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Management of Maritime Communities for Threatened and Endangered Species

by
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Maritime ecosystems along the Atlantic and Gulf coasts support the military mission of the United States Department of Defense (DoD). Since the DoD mission has not required large-scale urbanization of the coast, these ecosystems also provide high quality habitat for several federally threatened and endangered plant and animal species (TES). TES conservation is compatible with military land use, as long as native plant communities remain subject to the cycles of disturbance and regeneration characteristic of the coastal zone.

This report discusses four vegetation types that comprise the natural areas that support maritime TES: the overwash community, the sand dune community, the maritime shrub community, and the evergreen maritime forest community. Disruption of the natural processes of beach erosion and rebuilding through construction of seawalls, jetties, artificial dunes and beaches, roads, and urban areas is probably the most harmful human impact to maritime communities and their associated TES. Since the native maritime plant communities are relatively resilient to military training activities, conservation of this high quality TES habitat is not problematic on DoD lands. Protection of TES during critical times such as migration and the breeding season may be accommodated through seasonal or spatial restrictions on activities.

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Maritime ecosystems along the Atlantic and Gulf coasts support the military mission of the United States Department of Defense (DoD). Since the DoD mission has not required large-scale urbanization of the coast, these ecosystems also provide high quality habitat for several federally threatened and endangered plant and animal species (TES). TES conservation is compatible with military land use, as long as native plant communities remain subject to the cycles of disturbance and regeneration characteristic of the coastal zone.

This report discusses four vegetation types that comprise the natural areas that support maritime TES: the overwash community, the sand dune community, the maritime shrub community, and the evergreen maritime forest community. Disruption of the natural processes of beach erosion and rebuilding through construction of seawalls, jetties, artificial dunes and beaches, roads, and urban areas is probably the most harmful human impact to maritime communities and their associated TES. Since the native maritime plant communities are relatively resilient to military training activities, conservation of this high quality TES habitat is not problematic on DoD lands. Protection of TES during critical times such as migration and the breeding season may be accommodated through seasonal

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Executive Summary

Maritime ecosystems along the Atlantic and Gulf coasts support the military mission of the United States Department of Defense (DoD). Since the DoD mission has not required large-scale urbanization of the coast, these ecosystems also provide high quality habitat for several federally threatened and endangered plant and animal species (TES). TES conservation is compatible with military land use, as long as native plant communities remain subject to the cycles of disturbance and regeneration characteristic of the coastal zone.

Four vegetation types, the overwash community, the sand dune community, the maritime shrub community and the evergreen maritime forest community, comprise the natural areas that support maritime TES on DoD lands in the Southeast. The overwash community occurs in depressions where sand, sediment and salt water are deposited during storms. It is a grass-dominated community adapted to severe physical conditions, including burial. The sand dune community develops on accumulations of sand and soil deposits in the absence of overwash. It also is dominated by grass species which can withstand harsh conditions of wind, salt spray and shifting soils. Maritime shrub communities develop on stabilized, older dunes, farther from the shoreline, and are dominated by wax myrtle and yaupon holly. In areas sufficiently protected from storm exposure, shrub communities succeed to evergreen maritime forest. Maritime forests once covered extensive portions of the coast, but largely have been removed due to coastal development and logging.

Coastal vegetation is adapted to severe, periodic disturbances, which are functions of climate and geomorphology, and include dune and beach creation and destruction. Tolerance to wind, salinity, salt spray, and extreme microclimatic and nutrient conditions determine the composition of communities at various distances from the water's edge. Disruptions in the overwash and dune communities can affect the edaphic conditions farther inland, and thus affect the species dependent upon shrub and forest communities. Severe impacts from hurricanes often destroy an entire area and eliminate habitat for plant or animals. In such disturbance-prone ecosystems, refugia are critical for the long-term survival of species, especially small populations. Small, isolated and/ or spatially restricted populations are more likely to be extirpated than are large populations extending over large areas. It is likely that all individuals in small, localized populations will be killed from direct impact during severe storms.

Disrupting the natural processes of beach erosion and rebuilding is probably the most harmful human impact to maritime communities and their associated TES. Seawalls, jetties, artificial dunes, road building, artificial beach replenishment and urban development are incompatible with TES conservation. Although these activities are common on commercial and privately owned coastline, they generally have not occurred on DoD maritime lands. Off-road-vehicle traffic, other recreational activities, and military training exercises may directly affect the vegetation of maritime communities and reduce the success of listed animal species that utilize beach habitat for breeding. However, since the native maritime plant communities are relatively resilient to these activities, conservation of high quality TES habitat is not problematic on DoD lands. Protection of TES during critical times such as migration and the breeding season may be accommodated through seasonal or spatial restrictions on activities.

Foreword

This study was conducted for the Strategic Environmental Research and Development Program (SERDP) under the SERDP study, "Regional Guidelines for Managing Threatened and Endangered Species Habitats." Brad Smith is Executive Director, SERDP. The technical monitor was Femi Ayorinde, Conservation Program Manager.

The work was performed by the Natural Resource Assessment and Management Division (LL-N) of the Land Management Laboratory (LL), U.S. Army Construction Engineering Research Laboratories (USACERL) in cooperation with the U.S. Army Waterways Experiment Station (WES) Natural Resources Division. Ms. Gehlhausen was employed as a Scientist I and Ms. Harper was employed as a Research Associate under interagency agreements with the U.S. Forest Service, Rocky Mountain Range and Forest Experiment Station, and Colorado State University. Ms. Harper was responsible for the ecological description of the community. Ms. Gehlhausen was responsible for general land use impact analyses, and recommendations for the management of the community and the threatened and endangered species (TES) associated with the community. The USACERL principal investigator was Ms. Ann-Marie Trame. Mr. Chester O. Martin (WES) was responsible for managing WES's contribution to the work unit. Dr. William D. Severinghaus is Operations Chief, CECER-LL. The USACERL technical editor was Gloria J. Wienke, Technical Resources.

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Contents

List of Tables and Figures

Tables

Figures

1 Introduction

Background

Maritime communities (discussed as a group of four different community types) are found on military installations within 400 m of the Atlantic and Gulf coasts, both on the mainland and on barrier islands. These communities support multiple uses, including the Department of Defense (DoD) training and testing mission, threatened, endangered, and sensitive species (TES*) conservation, and recreational activities. Despite the primacy of the military training and testing mission, installations are required to maintain robust TES populations into the foreseeable future. Many of these populations, especially nesting sea turtles and shorebirds, rely on maritime communities for survival.

Management approaches to protecting TES, other natural resources, and natural plant communities are often designed to address immediate and local problems (M. Imlay, Natural Resource Specialist, Army National Guard Bureau, professional discussion, 18 August 1995). Although this approach can be rewarding and effective for an individual installation, it precludes any organized understanding of land-use impacts, or sharing of lessons learned, and can sometimes lead to repeated, inefficient efforts to solve similar problems throughout a region of the country. Duplication of effort needs to be reduced or eliminated.

This report is one product of an interlaboratory effort between the U.S. Army Construction Engineering Research Laboratories (USACERL) and the U.S. Army Engineer Waterways Experiment Station (WES) to generate habitat-based management strategies for TES on DoD lands in the southeastern United States (*Strategic Environmental Research and Development Program [SERDP] work unit "Regional Guidelines for Managing T&E Species Habitats"*; Martin et al. 1996). This effort is directed at developing strategies to manage TES and their habitats on a plant community basis, using methods that apply to multiple species and that apply across the southeastern United States. Any increase in understanding of the habitat requirements of listed TES will assist training and natural resource

* The acronym "TES" will be used instead of "T&E Species" in this report to conform to standard DoD terminology. "Candidate Species" (former C1 species) are also defined as those plant and animal species that, in the opinion of the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service, may qualify for listing as threatened or endangered pursuant to the Endangered Species Act; and "Species of Concern" (former C2 species).

personnel in complying with the Endangered Species Act (ESA), while giving them the information they need to reduce restrictions on the military mission. Furthermore, the results detailed in this report suggest that a great deal of additional effort is required before the process will be guided by solid scientific information (as required by the ESA).

Objectives

The objectives of this research were to compile known information, identify gaps in knowledge, and stimulate future research efforts on the potential positive and negative effects of human activities on the plant communities that serve as high-quality habitat for TES plants in the southeastern United States.

This SERDP work unit, in particular, was undertaken to reduce duplication of effort towards conservation of TES within the southeastern region. It is hoped that this review of information may be used to improve the ecological and economic effectiveness of TES habitat management. By understanding the ecological requirements of TES and the environmental resilience or sensitivity of TES habitats, installations acquire increased control over TES management and land-use decisions.

