Future Habitat and Population Viability of Shoreline-dependent Birds in Florida: Assessing Risk and Uncertainty under Climate Change

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Problem Statement

• Coastal military installations provide significant habitats and have high stewardship responsibility for a variety of shoreline-dependent organisms, including Threatened, Endangered, and At-Risk (TER-S) bird species.

• Land use changes and human population increases, coupled with uncertain predictions for sea level rise, and storm frequency and intensity, have created a significant planning challenge for natural resource managers.

• No consolidated approach available for integrating multi-scale climate, land use and ecosystem information into a systematic tool set to explore how climate variability and change may affect habitat and population dynamics for shoreline-dependent TER-S birds that are sentinels of a changing climate.
Overview

Varied Information & Data

Climatic Information:
- Sea-level
- Hurricane frequency
- Heavy rain frequency

Development Information:
- Pop/Development Increases
- Base Encroachment
- Changing expectations

Base Management:
- Training Schedules
- TER-S policies
- Expanding/Adapting training reqs

Landscape Information:
- Human land-use
- Land-cover
- Hydrology
- Elevation

Data Uncertainty and Scale Dependence

TER-S Model Tools at both Habitat and Population Scales

Habitat specific data:
- requirements for breeding, wintering, and stopover habitat

TER-S specific data:
- survival, fecundity, variability, dispersal

Modeled Uncertainty

Scientific/Model Results

Static (current) habitat suitability map

Possible Future habitat and population map(s)

Management-Useful Results

Comparing Management Alternatives with respect to Performance Metrics:
- Habitat/Species Resilience?
- Training schedules
- Cost?
Objectives

Goal - integrate multi-scale climate, land use and ecosystem information into a systematic tool set to:

(1) assess current vulnerability scenarios and information on selected Florida installations by documenting and reviewing Florida-specific climate, land use databases and information;

(2) develop a set of habitat- and species-based models for selected coastal TER-S,

(3) assess the current prediction level and assumptions of selected categories of TER-S models for use in benchmarking model performance and uncertainty levels,

(4) integrate scientific data, modeling and uncertainty results into a risk-informed, multi-criteria decision analysis system to allow systematic analysis of management options.
Climate change and sea-level rise are certainties.
With sea-level rise and increased storm frequency, recent projections of habitat loss for shoreline-dependent birds at important coastal sites in the U.S. range between 20 and 70% (Galbraith et al. 2002).
Current habitat assessments for shoreline-dependent birds suggest habitat is already a limiting factor.
Coastal birds that rely on dune, beach, and intertidal areas may be affected most.
Significant and multi-scale questions exist concerning the reduction of habitats and populations of shoreline-dependent organisms in response to climatic and anthropogenic drivers.
Objective: To gather and assess climatic inputs to habitat mapping and metapopulation modeling efforts

- Evaluation of Different GCM Emission Scenarios
- Downscaling to Local Climate
- Translation to Local Sea Level Rise
- Translation to Hurricane Frequency and Intensity
- Working in cooperation with SERDP/FSU/Donoghue and Southeast Climate Consortium/FSU/Morey

Sea bottom contours for Gulf of Mexico, showing West Florida Shelf, which can increase tidal surge through production of barotropic waves. Track is for Hurricane Dennis, 2005. Source: Dukhovskoy and Morey, 2008.
Focal Species - Snowy Plover (SNPL)
Charadrius alexandrinus – A beach-nesting and wintering species found year-round in FL

- **Status**
  State Threatened Species - FL Fish and Wildlife Conservation Commission
  “Extremely High Priority for Conservation” - US Shorebird Conservation Plan
  Potential Federal Candidate Species for Listing - USFWS

- **Importance of DoD Lands**
  Eglin AFB and Tyndall AFB, along with State Park and NPS shorelines accounted for 80% of all estimated nesting Snowy Plover pairs in the Florida Panhandle during recent statewide surveys.

