly arranged oppositely (at the base of the plant) early in the season and become alternate (near the top of the plant) later in the season. Leaves are 0.75 to 2 in long with blades narrowing at tip and have almost entire margins. Inflorescences are non-showy terminal racemes that appear in late summer and continue to elongate through early fall with leaf-like bracts below initial flowers and smaller bracts below later flowers. *Flowers* have cream to white to greenish petals that are 1.5 mm long. *Fruits* are achenes, 3.5 to 5 mm long, brown to yellow, and globe shaped. *Seeds* are retained in the dried calyxes of the flowers throughout the winter months until the plants begin to break apart and the seeds are dispersed as the plant parts are blown by beach breezes.

Propagation

Cutting propagation of seacoast marshelder is possible with 2- and 4-in stem cuttings. Cuttings obtained from early season flushes of growth that are flexible but not stiff (softwood cuttings) root with greater than 70% success without auxin application. Short lateral stems may be used to prepare 2-in cuttings and a quick-dip in 1,000 ppm IBA (Indole-3-butyric acid) will improve rooting for these lateral cuttings (Thetford and Miller 2002). Additionally, the success of rooting (rooting percentage) and quality of shoot tip cuttings (root number and root length) are variable across seasons (Raymer et al. 2008).

The following cutting propagation protocol is adapted from Thetford and Miller (2004). Collect 4-in softwood cuttings from the tips of non-branched terminal shoots in early spring through summer. Cuttings should not be collected from floral portions of the stem because these portions of the stem have no lateral buds from which to initiate new vegetative shoots. Cuttings may be rooted in 72-cell flats under mist for 3 to 4 weeks followed by hand watering for another 2 to 3 weeks in a well-draining substrate such as a commercial potting mix or 100% milled pine bark. Rooted cuttings may be fertilized with a complete fertilizer using a rate of 150 ppm N solution applied 1 to 2 times a week. Plants can be pruned to stimulate branching starting week 4 or 5 or up to 1 week after transplanting to larger pots. Plants perform well in 4-in and 1-qt pots and require 4 to 6 weeks of additional growth to develop a full rootball and a canopy of 6–8 in.

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Credit: Josiah Raymer, UF/IFAS

Credit: Josiah Raymer, UF/IFAS

Establishing productive nursery stock plants is possible for seacoast marshelder. The following is adapted from Raymer et al. (2008). Stock plants may be grown in 1-gal containers using a pine-bark substrate amended with 6 lb/yd^3 dolomitic limestone with 11 gm (recommend rate) of a 15N–3.9P–10K controlled-release fertilizer. Stock plants started in the spring from dormant liners have the most productive cuttings when taken during May to early June and August while stock plants established from actively growing liners are most productive from September to November. Every effort should be made to increase plant width by pruning during early spring and summer and a cutting harvest should be planned from May to early June. July should be a period to allow for vegetative growth before any subsequent harvests.

Seeds from a North Carolina population had physiological dormancy that was alleviated with cold stratification for at least 30 days at 4C (Van Der Valk 1974). The stratified seed then needed to be germinated with daily alternating temperatures of 10/15 or 15/25°C, in light or dark, to achieve high germination percentages. Seeds can be collected and readily germinate in fall (Graetz 1973). Similarly, seeds collected by the authors in fall, placed in a plastic bag, and stored at ambient temperature for 3 months germinated readily under intermittent mist.

Outplanting

Plants should be planted well above the mean high tide line on Gulf-facing foredunes. Small, one-year-old transplants have been successfully transplanted in early spring (Graetz 1973). The authors have successfully transplanted plants produced in 4-inch pots using a pine-bark substrate at nearly 100% survival in foredune locations both alone and in conjunction with other foredune grasses (Stoddard et al. 2014).

Literature Cited

Craig, R.M. 1975. "Woody vegetation for coastal dune areas." Proceedings of the Florida State Horticultural Society. 88:428–434.

Craig, R.M.1991. "Plants for coastal dunes of the Gulf and south Atlantic coasts and Puerto Rico." USDA SCS. Agriculture Information Bulletin, Issue no. 460.

Graetz, K.E. 1973. "Seaside plants of the Carolinas." USDA, SCS, and University of North Carolina Sea Grant Program. Sea Grant Publication.

Raymer, J., M. Thetford, and D.L. Miller. 2008. "Fertility rate of seacoast marshelder stock plants influences cutting production and rooting characteristics of stem cuttings." *HortTechnology*. 18(3):372–378.

Stoddard, M., D.L. Miller, L.C. Branch, and M. Thetford. 2014. "Endangered beach mouse: Linking population studies/habitat restoration to predict sea level rise." Final Report submitted to Gulf Islands National Seashore, Gulf Coast Cooperative Ecosystems Studies Unit Project H5000 02 A271. 130 p.

Thetford, M., and D.L. Miller. 2004. *Propagation and production of seacoast marshelder*. ENH-975. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/ep232

Thetford, M., and D.L. Miller. 2002. "Propagation of four Florida coastal dune species." *Native Plants Journal*. 3(2):112–120.

Van Der Valk, A.G. 1974. "Environmental factors controlling the distribution of forbs on coastal foredunes in Cape Hatteras, National Seashore." *Canadian Journal of Botany*. 52:1057–1073.

Lupinus westianus var. *westianus*

Gulf coast lupine

Fabaceae

Credit: L. Scott Jackson, UF/IFAS.

Gulf coast lupine (*Lupinus westianus* var. *westianus)* is listed as threatened by the Plants in the Preservation of Native Flora of Florida Act, Chapter 5B-40, Florida Administrative Code, 1998, amended (Wunderlin et al. 2017). The species is endemic to coastal counties in the western Panhandle of Florida. Two disjunct populations are noted with *Lupinus westianus* var. *aridorum* occurring only in the central peninsula of Florida. Gulf coast lupine occurs in beach dunes, coastal grasslands, coastal scrub, sandhills, and disturbed areas such as roadsides. Gulf coast lupine can be distinguished from a similar lupine (*L. diffusus*) by the lack of a petiole. Several pollinators are sustained by gulf coast lupine, and the inflorescences are remarkably showy. Lupines form symbiotic relationships with nitrogen-fixing microorganisms within the soil (Gutiérrez Mañero et al. 2003).

General Description

Gulf coast lupine is a shrubby biennial or short lived perennial herb that grows up to 3 ft tall. It is most commonly found on exposed and active sand dunes and on sandy disturbed areas. *Leaves* are alternately arranged and superficially appear simple but are in fact a compound leaf with only one leaflet (unifoliate). *Stems* are herbaceous when young but become woody with age. Inflorescences are terminal spikes that occur in the spring. *Flowers* have purple to blue corollas with red to purple spots on the standard, are densely arranged on the stalk, and resemble the flowers of peas. *Fruits* are hairy legumes.

Propagation

No published propagation information is available for gulf coast lupine. However seed germination of related lupine species has been studied. Lupine seeds exhibit physical dormancy and need to be scarified in order to germinate. Seeds of sky blue lupine (*Lupinus diffusus*), a related scrub species, achieved 70% germination following 20 seconds scarification in an electric seed scarifier (Forsbergs, Inc.) after one year in dry storage at room temperature (Campbell 2016). The authors were able to germinate sky blue lupine seed and grew seedlings in a climate-controlled greenhouse to a 3-inch height before all seedlings became chlorotic and died. We speculate the plants lacked the soil mycorrhiza in the production substrate and were unable to form symbiotic relationships with the nitrogen-fixing microorganisms required for their survival.

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Outplanting

No published outplanting information exists for gulf coast lupine. Other species of lupine have specific mycorrhizal associations and are notorious for poor survival rates during transplantation.

