What Does it Cost to Ensure Salt Marsh Migration?
Using Hedonic Modeling to Inform Cost-Effective Conservation

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Abstract

The preservation of salt marshes under rapid sea-level rise (SLR) requires the conservation of marsh transgression zones—undeveloped uplands onto which marshes can migrate. Optimal planning for conservation of this type requires information on the expected benefit of marsh conservation and the cost of land suitable for marsh migration in particular areas. While information is available on marsh benefits within the literature, prior research provides little insight on associated land conservation costs. The coastal hedonic pricing literature focuses primarily on developed land, and there are no models designed to predict the cost of conserving land suitable for marsh migration. This paper develops a unique hedonic property value model to predict cost and explore price patterns associated with purchases of undeveloped land suitable for salt marsh migration under SLR. The model is illustrated using a case study from the Eastern Shore of Virginia, with a dataset consisting of open-market sales of undeveloped land from 2014-2017. Particular attention is paid to characteristics that determine marsh migration potential such as coastal distance, elevation and connectivity. Results demonstrate the insight for conservation planning that can be provided by models of this type and the errors associated with the use of simplified proxies to predict conservation costs of land suitable for marsh migration.

Keywords: coastal adaptation; conservation; salt marsh; sea-level rise; salt marsh migration; transgression

JEL Codes: Q24, Q28, Q51, Q57

1. Introduction

The sustainability of dynamic coastal systems such as salt marshes depends on their capacity to adapt to climate-related changes such as rapid sea-level rise (SLR) (Duran et al., 2019; Gopalakrishnan et al., 2017). Salt marshes are regularly flooded intertidal habitats that provide multiple, highly valued ecological functions (Carr et al., 2018; Johnston et al., 2002a; Johnston et al., 2002b; Vernberg, 1993; Zedler and Kercher, 2005). The value of these systems is well established and has been recognized as one of the primary motivations for coastal adaptation and management (Barbier et al., 2013; Barbier et al., 2011; Bauer et al. 2004; Gopalakrishnan et al., 2017; Interis and Petrolia, 2016; Johnston et al., 2002a; Johnston et al., 2002b; Johnston et al., 2005; Milon and Scrogin, 2006; Petrolia et al., 2014; Saleh and Weinstein, 2016). Until recently, salt marshes at a global scale have been largely resilient to changes in sea level due to natural adjustments in elevation via vegetation growth and sediment accretion, and by migrating landward as sea levels rise (Kirwan et al., 2010; Kirwan et al., 2016a). However, there is now increasing concern about salt marsh loss given the accelerated and uncertain rise in sea level (Craft et al., 2009; McFadden et al., 2007), and concomitant calls for urgent action to preserve these valued ecosystems (Runting et al., 2017). There are many examples of public and private agencies investing in salt marsh conservation, for example as a natural and cost-effective means of coastal flood protection (Gedan et al., 2009; Temmerman et al., 2013; Zedler and Kercher, 2005).

Purchases of land for conservation purposes often occur opportunistically, based on land parcels that become available at any given time (Margules and Pressey, 2000). The inability of such behavior to meet optimal preservation goals (e.g., minimizing costs, maximizing net benefits for a given conservation goal, etc.) is well established (Ando et al. 1998; Armsworth et al., 2006; Babcock et al., 1997; Carwardine et al., 2008; Cronan et al., 2010). However, systematic planning for any type of optimal or cost-effective land preservation requires information that is often unavailable to decision-makers, including information on the expected costs and benefits of different types of conservation in different areas (Ando and Mallory, 2012; Carwardine et al., 2010; Costello and Polasky, 2004; Duke et al. 2014; Ferraro, 2003; Knight et al., 2011; Meir et al., 2004; Murdoch et al., 2007; Naidoo et al., 2006; Newburn et al., 2006). The costs and benefits of conservation land suitable for particular purposes often varies substantially—even within relatively small planning areas—and depend on a variety of factors (Albers et al., 2008; Ando and Mallory, 2012; Carwardine et al., 2010; Johnston et al., 2001; Naidoo et al., 2006; Polasky et al., 2001; Wallace et al., 2008). For planning purposes, moreover, decision-makers must have the capacity to forecast or estimate these costs and benefits moving forward, over parcels that are or might become available for future conservation purposes (e.g., via fee-simple purchases) in the target area.