- **Justification for Selection**
  • Species is easily surveyed; population data and estimates of population parameters are available.
  • SNPL is a good sentinel for detecting climate change effects on coastal habitats. Habitat changes are relatively easily detected and birds respond rapidly to these alterations.
Focal Species

Piping Plover (PIPL) (*Charadrius melodus*)

- The Piping Plover (SNPL), is federally listed as 3 separate sub-populations
- Birds from all populations winter in high numbers on Florida’s barrier islands during the non-breeding season
- DoD has high stewardship responsibility for this species

Red Knot (REKN) (*Calidris canutus*)

- Red Knots have declined dramatically during the past decade
- Species may be Federally listed in the near future
- This species “stops over” in Florida during spring and fall migration at various locations along the Atlantic and Gulf Coasts
Military Installations

- Coastal engineering and plover distribution data for Florida are maintained in a GIS.
- Eglin AFB and Tyndall AFB, along with State Park and NPS shoreline accounted for 80% of all estimated nesting Snowy Plover pairs in the Florida Panhandle during recent statewide surveys.
- Nesting and wintering SNPL, and wintering PIPL, rarely occur where beach nourishment has occurred (Lott 2008).
- Federal lands (primarily DoD and NPS lands which are rarely nourished or disturbed) are highly important for these species.
Objective: Assemble habitat information for PIPL, REKN, and SNPL (for habitat models); and SNPL population/demographic information to build metapopulation model.

- Coastal bird data are available from:
  - The International Piping Plover Census, a mid-winter survey that includes counts for both Piping Plovers and Snowy Plovers; (2001 and 2006), and,

- Initial habitat-mapping data are available in a GIS developed by Lott (2008) that shows breeding/wintering locations of birds relative to coastal engineering.

- SNPL habitat and demographic information sources vary, but will include current work at the University of Florida and Boise State University, along with various published studies of this species throughout its range.
**Information at Multiple Scales**

- Available Data at Regional, Local and Micro Scales
  - SNPL (breeding), PIPL (wintering), and REKN (migration) locations
  - Regional Development Scenarios, Land Use and Population (ha scale)
  - Coastal GIS with beach nourishment data
    - Geospatial/LIDAR (NOAA/CHARTS/SHOALS) (m scale)
    - Pre/Post Hurricane
  - Multiple General Circulation Model (GCM) Scenarios for climate and Sea Level Rise (SLR)
Objective: Collect human development, land use and topology information for Vulnerability Assessment and Model Inputs

- Land use classification and potential change, inland and shoreline digital information at different temporal and spatial scales.
- Florida 2060 (Zwick and Carr, 2006) (ha scale), Land Use and Human Population
- Florida 2003 Fish & Wildlife Commission, Land Use and Habitat Map (30m)
- USGS Digital elevation Map (30m scale)
**Land Use/Topography Data**

**Objective:** To gather and assess high precision topography data for detailed assessment of near shore habitats

- **High Resolution LIDAR (JALBTCX, NOAA)**
  - Spatial extent: Grain (1-2 m), extent (Selected Counties) and error estimation (±15 cm for topo)
  - Temporal extent: Frequency Pre/Post Selected Hurricanes

**CHARTS Lidar, Pre-Dennis (8/8/2005)** (JALBTCX, 2008)

**CHARTS Lidar, Post-Dennis (8/2005)** : (JALBTCX, 2008)
Objective: To assemble and review potential human interventions to habitat areas at near shore and regional scales

Global Scale: IPCC Development/Emission Scenarios influence ΔClimate/ ΔSLR

Regional Scale: Florida 2060 Growth Scenarios influence ΔLand Use & ΔPopulation

Regional Scale: State Beach Nourishment across NW Florida

Local Scale: Base Infrastructure and Training Plans
Habitat Suitability Mapping

Landscape maps: Human land-use, Land-cover, Hydrology, Elevation

Species/Habitat data: requirements for breeding, wintering, and stopover habitat

Climatic input: Sea-level, Hurricane freq., Heavy rain freq.