Literature cited

Campbell, G. 2016. "Dormancy and germination characteristics of two Florida native forbs, *Asclepias humistrata* and *Lupinus diffusus*." Masters thesis. University of Florida.

Gutiérrez Mañero, F.J., A. Probanza, B. Ramos, J.J. Colón Flores, and J.A. Lucas García. 2003. "Effects of culture filtrates of rhizobacteria isolated from wild lupine on germination, growth, and biological nitrogen fixation of lupine seedlings." *Journal of Plant Nutrition.* 26(5):1101–1115.

Wunderlin, R.P., B.F. Hansen, A.R. Franck, and F. B. Essig. 2017. *Atlas of Florida Plants.*[S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa. http://florida.plantatlas.usf.edu/

Morella cerifera

Synonym: *Myrica cerifera*

wax myrtle

Myricaceae

Credit: Jenna Dunn, UF/IFAS

Wax myrtle is one the most widespread plants in Florida, and it is found in coastal states west to Texas and north to New Jersey. The wax found around seeds can be melted down to make candles. The fruits of wax myrtle are important for birds and other wildlife, and the plant is a larval host for the banded hairstreak and redbanded hairstreak butterflies (*Satyrium calanus* and *Calycopis cecrops*, respectively) (Lotts and Naberhaus 2017). Wax myrtle has been shown to contribute substantial nitrogen addition to soils via symbiotic relationships with nitrogen-fixing microorganisms residing in soils (Permar and Fisher 1983).

General Description

Wax myrtle is an evergreen shrub to small tree with several trunks that can reach heights of 40 ft. *Leaves* are alternate, simple, narrowly oblanceolate, 2 to 6 in long by 0.4 to 0.8 in wide, aromatic, and dense, with a toothed margin toward the apex and surfaces covered in amber dots. It may require magnification to see the dots clearly. Inflorescences are catkins, male or female, axillary, 0.8 in long, numerous, and occur in early spring. The species is dioecious with pistillate and staminate flowers occurring on separate plants.

Fruits are rounded, blue, wax-coated drupes 2 to 4 mm in diameter.

Propagation

Credit: Sarah Lumban-Tobing, UF/IFAS

Southern nurseries usually produce wax myrtle from seed or cuttings. It is commonly used as a landscape plant. To propagate cuttings from plants existing on restoration sites, collect softwood cuttings and treat with moderate rates of IBA (Indole-3-butyric acid) at 5,000 to 8,000 ppm or mixtures such as 1,000 ppm IBA and 500 ppm NAA (1-Naphthaleneacetic acid). Root cuttings under intermittent mist; they will show root growth at approximately 4 weeks.

Seed germination requires removal of the wax coating from the fruit. Wash the fruit in warm detergent water and rinse with plain cool water. Seed require a cool, moist stratification period of 40 to 90 days. Seeds can be sown in open flats and covered with ¼ in of vermiculite. Stratification is necessary to overcome physiological dormancy; hence seed from more northern populations may have a longer stratification requirement than southern populations (Krochmal 1974).

Outplanting

The authors have successfully transplanted wax myrtle grown in 1-gal containers to Santa Rosa Island with a survival of 50 to 65% 15 months after planting, when plants

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were located a minimum of 560 ft from the gulf (Miller, Thetford, and Schneider 2008). Morella was not tolerant of the levels of salt spray when planted closer to the Gulf or when planted behind dunes less than 3.3 to 6.6 ft high. Transplants experienced significant foliar loss and twig death at 660 ft from the gulf when protective dunes were less than 6.6 ft high. Surviving plants exhibited regrowth from the basal portions of the plants, and we concluded that these plants would need additional dune development or should be planted further back from the Gulf within the dune field or located in close proximity to swales.

Plants grown from rooted cuttings in 60-cell flats have been successfully outplanted within the low dune field on barrier islands in the Panhandle of Florida (Lumban Tobing 2009). Plants should be placed at low spots of interdunal swales during the spring and should be initially irrigated if drought conditions are present.

Literature Cited

Krochmal, A. 1974. "Myrica L. Bayberry." In: Schopmeyer, C. S., ed. *Seeds of woody plants in the United States*. Agriculture Handbook no. 450. Washington: U. S. Department of Agriculture, Forest Service. pp. 548-550.

Lumban Tobing, S.T. 2009. "Germination and establishment of woody species with barrier island interdunal swales." Master's thesis. University of Florida.

Lotts, Kelly, and Thomas Naberhaus, coordinators. 2017. *Butterflies and Moths of North America*. http://www.butterfliesandmoths.org/

Miller, D.L., M. Thetford, and M. Schneider. 2008. "Distance from the Gulf influences survival and growth of three barrier island dune plants." *Journal of Coastal Research*. 24(3):261–266.

Permar, T.A., and R.F. Fisher. 1983. "Nitrogen fixation and accretion by wax myrtle (*Myrica cerifera*) in slash pine (*Pinus elliottii*) plantations." *Forest Ecology and Management*. 5(1):39–46.

Oenothera humifusa

seabeach evening primrose

Onagraceae

Credit: Josiah Raymer, UF/IFAS

Seabeach evening primrose is found in beach dunes throughout coastal counties in Florida, west to Louisiana, and as far north as New Jersey.

General Description

Seabeach evening primrose is an herbaceous perennial with horizontal stems forming a rounded, mounding canopy. *Leaves* are simple and alternate and wider than 1 mm with short, silky pubescence. *Stems* are prostrate, grow up to 3 ft long, and are covered with silky appressed pubescence. *Flowers* are axillary with 4 yellow petals that are 0.2 to 0.6 in long, 4 sepals that are 0.1 to 0.4 in long, and flattened bracts. They have a hypanthium that is longer than the ovary. *Fruits* are 10- to 35-mm-long dehiscent capsules with appressed hairs that give rise to numerous rounded seeds.

Propagation

No published seed propagation information is presently available for *O. humifusa*; however, other *Oenothera* species are well studied and have been shown to require light to germinate (Greiner and Köhl 2014). The authors collected stem cuttings in the fall and found the seeds present within the capsules already on the cuttings readily germinated in propagation flats under intermittent mist and natural photoperiod post-dehiscence. Seedlings initially form a low, broad rosette and are easily transplanted as small plugs after two weeks' growth in the propagation flat. Seedling growth is eventually lateral becoming multibranched. Seedlings will fill 4-in pots in 4 weeks when grown outdoors with overhead irrigation and fertilized with slow-release fertilizer.

Credit: Mack Thetford, UF/IFAS

The authors found stem cuttings of *Oenothera* rapidly and readily produce roots without auxin application. Apical stem cuttings taken in late April 2017 from Santa Rosa Island, Florida, rooted and filled 162-cell flats in less than 4 weeks while under intermittent mist and natural photoperiod in a controlled-environment greenhouse. Cuttings grown in 72-cell flats filled 4-in pots in 4 weeks when grown outdoors under overhead irrigation and fertilized with slow-release fertilizer.

In nursery culture, this plant may become infested with flea beetles (*Altica* sp). The preferred plant hosts of this insect are likely limited to the members of the evening primrose family, Onagraceae (Clark et al. 2004). The beetle is a problem on *Oenothera* in the spring (May–June in north Florida) when larvae and adults appear in large numbers and can feed on the host plant until it dies. The authors have not noted this insect to be a serious pest of *Oenothera* growing within coastal plant communities, likely related to

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the harsh environment and presence of natural enemies. Commercial pest management recommendations are available to manage the pest in nursery culture.

Outplanting

Credit: Steven Wagner, UF/IFAS

Plants in 4-in pots with fully developed rootballs and canopies have successfully been outplanted by the authors. In a preliminary trial, when planted in July on open beach areas behind low frontal dunes, transplant success was 43%. However, in subsequent plantings in early March survival was 100% after 2 months. Plants were outplanted on backdunes midslope at least 12 in from each other and existing perennial grasses. Fertilizer application (½ tsp Osmocote 18-6-12) improved the aesthetic appearance of plants and increased biomass for this plant but was not necessary for survival.

