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Improving management of a mid-Atlantic coastal barrier island through assessment of habitat condition

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ABSTRACT

To achieve desired environmental outcomes, environmental condition and trends need to be rigorously measured and communicated to resource managers, scientists, and a broader general audience. However, there is often a disconnect between responsive ecosystem monitoring and decision making for strategic long-term management. This project demonstrates how historical monitoring data can be synthesized and used for future planning and decision making, thereby closing the management feedback cycle. This study linked disparate datasets, collected for a variety of purposes and across multiple temporal and spatial scales, in order to assess and quantify current habitat conditions. The results inform integrated resource management decision-making at Assateague Island National Seashore (Maryland and Virginia, USA) by using ecological reference conditions to identify monitoring needs, areas of high vulnerability, and areas with potential for improved management. The approach also provides a framework that can be applied in the future to assess the effectiveness of these management decisions on the condition of island habitats, and is a replicable demonstration of incorporating diverse monitoring datasets into an adaptive management cycle.

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1. Introduction

The use of monitoring information to assess natural resource conditions in a clear and quantifiable way can improve managers' abilities both to manage resources and to operate more effectively in legal and political discussions (Fancy et al., 2008; Carruthers et al., 2012). Environmental score cards or report cards are seen as an important tool for this type of integrated assessment, to move beyond simply identifying ecosystem change and on to applying monitoring data to ecosystem management (U.S. EPA, 2002). Careful metric selection and a strong framework to link diverse metrics, collected at different spatial and temporal scales, can help to interpret trends in natural resource condition and to elucidate connections between condition and diverse stressors. Although more general assessments have been successfully carried out at global, national, and large regional scales (Ferreira, 2000; Kiddon et al., 2003; Turner et al., 2004; IPCC, 2007; Bricker et al., 2008; Heinz Center, 2008; Williams et al., 2009), frameworks for local-level assessments have focused primarily on a few, specific resources rather than providing a holistic evaluation of site conditions.

1.1. Developing a science-based management tool at ASIS

Assateague Island, a coastal barrier island on the central east coast of the United States of America, faces a range of local and regional threats yet lacked a clearly synthesized, science-based assessment of current ecosystem conditions and trends to link monitoring to strategic management planning. This project assessed natural resource conditions of Assateague Island National Seashore (ASIS) to demonstrate how historical monitoring data can be synthesized and used for future planning and decision making.

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The objectives of this assessment were as follows:

1) To quantify and evaluate the current condition of key natural resources using a habitat-based approach, by compiling existing datasets, institutional knowledge, and observational information;
2) To establish an effective framework to synthesize available data, and to document confidence level and trends for each key natural resource. This information was then combined to describe the overall condition of each habitat and ASIS as a whole;
3) To clearly identify data gaps or needs that would allow improved assessment of overall resource condition in future assessments;
4) To develop management strategies and recommendations, and a framework for assessing the effectiveness of those management actions.

1.2. Regional setting

1.2.1. Conditions and management of Assateague Island

Assateague Island, a barrier island along the coast of Maryland and Virginia (Fig. 1A), supports a diversity of ecosystems, species, and human uses. This region is microtidal and wave-dominated, and longshore drift moves sediment in a net southward direction annually (Fisher, 1967; Krantz et al., 2009). Major storms (extra-tropical northeasters and hurricanes) play a strong role in shaping these barrier islands (Krantz et al., 2009).

Assateague Island delineates a series of coastal bays within Maryland and Virginia. The six sub-watersheds that flow into these coastal bays stretch from Delaware in the north, through Maryland, and south into Virginia, with a total area of 453 km^2 (Fig. 1A). The majority of the watershed is composed of forest (38.4%), agriculture (33.3%), and wetland (16.3%), with an increasing proportion of residential, commercial, and urban development (10.4%). The 59.5 km long island and surrounding estuarine and marine waters are protected and managed by three different government agencies. The National Park Service (NPS) manages ASIS to protect natural resources while providing for compatible recreation. The park includes most of the Maryland portion of Assateague Island, some adjacent small marsh islands, marine waters up to 0.8 km beyond the mean high water line on the Atlantic (east) side, and estuarine waters extending 0.18–1.5 km on the bay-side (west), totaling an area of 16, 381 ha (Public Law 89-195; Fig. 1A).

1.2.2. Key features of Assateague Island

Physical features: The island is naturally dynamic and structured by storm activity (Stauble et al., 1993; Krantz et al., 2009). These storms cause island over-wash with large waves resulting in sand erosion and accretion, inlet formation and closure, and the creation of new marsh platforms where overwash reaches the bay.