The economics literature provides many estimates of non-market values that can be adapted in various ways to forecast salt marsh conservation benefits (Barbier et al., 2011; Brander et al., 2012; Ghermandi et al., 2010; Moeltner et al., 2019), and benefit transfer methods necessary to apply these estimates to new marsh conservation sites have been studied extensively (Johnston et al., 2015; Johnston et al., 2018). However, parallel predictive information is often missing for land conservation costs—and particularly for the cost of land suitable for specialized conservation goals. For example, to the knowledge of the authors, there are no published models designed to forecast the cost of land preservation of the type required to enable salt marsh migration, and hence that include variables and specifications designed for that purpose.

This paucity of predictive capacity for conservation costs is perhaps ironic—as land transaction prices may be easily observed in markets, whereas salt marsh benefits cannot be observed directly. Nonetheless, despite a mature hedonic pricing literature evaluating patterns in property values for developed residential parcels associated with various types of environmental changes (e.g., Bateman et al., 2001; Gopalakrishnan et al., 2011; Leggett and Bockstael, 2000; Lewis and Landry 2017; Netusil et al. 2014; Parsons and Powell, 2001; Smith and Huang, 1995), there is relatively little published information in the economics literature on systematic property value patterns related to the type of raw or undeveloped land that is targeted for most types of conservation activity—parcels *without* structures. Although some published findings regarding developed property prices likely apply to undeveloped land, others may not, leading to uncertainty regarding price patterns in the undeveloped land market. Similarly, mean prices for undeveloped land (e.g., from real estate sales databases) are often poor indications of the costs faced by conservation decision-makers seeking to purchase particular types of land in specific locations—for example land with the characteristics necessary for marsh transgression or other targeted conservation purposes.

Responding to this lack of information in the literature, this paper develops the first hedonic model of undeveloped land prices in the coastal zone that emphasizes land attributes relevant to salt marsh migration. The goal is a model able to forecast the cost (or market price) of fee-simple purchase and preservation of land suitable for salt marsh conservation under sea-level rise. Models of this type can serve multiple purposes for marsh conservation planning, such as (a) identifying the anticipated cost of purchasing land able to support marsh migration under alternative sea level rise scenarios (Duran et al., 2019), and (b) providing information necessary to plan for cost-effective marsh migration.

Unlike prior work in the "public hedonic" literature which analyzes transactions solely from particular conservation buyers (Loomis et al., 2004), and some other property value studies that use property appraisal data, here we develop an original hedonic price model using data on undeveloped land sales from all open market transactions. Data of this type are ideal for predicting the price of undeveloped land purchased on the open market, because they avoid potential selection biases that can be caused by restricting transactions to those made by conservation buyers alone,[1] along with potential inaccuracies associated with the use of appraisal data (which are approximations of actual sales prices, at best). The result is a more accurate perspective on prices paid for undeveloped land across the entire market, and hence what conservation organizations would spend for fee-simple, arms-length purchase and preservation of conservation land. Variables are specified to reflect the key land attributes relevant to marsh migration, such as elevation, connectivity, proximity to the coast, presence of wetland on the parcel, and land cover type, along with other variables expected to influence the market demand for undeveloped parcels.

The model is illustrated using a case study from the southern tip of Virginia's Eastern Shore (Accomack and Northampton Counties), drawing from an original, comprehensive dataset of undeveloped land purchases from 2014-2017.[2] Results demonstrate how models of this type can help predict the cost of land conservation purchases suitable for marsh migration, and characterize opportunities for more efficient marsh conservation via cost-effective land

[1] Purchases by conservation organizations are often guided by systematic land selection processes designed to meet internal objectives and are not always at arms-length, and hence do not provide a truly representative sample of undeveloped land sales across the market. The resulting selection biases in the data (Heckman 1979) can lead to misguided statistical inferences regarding the future cost of fee-simple, arms-length purchase and preservation of undeveloped conservation land.