Approach

To identify potential impacts, researchers reviewed the available literature and conducted interviews with community ecologists throughout the southeastern United States, with an emphasis on interviewing those people who have been involved in plant TES and plant community survey work on military installations. Site visits were made to military installations. Potential impacts were also discussed with military natural resources personnel, botanists, community ecologists, and military contractors, such as The Nature Conservancy (TNC) or state Natural Heritage Program (NHP) staff. Information also was taken from installation TES survey reports in which impacts and management were addressed. Land Condition Trend Analysis (LCTA) reports, Land Rehabilitation and Maintenance (LRAM) data, and academic and Federal agency literature on recreational effects on plant communities were also researched.

Scope

Within the context of the larger DoD mission, TES populations can be maintained through the following framework: (1) identify mission requirements, (2) identify TES requirements, (3) identify ideal compromises for meeting both TES and mission requirements, and (4) pursue these compromises and develop realistic, workable compromises. The fourth step should be executed through professional management of TES populations, at the installation level, to reduce restrictions on the military mission. This document partially contributes to the total TES and land-management process. It provides information to assist in identifying the needs of TES (step 2), and perhaps will assist in identifying options for compromise as well (step 3). The content of this report is not intended to provide the "bottom line" for management of TES on military lands — only to provide information from literature review for the consideration of installation land managers.

This report focuses on plant communities because they provide habitat for multiple species. By managing for plant communities, DoD has the opportunity to conserve multiple TES simultaneously. Plant communities are less ambiguous entities than complete ecosystems, and have been described and cataloged for many decades by ecologists and biogeographers. They provide a useful basis on which to understand and manage the natural systems that support military training and other land uses.

Four types of maritime communities were grouped together in this research due to similar influences of climate and proximity to the ocean (Stalter 1993a). Differences are caused primarily by the effect of early-successional, stabilizing vegetation on the location and character of different maritime communities. Overwash communities develop in interdunal swales or depressions on barrier islands in areas where overwash (sand, organic debris, and salt water) is deposited during hurricanes and storms. Dunes are formed by the constant accumulation of sand, which becomes stabilized by beach grass (*Ammophila breviligulata*) north of Cape Hatteras, and sea oats (*Uniola paniculata*) to the south (Stalter 1993a). As dunes stabilize, they protect areas behind them from salt spray and blowing sand, which allows for the development of shrub-dominated communities. Maritime forests develop in the coastal zone on stabilized dune systems located on the bay side of islands whose width and topography provide sufficient protection from storm exposure. Recommendations within this report are intended to be applied within these four community types within the Southeastern Coastal Plain (as delineated in Christensen 1988).

Due to the scope of this report, specific management recommendations are intended to be considered only for areas that trainers and resource managers recognize and manage as endangered species habitat. These recommendations are not intended to be applied across entire DoD installations (e.g., on areas required for use as maneuver training zones).

Mode of Technology Transfer

This report is to be used by DoD natural resource policymakers, installation land managers, and the natural resource research community, in conjunction with associated documents produced under this SERDP work unit (e.g., Trame and Harper 1997) and by Trame and Tazik (1995) to (1) develop ecosystem-based approaches to describe natural communities and TES habitat in relation to military activities, (2) evaluate military-related effects on those communities, (3) develop community-based strategies for supporting both military land use and TES habitat management, and (4) develop management solutions for military impacts to natural communities when management for TES habitat is a priority for a particular location.

Results of this report will be presented at the annual SERDP Symposium. In addition, this and companion volumes have been identified for life-cycle technology demonstration and support in the Conservation Technology Infusion effort being developed under the Army's environmental science and technology process.

2 Ecological Description

Range

Current Distribution

This report discusses coastal and barrier island maritime communities ranging from Delaware south to Florida and west to Texas. Five groups of barrier islands are recognized in the southeast region: Mid-Atlantic (Sandy Hook, NJ to North Island, SC), Sea Islands (South Island, SC to Cumberland Island, GA), Florida Atlantic (Amelia Island, FL to Cat Island, MS), and Louisiana/Texas (Chandeleur Island, LA to Isle Dernieres, LA and Bolivar Peninsula, TX to Brazos Island, TX) (Stalter and Odum 1993).

Distribution on Military Installations

The occurrence of maritime communities on military installations in the southeastern United States is noted in Table 1. The following installations provided information that indicated they do not support maritime communities (many due to interior locations): Camp Mackall and Fort Bragg, and Dare County Bombing Range, NC; Fort Jackson and Naval Weapons Station (NWS) Charleston, SC; Fort Pickett and Fort A. P. Hill, VA; Anniston Army Depot, Fort Rucker, Redstone Arsenal, and Fort McClellan, AL; Camp Blanding, Hulburt Field, Naval Air Station (NAS) Whiting Field, McCoy Annex/Naval Training Center (NTC), NAS Cecil Field, and NAS Jacksonville, FL; Fort Gordon, Moody Air Force Base (AFB), Fort Benning, Marine Corps Logistics Base (MCLB) Albany, and Fort Stewart, GA; Fort Polk, Barksdale AFB, Camp Villerie, and Louisiana Army Ammunition Plant (LAAP), LA; Camp McCain, Camp Shelby, Columbus AFB, Keesler AFB, and NAS Meridian, MS.

Table 1. Occurrences of maritime communities on military installations in the southeastern United States.

State	Service	Installation	Community	Reference
FL	Air Force	Eglin AFB	Beach dune, maritime hammock	Florida Natural Areas Inventory (FNAI) 1994b
		Tyndall AFB	Beach dune, maritime unconsolidated substrate, coastal grassland, coastal interdune swale, coastal dune lakes, maritime hammock	FNAI 1994a
NC	Navy	NAS Pensacola	Sand beaches and dunes	Anonymous 1988, FNAI 1988
	Army	Sunny Point Military Ocean Terminal (MOT)	Coastal fringe evergreen forest, interdune pond	M. Schafale, Community Ecologist, North Carolina Natural Heritage Program, professional discussion, 1994
	Marine Corps	MCB Camp Lejeune	Calcareous coastal fringe forest, maritime evergreen forest, maritime wet grassland, coastal fringe evergreen forest, upper beach, dune grass	LeBlond, Fussell, and Braswell 1994a, b
		Marine Corps Air Station (MCAS) Cherry Point	Coastal fringe evergreen forest, maritime evergreen forest	LeBlond, Fussell, and Braswell 1994c
		Marine Corps Outlying Field (MCOLF) Atlantic	Coastal fringe sandhill	LeBlond, Fussell, and Braswell 1994c

Community Type Descriptions

Description and classification here is based upon Stalter and Odum (1993). They defined four kinds of maritime communities: overwash, sand dune, shrub, and evergreen maritime forest. Additional sources of information considered in this classification include Christensen (1988), Stalter (1993a, b), and Martin (1991a-f).

Overwash

Overwash communities develop in interdunal swales or depressions on barrier islands in areas where overwash (sand, organic debris, and salt water) is deposited during hurricanes and storms. Plants that can withstand constant sand burial and other harsh conditions (i.e., erosion, salt spray, blowing sand, deposition) form the vegetation characteristic of this community (Stalter and Odum 1993; Figure 1).

Nomenclature.

1. System: Palustrine and Terrestrial (Allard 1990).

2. Cross-Classification (Allard 1990): This community is synonymous with maritime wet and dry grasslands in TNC's Southeastern United States Ecological Community Classification (Allard 1990). In Florida, overwash communities are a type of coastal grassland (Florida Natural Areas Inventory [FNAI] and the Florida Department of Natural Resources [FDNR] 1990), and in Louisiana, a coastal dune grassland (Smith 1988). In North Carolina they are termed maritime dry grasslands (Schafale and Weakley 1990), and in South Carolina, maritime grassland (Nelson 1986). In Georgia this community is synonymous with interdune meadow (Wharton 1978). In Virginia, this is a type of palustrine mid-height herbaceous and terrestrial mid-height herbaceous community (Rawinski 1990).

Figure 1. The overwash community (see arrow) exists in swales or depressions behind the front line of dunes.

3. Physiognomic Type: Palustrine and Terrestrial/Herbaceous Wetlands (Allard 1990).

Environmental Factors.

1. Topographic Position: Overwash communities occur in moisture-rich areas such as interdunal swales, sand flats, and sheltered depressions (Stalter 1993b).

2. Hydrology: Hydrology grades from palustrine in areas where the water table is less than 50 centimeters (cm) below the surface (these areas flood in heavy rains) to terrestrial in areas where the water table is between 50 and 150 cm below the surface (these areas rarely flood; Stalter and Odum 1993). Although palustrine areas are saturated with fresh water, overwash communities in general are susceptible to salt spray and salt water overwash during storms (Martin 1991a, b).

3. Disturbance Regime: In addition to salt water and sand overwash, burial of plants by wind blown sand affects this community (Martin 1991a, b).

4. Soil: Soils range from wet and sandy to excessively drained and composed of sand and shell with debris-derived organic matter and no horizon development (Martin 1991a, b).