Ecosystem features: Globally rare sand overwash habitat provides nesting sites for the threatened shorebird, *Charadrius melodus* (piping plover) (USFWS, 1985; IUCN, 2010). The threatened and globally rare dune annual, *Amaranthus pumilus* (seabeach amaranth) (USFWS, 1993; Tyndall et al., 2000; MNHP, 2010), is only found between the high tide line and the base of the primary dune. ASIS is an important site for many migratory bird species (Dinsmore et al., 1998), and supports populations of the native white-tail deer (*Odocoileus virginianus*), as well as the historically introduced sika deer (*Cervus nippon*) and horses (*Equus caballus*) (Keiper and Keenan, 1980; Keiper, 1985). Fresh water for these species is limited; Assateague Island has an independent groundwater system, with a freshwater lens 6–7 m deep in the center of the island, and less than 1 m near both shores (Hall, 2005). The groundwater migrates slowly, generally over 50 years (Dillow and Greene, 1999).

Human use: ASIS resources are used in diverse ways by over 2 million visitors a year (ASIS, 2007). Most people visit the beach and bays for recreation, swimming, surfing, boating, fishing, clamming, birding, trail-walking, and driving along the Over Sand Vehicle (OSV) zone. The Maryland coastal bays and offshore Atlantic fisheries support important commercial fisheries, and beach and bay-side fishing is a key attraction for visitors (Murphy and Secor, 2006; ASIS, 2008). The aesthetic appeal, beach access, and unique fauna (including the feral horses) are key reasons for visiting ASIS. The park comprises one of the longest sections of undeveloped coastline on the mid-Atlantic US coast, providing a rare dark sky experience. The hunting program is an important component of management for both white-tail deer and sika deer populations (ASIS, 2010b).

1.2.3. Threats to Assateague Island resources

Threats and stressors to the natural resources of ASIS occur at three main scales: within ASIS itself (164 km^2), within the surrounding watersheds (453 km^2), and within the mid-Atlantic region (310,000 km^2), recognizing that some interactions occur between these scales.

Changes to vegetation structure and dune erosion have been observed as a result of feral horse, white-tail deer, and exotic sika deer populations (Keiper, 1985; Furbish and Albano, 1994; Seliskar, 2003; Sturm, 2007, 2008); sika deer also compete with native white-tail deer for food, and their foraging habits are changing the character of forest and shrubland at ASIS (Hall et al., 2009). Many invasive plant species occur within ASIS, including the highly invasive strain of *Phragmites australis* which changes marsh surface height and hydrology, and displaces native marsh, forming large monocultures with low habitat value for marsh inhabitants (Stalter and Lamont, 1990; Rice et al., 2000; Wilson et al., 2009). Over-sand vehicles impact the beaches and have historically impacted dune areas. Historic mosquito ditches remain (Kennish, 2001), potentially impacting wading shorebirds (Clarke et al., 1984) and estuarine water quality (Koch and Gobler, 2009).

Historic anthropogenic actions also shape the island and its ecosystems. Remnants of an artificial dune, built in the 1950's along nearly the entire length of the island to protect formerly private lands, continue to prevent the natural processes of sand overwash, and a portion (approximately 6 km alongshore) is maintained to protect infrastructure within ASIS and Assateague State Park. More significantly, Ocean City Inlet, maintained since 1934 by 700 m long jetties that extend up to 400 m into the ocean, has changed the character of the coastal bays by increasing the salinity and oceanic flushing of the bay waters; it has also disrupted longshore transport of sediment along the island, resulting in sediment deprivation and therefore accelerated erosion at the northern end of Assateague Island (Krantz et al., 2009). This deprivation is being mitigated by a long-term project to deliver sediment into the ASIS nearshore to restore the natural pre-inlet alongshore transport rate of 144,000 $m^3\ yr^{-1}$ (Schupp et al., 2007). The coastal bays within and adjacent to ASIS are impacted by development (Boynton et al., 1996; Hall et al., 2009), agriculture (Fertig et al., 2009), and concentrated animal feeding operations (Beaulac and Reckhow, 1982; Mallin and Cahoon, 2003) throughout the adjoining watersheds, and are showing evidence of degrading water quality and loss of seagrass meadows (Wazniak et al., 2007).

The mid-Atlantic region includes some of the highest population densities in North America, resulting in regional scale stressors, such as poor air quality. The mid-Atlantic region has also experienced almost twice the global mean rate of relative sea level rise over the past century (3–4 mm yr^{-1}), which is predicted to increase a further 19 cm by 2030, resulting in increased coastal flooding and changes to coastal geomorphological processes (Najjar