**Landscape Conservation for Sea Level Rise Adaptation – A Regional Framework**

*A Case Study from the Structured Decision Making Workshop*

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# Decision Problem *(Bill, Andrew, Dorina)*

# *Decision [Ch. 2: Problem, Ch. 9: Linked Decisions] In one short paragraph, describe the decision in question. Include the context (who is the decision maker, under what authority do they act, who else has influence on the decision), the nature of the decision, and the timing and frequency of the decision.*

Structured decision making to address landscape conservation for sea level rise adaptation is based on the need to support allocation decisions in a regional context in the North Atlantic Landscape Conservation Cooperative (LCC) with an understanding of both the impact and uncertainty associated with sea level rise and storm impacts to coastal habitats. The decision maker is the LCC Steering Committee representing federal and state conservation agencies, tribes, non-governmental conservation organizations and universities in the North Atlantic LCC geographic area. These agencies operate under their own authorities but have agreed work through the LCC to set common goals, develop shared science capacity and work together to apply resulting science and tools to making conservation decisions. The specific decisions they are making related to sea level rise adaptation include where to invest how much of what resources to sustain ecological values of coastal habitats with an initial focus on beaches and tidal marshes. Specific options include managing and enhancing existing coastal habitats, restoring habitats to their former location and state and protecting adjacent uplands to allow for coastal habitats to migrate and adapt to sea level rise and storms. Decisions on allocating resources are generally made on an annual basis but may occur more frequently. The resulting decision problem developed by the team at the workshop was as follows: *optimize the allocation of conservation efforts in a spatially explicit manner in order to sustain ecological values of beaches and tidal marshes across the North Atlantic LCC in the face of storm impacts and sea level rise*.

# Background *(Bill, Andrew, Dorina)*

## Legal, regulatory, and political context

*Describe the relevant laws and regulations that necessitate and guide this decision, as well as the degree of stakeholder involvement.*

Although the actions that are the focus of the decision problem described above are primarily proactive land conservation decisions, a number of laws and regulations could affect these decisions. Actions that might impact federally-listed species such as the federally threatened piping plover that nest on beaches in the North Atlantic are subject to the Endangered Species Act. Federal, state and local permits may be needed for restoration and enhancement actions. There will likely be political issues associated with some decisions, particularly if there are trade-offs between sustaining ecological values of coastal habitats and maintaining or building new infrastructure. Planning and decisions will need to include federal, state and local stakeholders.

The North Atlantic LCC provides a forum for regional stakeholder involvement. The LCC Steering Committee has 34 formal members, including 14 agencies from northeast states and the District of Columbia, tribal representatives (initially through United South and Eastern Tribes), nine federal agencies, Canadian partners (initially through the Canadian Wildlife Service), and eight non-governmental organizations. The steering committee approved a governance document to guide the organization and function of the partnership. The steering committee meets in person at least twice a year and conducts at least two additional steering committee conference calls. There are a number of technical teams including a coastal team that recommended this Structured Decision Making case study. The LCC can develop consensus on the actions needed across the region for coastal adaptation to sea level rise.

## Ecological context

*Briefly describe the relevant ecological background.*

The North Atlantic LCC geographic area extends from southeastern Virginia north along the mid-Atlantic coast through New England to Nova Scotia and the Gaspe Peninsula of Quebec. The highly urban and suburban dominated landscapes of the southern part of the LCC coastal region support nearly one-quarter of the total U.S. population including large urban centers such as Washington, D.C., Philadelphia, New York City and Boston. Coastal habitats are among those most likely to be heavily impacted by sea level rise and increased storminess due to climate change, and with the level of human development along the coast of the North Atlantic LCC, these coastal habitats are threatened to be trapped between rising water levels and human infrastructure.

The North Atlantic LCC area encompasses a wide diversity of coastal ecosystems and habitat types, including large bays and estuary systems, beaches, coastal islands, salt marshes, rocky shoreline and major river systems. A number of fish, wildlife and plant species depend on these habitats such as piping plovers that nest and feed on beaches and salt marsh sparrows that nest in salt marshes. These coastal habitats also provide a variety of ecosystem services including flood abatement and carbon storage. Depending on a number of factors, these habitats may or may not be able to persist in place in the face of rising sea levels or may be able to migrate or reestablish at higher elevations. Scientists have developed and are developing many different models, tools, and visualizations that predict the level and impacts of sea level rise on coastal habitats and the species that use them.