Physiognomy/Structure. This community is dominated by a dense cover of grasses in wetter areas; in drier areas, grass cover is less dense and grasses are evenly distributed (Martin 1991a, b).

Commonly Associated Plant Communities. Overwash communities may grade into other maritime communities, such as sand dunes, shrub communities, or barrier island pond complexes. They may also grade into brackish or salt water marshes (Martin 1991b).

Successional Relationships. This community can succeed pond barrier island complexes as the land becomes drier due to drought-like conditions caused by the lowering of the water table or by sand deposition. After a dune ridge forms between the overwash community and the ocean, the initial species are replaced by a grassland-dominated flora, usually within 4 to 7 years (Johnson 1997). This community may be succeeded by shrub communities if protected from salt spray and overwash. Conversely, increased exposure to salt spray, overwash, and wind blown sand, caused by pushing back or loss of frontal dunes, can convert this community to a beach or dune grassland community (Martin 1991a, b). Herbaceous swale communities in the Florida panhandle eventually succeed to mesic flatwoods dominated by slash pine (*Pinus elliottii* var. *elliottii*; Johnson, Muller, and Bettinger 1992).

Biological Composition. At Cape Hatteras, NC, salt meadow grass (*Spartina patens*) was the dominant grass of the overwash community. Additional grasses characteristic of the drier overwash communities were salt meadow grass, marram grass (*Ammophila breviligulata*), broom sedge (*Andropogon virginicus*), muhly grass (*Muhlenbergia filipes*), and lovegrass (*Eragrostis pilosa*) (Stalter and Odum 1993). In the wetter overwash communities at Cape Hatteras, salt meadow grass and broom sedge are joined by rushes (*Juncus polycephalus*, sword-rush [*Scirpus americanus*], and *Fimbristylis spadicea* (Travis and Godfrey 1976, cited in Stalter and Odum 1993). The interdunal swales of Florida's panhandle can have variable species composition. Some sites are dominated by the halophytes fimbry sedge (*Fimbristylis castanea*) and joint-grass [*Paspalum distichum*], while others may be dominated by broom sedge and *Dichanthelium aciculare* or hair-grass (*Muhlenbergia capillaris*). Associates may co-occur on drier dune ridges (e.g., dune panic grass [*Panicum amarum*], seacoast marshelder [*Iva imbricata*]), or be limited to the wetter depressions (e.g., *Juncus polycephalus*, *J. scirpoides*, ovate-leaf water-pennywort [*Centella asiatica*], *Fuirena scirpoidea*, and *Rhychospora divergens*; Johnson 1997). Factors such as hydroperiod and salinity levels affect composition of overwash communities (Johnson 1997).

Sand Dune

Vegetation cover on sand dunes develops in the absence of overwash. The dune is formed by an accumulation of sand deposits, and is stabilized by beach grass north of Cape Hatteras, and sea oats to the south (Stalter 1993a; Figure 2). Once plants are in place, sand accumulates around their bases. These dune colonizers are adapted to the harsh environmental conditions of sand burial and salt spray. Once they become established and stabilize the dune, other species are able to establish (Stalter and Odum 1993). The sand dune community is formed as species become more abundant (Christensen 1988).

Nomenclature.

1. System: Terrestrial (Allard 1990).

2. Cross-Classification: This community is synonymous with dune grassland in TNC's *Southeastern United States Ecological Community Classification* (Allard 1990). In Texas, this community is synonymous with sea oats-bitter panicum series (Diamond 1990). In Louisiana, it is called coastal dune grassland

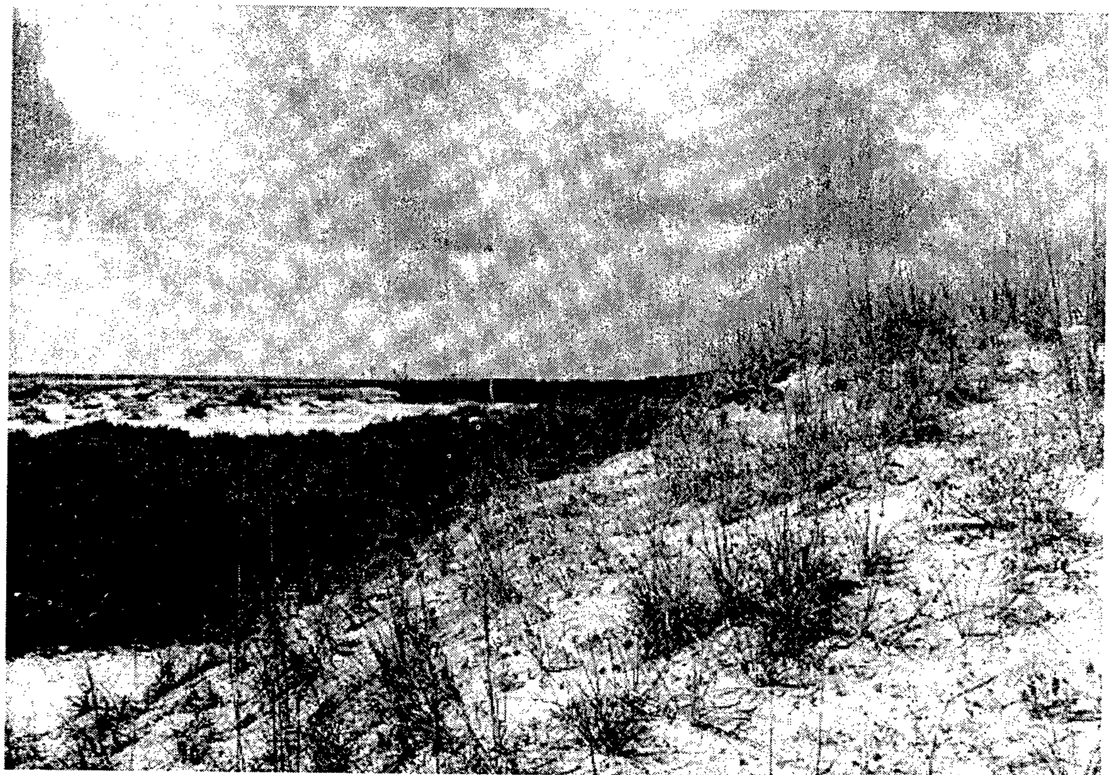

Figure 2. Dunes develop through an accumulation of sand that becomes stabilized by perennial grasses (foreground).

(Smith 1988). Other synonyms are dunes in Alabama (Currie 1989), beach dune herbland in Florida (FNAI and FDNR 1990), dune meadow in Georgia (Wharton 1978), maritime grassland in South Carolina (Nelson 1986), and dune grass in North Carolina (Schafale and Weakley 1990). In Virginia, sand dune communities are types of terrestrial herbaceous communities (Rawinski 1990).

3. Physiognomic Type: Terrestrial Herbaceous Vegetation (Allard 1990).

Environmental Factors.

1. Topographic Position: Sand dune communities develop on the foreslope, crest, and rear slope of frontal dune ridges (Martin 1991c). These communities occur on both mainland and barrier island foredunes (Stalter 1993b).

2. Hydrology: The hydrologic regime of the sand dune community is xeric to dry-mesic (Martin 1991c). This community generally receives high amounts of salt spray (Schafale and Weakley 1990).

3. Disturbance Regime: Blowing sand can bury plants and wind erosion may expose their roots. Salt spray and occasional storm overwash also affect the

sand dune community (Martin 1991c). Hurricane waves may destroy a foredune (Johnson and Barbour 1990). Fire rarely occurs (Martin 1991c).

4. Soil: This community is found on coarse, shifting or recently stabilized sands that may contain shell fragments. The sands range from mildly alkaline to strongly acidic. They are pale brown to yellow with low capacity for holding water and low organic matter content (Martin 1991c).

Physiognomy/Structure. Sand dunes are characterized by having sparsely to densely populated patches of grassy perennials. The amount of ground cover varies with the stability of the dune. Few widely scattered shrubs may occur (Martin 1991c).

Commonly Associated Plant Communities. The dune community lies closest to the beach and may grade into overwash communities, barrier island pond complexes, and maritime shrub or forest communities on the landward side (Martin 1991c; Schafale and Weakley 1990).

Successional Relationships. Sand dune communities develop when dune plants establish on shifting sands, stabilize the sand, and encourage the formation of frontal dunes (through sand build-up around the bases of plants). As long as a dune ridge remains at the shoreline, species composition remains stable (Johnson 1997). Formation of new frontal dune ridges provides protection for relict dune ridges from wind and salt spray, and leads to increased abundance of several grasses and forbs, including woody subshrubs (Johnson 1997) characteristic of the maritime shrub community. Once sand dune communities become stable and the effects of salt spray are mitigated, succession to shrub communities can occur as yaupon holly (*Ilex vomitoria*) and wax myrtle (*Myrica cerifera*) become established (Martin 1991c; Stalter and Odum 1993).