Literature Cited

Clark, S.M., D.G. LeDoux, T.N. Seeno, E.G. Riley, A.J. Gilbert, and J.M. Sullivan. 2004. "Host plants of leaf beetle species occurring in the United States and Canada (*Coleoptera: Megalopodidae, Orsodacnidae, Chrysomelidae* exclusive of Bruchinae)." *Coleopterists Society, Special Publication no. 2*. 476 pp.

Greiner, S., and K. Köhl. 2014. "Growing evening primrose (*Oenothera*)." *Frontiers in Plant Science.* 5(38):1–12.

Panicum amarum

bitter panicgrass, bitter panicum

Poaceae

Credit: Josiah Raymer, UF/IFAS

Bitter panicgrass is important in dune stabilization and building and often grows intermixed with sea oats on foredunes. It is also found spread throughout back dunes, interdunal swales, and coastal grasslands. This plant occurs throughout coastal Florida, except for the Big Bend coast, west to New Mexico, and along coastal northeast states to Massachusetts. A significant proportion of bitter panicgrass reproduction is by vegetative spread; its seeds are often sterile.

General Description

Bitter panicgrass is a bluish green, rhizomatous, perennial, clumping grass that can reach heights of 3.3 ft or more. Aboveground stems (culms) are thick, branch from lower nodes, can be upright or horizontal, and have glabrous (smooth) nodes and grey glabrous to glaucous (waxy) internodes. *Leaves* are up to 20 in long and 0.75 in wide, and have flat bases and smooth and involuted tips. The sheaths are glabrous with hairy upper margins. The ligules are membranous, up to 0.33 in long, and ciliate. Inflorescences are elongated panicles, up to 20 in long. They occur in late spring to late summer. Panicles are narrow, slightly nodding, and densely flowered. *Flowers* are typical grass spikelets, somewhat purple/gray, 0.33 in long, glabrous, and ovoid with lower glumes that reach half the spikelet length and are 3- to 9-veined. *Fruits* are smooth, shiny achenes and are also purple/gray.

Propagation

Above- and belowground portions of bitter panicgrass can produce new plants (Willis and Hester 2008). Culms with at least 2 nodes can be placed vertically in a pot with well-draining propagation medium (USDA NRCS 2017). Seedlings from a wild Louisiana population were successfully transplanted to a greenhouse and grown in 2L (0.53 g) pots with 1.6-mm sieved and sterilized sand collected at the growing site (Hester and Mendelssohn 1990). These same plants did not respond to micronutrient application but did respond positively to macronutrient fertilizer application one week after transplanting. Additionally, humic acid (80g/mL) has been used to increase biomass for container-grown bitter panicgrass (Willis and Hester 2008).

The authors collected elongated culms and dissected them into single-node cuttings. These cuttings were placed in a coarse propagation substrate containing milled pine bark. The cuttings were inserted vertically to a depth that placed the visible bud at the node even with the substrate surface. Cuttings placed under intermittent mist produce roots within a few days. Once roots are evident, the rooted cuttings should be placed on greenhouse benches to grow until new shoots are a few inches tall. Well-rooted liners can be transplanted to 4-in pots and outplanted within 4 to 6 weeks when rootballs are sufficiently dense to hold the

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substrate together when the plant is removed from the pot. Timing will depend on root growth rates.

The potential for collection of nonviable seed is high and likely to be an important factor in producing these plants from seed. Seed viability varies considerably across populations and year collected (Senaca 1969).

Outplanting

Miller et al. (2001) reported increased growth (more tillers and more branching) for bitter panicgrass when it was planted in March than when it was planted in December. Bitter panicgrass can be transplanted during the summer, but summer planting is not recommended unless supplemental water is available or rainfall is consistent (i.e., rainfall levels are average or above average). Planting without supplemental water in May, the lowest rainfall month is not recommended unless supplemental water is available or rainfall is consistent.

Literature Cited

Hester, M.W., and I.A. Mendelssohn. 1990. "Effects of macronutrient and micronutrient additions on photosynthesis, growth parameters, and leaf nutrient concentrations of *Uniola paniculata* and *Panicum amarum*." *Botanical Gazette*. 151(1):21–29.

Lamphere, J. 2017. "Plant guide – bitter panicum." USDA NRCS Golden Meadow Plant Materials Center. United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). The PLANTS Database. http://plants.usda.gov/plantguide/pdf/pg_paam2.pdf

Seneca, E.D. 1969. "Germination response to temperature and salinity of four dune grasses from the outer banks of North Carolina." *Ecology.* 50(1):45–53.

Willis, J.M., and M.W. Hester. 2008. "Evaluation of enhanced *Panicum amarum* establishment through fragment plantings and humic acid treatment." *Journal of Coastal Research*. 24(2B):263–268.

Miller, D.L., M. Thetford, and L. Yager. 2001. "Evaluation of sand fence and vegetation for dune building following overwash by Hurricane Opal on Santa Rosa Island, Florida." *Journal of Coastal Research*. 17(4):936–948.

Paronychia erecta

squareflower

Caryophyllaceae

Credit: Gabriel Campbell, UF/IFAS

Squareflower is found in beach dunes, coastal grasslands, and scrub. This plant is an endemic restricted to the coastal Panhandle of Florida, counties west of the Big Bend region, and west to Louisiana. The square outline of the inflorescence is unique and makes squareflower a desirable plant for coastal landscapes.

General Description

Squareflower is a multiple stemmed, herbaceous perennial species with a short canopy. *Leaves* are purple to pink to green, opposite, and up to 3 mm wide with linear to oblong papery stipules that are ½ to ¼ as long as the leaves. *Stems* are stout and round and curve upward. Inflorescences are multibranched corymbs branching with distinct regularity, which results in a characteristic branch pattern making the outline a square. *Flowers* are perfect, 2.5 to 3 mm long, and hypogynous, with 5 white sepals and no petals. They occur from March to November. *Fruits* are a single-seeded indehiscent utricle (achene).

Propagation

Credit: Gabriel Campbell, UF/IFAS

Auxin is not needed to initiate roots for stem cuttings of squareflower. The authors found wild collected apical stem cuttings (with or without floral buds) collected from late winter to late spring/early summer root readily within 2 weeks under intermittent mist. Adventitious roots produced by cuttings are very fibrous (small in diameter) and delicate, and much care was required when removing rooted cuttings from the propagation flats for transplanting to production containers. Plugs may require additional production time to allow sufficient root system formation and improvement of adventitious root connections to the cutting.

No published seed germination information is available for squareflower.

The authors found seeds collected in November and stored in the dark for 3 months in a greenhouse germinated readily within 2 weeks when placed on top of potting soil under intermittent mist with natural photoperiod in mid-February. A closely related species found in scrub (*Paronychia chartacea* subsp. *chartacea*) has been shown to not have seed dormancy (Stephens et al. 2012) but may require microorganisms (algae, lichens, cyanobacteria, mosses, fungi, and bacteria) within soil crusts to aid germination in the wild (Hawkes 2004).

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Outplanting

Production information for this species has only recently been refined; hence, the authors have had limited experience transplanting square flower to the coastal dunes. Square flower has been successfully transplanted in informal plantings when grown in 4-in pots within protected beach dune areas behind a primary dune ridge. No survival data were obtained, and further experience and information are needed to make an informed recommendation.

Credit: Gabriel Campbell, UF/IFAS

Literature Cited

Hawkes, C.V. 2004. "Effects of biological soil crusts on seed germination of four endangered herbs in a xeric Florida shrubland during drought." *Plant Ecology.* 170:121–134.