**Decision Structure**

*Describe each of these well enough so it’s clear how they all fit together. Keep in mind this is a prototype structuring of the decision. Presumably, the elements will all be revisited and developed more fully as the prototype moves toward implementation.*

## Alternative actions (Kevin, Andrew)

## [Ch. 4: Alternatives]

## What are the alternatives the decision maker has to choose among?

The team considered a range of actions that related to managing, enhancing, restoring, protecting and changing policy related to marshes and beaches. This long list of potential actions was simplified and organized into a few basic categories related to whether the action was focused on existing coastal habitats in their current location or future habitats in different locations.

1. Acquire Existing Habitat

The goal of this alternative is to maintain integral, high-quality, well-connected patches of existing beach, tidal marsh and related habitats that are most likely to persist in the face of sea level rise and increased storms and to protect habitats of high regional concern or responsibility (e,g, the best example of a particular habitat type or species concentration area). Acquisition would protect these areas from development and other (non-climate related) impacts and would allow for their management to increase persistence and habitat quality for fish, wildlife and plants.

1. Manage Existing Habitat - Resiliency

For existing protected lands and those newly acquired; this alternative would manage, enhance and restore habitats to increase persistence in the face of sea level rise, storms and other impacts. Examples include water and sediment management, filling or manipulation of ditches, invasive species control and management of human uses.

1. Acquire New Habitat – Future Buffering

An alternative for areas where there are good opportunities to buffer and thereby increase persistence of existing beach or tidal marsh habitats is to acquire adjacent upland areas to help ensure that these buffer areas are maintained and also allow for migration of marshes and beaches into these areas where appropriate. These adjacent areas will likely need to be managed to increase the likelihood of migration and creation of new habitats.

1. Manage New Habitat - Transition

In order to buffer impacts and assist with migration and transition of marshes and beaches, there will be a need to manage lands adjacent to existing habitats to allow them to buffer existing habitats and to allow for easier transition to marsh and beach. Examples could include managing vegetation or changing the grade or elevation of adjacent lands.

## Objectives (Erika, Kevin Andrew)

## [Ch. 3: Objectives, Ch. 6: Tradeoffs, Ch. 8: Risk Tolerance]

*What are the objectives? Are there constraints? If there are multiple objectives, how are they weighed against each other? Try to be as explicit and quantitative as possible.*

## Objectives specific to this decision problem were established by the working group. Fundamental objectives constitute the core of the decision-making process; means objectives are additional steps directly linked to these fundamental components, i.e., how fundamental objectives will be achieved. In order to arrive at the fundamental objectives, a list of all possible objectives were collectively brainstormed by the group and evaluated both in terms of their importance to the decision-problem and classification (fundamental or means). Ultimately, three fundamental objectives were identified and defined as follows:

## **Ensure persistence of native habitats.** Habitat migration and changes are anticipated outcomes of rising sea level and storm impacts. Due to the spatial extent of the North Atlantic LCC, these impacts and the response of certain habitats to them are likely to vary across the region. For example, storm and/or sea level rise impacts may be less severe in some locales than in others. Additionally, the presence of physical barriers, whether naturally occurring (i.e. topography) or built (i.e. seawalls) may limit inland migration, a natural means of habitat adaptation. Of fundamental concern to the North Atlantic LCC is the regional preservation of native coastal habitats, whether through the protection of existing habitats or acquisition of areas further inland where habitat migration is likely to occur. Habitat patch metrics (which include such measures as: the size, shape, juxtaposition, connectivity, conservation status of the patch; presence or absence of hardened shoreline and land use of buffer lands; and coastal processes such as sediment transport and wetland accretion), provide an established and ecologically-vetted means of identifying important habitats through the region. Coupling such metrics with predictions of sea level rise and storm-driven impacts will help decision-makers to hone in on spatially-explicit locations where acquisition, allocation and/or preservation efforts should be focused.