Biological Composition. The sand dune community is populated by specialized species adapted to the shoreline environment, and is fairly uniform in composition throughout the southeast region (Johnson and Muller 1993). Generally, beach grass dominates foredunes from Cape Hatteras, NC, northward, and sea oats dominate foredunes from North Carolina to Florida, and along the gulf coast (west Florida to southeast Texas). Dune panic grass is the dominant dune-building plant on some small islands in South Carolina, and is common throughout Florida. Other plant species characteristic of this community are sea rocket (*Cakile* spp.), sand spurs (*Cenchrus* spp.), croton (*Croton punctatus*), horseweed (*Conyza canadensis*), seaside spurge (*Euphorbia polygonifolia*), camphorweed (*Heterotheca subaxillaris*), dune pennywort (*Hydrocotyle bonariensis*), seacoast marshelder, and salt meadow grass.

Shrubs such as yaupon holly and wax myrtle may become established in stable areas protected from salt spray (Stalter and Odum 1993). Beach grass and sea oats will remain dominant on the foredunes. If an additional dune or dune complex forms closer to the shoreline, then other species may replace the dominant dune grasses. (A. Johnson, Community Ecologist, Florida Natural Areas Inventory, professional discussion, 12 April 1997).

Maritime Shrub

Protected areas immediately behind sand dunes are most commonly shrub communities (Figure 3). On the Atlantic coast, these communities are dominated by wax myrtle and yaupon holly. Pines such as slash pine and loblolly pine (*P. taeda*) may succeed the shrub stage and precede the climax forest (Stalter 1993a) (Figure 4). On the coast of panhandle Florida, the community is characterized by woody goldenrod (*Chrysoma pauciflosculosa*) and rosemary (Johnson, Muller, and Bettinger 1992).

Figure 3. Shrub communities along the Atlantic coast are dominated by yaupon holly and wax myrtle. This photo was taken in North Carolina.

Nomenclature.

1. System: Terrestrial (Allard 1990).

2. Cross-Classification: This community is synonymous with maritime dune shrub thicket in TNC's Southeastern United States Ecological Community Classification (Allard 1990), coastal dune shrub thicket in Louisiana's classification (Smith 1988), maritime shrub thicket in South Carolina's (Nelson 1986), maritime shrub thicket in North Carolina's (Schafale and Weakley 1990), and dune shrub thicket and interdune shrub thicket in Georgia's classification (Wharton 1978). In Alabama's classification, this community is named coastal scrub (Currie 1989), while in Florida it is called coastal strand (FNAI and FDNR 1990), and oak scrub (Johnson and Muller 1993). In Virginia's classification, this community is a kind of mesotrophic scrub (Rawinski 1990).

3. Physiognomic Type: Maritime Shrublands.

Environmental Factors.

1. Topographic Position: Maritime shrub communities occur on old stable dunes (Stalter and Odum 1993). They may also develop in interdunal sand flats that are protected from salt spray and water flooding (Martin 1991d). A community of similar composition may develop above the salt marsh community, but infrequent flooding will prevent trees from establishing (Stalter and Odum 1993).

Figure 4. Pines such as slash and loblolly sometimes form an intermediate stage between the shrub community and the climax maritime forest community.

2. Hydrology: The hydrology of shrub communities ranges from xeric on dune ridges to dry-mesic in interdunal sand flats where the water table can be close to the surface for most of the year. Salt spray and storm tides influence the hydrology of this community, although less so than in overwash or sand dune communities (Martin 1991d). Individuall plants in the community become protected from salt spray by the development of an impenetrable thicket (Stalter and Odum 1993).

3. Disturbance Regime: Disturbances to this community include storm tides, sand displacement, lack of protection from salt spray, and erosion (Schafale and Weakley 1990; Stalter and Odum 1993).

4. Soil: Soils of this community are generally sandy and have low water holding capacity (Martin 1991d; Stalter and Odum 1993). Sands on tops of dunes can be excessively drained (Martin 1991d). Shrub communities may also develop in more poorly drained soils (e.g., interdunal swale areas; Stalter and Odum 1993).

Physiognomy/Structure. This community is characterized by having a dense layer of shrub sized woody vegetation. Within this thicket, many lianas, or woody vines, also occur. Once the shrub vegetation becomes established, scrub forests develop under favorable environmental conditions. However, in areas that experience infrequent flooding (due to location in swales or exposure to storm tides), trees will not become established (Stalter and Odum 1993).

Commonly Associated Plant Communities. On the seaward side, the maritime shrub community may sharply grade into sand dune communities on less protected or actively moving dunes. It can also grade into overwash communities (Martin 1991d). This community also occurs above the salt marsh community (Stalter and Odum 1993) along the bayside of barrier islands.

Successional Relationships. In northeast Florida, woody goldenrod was found to invade after 18 to 23 years of dune stabilization. Rosemary began to dominate the community after 53 to 117 years (Johnson 1997). If the community is located in an area that does not flood and is sufficiently protected from salt spray and storm tides, succession will lead to the development of maritime forest (Stalter and Odum 1993). Increased protection from salt spray and storm tides on barrier islands generally results when an island grows seaward as sand accretes, forming new dunes. However, overwash and wind-blown sand during storms may result in advancing dunes that bury the shrub community (Martin 1991d).

Biological Composition. As a community of the transition zone between sand dunes and protected forest communities, maritime shrub composition varies across the southeast region. In addition, different sites may be in various stages of recovery from disturbance events. Saw palmetto (*Serenoa repens*) dominates in some regions of Florida (Johnson and Muller 1993). On the Atlantic coast, the first shrubs to become established and dominant are wax myrtle and yaupon holly. Other component shrub (S) and liana (L) species include:

rosemary (S)
peppervine (*Ampelopsis arborea*) (L)
saltwater false-willow (*Baccharis angustifolia*) (S)
silverling (*B. glomeruliflora*) (S)
mulletbush (*B. halimifolia*) (S)
American barberry (*Berchemia scandens*) (L)
Virginia creeper (*Parthenocissus quinquefolia*) (L)
winged sumac (*Rhus copallina*) (S)
poison oak (*R. toxicodendron*) (L)
greenbriers (*Smilax* spp.) (L)
muscadine (*Vitis rotundifolia*) (L)
Invading canopy species may include coastal red cedar (*Juniperus silicicola*), red bay (*Persea borbonia*), live oak (*Quercus virginiana*) and cabbage palm (*Sabal palmetto;* Stalter 1993a).

Canopy composition can vary and Stalter and Odum (1993) outline three scrub forest types (based on Hillestad et al. 1975) that may occur. The Dune Oak-Buckthorn Scrub Forest occupies tops and rear slopes of rear dunes and has a canopy of live oak, tough buckthorn, red bay, slash pine, and loblolly pine. The Pine-Oak Scrub Forest occurs on land that was previously timbered, has moderate to poorly drained soils, and was last burned approximately 20 to 25 years ago. The scattered overstory consists of pond pine (*Pinus serotina*) and slash pine, and the dense shrub layer includes live oak and saw palmetto. The Oak-Scrub Forest community occurs on moderately drained soils that were previously managed for pasture and timber production. The community has not been burned for at least 25 to 35 years and consists of a dense, scrubby growth of broad-leaved evergreens and scattered pines. The canopy is composed of live oak, slash pine, myrtle oak (*Quercus myrtifolia*), American olive (*Osmanthus americanus*), Chapman's oak (*Quercus chapmanii*), and red bay. Pond pine and longleaf pine (*P. palustris*) are less common (Stalter and Odum 1993).

Evergreen Maritime Forest

Maritime forests develop in the coastal zone on stabilized dune systems located on the bay side of islands whose width and topography provide sufficient protection from storm exposure (Figure 5). They are influenced by oceanic exposure; the vegetation of maritime forests is adapted to severe conditions such as salt spray, bright sunlight, wind shear, low water availability, and nutrient poor soils (Stalter and Odum 1993). Maritime forests once covered extensive areas along the Atlantic coast, but never a large proportion of coastal area. Since colonial times these areas have been exploited for timber and have suffered from habitat modification by free-ranging livestock (Bellis 1995).

Nomenclature.

1. System: Terrestrial (Allard 1990).

2. Cross-Classification: Examples of this community type in TNC's *Southeastern United States Ecological Community Classification* (Allard 1990) are South Atlantic Inland Maritime Forest and South Atlantic Barrier Island Forest.