Stephens, E.L., L. Castro-Morales, and P.F. Quintana-Ascencio. 2012. "Post-dispersal seed predation, germination, and seedling survival of five rare Florida scrub species in intact and degraded habitats." *American Midland Naturalist.* 167:223–239.

Physalis angustifolia

coastal groundcherry

Solanaceae

Credit: Gabriel Campbell, UF/IFAS

Coastal groundcherry occurs on beach dunes, coastal grasslands, coastal scrub, and disturbed areas. This plant is found throughout coastal counties on the west coast of Florida—except for the Big Bend region and the extreme southeasternmost counties—and more broadly west to Louisiana. Threatened and endangered beach mice and many other animals rely on this plant as a food source. Plants can be longed-lived and form relatively thick tuberous roots. Coastal groundcherry can hybridize with other *Physalis* species, particularly with *P. viscosa,* and has long frustrated plant taxonomists because of the inherent variation within the genus (Sullivan 1985).

General Description

Coastal groundcherry is an herbaceous perennial that forms thickened tuberous roots and stolons to spread asexually belowground, creating a sparse groundcover. *Leaves* are simple, alternate, linear, usually longer than 7 cm, mostly 8 times longer than wide, and glabrous. *Inflorescences* are solitary, axillary and bell- to wheel-shaped with a yellow corolla, occurring most months in frost-free areas. *Fruits* are yellow to orange edible berries that resemble a miniature tomatillo, being surrounded by a papery husk that looks like a tiny lantern.

Propagation

Credit: Mack Thetford, UF/IFAS

Stem cutting propagation of coastal ground cherry is readily accomplished from 4- to 6-in cuttings. Plants do not require auxin application to initiate roots, though auxin may decrease the time to rooting and improve rooting uniformity. Cuttings are placed under intermittent mist with root formation occurring within 2 weeks. Rooted cuttings should be removed from mist at the first sign of rooting, or they will quickly deteriorate and express signs of foliar oedema. Hand water until plants form sufficient roots to hold the propagation substrate when they are removed from the propagation cell.

Propagation of coastal groundcherry from seed is also easily accomplished. Sow seeds on the surface of a standard greenhouse media, keep them moist, and expose them to a natural photoperiod. The authors found dry, cleaned seed stored at room temperature in glass jars retain viability for at least 5 years.

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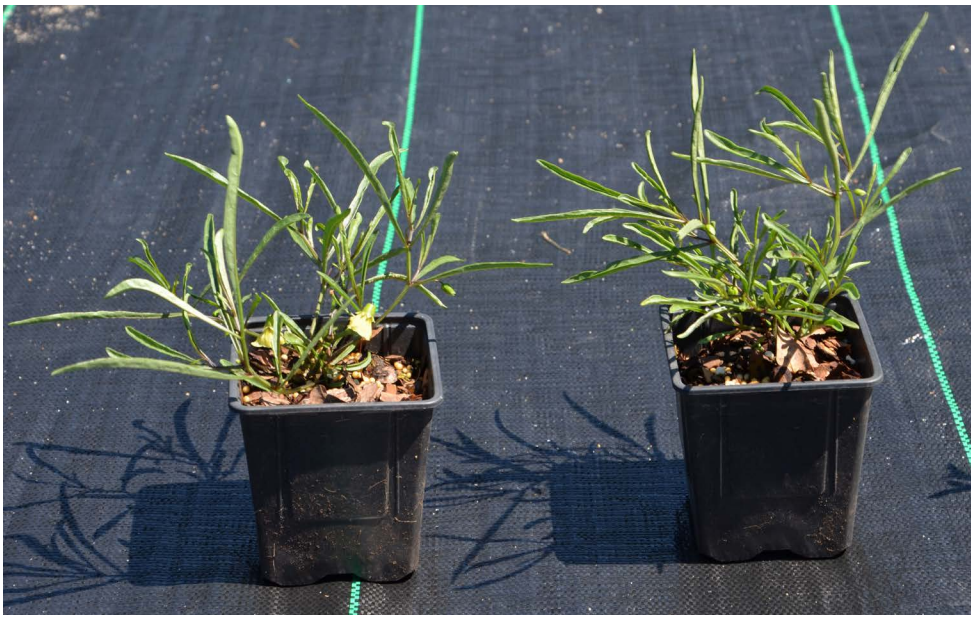
Van der Valk (1974) studied seed germination of a closely related species, *Physalis walteri* (Walter's groundcherry). Seeds were determined to need light to germinate at constant temperatures. Seeds can be germinated in dark only if they are exposed to alternating day/night temperatures (15/25 and 20/30°C). Germination was near 100%. Seeds can tolerate burial up to 2 cm.

Outplanting

Plants in 4-in pots with fully developed rootballs and canopies have successfully been outplanted by the authors. In a preliminary trial, when planted in July on open beach areas behind low frontal dunes, transplant success was 55%.

Plants grown in 4-in pots and in 72-cell flats with well-developed rootballs and canopies have been outplanted successfully by the authors in early February with greater than 75% survival after 3 months, though plants from 4-in pots had higher survival and were far more robust. Plants were outplanted on the backdunes at mid-slope at least 12 in from each other and from perennial grasses. Fertilizer application (½ tsp Osmocote 18-6-12) improved the aesthetic and increased biomass for this plant but was not necessary for survival.



Credit: Gabriel Campbell, UF/IFAS

Literature Cited

Sullivan, J.R. 1985. "Systematics of the *Physalis viscoa* complex (Solanaceae)." *Systematic Botany.* 10(4):426–444.

Van Der Valk, A.G. 1974. "Environmental factors controlling the distribution of forbs on coastal foredunes in Cape Hatteras, National Seashore." *Canadian Journal of Botany.* 52:1057–1073.

Polygonella polygama

October flower

Polygonaceae

Credit: Kari Ruder, UF/IFAS

October flower is widespread throughout Florida and more broadly in coastal states west to Texas and northeast to Virginia. October flower is found in dune and scrub plant communities and ruderal areas. The showy flowers and attractive foliage make this native plant a desirable ornamental for landscapes.

General Description

October flower is an herbaceous short-lived perennial that can reach heights of 3 ft. *Leaves* are simple, alternate, linear, stipulate, 0.5 to 5 mm wide and persistent when fruit are present with veins that appear parallel and with inconspicuous secondary venation. Stipules are fused together around the stem in an entire ocrea. Branches are partly fused to the stem as if arising between the nodes. *Inflorescences* are prolific; racemes occur from July to October. *Flowers* are white to pink and contain male and female parts. They lack a corolla, have superior ovaries, and are subtended by a bract and two bracteoles. *Fruit* is an 0.8- to 1-mm-wide achene.

Propagation

Germination requirements of October flower are known (Heather 2009; Heather 2010). Seeds have non-deep physiological dormancy that is alleviated by warm or cold, moist stratification, application of 1,000 ppm GA (Gibberellic acid), or time in storage. Seeds prefer cooler temperatures (22/11°C) to warmer ones. Seeds collected between November and February have been successfully germinated.

Stem cutting production is possible on summer softwood stem cuttings of October flower (Heather 2009; Thetford et al. 2012). Application of auxin, such as IBA (Indole-3-butyric acid) is not needed for root initiation but may improve rooting performance. Greenhouse-grown plants perform well in both peat- and bark-based propagation media (Smith et al. 2014).

Outplanting

Greenhouse-grown plants of October flower performed well in a trial garden as a native wildflower producer for several months, with peak flowering in October (Smith et al. 2014). Beach dune outplanting information is not presently available.

Literature Cited

Heather, A.E. 2009. "A study on propagation methods for two native wildflowers: *Polygonella polygama* and *Polygonella robusta*." Master's thesis. University of Florida.