## **Ensure persistence of native species.** The regional preservation of native wildlife species will be challenging under extreme sea level rise scenarios, particularly in areas where habitat migration is limited. The North Atlantic LCC has identified 12 surrogate species for beaches and tidal marshes that are a priority for regional protection. The assumption is that ensuring adequate preservation of these species will in turn preserve other species for whom habitat and resource needs are similar. Species persistence will be evaluated by the habitat suitability and/or anticipated change in occupancy of these species on a land parcel under a variety of sea level rise scenarios, and will be used to determine where regional resources are best distributed among habitats to ensure diversity and preservation.

## **Conserve ecosystem services.** Ecosystem services represent the use- or natural resources-value of a land parcel in the region. The often unaccounted for or unquantified loss of inherent habitat functions and consumptive/non-consumptive uses are important to spatially identify and prepare for under sea level rise scenarios. This way, existing or new parcels that may compensate for such losses can be targeted for management or acquisition allocation. Ecosystem services defined as particularly important to the North Atlantic LCC are: 1) flood abatement to adjacent built areas; 2) acres available for carbon storage (tidal wetlands); 3) non-consumptive uses such as wildlife observation and tourism; 4) consumptive uses such as hunting, fishing, and recreation.

## All three fundamental objectives in many ways complement one another and therefore are not mutually exclusive. For example, the preservation of native habitats will also support the preservation of native species and vice versa; similarly the conservation of ecosystems services will also serve to preserve native wildlife species and their habitats. Under the definition of this decision problem, however, the working group felt these three objectives were sufficiently distinct to list separately with the understanding that overlap among them does occur.

## Predictive model (Erika)

##  [Ch. 5: Consequences]

*What features are necessary in a model that will predict the consequences of each action in terms that are relevant to the objectives? Do such models exist? If not, what would it take to create them? Note that the purpose is to give a sense of what the model does; you do not need to describe it in excruciating detail.*

The working group recognized that two phases of a modeling effort may be necessary in this decision problem. The first will seek to provide regional and sub-regional predictions of coastal response to a range of sea level rise and storm vulnerability forecasts over several time steps. More specifically, storm vulnerability and sea level rise scenarios will be used to drive the model and determine where within the North Atlantic LCC region coastal areas are anticipated to inundate vs. dynamically respond to these drivers. Outputs from this modeling effort will be overlain with habitat information (patch metrics) to provide decision-makers with a regional overview of the current distribution of beach and marsh systems that may have the ability to migrate (dynamically respond) to such impacts. U.S. Geological Survey researchers at the Woods Hole Coastal and Marine Science Center will model sea level rise and storm impacts through a collaborative effort with the Northeast Climate Science Center, and results are expected in the spring of 2013.

Once sea level rise modeling outputs are made available, the definition of a process to evaluate the alternatives and their consequences (allocation of resources) will be important to ensure effective decision-making for the region. The extensive spatial and temporal nature of the decision problem means that a straightforward comparison of alternatives may be quite challenging. For example, is it more important for the North Atlantic LCC to allocate resources for the management and preservation of already protected lands within the region, or to acquire habitats that may provide potential for a dynamic response to climate change impacts? Should resources be focused on those areas most likely to dynamically respond in the future, regardless of location, or to ensure a broad regional distribution of preservation? Once decision-makers have been explicitly identified, a second level of modeling may be useful to more directly compare and weight alternatives and consequences against one another to ensure a reasonable and transparent course of action communicable to regional partners.

# Decision Analysis *(Tim, Matt)*

# *Describe methods for finding the solution to the problem, such as optimization, simulation, decision trees, Bayes nets, etc. Give a sense of the form of the solution (what does the answer look like?). Show preliminary results, if available, even if they’re just a caricature of the results. [This isn’t covered specifically in Smart Choices, but Chs. 6, 7, and 8 give a few examples of how this analysis can proceed. You’ll need to rely on the consultants for a larger view of this component.]*

# Uncertainty *(Adam)*

# *[Ch. 7: Uncertainty]*

*Are there aspects of the predictive model that are unknown or disputed? Can alternative models be used to express this uncertainty? Would sensitivity analysis provide a sense of how robust the decision is in the face of such uncertainty? If the decision is iterated over time, can an adaptive process, with appropriate monitoring, be put into place to reduce uncertainty and improve decision making over time?*

# Discussion *(Andrew, Dorina)*

## Value of decision structuring

*Does this decision structure provide an advantage to how the problem had been approached in the past? If so, what are the advantages?*

The decision structure helps to organize and focus the model development on key decisions that are needed to maintain the ecological values of beaches, marshes and other tidal habitats. It provides a stronger link between sea level rise models and information needed for conservation decisions.

