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Integrated conceptual ecological model and habitat indices for the southwest Florida coastal wetlands

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ABSTRACT

The coastal wetlands of southwest Florida that extend from Charlotte Harbor south to Cape Sable, contain more than 60,000 ha of mangroves and 22,177 ha of salt marsh. These coastal wetlands form a transition zone between the freshwater and marine environments of the South Florida Coastal Marine Ecosystem (SFCME). The coastal wetlands provide diverse ecosystem services that are valued by society and thus are important to the economy of the state. Species from throughout the region spend part of their life cycle in the coastal wetlands, including many marine and coastal-dependent species, making this zone critical to the ecosystem health of the Everglades and the SFCME. However, the coastal wetlands are increasingly vulnerable due to rising sea level, changes in storm intensity and frequency, land use, and water management practices. They are at the boundary of the region covered by the Comprehensive Everglades Restoration Plan (CERP), and thus are impacted by both CERP and marine resource management decisions. An integrated conceptual ecological model (ICEM) for the southwest coastal wetlands of Florida was developed that illustrates the linkages between drivers, pressures, ecological process, and ecosystem services. Five ecological indicators are presented: (1) mangrove community structure and spatial extent; (2) waterbirds; (3) prey-base fish and macroinvertebrates; (4) crocodilians; and (5) periphyton. Most of these indicators are already used in other areas of south Florida and the SFCME, and therefore will allow metrics from the coastal wetlands to be used in system-wide assessments that incorporate the entire Greater Everglades Ecosystem.

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1. Introduction

Coastal wetlands form a critical ecotone at the boundary between freshwater and marine environments and thus provide essential habitats and nutrients to both systems. They are valued by society because they stabilize the coastline and provide protection from storm surge and flooding, improve water quality by filtering nutrients, sequester carbon, and provide aesthetic, recreational and tourism value. Yet, the coastal wetlands are particularly vulnerable to impacts from sea level rise and changes in intensity and frequency of coastal storms. The IPCC (IPCC, 2007, p. 9) has identified coastal mangrove and salt marshes as environments that "are likely to be especially affected by climate change" due to "multiple stresses" associated with changing climatic patterns. In south Florida, availability of freshwater also is affected by water-management practices, and restoring flow of freshwater through the wetlands is a key component of the Comprehensive Everglades Restoration Plan (CERP; see Ortner et al., 2014). The goal of this paper is to provide an Integrated Conceptual Ecological Model (ICEM) for the southwest Florida coastal wetlands and to highlight indicators that can be used to monitor natural and anthropogenic change in the coming decades. A tremendous amount of research has been conducted on this region of Florida and it is not within the scope of this paper to provide a thorough review. The references included support the development of the ICEM and selection of the indicators.

1.1. Area included in the model

Within the context of the MARES (MARine and Estuarine goal Setting; see Ortner et al., 2014) Southwest Shelf ICEM we have defined the coastal wetlands as the saltwater zone landward of the coastal margin, which includes the marshes, flats, and mangroves and the intermittent creeks, channels and rivulets that flow through these areas (Fig. 1). The entire region is characterized by gently sloping topography with elevations less than a few meters above sea

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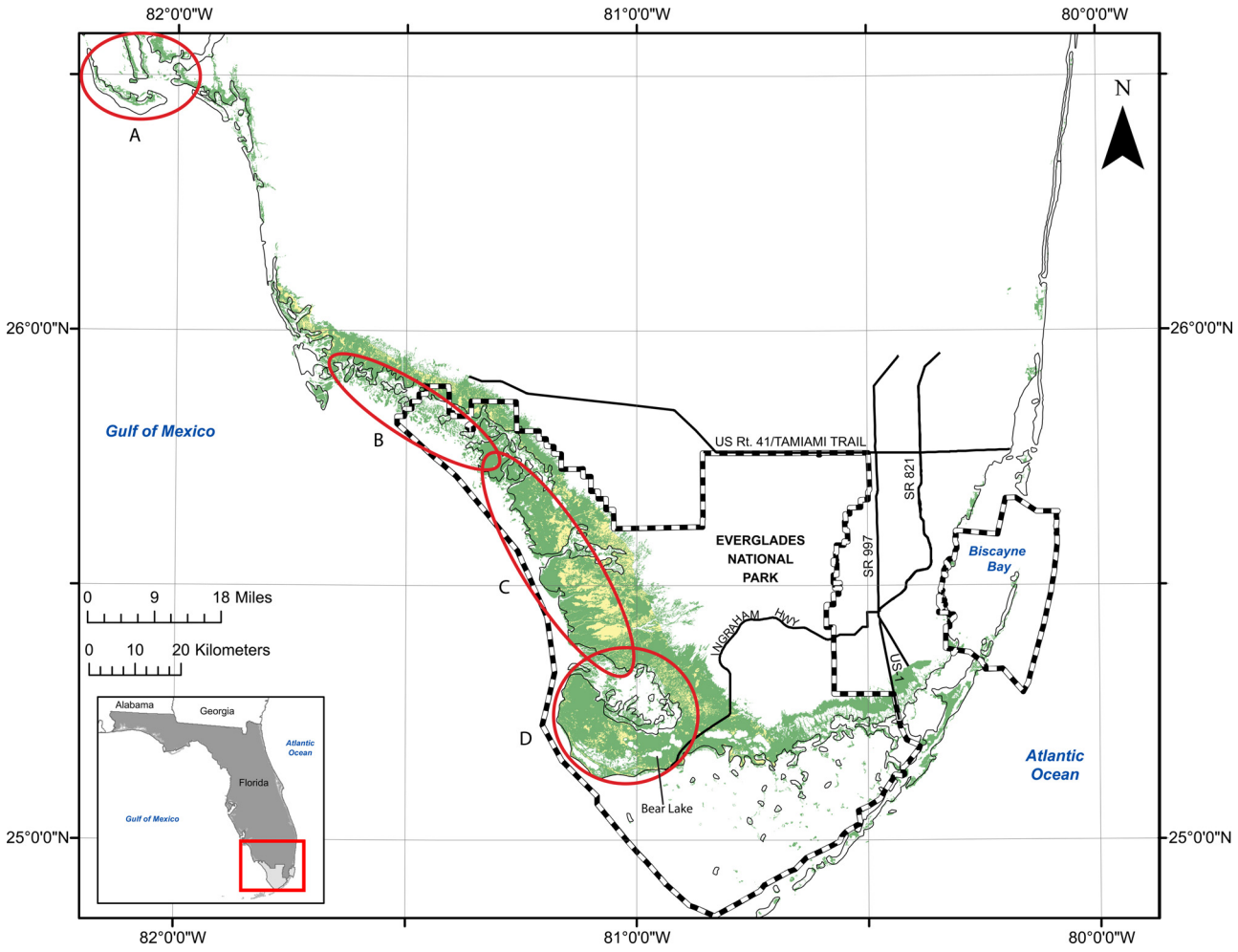

