Geomorphology 199 (2013) 129–137

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Change in distribution and composition of vegetated habitats on Horn Island, Mississippi, northern Gulf of Mexico, in the initial five years following Hurricane Katrina

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ARTICLE INFO

Article history:
Accepted 16 November 2012
Available online 27 November 2012

Keywords:
Barrier islands
Coastal vegetation
LIDAR
Hurricane
Recovery

ABSTRACT

In the northern Gulf of Mexico, sudden alterations to barrier islands occur relatively often as a result of hurricanes. Barrier island vegetation is affected by storm impacts, such as burial under sand overwash and direct removal by erosion, and also by wind-driven salt spray and flooding by saltwater tidal surge. This study utilized field surveys in conjunction with remotely-sensed data to evaluate changes in the composition and distribution of vegetation on Horn Island, Mississippi, U.S.A., in the initial five years after Hurricane Katrina. The majority of habitat change occurred closer to the shoreline and in areas of overwash. Habitat change was most often associated with an adjustment to higher-elevation plant communities at the expense of wetlands. In addition, substantial tree and shrub mortality as a result of wind, storm surge, salt-spray, and saltwater flooding reduced maritime forest and stable dune habitat, decreasing habitat stability and ecosystem maturity. The lag time in vegetation establishment and foredune development following the storm allowed for sediment transport into back-barrier habitats. Thus, postponing restoration efforts, such as dune plantings or fencing, until at least one full growing season has elapsed following a hurricane may provide back-barrier habitats with the sediment deposition needed to offset sea-level rise and subsidence.

1. Introduction

The response and recovery of barrier islands in the northern Gulf of Mexico following tropical storms has recently focused on morphological responses (Otvos and Carter, 2008; Morton, 2010) with some added focus on dune response (Houser et al., 2008; Claudino-Sales et al., 2010) and dune recovery (Pries et al., 2008; Priestas and Fagherazzi, 2010). On St. George Island in Florida, long-term studies have focused on disturbance and recovery of dune and swale vegetation (Miller et al., 2010). The recovery of all vegetated, terrestrial habitats on barrier islands following tropical storms, however, has not commonly been examined (Otvos and Carter, 2008). The goal of this study was to examine the response and recovery of all vegetated, terrestrial habitats on Horn Island, Mississippi following Hurricane Katrina.

Prior to Hurricane Katrina (August 29, 2005), Horn Island was approximately 22-km long (E–W), a maximum of 1 km wide (N–S), and included approximately 1300 ha of land area above mean-high tide level (Otvos and Carter, 2008). The eye of Hurricane Katrina (Category 3 on the Saffir-Simpson scale) passed 90 km due west of Horn Island, with maximum sustained wind speeds of 160 km h^{-1} and storm surge depth of around 5.8 m (Fritz et al., 2007). During Katrina, the eastern 3.3 km sand spit was eliminated, and a 700 m wide breach on the western end separated the majority of the island from the western tip (Otvos and Carter, 2008). Washover sand deposits could be located up to 430 m inland, with return flow channels that were larger and more numerous towards the western end of the island (Morton, 2010).

This study utilizes a combination of field data and remotely-sensed data to compare and quantify changes in the composition of plant species along with sediment distribution on Horn Island, Mississippi, in the initial five years following Hurricane Katrina. Ground data for this study included the composition of vascular plant species sampled for 100 transects in 2004–2005, prior to Hurricane-Katrina and following Hurricane-Katrina in 2005–2006, 2007, and 2010. Island elevation was evaluated by Light Detection and Ranging (LIDAR) data, acquired pre-Hurricane Katrina in 2004 and post-Katrina data in 2005, 2007, and 2010. A vegetation map, representing habitat-types in 2010, produced by a supervised classification technique which combined hyperspectral imagery and LIDAR, was compared with a vegetation map from 2004 to quantify change in areal coverage and habitat-type.

2. Study area

Located 18 km seaward of the Mississippi mainland shore, Horn Island (30° 13′N, 88° 40′W) (Fig. 1) was placed under the jurisdiction of the Gulf Islands National Seashore, U.S. National Park Service (U.S.N.P.S.), in 1971 and is designated as a Wilderness Area in the National Wilderness Preservation System. The island is part of a 105-km long, regressive barrier island chain spanning westward

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http://dx.doi.org/10.1016/j.geomorph.2012.11.010

from the mouth of Mobile Bay, Alabama to the Mississippi–Louisiana border, including Dauphin Island, Alabama and Petit Bois, Horn, Ship, and Cat Island, Mississippi (Fig. 1). Together these islands form the southern boundary of the Mississippi Sound.

The north-central Gulf of Mexico is microtidal with tidal ranges less than 0.50 m (Rosati et al., 2007). Nearshore sediment is transported westward mainly by the predominant southeasterly wind-driven waves and associated westerly alongshore current (Morton, 2008; Otvos and Carter, 2008). Mississippi Sound barrier islands have decreased in land area since first accurately charted *ca*. 1850 (Morton, 2008; Otvos and Carter, 2008). An accelerated rate of island land loss, since the early 20th century, has been attributed in part not only to sea level rise, coastal subsidence, and frequent impact by hurricanes, but also to the trapping of sand in local navigation channels, thus, removing transport of sand to the islands by the westward littoral drift (Morton, 2008; Otvos and Carter, 2008).

Horn Island originated 3000–4000 years ago (Otvos, 1970) on a Holocene sand platform that is about 12 m in thickness (Otvos, 1979). Interior dune ridges range from 3 to 7 m in elevation forming the highest elevation on the island, and forested dune ridges flank water-filled swales (Otvos and Carter, 2008). The sediment is composed of quartz sand, heavy minerals, and shell (Cipriani and Stone, 2001). The climate is humid and subtropical with an average annual precipitation of 155 cm and an average air temperature of 12 °C in the winter and 28 °C in the summer calculated from 50 years of weather data collected by a NOAA, National Climate Data Center, Cooperative Weather station located in Biloxi, Mississippi (30°23′N, 88°00W).