Heather, A.E. 2010. "Non-deep physiological dormancy in seeds of two *Polygonella* species with horticultural potential." *HortScience.* 45(12):1854–1858.

Smith, A.M., S.B. Wilson, M. Thetford, K.L. Nolan, and C. Reinhardt Adams. 2014. "Performance of nine Florida native wildflower species grown in varying container substrates." *Native Plants Journal.* 15(1):75–86.

Thetford, M., A.E. O'Donoughue, S.B. Wilson, and H.E. Pérez. 2012. "Softwood cutting propagation of three Polygonella wildflower species native to Florida." *Propagation of Ornamental Plants.* 12(1): 58–62.

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Quercus geminata

sand live oak

Fagaceae

Credit: Mack Thetford, UF/IFAS

Sand live oak is found throughout northern Florida, more broadly west to Louisiana, and northeast to North Carolina. It is found in beach dunes, backdunes, sandhills, coastal areas, and inland areas with deep sandy soils. While this plant forms trees farther inland, it is commonly reduced to shrubs and sub-shrubs because of the extreme environmental conditions of the coast. The acorns of this plant are a valuable food source for wildlife. Sand live oak is available also in commercial nurseries and is often used as a landscape plant.

General Description

Sand live oak is within the white oak group and may be present as a shrub or tree with thick, roughly ridged, furrowed bark. The white oak group (synonym sect. Lepidobalanus or Leucobalanus) produce acorns that mature in 6 months (current season growth) and are frequently described as sweet or slightly bitter. *Leaves* are alternate, simple, thick, coriaceous, coarsely veined and 0.75 to 5 in long by 0.25 to 1.5 in wide. Upper leaf surfaces are dark green and glabrous, lower surfaces are dull gray to white and pubescent, and petioles are densely pubescent. Leaf margins are revolute, and the leaf blade is cupped, which gives it the shape of a boat. *Inflorescences* are catkins that appear in spring. *Fruits* are acorns, 0.4 to 0.8 in long and pointed; borne in a tapering cup that is about 0.3 in deep and has imbricate scales.

Propagation

Credit: Gabriel Campbell, UF/IFAS

Cutting propagation of sand live oak is not a practical approach for oak restoration because it would limit genetic diversity. Propagation from seed is accomplished easily. Acorns of *Q. geminata* are viviparous. The radical of the embryo does not stop growing necessitating immediate planting following seed harvest. Select acorns that are brown as yellowish acorns are generally not mature. Mature acorns will easily separate from the acorn cup. Collect acorns from branches rather than from the ground to minimize the collection of seeds containing weevil larvae. Perform a standard float test (discard those that float in water) to help eliminate acorns with underdeveloped seed and many impacted by weevils.

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Acorns can be planted on the surface of a well-drained production substrate or the acorns may be covered lightly to a depth equal to the acorn diameter. Shoot emergence follows initial root system development.

Credit: Gabriel Campbell, UF/IFAS

Outplanting

Protect seeds planted in the wild from herbivores and high salinities. Bury them in the soil at a depth approximately the diameter of the acorn (Lumban Tobing 2009). Polyacrylamide gel is not recommended for outplanting of nursery-grown transplants from containers (Miller et al. 2013). The authors suggest outplanting in association with depressions to mimic natural dune-building processes that occur with sand accretion, to reduce initial drought stress, and to use explants with a deep root volume.

Literature Cited

Griffin, J., and N. Bassuk. 1996. *Preliminary progress on the asexual propagation of oaks.* Combined Proceedings, International Plant Propagators' Society. 46:487–494.

Lumban Tobing, S.T. 2009. "Germination and establishment of woody species with barrier island interdunal swales." Master's thesis. University of Florida.

Miller, D.L., M. Thetford, and L.W. Atwood. 2013. "Effect of polyacrylamide gel on woody plant establishment in barrier island swales." *Natural Areas Journal.* 33(4):500–508.

Quercus myrtifolia

myrtle oak

Fagaceae

Credit: Ashlynn Smith, UF/IFAS

Myrtle oak is one of the three scrub oaks characteristic of scrub communities. It occurs on coastal regions of the Florida Panhandle and throughout the Florida peninsula and coastal southeastern United States west to Mississippi and east to South Carolina. The acorns of myrtle oak are an important food source for wildlife.

General Description

Myrtle oak is within the red oak group and may be present as a shrub or tree. The red oak group (synonym sect. Erythrobalanus) produces acorns that mature in 18 months (generally on the previous season's growth at maturity) and are frequently described as very bitter. Myrtle oak is an evergreen shrub to small tree that can reach heights of 40 ft. *Leaves* are simple, alternate 0.8 to 3 in long by 0.4 to 2 in wide, variably shaped (elliptic, oblong, or oval), with margins entire to lobed and revolute, dark green upper surfaces and dull to yellowish green lower surfaces. When mature, leaves lack pubescence. *Inflorescences* are catkins that appear in spring. *Fruits* are globose acorns; the insides of the acorn shells are woolly.

Propagation

The authors have successfully germinated this plant in tree tubes within a climate-controlled greenhouse. After a late fall collection of acorns, plants were grown in a medium of 3 parts pine bark to 1 part horticulture media growing mix. Only collect acorns in late fall while still attached to the plant and without holes to avoid collecting seeds with weevil larvae inside. Perform a float test, discarding any acorns that float in water, to eliminate acorns with underdeveloped seed and many impacted by weevils.

No cutting propagation procedures for this species have been published. Additionally, cutting propagation is not considered a practical approach for oak restoration because it would limit genetic diversity. Other species of oak have been propagated from stem cuttings with various success and requirements (Griffin and Bassuk 1996).

Outplanting

Protect seeds planted in the wild from herbivores and high salinities, and bury them in the soil at a depth approximately the diameter of the acorn (Lumban Tobing 2009). The authors suggest outplanting in depressions to mimic natural dune-building processes that occur with sand accretion and to reduce initial drought stress.

Literature Cited

Griffin, J., and N. Bassuk. 1996. *Preliminary progress on the asexual propagation of oaks*. Combined Proceedings, International Plant Propagators' Society 46:487-494.

Lumban Tobing, S.T. 2009. "Germination and establishment of woody species with barrier island interdunal swales." Master's thesis. University of Florida.

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Schizachyrium maritimum

gulf bluestem, maritime bluestem

Poaceae

Credit: Josiah Raymer, UF/IFAS

Gulf bluestem occurs throughout the Florida Panhandle and in neighboring coastal states. Gulf bluestem helps stabilize dunes, forms thick stands in areas leeward of slopes (Craig 1991), replaces sea oats as the dominant species on protected foredunes behind a seaward ridge after 2 to 17 years (Johnson 1997), and occurs throughout flatwoods and disturbed areas. This plant is very closely related to little bluestem (*Schizachyrium scoparium*), and its taxonomic position is not entirely agreed upon by taxonomists; hence information may also be located using the taxonomic synonym *Schizachyrium scoparium* var. *scoparium*.

General Description

Gulf bluestem is a rhizomatous perennial grass with numerous crowded culms that reach heights of 1.5 ft. *Leaves* are clasping, sheathing, and flat at the base. They are up to 0.4 in wide and 6 in or more long, green or glaucous (chalky gray) with a bronze purple tinge. Ligules are 0.5 to 1 mm long. Culms are erect and, with age, the elongated culms become prostrate. Inflorescences are axillary and terminal, solitary racemes, with an inconspicuous rachis. *Flowers* are paired spikelets: a scabrous, 11-mm-long, sessile fertile spikelet, and a pedicellate, sterile or staminate, 10-mm-long spikelet. *Fruits* are caryopses.

