The Cost of Ensuring Salt Marsh Migration Under Sea Level Rise

A Property Value Model to Ensure Ecosystem Service Conservation

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Estimating Preservation Cost

• Planning for salt marsh ecosystem service preservation via land purchases requires information on the expected benefit and cost of acquisition.

• The use of simpler cost measures are often poor predictors of the actual acquisition cost.

• This presentation illustrates a novel hedonic model designed to forecast the cost of preserving land to ensure the provision of salt marsh related ecosystem services.

• Hedonic property value models predict the price of land purchases as a function of parcel and area attributes.
Research Objectives

• This research focuses on coastal land conservation for salt marsh migration, and:
  • Develops a hedonic model of vacant land prices, emphasizing land attributes that affect marsh migration suitability.
  • Model identifies opportunities for cost effective marsh conservation via implicit price estimates.
  • Demonstrates how simpler measures of land cost lead to poor estimates.
Importance of Salt Marsh & Transgression Zones

• Salt marsh habitats provide many valuable ecosystem services.
  • Erosion control, flood defense, water purification, & habitat for aquatic species.

• However, these habitats are likely to shrink over time due to:
  • Rapidly rising sea levels as a result of global warming.
  • The armoring of land from unwanted salt marsh encroachment

• Marsh sustainability often requires the conservation of transgression zones (land suitable for landward marsh migration as seas rise)
The Hedonic Model

• This model is designed to incorporate characteristics relevant to salt marsh migration.

• \( P = P(N, C, M) \)
  
  • \( N \) = neighborhood characteristics (e.g., distance to CBD, distance to closest park)
  
  • \( C \) = all other characteristics unrelated to marsh migration suitability (e.g., airport zoning)
  
  • \( M = (Coastal Distance, Elevation, Land Cover) \)
The Data and Site Selection

• Data was collected from sales of vacant land in Accomack County and Northampton County between January 2014 and June 2017.

• This data was coupled with information relating to the parcel’s geospatial environment.
  • Land cover information was taken from the National Land Cover Database.
  • Elevation information was taken from the U.S. Geological Survey.
# Selective Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adj. Price Per Acre</td>
<td>Price per acre adjusted to 2017$</td>
<td>309.8</td>
<td>87542</td>
<td>5113</td>
<td>7818</td>
</tr>
<tr>
<td>Acreage</td>
<td>Parcel size measured in acres</td>
<td>5</td>
<td>326.5</td>
<td>40.08</td>
<td>50.01</td>
</tr>
<tr>
<td>Forestland</td>
<td>Percentage of parcel classified as forestland</td>
<td>0</td>
<td>100</td>
<td>38.56</td>
<td>34.04</td>
</tr>
<tr>
<td>Wetland</td>
<td>Percentage of parcel classified as wetland</td>
<td>0</td>
<td>96.63</td>
<td>7.316</td>
<td>17.83</td>
</tr>
<tr>
<td>Farmland</td>
<td>Percentage of parcel classified as farmland</td>
<td>0</td>
<td>100</td>
<td>50.34</td>
<td>36.48</td>
</tr>
<tr>
<td>Elevation</td>
<td>The midpoint between the highest and lowest elevation points on the parcel measured in meters</td>
<td>0.100</td>
<td>15.40</td>
<td>6.562</td>
<td>4.419</td>
</tr>
<tr>
<td>Coastal Distance</td>
<td>Distance of the parcel to the coast measured in meters</td>
<td>29</td>
<td>5437</td>
<td>1504</td>
<td>1246</td>
</tr>
</tbody>
</table>
### Hedonic Model Results

