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Integrating conservation costs into sea level rise adaptive conservation prioritization

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ABSTRACT

Biodiversity conservation requires strategic investment as resources for conservation are often limited. As sea level rises, it is important and necessary to consider both sea level rise and costs in conservation decision making. In this study, we consider costs of conservation in an integrated modeling process that incorporates a geomorphological model (SLAMM), species habitat models, and conservation prioritization (Zonation) to identify conservation priorities in the face of landscape dynamics due to sea level rise in the Matanzas River basin of northeast Florida. Compared to conservation priorities that do not consider land costs in the analysis process, conservation priorities that consider costs in the planning process change significantly. The comparison demonstrates that some areas with high conservation values might be identified as lower priorities when integrating economic costs in the planning process and some areas with low conservation values might be identified as high priorities when considering costs in the planning process. This research could help coastal resources managers make informed decisions about where and how to allocate conservation resources more wisely to facilitate biodiversity adaptation to sea level rise.

1. Introduction

There is an increasing body of literature demonstrating the importance of applying cost considerations to tools in conservation decision making (Naidoo et al., 2006; Watzold et al., 2006). Naidoo and Ricketts (2006) conducted a spatial evaluation of the costs and benefits of conservation in the Mbaracayu Biosphere Reserve in Paraguay and found that understanding the trade-offs between conservation and economic development can powerfully inform conservation decision-making. However, there is also concern about focusing too narrowly on economic factors in conservation planning that may lead to the opportunistic selection of conservation areas thus we need to understand how much weight should be given to economic considerations (Arponen et al., 2010).

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In a dynamic world where costs and conservation priorities are shifting, we need to be as efficient with our spending as possible. Sea level rise is one example that will lead to the shifting of conservation priorities. As sea level rises, conservation decision making not only involves consideration of costs but also consideration of sea level rise impacts (Mills et al., 2014; Runting et al., 2013). In response to sea level rise, some tidal wetlands in areas with low freshwater and sediment supplies will "drown" in locations where sea level rise outpaces their ability to accrete vertically (Nyman et al., 1993) and some salt marshes are expected to move upslope with the rising sea water (Brinson et al., 1995). However, human development is likely to limit this migration (Donnelly and Bertness, 2001). In low-lying coastal regions such as Florida, since many species are located only within coastal areas, without adaptation strategies, species, habitat and the entire coastal ecosystem are likely to be lost (Noss, 2011, Hoctor et al. 2014). Providing explicit information about where existing reserves should be enlarged and new conservation areas should be created to facilitate biodiversity adaptation to sea level rise has been recommended by conservation biologists as one of the most urgent research needs necessary to maintain biodiversity and resilient ecosystems in Florida (Noss, 2011).

Considering both costs and sea level rise in conservation reserve design has real world implications. Coastal reserve managers need the critical information about where their reserves could be expanded or where new conservation lands could be created to facilitate biodiversity adaptation to sea level rise. More importantly, they need to know how to conserve efficiently in the face of sea level rise and land use change. The need for conservation efficiency in sea level rise adaptive conservation planning from natural resource managers provides a good opportunity for conservation planners to integrate costs into sea level rise adaptation planning process. Fortunately, spatial economics, which deals with the allocation of scarce resources over space, and the location of economic activity, have been increasingly incorporated into conservation planning and reserve design (Naidoo et al., 2006).

In this study, we used an integrated modeling process that incorporates a coastal impact model that simulates coastal wetland conversions and shoreline modifications from long-term sea level rise (Sea Level Affecting Marsh Model; SLAMM; (Clough et al., 2010) and species habitat models in a novel way to identify sea level rise adaptive conservation priorities in a coastal area of northeast Florida. Both costs of conservation and sea level rise were integrated in the planning process that aims to achieve conservation efficiency. Cost of conservation was incorporated into the planning process by using a cost layer while sea level rise was incorporated into the planning process by using a coastal impact model that simulates wetlands and shoreline changes due to long term sea level rise. The associated goal of this planning is to assist reserve managers in seeking opportunities for additional habitat protection to facilitate biodiversity adaptation to sea level rise while minimizing economic costs. Research results can be used by reserve managers to purchase new lands to supplement lost species habitat due to rising sea levels.

2. Methods

2.1. Study area

The Matanzas River Basin in Northeast Florida is a salient case study for adaptive conservation design (Fig. 1). Located along Northeast Florida's Atlantic coastline, the Matanzas River Basin consists of the southern proportion of the Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR) and other conservation lands. It is one of the most valued and threatened areas along the Florida coastline and it is home to many species of plants, animals, fungi and microorganisms distributed among various habitats in the basin. The basin covers approximately 40,470 ha between the City of St. Augustine and the City of Palm Coast and a large area of rural lands to the west. The basin has nearly 90% of its land in undeveloped natural or rural condition, thus providing a rare opportunity to incorporate sea level rise into future conservation and land-use plans with little conflict with existing development. In addition, land value in this area varies a lot due to different land use types thus it provides a good research opportunity to integrate costs of conservation in the planning process to identify conservation priorities that considers dollar cost of land protection.

2.2. Sea level rise scenarios

Predictions about sea level rise are constantly improving with increased model sophistication and data accuracy (Grinsted et al., 2010; Cameron et al., 2012). The newly released 5th Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC) reported a predicted sea level "rise of 40–60 cm by late in the century and a worst case of 1.0 m by 2100". (Church et al., 2013, p. 1445). However, the report also concluded that sea levels could rise much higher than the "likely" range in the 21st century "if the sections of the Antarctic ice sheet that have bases below sea level were to collapse" (Church et al., 2013).

Sea level rise scenarios are fundamental to vulnerability assessments and all other following parts of the adaptation planning process in coastal areas. For this research, we chose scenarios of 0.5, 1.0, and 2.5 m sea level rise by 2100 for the adaptive conservation design. The 0.5 m sea level rise projection is the lowest case scenario and it falls in the "likely" sea level rise range projected by AR5. The 1.0 m sea level rise projection is the intermediate case scenario and it is the worst case "likely" sea level rise projection according to AR5. We chose 2.5 m as the highest sea level rise scenario because this