Credit: Gabriel Campbell, UF/IFAS

Propagation

Cutting propagation protocols are described by Thetford and Miller (2002, 2004). Collect cuttings from basal portions of elongated culms during the growing season. If plant material is limited, cuttings can be taken from material above the basal 4 in of shoots, but these cuttings will need auxin (1,000 ppm IBA (Indole-3-butyric acid)) applications and will have only limited success. Collection of cutting material from older portions of the culms is necessary to ensure mature nodes are present on the cutting material.

Place cuttings in 72-cell flats with a well-drained substrate under intermittent mist for 3 to 4 weeks under natural photoperiod. Remove rooted cuttings from mist and hand water as needed for an additional 1 or 2 weeks. Fertigate 1 to 2 times a week with 150 ppm N fertilizer. On week 5 or 6 transplant to 4-in or 1-gal pots. Continue with container production for an addition 4 to 6 weeks to achieve a full rootball and a canopy of 6–8 in.

Propagation by seed is possible, but no published studies quantify optimal germination conditions or viability percentages. The authors have germinated field-collected seed in community flats with great success. However, it is noted that seeds appear to have an after-ripening requirement,

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because initial germination does not occur under standard greenhouse germination conditions until 35 to 40 days after sowing. Gulf bluestem plants readily seed in nursery ground beds and in neighboring pots in outdoor research production areas in Milton, Florida.

Credit: Gabriel Campbell, UF/IFAS

Outplanting

Gulf bluestem restoration planting should take place in the summer months, particularly June (Miller et al. 2008; 2014). Plants should be placed no closer than 130 ft (328 ft is the recommended distance) inland from the mean high tide line of the Gulf of Mexico from the foredunes into the coastal grassland and backdunes. Planting efforts in spring or fall have proven to result in high plant mortality because of sand loss and root exposure around transplants (Miller et al. 2014). Widely spaced transplants also are vulnerable to increased sand loss; therefore transplants should be no more than 12 in apart. Transplants are not detrimentally affected by sand burial but are susceptible to decreased survival from competition with other dune plants, particularly sea oats. Plants should be placed in areas with reduced wind exposure, such as areas with intact dunes, recovering dunes, or where the distance between barrier islands and mainland is reduced (Miller et al. 2008). Plantings with large contiguous areas will reduce the edge effect, which is deleterious for transplant survival in this species.

Literature Cited

Craig, R.M.1991. "Plants for coastal dunes of the gulf and south Atlantic coasts and Puerto Rico." USDA SCS. Agriculture Information Bulletin 460.

Johnson, A.F. 1997. "Rates of vegetation succession on a coastal dune system in northwest Florida." *Journal of Coastal Research*. 13(2):373–384.

Miller, D.L., M. Thetford, and M. Schneider. 2008. "Distance from the Gulf Influences Survival and Growth of Three Barrier Island Dune Plants." *Journal of Coastal Research*. 24(4A):261–266.

Thetford, M., and D. Miller. 2002. "Propagation of four Florida coastal dune species." *Native Plants Journal.* 3(2):112–120.

Thetford, M., and D. Miller. 2004. *Propagation and production of Gulf bluestem*. ENH-974. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ep231

Miller, D.L., M. Thetford, J. Dupree, and L. Atwood. 2014. "Influence of seasonal changes and shifting substrate on survival of restoration plantings of *Schizachyrium maritimum* (Gulf bluestem) on Santa Rosa Island, Florida." *Journal of Coastal Research.* 30(2):237–247.

Solidago sempervirens

seaside goldenrod

Asteraceae

Credit: Leslie Atwood, UF/IFAS

Seaside goldenrod is highly tolerant of both saline soils and salt spray and is usually found on beach dunes, tidal marshes, and disturbed areas throughout coastal areas from Mexico North to Maine and on islands in the Bahamas. It is a prolific flower- and seed-producer. It attracts many pollinators, including birds, native bees, honey bees, butterflies (especially Monarch butterflies), and beneficial insects. The flowers are an important food/energy source for fall migrating monarch butterflies traveling the Atlantic coastal flyway (Sheahan 2014).

General Description

Seaside goldenrod is a perennial, herbaceous, clump-forming, stoloniferous species with high salt- and drought-tolerance. The plant may achieve heights of 1.3 to 6.6 ft and clumps may spread to widths of 1.6 ft.

Leaves initially in rosettes up to 40 centimeters long, glabrous, linear, entire, with cauline leaves that gradually reduce upward, appressed to the stem, and somewhat fleshy. Inflorescences are yellow heads in terminal panicles occuring from summer to fall. Panicles may be bent backwards and are arranged on one side. Yellow ray flowers are up to 5 mm long. *Fruits* are hairy achenes up to 2 mm long ripening in late summer to fall.

Propagation

Seeds from a North Carolina population, needed cold stratification and light to achieve high germination in constant 15 or 25°C or alternating day/night temperatures of 10/15, 15/25, or 20/30°C. (Van Der Valk 1974). Seeds are reported to remain viable for up to 2 years when stored below 40°F (Sheahan 2014). Because of the reported need for light to promote germination, seeds planted in the field should only be buried enough to prevent wind-caused movement.

Credit: Gabriel Campbell, UF/IFAS

The authors collected wild-grown seed from a Florida coastal plant community in late fall and minimally cleaned and non-graded seed were sown on the surface of Fafard 3B potting mix with a light dusting of vermiculite. Seeds germinated with high success within two weeks of sowing.

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Seedlings remained under intermittent mist for two weeks after germination before they were transplanted, suggesting these plants do not degrade under long periods of mist exposure. Four weeks after sowing, seedlings were transferred to 4-inch pots with an amended 100% pine-bark substrate and transferred to outdoor production in mid-January. By week 12, plants in 4-inch pots were large enough to have a sufficient rootball and canopy for outplanting. Plants retained in 1-gallon nursery containers began to initiate inflorescences by June.

Outplanting

Credit: Gabriel Campbell, UF/IFAS

Plants grown in 4-inch pots with well-developed rootballs and canopies have successfully been outplanted by the authors in late February with near 100% survival after 2 months. Plants were outplanted on backdunes, mid-slope at least 12 in from each other and from existing perennial grasses. Fertilizer application (½ tsp Osmocote 18-6-12) improved the aesthetic appearance and increased biomass for this plant but was not necessary for survival.

Credit: Gabriel Campbell, UF/IFAS

Literature Cited

Van Der Valk, A.G. 1974. "Environmental factors controlling the distribution of forbs on coastal foredunes in Cape Hatteras, National Seashore." *Canadian Journal of Botany.* 52:1057–1073.

Sheahan, C.M. 2014. "Plant Guide for seaside goldenrod (*Solidago sempervirens*)." USDA-Natural Resources Conservation Service, Cape May Plant Materials Center. Cape May, 08210.

Uniola paniculata

sea oats

Poaceae

Credit: Josiah Raymer, UF/IFAS

Sea oats occur throughout Florida on beach dunes and beaches and on coastal areas west to Texas and north to Maryland. Sea oats are vital dune builders that accumulate sand and prevent erosion due to wind, waves, and large storms. As sand is trapped by the long leaves of sea oats, vertical growth is stimulated, and rooting occurs at the buried nodes. This plant is extremely drought- and salt-tolerant, grows up to the high tide line of beaches, and propagates both vegetatively and by seed in the wild (Shadow 2007).

General Description

Sea oats are perennial grasses that form large colonies by extending culms upright and forming glabrous horizontal rhizomes as sand accumulates around the culms. *Leaves* are flat, involute at tips, up to 24 in long and 10 mm wide, and have ligule hairs up to 5 mm long. Inflorescences initiate in late spring with a single inflorescence elongating from an individual culm. *Inflorescences* rise above the leaves in summer, and florets of the inflorescences mature by early fall. Flowering culms reach heights of 6 ft or more and terminate in open panicles of nodding, laterally compressed, arching spikelets that become the color of straw as the outer glumes mature. Florida law prohibits the collection of sea oats inflorescences without a permit. *Fruits* are caryopses, and although inflorescences are present in late summer, the seed do not fully develop until fall. Sea oats produce very few seed within the large panicles, but the seed that are produced are generally viable.