**Dependent Variable = Natural Logarithm of Adjusted Sales Price**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient (S.E.)</th>
<th>Variables</th>
<th>Coefficient (S.E.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestland</td>
<td>-0.0448*** (0.0158)</td>
<td>Developed Open Space</td>
<td>-0.0691*** (0.0201)</td>
</tr>
<tr>
<td>Wetland</td>
<td>-0.0509*** (0.0162)</td>
<td>Log(Elevation)</td>
<td>0.309** (0.133)</td>
</tr>
<tr>
<td>Farmland</td>
<td>-0.0410*** (0.0157)</td>
<td>Log(Coastal Distance)</td>
<td>-0.174** (0.0866)</td>
</tr>
<tr>
<td>Barren Land</td>
<td>-0.0447** (0.0173)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| $N$             | 223                | $R^2$           | 0.633              |

* $** p < 0.05$, $*** p < 0.01$

- These results control for other neighborhood and environmental characteristics (location, zoning, proximity to the highway), not shown above.
Implicit Price Results

<table>
<thead>
<tr>
<th>Implicit Price Using Mean Values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>$3,605/m</td>
</tr>
<tr>
<td>Distance to Coast</td>
<td>-$9/m</td>
</tr>
</tbody>
</table>

• The implicit price for elevation is interpreted as the extra cost to an average parcel for an additional meter of elevation.
• The implicit price for distance to the coast is interpreted as the reduced cost to an average parcel when located an additional meter further from the coast.
### Cost Prediction Comparisons

<table>
<thead>
<tr>
<th>Coastal Distance (meters)</th>
<th>250</th>
<th>200</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted Forest Cost</td>
<td>$2,739/acre</td>
<td>$2,847/acre</td>
<td>$3,211/acre</td>
</tr>
<tr>
<td>% Error w. All Vacant</td>
<td>87%</td>
<td>80%</td>
<td>59%</td>
</tr>
<tr>
<td>% Error w. Coastal Vacant</td>
<td>116%</td>
<td>108%</td>
<td>84%</td>
</tr>
<tr>
<td>% Error w. Mostly Forest</td>
<td>34%</td>
<td>29%</td>
<td>14%</td>
</tr>
</tbody>
</table>

*Elevation = 0.58 meters*

- The top row shows the model predicted cost per acre of preserving coastal forestland suitable for marsh migration under an optimistic SLR scenario by 2100.
- ‘All Vacant’ is the mean cost per acre of all vacant land.
- ‘Coastal Vacant’ is the mean cost per acre of vacant land within 1 km of the coast.
- ‘Mostly Forest’ is the mean cost per acre of vacant land with at least 75% forest cover.
Leave-one-Out Prediction Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Model Prediction</th>
<th>All Vacant Land</th>
<th>All Coastal Vacant Land</th>
<th>Mostly Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Abs. % Error</td>
<td>174%</td>
<td>952%</td>
<td>895%</td>
<td>362%</td>
</tr>
<tr>
<td>Standard Dev.</td>
<td>236%</td>
<td>1993%</td>
<td>1881%</td>
<td>838%</td>
</tr>
<tr>
<td>Min. Abs. % Error</td>
<td>1%</td>
<td>19%</td>
<td>24%</td>
<td>13%</td>
</tr>
<tr>
<td>Max. Abs. % Error</td>
<td>908%</td>
<td>9624%</td>
<td>9083%</td>
<td>4029%</td>
</tr>
</tbody>
</table>

- The analysis is based on predictions in the cost of parcels suitable for marsh migration.
- Suitability was based on:
  - The parcel being within 100 meters of current salt marsh habitats.
  - The parcel having an elevation of at most 2 meters.
- Results show the relative gains in accuracy when using a predictive model of cost that incorporates salt marsh migration suitability criterion.
Conclusion

• Some features related to marsh migration suitability are associated with price premiums (closer coastal proximity) while other features are associated with price discounts (lower elevation).
  • Land type (forest vs. farm) is also an influential factor in marsh migration and conservation cost.

• Simulations show significant errors in conservation cost predictions with the use of simpler measures.

• Accurate predictions in the cost of land purchases for the conservation of salt marsh ecosystem services requires cost information related to marsh migration suitability.
Questions?

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