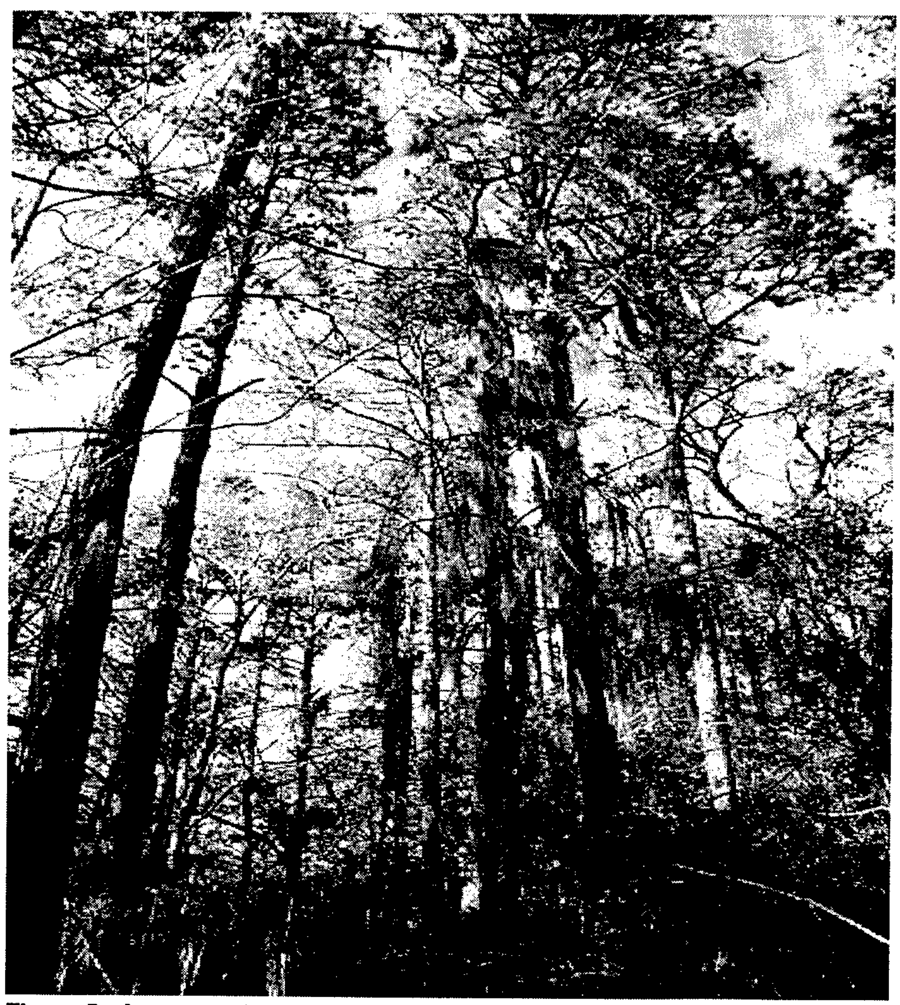

Figure 5. A mature climax maritime forest in North Carolina.

Synonyms for this community used in state classification schemes are xeric hammock in Alabama (Currie 1989) and maritime hammock in Florida (FNAI and FDNR 1990). In Georgia, upland maritime forests, maritime strand forests, and interdune forests are examples of this community (Wharton 1978). This community is called maritime oak forest in Mississippi's classification (Wieland 1990), and maritime forest in South Carolina's (Nelson 1986). Schafale and Weakley (1990) subdivided this community into three types in North Carolina: Maritime Evergreen Forest, Maritime Deciduous Forest, and Coastal Fringe Evergreen Forest. In Texas, this community is termed the coastal live oak - sugarberry series (Diamond 1990), and in Virginia, submesotrophic forest (Rawinski 1990; Diamond 1990).

3. Physiognomic Type: Temperate Maritime Forest (Allard 1990).

Environmental Factors.

1. Topographic Position: Maritime forests occur on relic dune ridges and old stable dunes (Figure 6). They occupy a narrow band along the coast. They also occur on interior uplands of barrier islands (Stalter and Odum 1993; Martin 1991e, f).

2. Hydrology: Xeric to mesic (Martin 1991e, f).

Figure 6. Former dunes and swales are still apparent in the topography at this site.

3. Disturbance Regime: Dune migration, erosion, loss of protective dunes, and infrequent and highly destructive fires are part of the natural disturbance regime that affects the maritime forest (Schafale and Weakley 1990). Fires in this community probably occur with a return interval no less than 26 to 100 years (Martin 1991f).

Physiognomy/Structure. Evergreen Maritime forests have low to moderately high, mostly closed canopies (Martin 1991e, f). Live oak, a dominant arborescent coastal species, rarely grows more than 5 to 15 meters (m) high when it develops in old ocean-facing dunes subject to salt spray (but it can grow to 20 to 25 m tall farther inland; Stalter and Odum 1993). The subcanopy/shrub layer is usually well developed and also dominated by evergreen shrubs (Martin 1991e, f; Stalter 1993a); lianas are common throughout. The herbaceous layer is generally sparse (Martin 1991e, f).

Commonly Associated Plant Communities. This community may grade into salt or brackish marsh, shrub swamp (similar to maritime shrub, occurring in swales) or dune grass communities (Figure 7; Martin 1991e, f). The community may grade into longleaf pine-turkey oak (*Quercus laevis*) sandhill on higher, drier sites in the northern limits of its range (Schafale and Weakley 1990). The community can be associated with pond complexes (Martin 1991e, f).

Figure 7. The maritime forest is found very close to open, sparsely vegetated rear dunes and scattered individual shrubs.

Successional Relationships. Maritime forests are the end result of primary succession on coastal dune systems (Stalter and Odum 1993).

Biological Composition. Canopy dominants include live oak and laurel oak (*Quercus laurifolia*), often accompanied by southern magnolia (*Magnolia grandiflora*). Slash and loblolly pines can be dominant in early stages of succession (Figure 5). Slash pine is also commonly encountered with live oak on coasts from west Florida to Mississippi. American holly (*Ilex opaca*) may also occur, but this species is most prevalent in New Jersey and New York (Stalter and Odum 1993). In most areas of Florida, three species (cabbage palm, live oak, and red bay) make up most of the canopy layer. Extreme western Florida panhandle communities are characterized by sand live oak (*Q. geminata*) and coastal red cedar (Johnson and Muller 1993). Cabbage palm is commonly associated with maritime evergreen forests ranging from the Florida coast to Bull Island, SC (Stalter and Odum 1993). Live oak and laurel oaks are not dominant at Jockey Ridge, NC, where live oak is replaced by southern red oak (*Quercus falcata*). Loblolly pine codominates the canopy with southern red oak. American holly is the most important understory tree; several American beech (*Fagus grandifolia*) are also present (Stalter and Odum 1993).

Dominant shrubs (S) and lianas (L) in the evergreen maritime forest are similar to those in the maritime shrub forest. In addition to those listed in *Biological Composition* (p 22), beauty berry (*Callicarpa americana*) (S), Japanese honeysuckle (*Lonicera japonica*) (L), poison ivy (*Rhus radicans)* (L), and blackberry (*Rubus trivialis)* (S) may occur (Stalter 1993a).

Herbs include Spanish moss (*Tillandsia usneoides*), which often drapes over the forest trees. In the herbaceous layer, tick trefoils (*Desmodium* spp.), smooth elephants feet (*Elephantopus* spp.), St. John's wort (*Hypericum* spp.), partridgeberry (*Mitchella repens*), shortleaf basket grass (*Oplismenus setarius*), panic grasses (*Panicum* spp.), crown grasses (*Paspalum* spp.), and sea oats (*Uniola* spp.) can occur (Stalter 1993a).

Natural Disturbance Regime

The dynamic nature of barrier islands results in constant disturbance to maritime communities. Coastal disturbance and the resulting vegetation are closely tied to geomorphic processes such as rising sea level, erosion of foredunes, and sand burial of maritime scrub and evergreen forest (Christensen 1988). Additionally, barrier islands are constantly migrating, either parallel to the coast or toward the coast, and land available for terrestrial organisms is constantly being created and eroded (Johnson and Barbour 1990); the rate of island turnover may be as brief as 200 to 400 years (Christensen 1988). Erosion occurs constantly but may be extremely severe during hurricanes or "nor'easters", when huge amounts of sand are picked up and deposited elsewhere. These storms may also create new inlets, thus dividing an island into two or more islands (Johnson and Barbour 1990). Dunes that are removed during a storm are eventually replenished when sand builds up and forms a sand bar that migrates shoreward; through time, the sand bar is picked up by the wind and blown onto the beach (Doyle et al. 1984).

The composition of maritime communities is governed by steep gradients of salinity, soil, and microclimate (Christensen 1988). Generally, conditions near the ocean are most severe and are mitigated with increasing distance from the coast. On the beach and seaward face of the foredune, the soil is two to three times more saline, wind speeds are higher, salt spray is more intense, and soil nutrient content is lower compared to behind the foredune. Conditions such as salt spray are most stressful on the crest of the foredune and decrease beyond that point (Barbour et al. 1973). With the exception of interdunal ponds and overwash communities that support freshwater marsh species, soil moisture does not seem to be important in determining the plant composition of the beach and dune grassland communities (Barbour et al. 1973; Oosting and Billings 1942), probably because the sandy soil allows rainwater to percolate to a water table that is deeper than plant roots.