Objective: Integrate the previous task information into a set of habitat suitability maps for management review and for modeling input

- Review Available spatial databases
  - Spatial extent: Grain, extent and error estimation
  - Temporal extent: Frequency
- Coordinate with ongoing studies of Plover habitat research in NW Florida (Johnson and Pruner, Univ. of Florida; Heath, Boise State Univ.)
Habitat Suitability Mapping

- Mapping Habitat Types with LIDAR in NW Florida (Jackson et al., 2008)
- Assessing Confidence in Habitat Classification (Zharikov et al., 2005)
  - K Means Clustering and Confusion Matrix Analysis for assessing classification accuracy

(Rahmstorf, 2007)
Using the habitat and stressor maps created in the previous tasks as inputs, the RAMAS metapopulation model will simulate potential future population sizes, probabilities of decline or recovery by “superimposing” climate change and development factors on top of current habitat conditions.
MetaPopulation Modeling with RAMAS GIS

- Population dynamics (survival, growth, reproduction, dispersal); local extinction / recolonization
- Hundreds of applications of the metapopulation approach to specific cases of threatened species conservation.
- General principles, functions, and methods of modeling are known.
- Much information necessary for specific application of models to Snowy Plovers is known.
Mathematical models are built in the presence of uncertainty.

Uncertainty analysis (UA) is used to propagate all these uncertainties, using the model, onto the model output of interest.

Sensitivity analysis (SA) is the study of how the uncertainty in the output can be apportioned to different sources of uncertainty into model input.

UA and SA are used to:
1. Explore model behavior,
2. Identify factors that will have small / large influence on outputs,
3. Identify factors that need to be estimated more accurately,
4. Characterize interactions between factors and
5. Determine possible simplifications of the model.
Objective: Assess the influence of different model inputs on RAMAS outputs

(1) Estimate probability distributions of model inputs, (2) SIMLAB program provides structured sampling of inputs to RAMAS simulations, (3) selected RAMAS output matrices are flagged for (4) Morris screening analysis, (5) selection of parameters are iterated back into SIMLAB input matrices for more detailed runs, (6) analysis of model output variance and interactivity.
Integrating Model Information into Analysis of Base-Level Management Responses

- Linkage of base management alternatives, performance criteria, simulation results and uncertainty levels
- Rich academic literature with isolated but significant agency applications
- Significant software resources (low cost or free)
- Indicator of success - development of base-specific decision matrices with preliminary trade-off analysis
Multi-Criteria Decision Analysis

Objective: Use multi-criteria decision analysis to assess various management options with respect to habitat change and other existing decision drivers

- Develop problem and objectives to TER-S decisions
- Describe feasible alternatives for further analysis
- Generate/define useful criteria for success or failure,
- Evaluation with RAMAS/SIMLAB for estimation of habitat and population effects
- Construct matrix of alternatives and criteria, assign weights for comparison of alternatives with iteration to previous levels as required by TER-S managers.
Current Vulnerability Assessment

Objective: Evaluate vulnerabilities for selected TER-S with respect to current human/habitat/base management conditions

- Existing Habitat Information and Population Summary
- Current Climatic Vulnerabilities to TER-S populations
- Base Management Alternatives and Success Criteria
- Evaluation with RAMAS for estimation of habitat and population effects
- Sensitivity/Uncertainty Analysis of Model Inputs and Structure
- Tradeoff Analysis of Management Options
Habitat Suitability Mapping: Current and Future Vulnerabilities

- Approach: Comparison of several frameworks
  - Simple bathtub model rise
  - SLAMM (empirical relationships)
  - SERDP/FSU/Donoghue/Morey simulations with LIDAR

- Example: SLAMM v5 model (Clough, 2008) for selected shorebird habitats in California (Galbraith et al., 2002) and habitat change in Florida (Clough 2006)

(Source: Clough, 2006)
Objective: Evaluate future vulnerabilities for selected TER-S with respect to management alternatives and climatic conditions

- Future Habitat and Population Vulnerabilities as simulated by RAMAS
- Human Development Scenarios
- Revision of Base Management Alternatives and Success Criteria (with respect to SLR and Storm Frequency Scenarios)
- Effects of Uncertainty on Management Decisions

(Rahmstorf, 2007)
Discussion

• Summer 2009: database collection and documentation

• Fall 2009: Upcoming framework paper highlighting proof-of-concept of integrated tools

• Spring 2009: Vulnerability Assessment under present conditions

• Challenges
  • Scales and appropriate levels of habitat representation
  • Integration of tools
  • How does variability or uncertainty effect management decisions?
Questions?