Horn Island contains a variety of habitats including beach dune, swale, lagoon, freshwater and saltwater marsh, and maritime forest. For this study, habitat-types were defined according to an earlier Horn Island classification system (Eleuterius, 1979) with modification of a few names. These habitat-types include: marsh, meadow, woodland, stable dune, and beach–dune complex. Marsh habitat is found at the lowest elevations on Horn Island and is characterized by flooded to near-saturated soils with nearly 100% vegetation cover (Lucas and Carter, 2008). It is dominated by black needle rush (*Juncus roemerianus*) and saltmeadow cordgrass (*Spartina patens*). These are dominant species in marsh habitat in the northern Gulf of Mexico (Looney et al., 1993; Lonard et al., 2010) and they were also the most prevalent marsh species for Horn Island in the late 1970s as well as in 2004 (Lucas and Carter, 2010). Meadows are located in swales between dunes at elevations slightly greater than those of marsh (Lucas and Carter, 2010). Soils vary from wet peat covered by vegetation to exposed, often drier, sandy areas. Meadows are characterized primarily by herbaceous vegetation dominated by torpedo grass (*Panicum repens*) (Lucas and Carter, 2010). Woodland habitat is found at elevations similar to those of meadows, greater than those in marsh and less than elevations characteristic of stable dunes (Lucas and Carter, 2008). Woodland habitat, which includes the least land area, is characterized by an overstory of slash pine (*Pinus elliotii*) with occasional sand live oak (*Quercus geminanta*) and an understory of barren areas to dense tickets of wax myrtle (*Morella cerifera*), yaupon holly (*Ilex vomittoria*) and eastern baccharis (*Baccharis halimifolia*) (Eleuterius, 1979; Lucas and Carter, 2008). Stable dunes are relatively immobile and support sparse vegetation coverage by perennial shrubs and trees. Stable dune has also been referred to as wooded dune (Gibson and Looney, 1992), shrub dune (Burkhalter, 1987), stabilized dune (Doing, 1985), fixed dune (Moreno-Casasola and Espejel, 1986), and relic dune (Eleuterius, 1979). Stable dunes form the greatest elevations on Horn Island and are characterized mainly by woody goldenrod (*Chrysoma pauciflosculosa*), beach rosemary (*Ceratiola ericoides*) and rock rose (*Helianthemum arenicola*) (Eleuterius, 1979; Lucas and Carter, 2008). Beach–dune complex, for the purpose of this study, consists of beach/backshore, overwash, foredune and active secondary dunes. The vegetation of

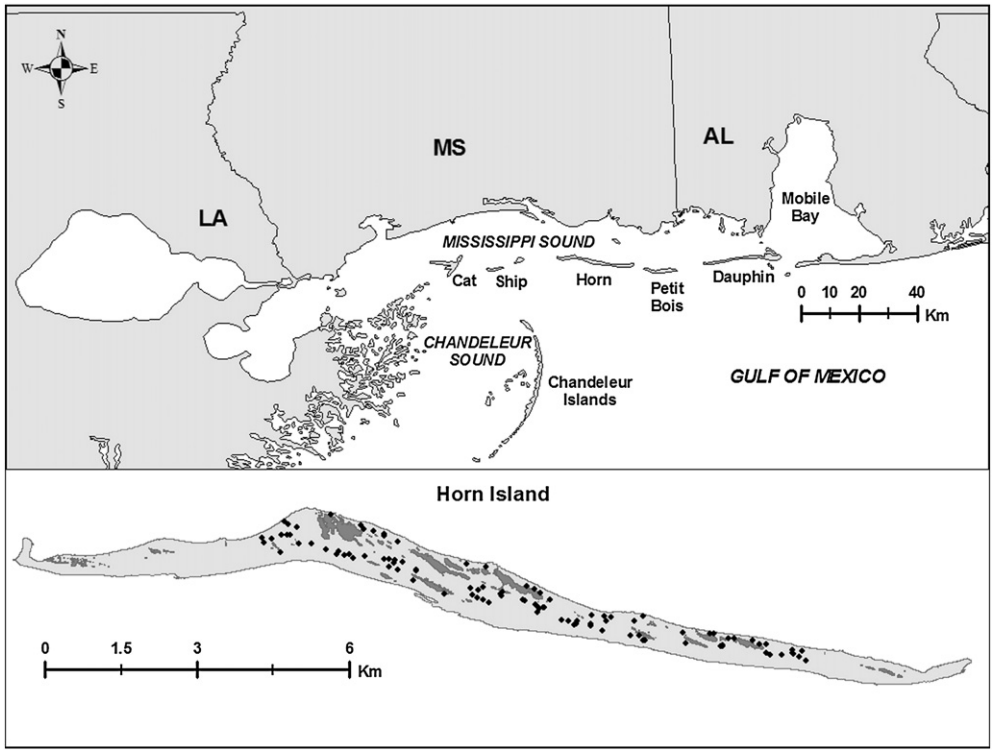

Fig. 1. Map of Horn Island, Mississippi U.S.A. (30°13′N, 88°40′W) along with nearby barrier islands of the north-central Gulf of Mexico. The expanded map of Horn Island shows the 100, 15-m line transect locations. Darker gray areas represent inland ponds or lagoons. No transects were established on the eastern and western ends of the island because these areas were subject to a disturbance and possible vegetation change between image acquisition and original transect sampling in 2004.