Tolerance to salt spray has repeatedly proven to be the most important factor in determining which species are able to survive the harsh conditions of the beach and foredune (Barbour et al. 1973; Oosting 1945; Oosting and Billings 1942). Salt spray was found by Oosting and Billings (1942) to be well correlated with the two main species on the beach and foredune in North Carolina: sea oats and little bluestem (*Andropogon littoralis*). Sea oats was more tolerant of salt spray and unstable soil conditions and was found in more exposed areas, while little bluestem tended to grow in the protected area on the seaward face of the rear dune. Experiments have demonstrated that sea rocket is a poor competitor for light; this may explain why sea rocket does not persist in less disturbed grasslands beyond the foredune (Barbour et al. 1973). Thus, disturbance to the beach and dune community allows for the continued existence of pioneer species that are poor competitors for resources outside of their highly disturbed environment. Beyond the rear dune, the first dune behind the foredune, conditions become more conducive to plant growth—soil organic matter increases with increasing plant cover, which in turn increases the water and nutrient holding capacity of the soil. In addition, wind-driven sand and salt spray are less severe stresses (Barbour et al. 1973).

Beyond the rear dune where maritime shrub and forest communities develop, salt spray continues to modify plant growth. As trees grow, the forest takes on an aerodynamic shape that allows wind to blow over it without depositing salt. This occurs when new buds that develop above the canopy are killed from salt deposition. Any disruption of this forest profile, due to natural events such as hurricanes or human influences such as road construction, can be detrimental to the forest. Once salt spray is able to penetrate the canopy, it can kill the leaves and eventually the trees it contacts (Johnson and Barbour 1990; M. Schafale, Community Ecologist, Louisiana Natural Heritage Program, Fall 1996).

The most extreme natural disturbance to which maritime communities are exposed are hurricanes and other severe storms. Weather summaries between 1885 and 1971 showed that a hurricane hit the Florida coast on average about once per year (Johnson and Barbour 1990). Plants are thought to survive natural perturbations such as storms and dune migration through adaptations in vegetative growth patterns and dispersal strategies (Johnson and Barbour 1990). However, few studies have documented the mechanisms or rates of reestablishment of vegetation zones after storms or on newly formed portions of barrier islands (Johnson and Barbour 1990; Valiela et al. 1996). Seeds of dune species, such as sea rocket, become dormant when exposed to high salt concentrations. Dormancy allows them to be dispersed by ocean currents and subsequently germinate when they are redeposited on land (Barbour et al. 1973). In addition, the horizontal growth pattern of many dune species, through stolons, may allow the plant to persist even as the dunes shift through time (Johnson and Barbour 1990).

Severe storms can eliminate vegetation either at the time of impact by blowing dunes away or months later by disrupting the natural protection of reardunes by foredunes, thus allowing erosion to eventually eliminate vegetation on rear dunes. For example, erosion of dunes after Hurricane Bob (1991) was sufficient to eliminate stands of beach rose (*Rosa rugosa*) on Cape Cod 18 months after impact (Valiela et al. 1996). Hurricane Opal impacted populations of Cruise's golden aster and Godfrey's golden aster in 1995. Of 36 sites in Florida visited the following year, 40 percent of the Cruise's golden aster populations were destroyed, 30 percent were substantially diminished, and 30 percent appeared unaffected. Thirty-eight percent of the examined Godfrey's golden aster populations were destroyed, 12 percent were substantially diminished, and 50 percent unaffected. Many populations of both species survived, throughout their ranges, to serve as seed sources for recolonization of suitable habitat (Johnson 1996/1997). Hurricanes can kill leaves and buds in maritime forests within 100 m of shore or possibly beyond, although this is often not the result if enough rain follows the hurricane to wash the leaves of salt (Valiela et al. 1996). A curious response of vegetation to hurricanes was the off-season blooming of certain species that occurred a month after the impact of Hurricane Bob. While not lethal, this response dramatically decreases the reproductive output of affected populations the following year (Valiela et al. 1996). Another potential impact of hurricanes is the disruption of the nutrient regime of maritime forest soils by salt inundation. Sodium saturation of cation exchange sites, as well as damage to soil microbes and roots may result in a long term impairment of the ammonium retention capacity of the soil-plant ecosystem (Valiela et al. 1996).

Animals may also be affected by a hurricane's alteration of their habitats. When the beach rose was eliminated from Cape Cod dunes, a population of meadow voles (*Microtus pennsylvanicus*) disappeared, as did other fauna that the rose had supported. The population of Santa Rosa beach mouse, a SAR, on Eglin AFB's Santa Rosa Island was reduced by one-half by Hurricane Opal. The population of St. Andrews beach mouse (*Peromyscus polionotus peninsularis*), a Florida endangered species and SAR, on Tyndall AFB's Crooked Island, also may have been eliminated by Hurricane Opal (Carl Petrick, Natural Resources Manager, Eglin Air Force Base, professional discussion, 1996). Birds are not thought to be severely threatened by hurricanes (Valiela et al. 1996), and sea turtle nesting sites may have actually been improved by the overwash of seawater and newly deposited sand as a result of Hurricane Andrew in 1992 (Pimm et al. 1994). The long-term biological consequences of hurricanes may be viewed from the perspective that maritime communities are adapted to severe disturbance and therefore should be able to sustain the damage incurred. However, because of low population numbers and the reduction in habitat by human conversion of barrier islands, populations of rare taxa should be monitored and managed (Loope et al. 1994).

3 Biodiversity and TES

Large-scale industrial impacts to maritime communities began in the 20th century, with construction of bridges, jetties, and sea walls that disrupted sand erosion and deposition processes (Stalter and Odum 1993). Since 1950, urban development in coastal areas has increased by 153 percent, eliminating 50,000 hectares (ha) of wetlands, grasslands, salt flats, and dune areas, and 6,500 ha of maritime forest on the Atlantic and Gulf coasts (Stalter 1993a; Stalter and Odum 1993). Only 5 percent of barrier islands along the Atlantic and Gulf coasts are protected as national seashores and wildlife refuges. As the value of coastal property continues to appreciate and federal tax law includes incentives such as tax write-offs for property loss as a result of hurricane damage, natural coastal communities will continue to be lost to expanding urban development (Stalter 1993a, b).

Approximately 12,100 ha of maritime communities occur on at least 7 military installations; these areas are known to support at least 13 rare species. Rare species continue to exist on DoD installations because their natural habitats remain relatively undisturbed compared to privately owned coastal land. For example, Eglin AFB supports the major panhandle population of Florida perforate cladonia (*Cladonia perforata*), a federally endangered species (Johnson, Muller, and Bettinger 1992), and Marine Corps Base (MCB) Camp Lejeune had the only known extant representative of the calcareous coastal fringe forest community type (LeBlond, Fussell, and Braswell 1994a), until it was destroyed by Hurricane Fran in September, 1996. However, with the exception of land owned by the federal government, TNC, and state parks, the outlook is bleak for coastal lands in the southeastern United States; they are being rapidly developed (Stalter 1993a). Therefore, the DoD can take pride in its management of these communities and the associated rare species.

Maritime communities support several federally endangered and threatened plant and animal species and former candidate species (which are called species at risk, [SAR]; Tables 2 and 3). Most of the rare species occur in beach and dune communities, but some occur in maritime shrub and evergreen forest communities. Seabeach amaranth (*Amaranthus pumilus*), a federally threatened plant that grows on foredunes and the upperbeach, has been reduced to one-third of its original range of Atlantic beaches from Massachusetts to South Carolina (Weakley and Bucher

1991). Florida perforate cladonia, a federally endangered species, occurs in rosemary (*Ceratiola ericoides*) scrub on dunes in the Florida panhandle (Johnson, Muller, and Bettinger 1992). Animals such as federally threatened sea turtles (e.g., loggerhead turtle [*Caretta caretta*] and green turtle [*Chelonia mydas*]), and the snowy plover (*Charadrius alexandrinus*), nest on coastal beaches. The piping plover (*Charadrius melodus*), a federally endangered species, winters on coastal beaches throughout the southeastern United States. The peregrine falcon (*Falco peregrinus*), a federally threatened species, uses barrier islands and other coastal habitats as stopover habitat during autumn migration. The endangered interior populations of least tern (*Sterna antillarum*); may use coastal beaches as stopover habitat en route from South American wintering habitat to breeding habitats in the interior United States (Mitchell *in prep*).