## Further development required

*What needs to happen to this prototype next? What elements need to be developed further, and how should that development proceed? For example, does a stakeholder group need to be consulted to refine the objectives, and if so, how should that discussion occur? Does a more refined model need to be developed? Etc.*

The prototype needs significant further development in order to be useful. It is envisioned that further development will happen through the SDM team working with modelers at the USGS Coastal and Marine Geology Program and the modelers working at the University of Massachusetts Amherst on a modeling framework for the North Atlantic LCC. A list of next steps follows:

Higher Priority and/or Foundational:

1. *Set thresholds/measures for habitat patch metrics (across the board)*
2. *Select suite of species to use as surrogates for habitat suitability models relative to persistence of native species*
3. *Spatial resolution of habitat complex persistence (>30m)*
	* *Patch size min (e.g. 2ha)?*
4. *Refine spatial resolution of model*
5. *Build predictive sub-model of persistence of beach and marsh complexity*
6. *Time scale? (e.g. 2060?)*
7. *Link management actions to fundamental objectives via Erika’s model*
8. *Sort out how to predict /measure presence of invasive species – then how this might*
9. *Atmospheric deposition (of pollutants?) as additional stressor*
10. *Uncertainties: accretion rates, available lands to acquire*
11. *Nested decisions of sub-regional (and local?) within the regional allocation*
12. *Consider objectives for scale of pairs of subregions (e.g. N&S)*
13. *Adjacency to urban development*
14. *Factor in mosquito control*
15. *Consider cost issues*

Largely Done and/or Low Hanging Fruit:

1. *How to deal with human infrastructure issues?*
	1. *Intersection with conservation efforts?*
2. *Account for vulnerability*
3. *Define natural capital, ecosystem services, coastal habitat, conservation efforts,*
4. *Policy maker = one w/ ability to allocate resources*
5. *Consider ecoregions within N. Atlantic*
6. *Consider ecoregions within discrete SLR scenarios*
7. *Consider:*
	1. *Sub-tidal systems*
	2. *Maritime systems*
	3. *Alternative sub-regionalization*
	4. *Partial controllability*
8. *Revisit measures of fundamental objectives*

## Prototyping process

*How did you develop this framework and what lessons were learned? What wrong turns did you take, how did you straighten them out, what would you do differently next time? How did you avoid getting bogged down in the details? What were the different roles that people played?*

The group spent a fair amount of time on the problem statement and fundamental objectives and then used four states as sub regions for the first prototype. The simplification and refinement of the fundamental objectives and alternatives was critical for making progress in the second prototype. The real progress came as we began to visualize the decisions in flow charts and spatially. It was critical that we had a modeler as part of the team that is able to follow up on model development following the workshop.

# Recommendations *(Tim, Dorina)*

*In two paragraphs, summarize your recommendations for (1) how the decision should be structured; and (2) what steps need to be taken to develop and implement this structure.*

(from our final ppt)

* Complete initial report – six weeks (oops)
* Organize support team for ongoing modeling efforts
* Team to support modeling at USGS Woods Hole –
	+ Erika Lentz developing sea level rise spatial model to link with Decision Model
	+ Match model inputs and outputs – next month?
	+ Review initial spatial data outputs – January
* Explore options to link SLR model to allocation decision model and fully develop decision model?
* Incorporate models into overall LCC Decision Support Framework – next 12 months

# Literature Cited (all)

Hammond JS, Keeney RL, Raiffa H. 1999. Smart Choices: A Practical Guide to Making Better Life Decisions. Broadway Books, New York.

# Tables

# Figures

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