Propagation

It is illegal to collect sea oats for any reason in the wild without proper permitting. Sea oats can readily be propagated from seed and rhizome fragments. When growing sea oats, minimal fertilizer and irrigation inputs is encouraged (Bachman and Whitwell 1995).

Sea oats rhizomes uprooted by hurricanes and deposited on top of soil can be salvaged as planting material within 3 days after the hurricane and stored for an initial 8 days with sufficient moisture before being planted in pots or the ground (Miller et al. 2003).

Germination of sea oats seeds has been well studied for decades. For Florida Panhandle populations, sea oats seeds require a period of cold stratification before germination, however southern Florida populations lose such requirements (Pérez and Kane 2016; Senaca 1972). Dormancy in Florida Panhandle sea oats can be broken by cold stratification for 15 to 30 days at 40°C (Senaca 1972). Near 100% germination of Florida Panhandle sea oats is possible with a 35/18°C diurnal fluctuation (Senaca 1972). A North Carolina population of sea oats seeds preferred fluctuating temperatures to constant temperatures (Burgess et al. 2002). Photoperiod neither enhances nor suppresses sea oats seed germination (Burgess et al. 2002; Senaca 1972). Sea oats seeds can be stored in airtight jars at room temperature (Nabukalu and Knott 2013) or in a refrigerator (~5°C)

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(Pérez and Kane 2016) for at least a year without significant loss of seed viability.

Plants grown from seed have been successfully propagated in a nursery setting under a shadehouse. The following protocol was developed by Bachman and Whitwell (1995). Place seeds (2 seeds per cell) 1 in deep within 40-cell flats with a 1:1 volume mix of peat moss and perlite. Immediately drench with fungicide (Banrot) and fertilize at recommended nursery-production rates (Bachman and Whitwell 1995). Transfer seedlings to 1-gal nursery containers with a 4:1 volume mix of pine bark and sand. Containerized plants require fertilizer and have been produced with twice-weekly liquid fertilization while others have used slow-release fertilizers at the standard gallon nursery production rates as recommended by the fertilizer manufacturer. When transplanting to containers it is important to place plants with their crowns even with the surface of the production substrate. While growing in containers, plants may require frequent irrigation.

Outplanting

Sea oats have been successfully outplanted with over 70% survival after 1 year when planted in monoculture or in conjunction with 3 other native beach dune plants (Miller et al. 2001; Stoddard et al. 2014). Transplants were seedlings grown with 4 in rootballs (Miller et al. 2001; Stoddard et al. 2014). Recent work by Hooton et al. (2014) has demonstrated a potential to enhance sea oats establishment and seedling maturation. Hooton demonstrated that wheat straw used as a surrogate wrack increased plant vigor, increased inflorescence production, and increased sand accumulation over a 2-year period compared to conventional planting without a surrogate wrack. Sea oats roots grow in mutualism with fungi that enhance their access to nutrients and moisture in the soil. Nursery production may be enhanced by the use of potting media inoculated with vesicular-arbuscular mycorrhizal fungi (*Glomus* sp.) (Sylvia and Burks 1988). Seedlings grown in a nursery inoculated with vesicular-arbuscular mycorrhizal (*Glomus* sp.) fungi had enhanced outplanting success across Florida beaches compared to non-inoculated plants (Sylvia 1989).

Credit: Mack Thetford, UF/IFAS

Literature Cited

Bachman, G.R., and T. Whitwell. 1995. "Nursery production of *Uniola paniculata* (southern seaoats)." *HortTechnology.* 5(4)295:298 http://horttech.ashspublications.org/content/5/4/295.full.pdf

Burgess, T., F. Blazich, and D. Nash. 2002. "Seed germination of southern seaoats (*Uniola paniculata*) as influenced by stratification, temperature, and light." *Journal of Environmental Horticulture.* 20(3):180–183.

Hooton, N., D.L. Miller, M. Thetford, and S.B. Claypool. 2014. "Survival and growth of planted *Uniola paniculata* and dune building using surrogate wrack on Perdido Key Florida, USA." *Restoration Ecology*. 22(5):701–707.

Stoddard, M., D.L. Miller, L.C. Branch, and M. Thetford. 2014. "Endangered beach mouse: Linking population studies/habitat restoration to predict sea level rise." Final Report submitted to Gulf Islands National Seashore, Gulf Coast Cooperative Ecosystems Studies Unit Project H5000 02 A271. 130 p.

Miller, D.L., M. Thetford, and L. Yager, 2001. "Evaluation of sand fence and vegetation for dune building following overwash by Hurricane Opal on Santa Rosa Island, Florida." *Journal of Coastal Research*. 17(4):936–948.

Miller, D.L., L. Yager, M. Thetford, and M. Schneider. 2003. "Potential use of *Uniola paniculata* rhizome fragments for dune restoration." *Restoration Ecology*. 11(3):359–369.

Nabukalu, P., and C. Knott. 2013. "Effects of seed storage environment on sea oats (*Uniola paniculata*)." *Ecological Restoration*. 31(1):16–19.

Pérez, H.E., and M.E. Kane. 2016. "Different plant provenance same seed tolerance to abiotic stress: implications for ex situ germplasm conservation of a widely distributed coastal dune grass (*Uniola paniculata* L.)." *Plant Growth Regulation.* 82(1):123–137.

Senaca, E.D. 1972. "Germination and seedling response of Atlantic and Gulf Coast populations of *Uniola paniculata*." *American Journal of Botany.* 59(3):290–296.

Shadow, R. 2007. “Plant fact sheet for sea oats (*Uniola paniculata* L.).” USDA NRCS, East Texas Plant Material Center. United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). 2017. The PLANTS Database. https://plants.usda.gov/factsheet/pdf/fs_unpa.pdf

Sylvia, D. M. 1989. “Vesicular-arbuscular mycorrhizal fungi associated with *Uniola paniculata* in Florida foredunes.” *Mycological Society of America*. 78(5):728–734.

Sylvia, D.M. 1988. “Selection of a Vesicular arbuscular fungus for practical inoculation of *Uniola paniculata*.” *Mycologia*. 80(4):565–568.

Coastal Plant Species Form, Structure, Position, and Food Source Characteristics

Species	Common name	Form	Structure	Position	Food	Page
Asclepias humistrata	sandhill milkweed	F		B	I	33
Balduina angustifolia	coastalplain honeycombhead	F	S	D,B	I	35
Ceratiola ericoides	Florida rosemary	W	S	B	M,I	37
Chrysoma pauciflosculosa	woody goldenrod	W	S	D,B		39
Chrysopsis species	goldenaster	F	S	D,B	M,I	40
Conradina canescens	false rosemary	W	S	B		43
Crocanthemum arenicola	coastal sand frostweed	F	S	B		45
Geobalanus oblongifolius	gopher apple	W	B,S	B	M	46
Hypericum tenuifolium	Atlantic St. John's wort	W	S	D		48
Ilex glabra	inkberry	W	S	B	M	50
Ilex vomitoria	yaupon	W	S	B	M	51
Ipomoea sp.	morning-glory	F	S	F,D	M	53
Iva imbricata	seacoast marshelder	F	B,S	F	M	55
Lupinus westianus var. *westianus*	gulf coast lupine	F		B		57
Morella cerifera	wax myrtle	W	S	D,B	M,I	59
Oenothera humifusa	seabeach evening primrose	F	B,S	F,D	M,I	61
Panicum amarum	bitter panicgrass	G	B,S	F,D	M	63
Paronychia erecta	squareflower	F	B,S	D,B		65
Physalis angustifolia	coastal groundcherry	F	S	D,B	M,I	67
Polygonella polygama	October flower	F		B		69
Quercus geminata	sand live oak	W	B,S	B	M	70
Quercus myrtifolia	myrtle oak	W	B,S	B	M	72
Schizachyrium maritimum	gulf bluestem	G	B,S	F,D,B	M	73
Solidago sempervirens	seaside goldenrod	F		D,B		75
Uniola paniculata	sea oats	G	B,S	F,D	M	77

Form - herbaceous-forb (F), herbaceous-graminoid (G), woody (W)

Structure- builder (B), stabilizer (S)

Position- foredune (F), backdune (B), dune field (D)

Food source- beach mice (M), insect pollen, nectar source (I).

