Final Report

Project Title and Number: 2013-0111-001

Application of Light Detection and Ranging (LiDAR) Data to Support Science-Based Management of Salt Marsh and Barrier Island Habitat in Marine Protected Networks

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Summary of Accomplishments

The broader goal of this stewardship project was to develop and apply geospatial information and tools to direct strategies for climate change adaptation with respect to rising sea level in the MidAtlantic region, using the Edwin B. Forsythe National Wildlife Reserve (EBFNWR) and the Jacques Cousteau National Estuarine Research Reserve (JC NERR) as a case study. The approach itself consisted of three major phases: 1) undertaking a highly detailed mapping of relevant land cover information using remotely sensed imagery over the entire EBFNWR area, 2) mapping the current distribution of target wildlife species based on that detailed land cover data, and 3) applying existing sea level rise (SLR) models to these habitat maps to characterize the potential impacts to individual species. While our simple assessment was informative, we suggest that more sophisticated modeling of the response of salt marsh and barrier island beach environments to long term sea level rise and episodic storms is needed to better inform conservation managers on the future availability of critical coastal habitats.

2. Project Activities & Outcomes

Activities

Sea level rise is a physical reality that is impacting the New Jersey and the entire MidAtlantic (New Jersey, Delaware, Pennsylvania, and New York) coastline (Titus and Strange, 2008; NOAA, 2012). Through their land use planning, development and management decisions, refuge managers will greatly influence future impacts of sea level rise and global climate change on wildlife populations. Mitigating the impact of sea level rise is a local decision-making challenge and is going to require site-specific remedies. Faced with a variety of conflicting mandates and uncertainty as appropriate responses, managers will greatly benefit from place-based decision support system tools that outline a range of geographically targeted management options. To address this priority, this study was undertaken to assess the potential of emerging geospatial information techniques (i.e., LiDAR and semi-automated object based classification) to developing relevant geospatial data to support science-based management of coastal marsh and barrier island habitat.

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A workshop was hosted on March 22, 2013 at the JCNERR Education Center in Tuckerton, NJ to inform federal, state, local and non-profit coastal reserve managers of the results of this NFWF project and to share information on ongoing projects related to the consequences of SuperStorm Sandy and sea level rise on coastal habitats management and restoration.

Outcomes

Object-oriented image analysis and high spatial resolution digital orthophotography (1 foot ground resolution cell) was used to create highly detailed map of land cover/habitat features for the 512-sq mi study area. In terms of spatial detail, features as small as 1/10 acre were delineated and classified into one of 27 different land cover categories (focusing primarily on coastal marsh and barrier island landscapes) with an acceptable degree of accuracy. While the digital orthophotography for a high level of detail, inconsistency in radiometric response across individual photo frames made for a challenge in developing universally applicable spectral signatures for individual land cover classes. The semi-automated object-based land cover mapping process using Definiens eCognition software also requires high level of image analyst training and development. The classification rule-base developed for this project was documented for potential adoption and application elsewhere. The resulting land cover map is also made available for free download.

The detailed land cover/habitat features GIS data was then classified into individual target species habitat maps based on detailed habitat description provided by EBFNWR staff wildlife biologists. Of the 14 species deemed suitable for the study, it was possible to translate written habitat descriptions to distribution maps for 11. Furthermore, these were successfully broken down to reflect specific habitat uses. The three remaining species had specific habitat requirements that could not be described by land cover alone. In such cases, supplemental data, where available, could be used to account for those specific requirements with relatively little data. What is important is that greater detail in land cover data allows for greater flexibility in mapping of habitat distribution.

The projected water inundation maps were developed from LiDAR-derived digital elevation model (DEM) data using standard protocols developed by the NOAA Coastal Services Center (from whom we received advice and assistance). Assessing the potential impact of future sea level rise and coastal inundation proved more problematic. Many of the target species rely on coastal salt marshes and barrier island beaches that are already inundated on a regular daily to monthly basis (i.e. to MHHW). While a simple assessment of inundation of existing beach habitat was feasible and showed expected declines of >10% by 2050, a more nuanced long term view that includes changes in future beach configuration is needed but not deemed feasible within the scope of this project.

To further examine longer term changes (i.e. out to 2050) in the coastal salt marsh habitats, we undertook a slightly more sophisticated modeling of future coastal marsh landscape distribution under projected sea level rise. Due to its dependence on low and high salt marsh habitats for both breeding and feeding, the salt marsh sparrow (*Ammodramus caudacutus)* was chosen for further investigation and modeling. With an expected sea level rise of slightly over 1.3 feet by 2050 (Miller and Kopp, 2012), our results suggest that the availability of salt marsh sparrow habitat will not be greatly impacted. If sea level rises at a faster rate (i.e., to 3 feet) during that time interval, then we would predict a more significant loss of available marsh habitat to mud flat and open water (approximately 15%). This may be balanced by some gain in "new" marsh generated at the marsh-upland edge. However, the quality of that marsh to support salt marsh sparrows in the near term is unknown.

