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Sea level rise and prescribed fire management: Implications for seaside sparrow population viability

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ABSTRACT

In the Chesapeake Bay, Maryland, unusually high rates of sea level rise threaten endemic tidal marsh birds, while prescribed burning benefits these bird populations. Effective conservation of tidal marsh birds requires that management actions be prioritized based on their impact to the long-term population viability for these species. We used a population viability analysis to evaluate the relative influence of two sea level rise scenarios and two prescribed fire management scenarios on the population viability of seaside sparrows, a tidal marsh obligate species, at Blackwater National Wildlife Refuge and Fishing Bay Wildlife Management Area. Marsh loss caused by rising sea levels had a greater impact on seaside sparrow population viability than did prescribed fire. Limiting marsh loss over the next 50 years to 15% of the present extent caused a 19% probability of reaching the quasi-extinction threshold, while losing 33% of extant marsh caused a 50% probability of reaching the quasi-extinction threshold. Prescribed fire increased the likelihood of seaside sparrow persistence; increasing the amount of frequently-burned marsh from 12% to 53% lowered the quasi-extinction probability from 0.20 to 0.10. Slowing the rate of marsh loss will have a greater positive effect on seaside sparrow viability than increasing the frequency of prescribed fire. Sea level rise poses the single greatest threat to the long-term persistence of tidal marsh bird populations.

1. Introduction

Tidal marshes form the transition zone between terrestrial and marine ecosystems in many regions of the world (Mitsch and Gosselink, 2000), and have high levels of endemism in their vertebrate communities, particularly in eastern North America (Greenberg and Maldonado, 2006). Seaside sparrows (*Ammodramus maritimus*) are one such endemic species and breed exclusively on tidal marshes from Maine to Texas (Post and Greenlaw, 1994). Since European colonization, seaside sparrow habitat has been reduced through the loss of approximately half of all coastal wetlands in the continental United States (Dahl, 1990; Tiner, 1984). The early causes of coastal wetland loss included draining, filling and development (Tiner, 1984), while most losses in recent decades can be attributed to erosion, subsidence and sea level rise (Dahl, 2011; Dahl and Stedman, 2013).

Given the seaside sparrow's designation as both a regional (Atlantic Coast Joint Venture, 2008) and national (U.S. Fish and Wildlife Service, 2008) conservation priority, managers are challenged with maintaining existing tidal marsh habitat in the face of global sea level rise, which has been shown to threaten seaside sparrow viability (Shriver and Gibbs, 2004). Worldwide, sea levels are predicted to rise 0.26–0.97 m by 2100 (IPCC, 2013), which could convert 33% of all coastal wetlands to open water (IPCC, 2007). The impacts will be especially pronounced in the Chesapeake Bay, Maryland, where local land subsidence, isostatic rebound and lack of sediment input have resulted in a rate of sea level rise that is nearly twice the average global rate (Kearney, 1996; Stevenson and Kearney, 2009; Wilson et al., 2007). Evidence of these effects within the Chesapeake Bay region can be seen in Dorchester County, MD, which lost approximately 1500 ha of tidal marsh between 1938 and 1989 (Rizzo, 1995). By 2060, an additional 33–50% of Dorchester County marshes are predicted to be lost (Glick et al., 2008).

Since at least the 1930s, marshes in Dorchester County have been managed with prescribed burning to create favorable conditions for waterfowl, facilitate the removal of invasive species, and reduce wildfire risk (Griffith, 1940; Hackney and de la Cruz, 1981; Nyman and Chabreck, 1995). Winter prescribed burns also positively impacted northern seaside sparrows (*A. m. maritimus*) in Dorchester County by increasing density and nest survival (Kern et al., 2012). To fulfill the aforementioned management

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objectives, burning is likely to continue for the foreseeable future; however, the long-term impact of various prescribed fire regimes on seaside sparrow populations is not known. Here, we use a population viability analysis to understand the effect of marsh loss and prescribed burning on seaside sparrow population persistence.

Because resources to support conservation and wildlife habitat management are limited, any action represents a tradeoff between various alternatives (Hughey et al., 2003). Many tools for evaluating and prioritizing conservation actions exist, but decision-makers often fail to use experimental evidence, and rely instead on experience or tradition (Pullin et al., 2004). To avoid this pitfall, it is often necessary to evaluate the biological benefits of management alternatives in a way that is accessible and practical for conservation professionals and decision-makers.

Population viability analysis (PVA) is a technique that evaluates the vulnerability of a population to local extinction under various scenarios (Akcakaya, 2004; Brook et al., 2000). One of the most appropriate uses of PVA is to compare the relative effects of different management options on population size and probability of extinction (Reed et al., 2002). For this reason, we used PVA as a quantitative tool to evaluate the effect of two marsh loss scenarios and two fire management scenarios on the seaside sparrow population at Blackwater National Wildlife Refuge (NWR) and Fishing Bay Wildlife Management Area (WMA) in Dorchester County, Maryland. To determine the relative effects of sea level rise on seaside sparrow population persistence, we used two marsh loss scenarios: 15% marsh loss and 33% marsh loss. To determine the effects of different levels of prescribed fire on seaside sparrow persistence, we used a minimum and an average burn scenario. We estimated seaside sparrow viability over 50 years to assist land managers in prioritizing the management actions that will provide the greatest positive effects for seaside sparrows, and likely other tidal marsh species.