Terms and Definitions

Term	Definition
Achene	a small, dry, indehiscent fruit with a single locule, ovule, and seed with the seed attached to the ovary wall at a single area
Androecium	all the stamens of a flower; the collective male portion of a flower
Acute	tapering to a pointed apex, with more or less straight sides
Apex	the tip, point farthest from point of attachment
Apical	located at the apex or tip
Arachnoid	bearing long, cobwebby, entangled hairs
Asexual	reproducing without sexual union
Axillary	occurring in the upper angle between a leaf stalk or branch and the stem or trunk from which a flower or bud is growing
Basal leaves	leaves at the base (proximal end) of the stem
Bract	a specialized or modified leaf at the base of an inflorescence or flower
Calyx	the collective name for all the sepals of a flower
Campanulate	bell-shaped
Caryopsis (plural caryopses)	a dry, one-seeded, indehiscent fruit with the seed coat fused to the walls of the fruit, as in the fruits of the grass family; a grain
Catkin	an inflorescence consisting of a dense spike or raceme of unisexual flowers without petals
Cauline	of, on, or pertaining to the stem, as leaves arising from the stem above ground level
Clasping	of leaves having a base that partially wraps around the stem; amplexicaul
Colonial	forming colonies; usually refers to groups of plants connected to one another by underground organs
Coriaceous	with a leathery texture
Corolla	the collective name for all the petals of a flower
Corymb	flat or round-topped racemose (raceme-like) inflorescence where lower pedicels (flower stalks) are longer than upper pedicels
Culm	a hollow or pithy stalk or stem, as in the grasses, sedges, and rushes
Decumbent	reclining on the ground but with the tip ascending
Dehiscent	splitting open at maturity or when ripe, as in fruits and anthers
Disk flower	tubular (rayless) flower of the Asteraceae inflorescence
Drupe	a fleshy, indehiscent fruit with a stony endocarp (pit) surrounding a usually single seed, as in a peach or a cherry
Entire	a continuously smooth edge; not toothed, notched, or divided
Flower	a reproductive structure of flowering plants usually composed of non-sexual (sepals and petals) and sexual (stamens and pistils) parts arranged on a central floral stem (axis)
Glabrous	smooth, hairless surface; not pubescent
Glaucous	covered with a grayish, bluish, or whitish waxy coating that is easily rubbed off

Term	Definition
Glume	one of the paired bracts at the base of a grass spikelet; used as an aid in grass identification
Hypanthium	a cup-shaped structure (floral cup) usually formed from fusion of the basal parts of the sepals, petals, and anthers, commonly surrounding or enclosing the pistils, as in the flowers of the rose or cherry
Hypogynous	having flower parts (sepals, petals, and anthers) situated below the female parts of the flower (pistil)
Imbricate	overlapping, like tiles or shingles on a roof
Indehiscent	remaining closed at maturity, not opening spontaneously at maturity
Inflorescence	the part of a plant that is flowering; a cluster of flowers; an arrangement of flowers on a stem
Internode	portion of a stem between two nodes
Involucre	whorl of bracts attached below (subtending) a flower or inflorescence
Involute	with the margins rolled inward toward the upper side
Lanceolate	much longer than wide, tapering to the apex with widest point below middle; lance-shaped
Ligule	an outgrowth at the junction of a leaf and leaf sheath; the presence, size, shape, and surface texture of a ligule can be used to identify grasses or sedges
Locule	a small cavity within the chambers of an ovary or anther of a flower
Monotypic	a taxon with only a single representative, such as a genus with a single species, or a family with a single genus
Node	the position on the stem where leaves or branches originate
Oblanceolate	inversely lanceolate with a rounded apex and a tapering base (widest between middle and apex); contrast with lanceolate
Obtuse	blunt or rounded at the apex; with the sides coming together at the apex at greater than a 90 degree angle
Ocrea	a sheath around a stem formed by the cohesion of two or more stipules, characteristic of the Polygonaceae
Outcross	transfer of pollen from the anthers of the flowers of one plant to the stigma of the flower of another plant
Ovoid	egg-shaped (applied to three-dimensional structures)
Ovule	female reproductive structure within the pistil of a flower in a seed-bearing plant that develops into a seed
Panicle	a multi-branched, cone-shaped, racemose inflorescence with flowers maturing from the bottom upward
Pappus	tufts of hairs on each seed of some Asteraceae that assist in wind dispersal
Pedicel	the stalk of a single flower in an inflorescence, or of a grass spikelet
Peduncle	the stalk of an inflorescence or of a solitary flower
Petiole	a stalk that attaches a leaf to a stem
Phyllary	an individual bract of the collection of bracts (involucre) forming the base of an inflorescence of the Asteraceae, used as an aid in identification
Pubescent	covered with trichomes (hairs)
Raceme	an unbranched elongated inflorescence with pedicellate (with a pedicel) flowers maturing from the bottom up
Rachis	the main axis of a structure, such as a compound leaf or an inflorescence
Ray flower	flowers with strap-like corollas that often occur within the periphery of the inflorescence of the Asteraceae.

Term	Definition
Rhizome	a horizontal underground stem that forms the primary vegetative axis (non-reproductive stems) of a plant
Rosette	a dense cluster of leaves on a stem at or near ground level
Scabrous	rough to the touch due to the structure of the epidermal cells or to the presence of short stiff tri-chomes (hairs)
Serrate	saw-toothed leaf margin with teeth that point forward
Sessile	without a stalk; lacking a pedicel (flower stalk) or a petiole (leaf stalk)
Staminate	a flower bearing stamens but not pistils, as a male flower that does not produce fruit or seeds
Stipule	an appendage found at the base of the petiole in some plants; may be ephemeral to persistent, minute to large, glandular to leaflike
Subspecies	a taxonomic rank subordinate to species (abbreviated "subsp." or "ssp."; plural: "subspecies")
Stoloniferous	having a creeping stem formed at the base of a plant and often having very small leaves at its nodes (stolon), also rooting at the nodes, and developing new plantlets/plants that will eventually root and separate from the mother plant.
Terminal	at the tip or apex
Trichome	a hair-like outgrowth of the epidermis
Umbel	an inflorescence having a rounded or flat top, with the pedicels arising from a common point resembling an umbrella
Xeric	of dry areas
Zygomorphic	bilaterally symmetrical; having only one plane of symmetry, usually the vertical plane, referring to a flower, calyx or corolla; compare radial symmetry which has similar parts regularly arranged around a central axis.

Conversions/Equivalents

1 inch	2.54 centimeters
1 foot	0.3048 meter
1 gallon (US)	3.785 liters
1 cubic yard	1.308 cubic meters
1 centimeter	0.3937 inch
1 meter	39.37 in
1 liter	1.057 quarts
1 pound (US)	0.4536 kilograms

Percent to ppm conversion table

Percent (%)	ppm
0.0001%	1 ppm
0.001%	10 ppm
0.01%	100 ppm
0.1%	1000 ppm

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