The SLAMM-type model and the input parameters (e.g., marsh vertical accretion rate) we employed in this study needs further validation. SLAMM also provides the ability to examine other factors such as lateral erosion and overwash that might be useful if adequately calibrated. Ongoing sediment elevation table studies being conducted by the USFWS EBFNWR and the MidAtlantic Coastal Wetlands Assessment (MACWA) program will provide valuable insights into vertical marsh accretion rates. A SLAMM-type model is needed predict that availability and quality of beach habitats for beach nesting dependent birds is needed. While there are computer-based process models to forecast coastal erosion and shoreline retreat, these need further research and testing before they can be used to inform conservation management (McLeod et al., 2010). The changing configuration of Holgate and Little Beach as a consequence of SuperStorm Sandy provided a ready demonstration of the already well-recognized fact that barrier island beaches are a highly dynamic environment.

3. Lessons Learned

Assessing the potential impact of future sea level rise and coastal inundation proved more problematic. Many of the target species rely on coastal salt marshes and barrier island beaches that are already inundated on a regular daily to monthly basis. Two species were chosen for further consideration: piping plover (*Charadrius melodus)* as a target beach nesting/foraging dependent species; and, the salt marsh sparrow (*Ammodramus caudacutus)* as a target salt marsh nesting/foraging species. With an expected sea level rise of slightly over 1.3 feet by 2050, our results suggest a decline in available piping plover beach nesting beach habitat (above MHHW) of >10%. The coastal marsh landscape change model was used to examine the issue of future habitat change to the feeding habitat of the salt marsh dependent species, the salt marsh sparrow. Our results suggest that the availability of salt marsh sparrow habitat will not be greatly impacted by 2050. If sea level rises at a faster rate (i.e., to 3 feet) during that time interval, then we would predict a more significant loss of available marsh habitat to mud flat and open water (approximately 15%). This may be balanced by some gain in "new" marsh generated at the marsh-upland edge. However, the quality of that marsh to support salt marsh sparrows in the near term is unknown. In many cases, the area available for marsh retreat is impeded by nonconvertible land cover types such as urban land. These zones may become increasingly impeded as urban development continues. Ecological factors such as biological limitations on the rate at which marsh expansion is able to keep pace with sea level rise, and the ability of more desirable high salt marsh vegetation (i.e., *Spartina patens*) to compete with invasive *Phragmites* may not be fully accounted for in this model.

While our simple assessment was feasible, we suggest that a more nuanced long term view that includes changes in future beach configuration is needed but was not feasible within the scope of this project. To further examine longer term changes in the coastal salt marsh habitats, we undertook a slightly more sophisticated modeling of future coastal marsh landscape distribution under projected sea level rise. Additional research and testing is needed on more sophisticated modeling of the response of salt marsh and barrier island beach environments to long term sea level rise and episodic storms to better inform conservation managers on the future availability of critical coastal habitats.

4. Dissemination

A workshop was hosted on March 22, 2013 at the JCNERR Education Center in Tuckerton, NJ to inform federal, state, local and non-profit coastal reserve managers of the results of this NFWF project and to share information on ongoing projects related to the consequences of SuperStorm Sandy and sea level rise on coastal habitats management and restoration. For more information on the results of that workshop see Appendix A (the notes on the workshop were distributed to the various participants).

A project website (http://www.crssa.rutgers.edu/projects/coastal/slrhabitat) was created providing a short description of the project and access to the final report (Appendix A) and the core GIS digital files (e.g., EBFNWR land cover map and the marsh retreat zone map). These GIS data files along with FGDC-compliant metadata are available for free download.

No specific management actions resulting from the project on the part of EBFNWR or JCNERR staff as a direct result of this project have yet been implemented. The PI for this NFWF project (R. Lathrop) will be working with several of the non-profit groups in attendance at the March 22 workshop to further examine the impacts of Hurricane Sandy on coastal habitat, to assess vulnerability to future storms and recommend ecological restoration possibilities.

5. Project Documents

The following graphics, documents and GIS data files have been uploaded

Figure 1. Study Area showing the boundaries of the Edwin B. Forsythe National Wildlife Reserve (EBFNWR) and Jacques Cousteau National Estuarine Research Reserve (JC NERR) within the state of New Jersey.

Figure 2. Base land cover map

Figure 3. Percent negative change in piping plover habitat due to inundation as compared to base land cover and MHHW.

Figure 4. Change in composition of salt marsh sparrow feeding habitat based on coastal marsh landscape change model results.

Appendix A. Final Report with detailed methods

Powerpoint (as pdf) presented at march 22, 2013 workshop

Acknowledgments

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