2. Methods

We modeled the viability of the seaside sparrow population on Blackwater NWR and Fishing Bay WMA, which comprise the Southern Dorchester County Important Bird Area (National Audubon Society, 2009; Fig. 1). This study area contained 14,000 ha of tidal marsh that was dominated by eastern baccharis (*Baccharis halimifolia*), spikegrass (*Distichlis spicata*), black needlerush (*Juncus gerardii*), chairmaker's bulrush (*Schoenoplectus americanus*), smooth cordgrass (*Spartina alterniflora*), big cordgrass (*Spartina cynosuroides*), and meadow cordgrass (*Spartina patens*; U.S. Fish and Wildlife Service, 2006).

2.1. Scenario development

We created two scenarios to model the effects of marsh loss due to sea level rise on seaside sparrow population viability over 50 years. We defined 15% and 33% marsh loss scenarios and removed the appropriate number of sparrows based on the area lost during each simulation year. We based sparrow abundance estimates on our previous estimates of breeding sparrow densities in these marshes (Kern et al., 2012). We also incorporated the effects of marsh loss by assigning a negative temporal trend in carrying capacity such that after 50 years, carrying capacity was 15% or 33% lower than at year zero, respectively.

We developed two prescribed fire scenarios to model the effects of a minimum level and an average level of burning. Input from biologists and managers at Blackwater NWR was incorporated to ensure that each scenario reflected a realistic fire management option. In the minimum burn scenario, burning occurred to fulfill annual obligations for long-term fire research and wildland–urban interface (WUI) maintenance. The average burn scenario represented status quo fire management and was based on the Blackwater NWR and Fishing Bay WMA burn history over 24 years.

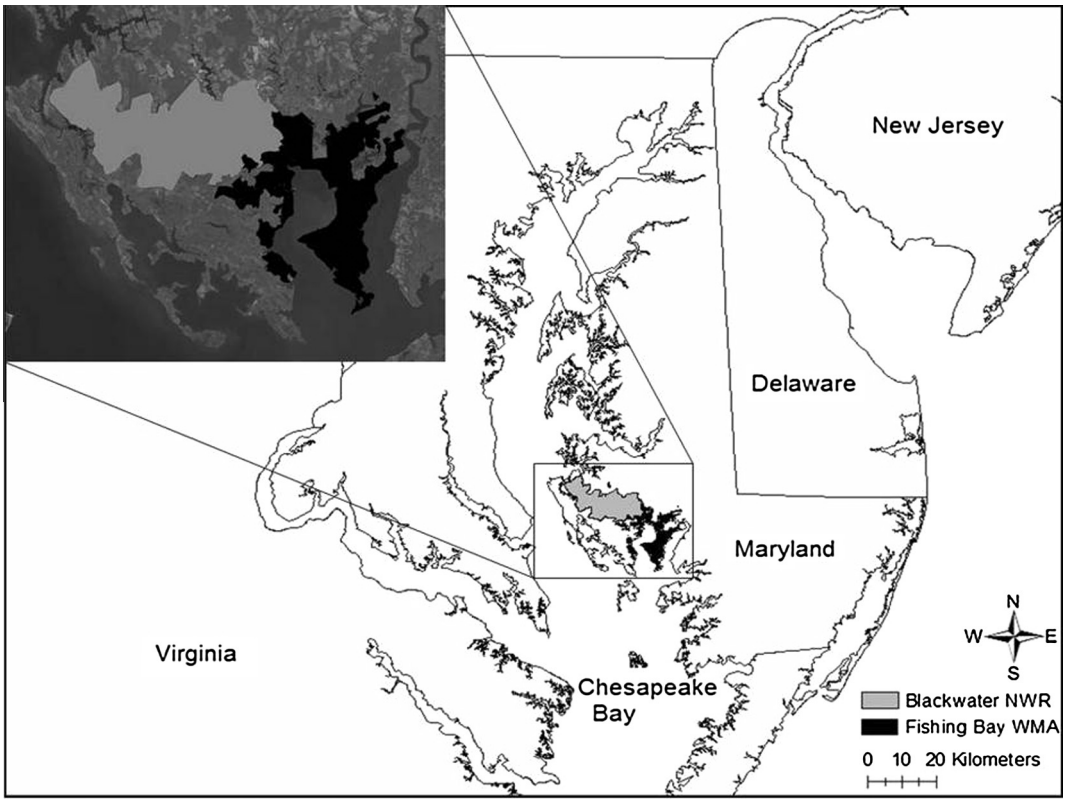

Fig. 1. Blackwater National Wildlife Refuge and Fishing Bay Wildlife Management Area, Dorchester County, Maryland.