Fig. 1. Map of southern Florida showing the distribution of the southwest coastal wetlands. Mangroves are shown in green and salt marsh areas in yellow (salt marsh only shown for areas inside Everglades National Park). The position of Everglades National Park, and the four provinces discussed in the text (red ovals) are shown: (A) barrier island province, (B) Ten Thousand Island province, (C) Everglades/Shark River Slough province, and (D) Cape Sable/Whitewater Bay province. (For interpretation of the references to color in text, the reader is referred to the web version of this article.)

Mangrove distribution data from Florida Fish and Wildlife Conservation Commission (2011).

level (Zhang, 2011). The southwest Florida coastal zone includes more than 60,000 hectares of mangroves (Smith et al., 1994), 161,996 hectares of estuarine forested scrub–shrub (includes mangrove forests, dwarf mangroves, and buttonwoods), and 22,177 hectares of salt marsh (primarily *Spartina* and *Juncus*)(Field et al., 1991). NOAA's Coastal Wetlands Inventory (Field et al., 1991) lists the Ten Thousand Islands as having the largest extent of coastal wetlands of any estuarine drainage in the continental United States. The southwest Florida coastal wetlands are divided into four provinces (Fig. 1) based on the dominant coastal features: Barrier Island, Ten Thousand Islands, Everglades/Shark River Slough and Cape Sable/White Water Bay. These provinces are, for the most part, very similar and are not specifically differentiated in the ICEM (Fig. 2). There are, however, differences in some ecosystem services and the role of the drivers for each of the four provinces. These differences were compiled into cross-sectional transect figures for each region (see Fletcher (2014) for an example; see Nuttle and Fletcher, 2013 for four diagrams of southwest Florida provinces).

The barrier islands are the most unique of the four provinces because they are extensively developed compared to the other provinces. In addition, they are characterized by beaches and wetlands dominated by herbaceous marshes, compared to the mangrove dominated provinces to the south (see Marshall et al. (2014) for discussion of issues related specifically to beaches). The urbanization of the barrier islands has resulted in the destruction of wetlands, changes in water flow from the upland along with concurrent polluted runoff, stabilization of barrier islands and greater demands on the environment in the form of increased fishing pressure and the extraction of ground water to provide drinking water (Barnes, 2005). Besides direct urbanization in the barrier island province, the overall development of southern Florida has led to large scale changes in water management practices (defined here as the anthropogenic storage and distribution of water) resulting in polluted water from Lake Okeechobee being discharged in much larger quantities than natural into the inshore bays through the Caloosahatchee River (Barnes, 2005; Light and Dineen, 1994; Lodge, 2010). This discharge of polluted water has resulted in algal blooms and red tides within the bays and red tides and blackwater events offshore (Barnes, 2005; Keller and Causey, 2005).

The Ten Thousand Islands, Everglades/Shark River Slough and Cape Sable/White Water Bay provinces have been described by Davis et al. (2005, p. 832) as "a brackish water ecotone of coastal bays and lakes, mangrove and buttonwood forests, salt marshes, tidal creeks, and upland hammocks." Tidal range in this region is small (typically 0.3–0.6 m). The amount of freshwater flow from the Everglades is a significant factor distinguishing these three provinces. The Everglades region receives much more freshwater through Shark River Slough then the Ten Thousand Islands,