Many species at risk inhabit maritime communities as well. These species include Godfrey's golden aster (*Chrysopsis godfreyi*), found on foredunes and dune crests (Johnson 1993a), Chapman's sedge (*Carex chapmanii*), found in evergreen maritime forests (LeBlond, Fussell, and Braswell 1994a), and the Santa Rosa beach mouse (*Peromyscus polionotus leucocephalus*) which lives on the beaches (Johnson, Muller, and Bettinger 1992). State-listed species include moundlily yucca (*Yucca gloriosa*, NC-significantly rare), which grows in the maritime evergreen forest, Cruise's golden aster (*Chrysopsis gossypina* ssp. *cruiseana*, FL-endangered), which grows behind foredunes and in blowouts and other disturbed areas in the evergreen forest (Johnson 1993b), and the Florida population of least tern (FL-threatened) which nests on the beaches (Johnson, Muller, and Bettinger 1992).

Table 2. Federally threatened, endangered, and species at risk occurring in maritime communities on installations in the southeast region.

Common Name	Scientific Name	Installation	Status*	Habitat/Community
Forbs				
Amaranth, Seabeach	Amaranthus pumilus	Marine Corps Base (MCB) Camp Lejeune	T	Overwash flats and accreting ends of islands and lower foredunes and upper strands of noneroding beaches. Occasionally it establishes temporary populations in other habitats, such as sound-side beaches, blowouts in foredunes, and sand and shell material placed as beach replenishment on dredge spoil. This species does not occur on well-vegetated sites (Weakley and Bucher 1991). Occurs on the upper beach community at Camp Lejeune (LeBlond, Fussell, and Braswell 1994a).
Aster, Cruise's Golden	Chrysopsis gossypina ssp. cruiseana	Eglin Air Force Base (AFB)	SAR	Found on bare sand in hollows behind foredunes, in blowouts, or in disturbed areas within stable backdune areas with woody vegetation. Not found on recently colonized dunes nor with sea oats on foredune-facing beach (Johnson 1993b).
Aster, Godfrey's Golden	Chrysopsis godfreyi	Eglin AFB Naval Air Station (NAS) Pensacola Tyndall AFB	SAR	Occurs on both mobile and stable dunes, which are dominated by sea oats and Gulf bluestem. Can be found in large, pure populations on backdunes. It also occurs in sunny openings within or near scrub (FNAI 1994a; Johnson 1993a).
Grasses, Rushes, and Sedges				
Sedge, Chapman's	Carex chapmanii	MCB Camp Lejeune	SAR	Occurs frequently in well-drained hammock woodlands or cleared areas of these, always on sands or sandy loams. Typical surrounding forests are beech-magnolia-southern hard maple or red maple, with some oak and pine (Kral 1983). At Camp Lejeune, it occurs in calcareous coastal fringe forests (LeBlond, Fussell, and Braswell 1994a).
Non-vascular Plants				
Cladonia, Florida perforate	Cladonia perforata	Eglin AFB	E	At Eglin, occurs in rosemary scrub and at the edge of slash pine forest (Johnson, Muller, and Bettinger 1992).

*Federal Status Rankings: E = Endangered; T = Threatened; C = Candidate Species (former C1 species); SAR = Species at Risk (former C2/C3 species).

Table 3. Federally listed threatened, endangered, and species at risk occurring in maritime communities on military installations in the southeast region.

Common Name	Scientific Name	Federal Status**
Mammals		
Mouse, Southeastern Beach	*Peromyscus polionotus nivciventris*	T
Mouse, Choctawhatchee Beach	*Peromyscus polionotus allophyrs*	E
Mouse, St. Andrew's Beach	*Peromyscus polionotus peninsularis*	E
Mouse, Santa Rosa Beach	*Peromyscus polionotus leucocephalus*	SAR
Birds		
Plover, Piping	*Charadrius melodus*	E
Plover, Snowy	*Charadrius alexandrinus*	SAR
Falcon, Peregrine	*Falco peregrinus*	T
Reptiles and Amphibians		
Turtle, Loggerhead	Caretta caretta	T
Turtle, Green	Chelonia mydas	T (Breeding populations in Florida are Endangered)

*Information provided by R. Fischer, Wildlife Biologist, WES, professional discussion, October 1997.

**Federal Status Rankings: E = Endangered; T = Threatened; C = Candidate Species (former C1 species); SAR = Species at Risk (former C2/C3 species)

4 Impacts and Management

Based on a review of the literature and discussions with experts, it can be concluded that the maritime communities on military installations are in far better shape than those on privately owned land. These communities are in "pristine condition" on Tyndall AFB (FNAI 1994a), and in "excellent ecological condition" on Eglin AFB (C. Petrick). Both Tyndall and Eglin, as well as MCB Camp Lejeune, have monitoring programs for endangered shorebirds and sea turtles, and these installations are important breeding sites for these animals (J. Hammond, Threatened and Endangered Species Specialist, MCB Camp Lejeune, professional discussion, 1996; Johnson, Muller and Bettinger 1992; A. Johnson, Community Ecologist, Florida Natural Areas Inventory, April 1997). The coastal areas in the southeastern United States have largely been converted for recreational use and housing, so the areas located on military installations, as well as those in state and national parks, are almost the only coastal areas left in a natural state. Compared with large-scale land conversion, disturbance due to military uses of these communities is minimal. The following recommendations are made to promote continued conservation of high quality maritime communities on DoD lands.

Community Conversion and Alteration of Disturbance Regimes

Impacts

While healthy, contiguous communities are well adapted to severe disturbances, they are sensitive to alteration of the natural processes of erosion and rebuilding brought about by beach stabilization structures such as seawalls, jetties, and groins. Seawalls are designed to absorb the full impact of the sea to prevent beach erosion; instead, they actually exacerbate the process of erosion because they prevent the natural process of beach replenishment from occurring by cutting the beach off from its offshore source of sand. This is especially disruptive in areas where longshore sand transport occurs because the beach continually erodes down the coast and eventually disappears (Doyle et al. 1984). Jetties and groins both succeed in preventing sand from being lost in the longshore current, but they result in the accretion of sand on the updrift (source side of current) while the downdrift (sink side of current) becomes eroded (Doyle et al. 1984; Johnson and Barbour 1990).

Artificial beach replenishment (dredging sand from offshore and dumping it on beach and former dunes) creates a steeper beach that almost always leads to more rapid rates of erosion than those that preceded replenishment; in addition, this process disrupts offshore ecosystems and wave patterns, which causes further damage to the beach in the long run (Doyle et al. 1984).

Coastal communities can be disturbed through the building of artificial dunes that are stabilized with grasses such as beach grass and sea oats. Problems have been encountered when dune grasses were planted outside their natural range (A. Johnson, professional discussion). While natural dunes are circular or oval in shape and never present a continuous barrier to oceanic overwash, these artificial dunes form a continuous ridge several miles long (Odum, Smith, and Dolan 1987). Dune ecosystems in their natural state are highly resilient; although they may be altered drastically by storms, they will recover and are sustainable in the long run. In contrast, artificially stabilized dunes are more resistant to short-term change, but they are not replenished through natural processes over time, and require continued intervention (Odum, Smith, and Dolan 1987). Maintenance of an artificial dune system in North Carolina cost more than $20 million between 1950 and 1970 (Odum, Smith, and Dolan 1987). In short, disruption caused by beach stabilization and subsequent replenishment is both costly and temporary, and it should be avoided when possible (Doyle et al. 1984).

Maritime forest areas are threatened by development for housing, recreational structures, and cultural infrastructure, such as roads, electrical transmission lines, and water and waste-water systems. Developers now realize that shoreline erosion is an uncontrollable geological phenomenon that makes beachside areas unstable for development. As a result, maritime forests have become favored sites for development; and at current rates of development, unprotected areas of maritime may be eliminated by the year 2000 (Bellis 1995). Maritime forests perform an important function by stabilizing otherwise migrating dunes, protecting inland areas from erosion during storms, and collecting and storing precipitation in surface vegetation. Thus, their loss not only eliminates rare natural communities but also eliminates the critical processes that stabilize coastal systems (Bellis 1995).

Management Recommendations

Currently, the impact of developing roads and buildings in maritime communities on military installations is minimal, as is that of beach stabilization (A. Johnson; C. Petrick, Chief, Fish and Wildlife Branch, Eglin AFB, professional discussion, Fall 1996; and C. Peterson, Director, Fish and Wildlife Department, MCB Base Camp Lejeune, professional discussion, 1996). Since development and beach stabilization are the most serious threats to maritime communities in the southeast region of the United States, it is recommended that the DoD continue to avoid such activity in these communities.

