Analyzing the Role Coastal Habitat Plays in Storm Protection

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The Problem

Losses from Natural Hazards are Increasing
The Opportunity

Ecosystems Can Mitigate Losses

(Gedan et al. 2011)
Pilot Site: Freeport, TX

- Stratton Ridge
- Largest Undeveloped Parcel
- Plant B
- Oyster Creek
- Plant A
- Outside of levee system
- Brazoria National Wildlife Refuge
- San Bernard Wildlife Refuge
- Largest Undeveloped Parcel
Question

Can understanding how coastal habitats help protect Stratton Ridge from storms:

• improve levee design
• reduce costs from storms and storm protection especially in the face of sea level rise/ local subsidence?

Green and Gray Infrastructure Solutions:
Valuation for Corporate Coastal Hazard Mitigation

Local Subsidence
Climate Change
Development
Management Options

Green Infrastructure

Co-benefits

Natural Hazard Mitigation

Economic Costs and Benefits to Business and Public

Biodiversity

Gray Infrastructure
Scenarios for Cost-benefit Analysis

Advancements from Previous Modeling:
- Habitat (land cover)
- Sea level rise
- Waves

Sea Level Rise Changing Land Area

<table>
<thead>
<tr>
<th>Year</th>
<th>Current Sea Level Rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>2 m</td>
</tr>
<tr>
<td>2050</td>
<td>1.5 m</td>
</tr>
<tr>
<td>2075</td>
<td>1 m</td>
</tr>
<tr>
<td>2100</td>
<td>0.69 m</td>
</tr>
<tr>
<td></td>
<td>0.39 m</td>
</tr>
</tbody>
</table>

Land Cover: Dry Land (represent previous model assumption)

Coastal Habitat (represent current habitat)

Each land cover modeled with and without levees

Hurricanes (Category 1-5)

Waves

Surge

Changing Land Area

Advancements from Previous Modeling:
- Habitat (land cover)
- Sea level rise
- Waves

Each land cover modeled with and without levees
Methods: Approach

1. Model future land cover with sea level rise, development
2. Identify levee design for 100 yr storm
3. Analyze flood and damages from Cat 1-5 storms
4. Compare avoided damages
5. Assess other public and ecosystem benefits
6. Evaluate opportunities to enhance/protect values
Methods: Tool Box

Cost-Benefit Analysis

ArcGIS Analysis
FEMA Standards
Dow Levee Cost Model
InVEST Coastal Protection Model
InVEST Fisheries
InVEST Recreation, Recreational Values Database
InVEST Biodiversity
InVEST Carbon
Strategy costs

Hazard
Economic Damage Functions

Cost-Benefit Analysis
Results: Coastal Habitat Will Decrease with Sea Level Rise

- Current-2050, 0.57 m sea level rise
- Current-2100

<table>
<thead>
<tr>
<th></th>
<th>Development</th>
<th>Un-Protective Habitat</th>
<th>Protective Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current-2050</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current-2100</td>
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</tbody>
</table>
Results: Habitat Reduces Flood Heights and Levee Costs

Habitat Impacts:
- Lower flood height
- Lower levee costs

⇒ Small cost savings

Sea level rise:
- Higher flood height
- Higher levee costs

⇒ Medium/large additional costs

(Note: Calculations are very conservative because they use average values and do not consider effect on surge/)

Flood Height = surge + wave + sea level rise - elevation
Results: Habitats Reduce Expected Costs

Levee is built to protect against 100 year storm in 2050

Avoided Costs due to Habitat

Components of avoided costs:
• avoided property damages
• avoided business interruption
• levee construction costs

⇒ Small avoided costs

(Note: Calculations are very conservative because they use average values and do not consider effect on surge/)

Levee is built to protect against 100 year storm in 2050
## Results: Coastal Habitats Provide Large Public Benefits

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided storm damages to community</td>
<td>Present Value: $23 million</td>
</tr>
<tr>
<td>Carbon Sequestration</td>
<td>Present Value (to 2025): $30 million</td>
</tr>
<tr>
<td>Recreation</td>
<td>Present Value: $130 million</td>
</tr>
<tr>
<td>Fisheries</td>
<td>12 fisheries species have enhanced catch due to marsh</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>$&gt;300 bird species depend on coastal habitat</td>
</tr>
</tbody>
</table>
Potential Option: Restoration

Identify lands:
- Greatest potential increase in surface roughness
- Least cost
- Greatest revenue potential
- Public/ecosystem benefits

Costs/Benefits Habitat Restoration

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Relative PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Storm Damages</td>
<td>+ +</td>
</tr>
<tr>
<td>Wetland credits</td>
<td>+ + + +</td>
</tr>
<tr>
<td>Public</td>
<td>+ + ++</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>+ + + +</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restoration Costs</td>
</tr>
<tr>
<td>Lost Grazing Revenue</td>
</tr>
<tr>
<td>Transaction Costs</td>
</tr>
<tr>
<td>NPV (private) (+public)</td>
</tr>
</tbody>
</table>

Grazing Land  Coastal Habitat

=> Increases surface roughness by 50-150%
Business Impact

Pilot Site:
• Minimal impact to current decisions
• Enhanced risk modeling
• Potential for wetland banking

General:
• Improved understanding:
  – effects of habitats, sea-level rise
  – value of restoring/protecting coastal habitat
• Transferable methods

(Images courtesy of Dow)
Conservation Impact

- Breaking new ground for **science**
- Developing **new methods** with business and industry-standard catastrophe modelers
- Building **awareness** of value
- Identifying **potential win-win for business & conservation:**
  - Wetland mitigation banking
  - Oyster restoration
  - Synergies with regional initiatives
    - National Wildlife Refuge looking for properties for marsh migration
    - Lonestar Coastal Natural Recreation Area (LSCNRA) proposal
Future Challenges

Science
• Effect of habitats on surge
• Incorporating effects of various habitat types
• Marsh response to sea level rise
• Dynamic behavior of property owners
• Difficult to test empirically

Implementation
• Missing information
• Not yet a best available technology option
• Need large habitat areas for protection

Policy & Economic Incentives
• Benefits are avoided costs not increased cash flow
• No policies directly enhance incentives for green infrastructure

Proposal: Standards to Plan for Natural & Built Capital Maintenance
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