Off-Road Vehicle Use

Impacts

Maritime vegetation normally acts as a break that decreases velocity of water and traps sand; reductions in vegetation due to physical disturbance may increase oceanic overwash (Hosier and Eaton 1980). The use of off-road vehicles (ORVs) has been shown to disturb the upper layer of sand, thus increasing erosion of the beach. If the foredunes cease to protect the maritime evergreen forest from salt spray, the trees will be killed (M. Schafale). ORV use has also been shown to compact soil at depths of 5 to 15 cm, which increases the water content of dry, sandy soil and decreases diurnal air temperature ranges (Liddle and Moore 1974; Hosier and Eaton 1980). Responses of the plant community to these changes included reduced total plant cover, reduced species richness and diversity, and altered species composition. One study conducted in a dune ecosystem in North Wales found that disturbance by ORVs increased soil bulk density and reduced biomass and species numbers in the most impacted areas. Unfortunately, if damage occurs, recovery of vegetation may take decades (A. Johnson). However, moderate disturbance seemed to favor dicotyledons over monocotyledons, and low levels of disturbance may have stimulated greater production of some plants (Liddle and Greig-Smith 1975). For these reasons, the intensity of trampling is an important factor; low to moderate disturbances may not be too damaging.

Research in other plant communities supports these results. Soil compaction resulting from ORV traffic can reduce the moisture and oxygen available to germinating seeds, and can cause mechanical impedance to seedling emergence, thus affecting species composition (Hartgerink and Bazzaz 1984; Montemayor 1995). Further studies of this nature are needed to evaluate the importance of this factor in maritime communities.

Off-road vehicle impacts to wildlife populations have been documented. ORVs may crush eggs and chicks of shorebirds. Unfledged piping plover chicks tend to walk or run along tire ruts and stand motionless as vehicles pass by—behavior that increases the susceptibility of plover chicks to mortality from vehicles (Melvin, Griffin, and MacIvor 1991). Pfister, Harrington, and Lavine (1992) found that abundance of two shorebirds, sanderling (*Calidris alba*) and short-billed dowitcher

(*Limnodromus griseus*), was negatively correlated with vehicle abundance. The tracks of ORVs also disrupt the breeding of loggerhead sea turtles. The young turtles tend to follow the tracks instead of crawling straight toward the water; thus, they suffer increased exposure to predators as they attempt to make their way to the ocean (Cox, Percival, and Colwell 1994; M. Schafale). Other threats to sea turtle reproductive success include crushing of eggs or hatchlings by ORVs, disturbance by beachwalkers with flashlights of nesting females resulting in nest abandonment before egg deposition, and predation by dogs (*Canis familiaris*), coyotes (*C. latrans*), and ghost crabs (*Ocypode* spp.; Cox, Percival, and Colwell 1994).

Management Recommendations

ORV use on military installations is restricted to certain areas on beaches and dunes. These restrictions are adequate and should be continued. Within a designated area, moderate, dispersed ORV use should be encouraged, since repeated ORV use in a very small area may be more damaging than less frequent use over a larger area. Dunes and beaches are well adapted to disturbance and can recover from soil disturbance if dune-binding vegetation is not continually broken up by vehicles. A monitoring program can provide early warning if damage has begun to destabilize the entire dune system. Unlike less dynamic plant communities, the dune communities should recover quickly if they are provided reasonable rest periods.

Whenever possible, additional dune access roads through maritime evergreen forest should be avoided, to reduce the exposure of trees to damaging salt spray (M. Schafale). Finally, special concern should be given to the presence of vehicles in areas where shorebirds and sea turtles are either migrating or breeding. Pfister, Harrington, and Lavine (1992) recommended closing beaches to ORVs during shorebird migration. This recommendation is already followed on many installations and should be continued for all endangered and threatened animals occurring on military installations, especially during critical times in their reproductive cycle.

Recreation

Impacts

The biggest threat to shorebirds on military installations may be recreational beach use (FNAI 1994a). Accessible beaches are usually available for public recreation, but these areas represent a small proportion of all maritime communities on installations. The piping plover, a shorebird listed as federally threatened, has suffered regional losses in habitat due to alternating dune and beach erosion and accretion. For example, fences placed across an area used for nesting may create a physical barrier to plovers, and the planting of beach grass can result in a foredune that is too densely vegetated to be used for nesting by plovers (Melvin, Griffin, and MacIvor 1991). In addition to these structural changes, human recreation disturbs plovers and may discourage birds from nesting. Recreational and tour boat landings on shorebird nesting beaches is a significant problem in some areas (A. Johnson). Nesting attempts may fail due to crushed eggs, displaced chicks and/or nest abandonment. Chicks have been shown to spend more time sitting and watching humans than feeding and brooding, thus depleting their energy reserves and making them more susceptible to inclement weather and predators (Anderson and Keith 1980; Flemming et al. 1988). Predation is a major factor limiting reproductive success for piping plovers as well as other shorebirds such as the least tern and snowy plover (Koenen, Utych, and Leslie 1996; Melvin, Griffin, and MacIvor 1991). Although predation has always been a factor in the lives of shorebirds, it has increased with increased human activity in the coastal zone due to food scraps and other garbage being left on beaches where it attracts predators (Melvin, Griffin, and MacIvor 1991).

Human trampling can disturb critical barrier beach features through erosion and vegetation cover destruction, which in turn may have a negative effect on maritime shrub and forest areas (M. Schafale). McDonnell (1981) analyzed long-term human trampling ranging from low to high intensity, on coastal dune vegetation in Massachusetts. All levels of trampling significantly lowered species diversity, and heavy trampling caused a drastic reduction in species diversity and total vegetation cover. Moderate trampling reduced species diversity but not cover. This result is probably due to the fact that moderate trampling favors some species such as beach grass over other more sensitive species such as beach-heather (*Hudsonia tomentosa)*. Trampling may result in changes in plant communities by preventing succession in interdune and backdune areas and favoring disturbance-tolerant foredune species like beach grass. In general, moderate trampling is not a problem on foredunes. For example, Godfrey's golden aster is adapted to the severe disturbance of its natural habitat on foredunes; populations can recolonize disturbed areas (A. Johnson).

Management Recommendations

The current extent of recreational beaches should be maintained, and not increased. Discourage disruption of dune vegetation by foot traffic, possibly through the use of fences that keep people off the dunes. Restrict beach access during sea turtle and shorebird nesting and breeding times. Anderson and Keith (1980) recommend total exclusion of humans from recreational areas at certain times of the year where shorebirds are nesting. Although this may seem drastic, it may be necessary to reverse the current trend of declining numbers of shorebird populations.

Military Training

Impacts

Military training does not occur in maritime evergreen forest or shrub communities, and training on beach and dune communities is done on foot (LeBlond, Fussell, and Braswell 1994a) except for occasional amphibious assault exercises (S. Gehlhausen, personal observation). Training on foot can be assumed to have impacts to soil and plant communities similar to recreational foot traffic described above. Impacts to wildlife communities, such as shorebirds and sea turtles, as a result of mechanized military training are similar to those described above for ORV use.

Management Recommendations

Low to moderate training levels should not harm dune and overwash communities. The communities can even sustain infrequent intensive training exercises, as long as a recovery period is provided to allow stabilizing revegetation to occur. Recovery time after a training session may vary from site to site, and research to determine how long it takes a community to recover from training activities is needed. Times and places that are essential to breeding TES populations should be avoided when planning training activities. Shrub communities and maritime forests are less adapted to constant physical disruption, and thus are less resilient to intensive training activities. However, they should provide opportunities for foot training exercises without sustaining significant damage.

5 Summary and Recommendations

The maritime communities that occur on military installations are critical refugia for endangered and threatened plant and animal populations. As more and more private land is developed every day, the proper management of these communities on public lands is critical to the survival of rare taxa. The DoD should take pride in its past record of stewardship of its maritime communities, and continue to practice sound management in the future. In order to accomplish this goal, continued monitoring of rare taxa and management for their survival is recommended. This includes minimizing foot and ORV traffic in critical habitats during wildlife nesting and migration, conducting training maneuvers over several sites to minimize heavy trampling, restricting public beach access during critical times for wildlife, and discouraging development and artificial beach stabilization. With minimal effort, the DoD can ensure that these communities will continue to be a part of a healthy, functioning ecosystem supporting several rare species that are in danger of extinction due to large-scale land conversion on nearby private lands.

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List of Acronyms

AFB	Air Force Base
DoD	Department of Defense
FDNR	Florida Department of Natural Resources
FNAI	Florida Natural Areas Inventory
FWS	Fish and Wildlife Service
LAAP	Louisiana Army Ammunition Plant
MCB	Marine Corps Base
MCLB	Marine Corps Logistics Base
MOT	Military Ocean Terminal
MCAS	Marine Corps Air Station
MCOLF	Marine Corps Outlying Field
NAS	Naval Air Station
NHP	Natural Heritage Program
NTC	Naval Training Center
NWS	Naval Weapons Station
ORV	Off-road Vehicle(s)
SAR	Species at Risk
SERDP	Strategic Environmental Research and Development Program
TES	threatened, endangered, and sensitive species
TNC	The Nature Conservancy
USACERL	U. S. Army Construction Engineering Research Laboratories
USAWES	U. S. Army Waterways Experiment Station

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