[2] This case study area was chosen, in part, because of the relative importance of salt marsh migration as a motivation for local land preservation. The Virginia Coast. Manage. Program works in collaboration with The Nature Conservancy, the Virginia Department of Conservation and Recreation, Virginia Department of Game and Inland Fisheries, and the U.S. Fish and Wildlife Service to acquire coastal lands on the southern tip of the Eastern Shore, with salt marsh persistence as a primary goal. The Nature Conservancy owns 14 of the 18 barrier and marsh islands off of Virginia's Eastern Shore, and most of the Atlantic Ocean coastline which the Virginia Coast Reserve protects and manages through land acquisitions (McGowan, 2017).

purchases. For example, model results suggest that some attributes necessary for marsh migration (e.g., shorter distances to the coast) are associated with higher land prices, as expected, while others (e.g., lower elevation) are associated with lower property prices. Results such as these can be used to identify opportunities for improved targeting of land conservation based on the co-occurrence of features with high conservation value and low (or negative) effects on market price. Although illustrated for a specific case study, similar methods could be applied to predict the cost of undeveloped land suitable for salt marsh migration in other areas. From a general perspective, the model also demonstrates the potential insight that can be provided by hedonic property value models that focus on undeveloped land, in contrast to the overwhelming focus of the current hedonic literature on developed residential properties.

The paper proceeds as follows. In section 2, we begin with a general introduction to marsh conservation and the potential insights that may be drawn from models that predict land conservation costs. As part of this discussion, we review the prior literature that models prices for undeveloped land. In section 3, this is followed by a description of the hedonic model specification and data. Finally, in section 4, we then present model results and discuss implications for coastal marsh conservation.

2. Predicting land cost for salt marsh migration

Human activities have led to large losses of salt marsh habitats over time, with approximately 50 percent of historical salt marshes lost or degraded worldwide (Barbier et al., 2011). Further marsh losses due to sea level rise are expected, with some regional analyses forecasting an additional 20 to 45 percent marsh loss by 2100 (Ashton et al., 2008; Kirwan and Megonigal, 2013). The widely recognized value and vulnerability of salt marshes has led to worldwide efforts to ensure the future persistence of these systems (Bromberg and Bertness, 2005; Durey et al., 2012; Gedan et al., 2009; Kirwan and Megonigal, 2013; Temmerman et al., 2013; Thorne et al., 2012; Zedler and Kercher, 2005). Given limits in the extent to which marshes can build elevation naturally (and hence keep up with sea level rise in a single location), many of these actions have emphasized the purchase and preservation of marsh transgression zones (Kirwan and Megonigal, 2013; Kirwan et al., 2016a).

The preservation of undeveloped land near coastal regions, however, does not guarantee marsh migration. The extent to which these preserved upland transgression zones will eventually become marshland depends on features of the land that influence marsh migration potential. Many land characteristics influence marsh migration and persistence, including location (e.g., proximity to coastlines, marshes), elevation, connectivity[3], and land cover, among others (Donnelly and Bertness, 2001; Kirwan and Megonigal, 2013; Pethick, 2001; Temmerman et al., 2013). For example, locations with low elevation, and high tidal inundation frequency and duration, reduce the chances of marsh migration (Temmerman et al., 2013). In contrast, locations with greater connectivity between salt marshes, subtidal ecosystems, and adjacent terrestrial ecosystems, increase the chance that marsh vegetation will emerge (Kirwan et al., 2016b).

In addition, land preservation is not always necessary to promote marsh migration. Preservation is only required in cases where private landowners are expected to take actions to prevent unpreserved land from becoming marsh (e.g., through armoring, sediment deposition to increase elevation, etc.). If private landowners do not take such actions—thereby allowing marsh migration into unpreserved land—then migration can occur with no land preservation. This issue relates to the concept of additionality, or whether the environmental outcomes provided by a

[3] Connectivity is about the degree of movement of organisms or processes (e.g., soil, fire, wind, water, plants, animals) where more movement implies more connectivity, and it is scale, species, and process dependent (Crooks and Sanjayan, 2006).

policy intervention would have been provided in the absence of that intervention (Pattanayak et al., 2010). This is particularly relevant for marsh migration where the probability of armoring land to prevent marsh migration may vary across different types of land, such as farm versus forest (Duran et al., 2019).

Considerations such as these imply that only a small proportion of undeveloped land in any coastal region will be of high value for marsh conservation purposes—or promoting marsh migration. Land with different characteristics will have different value to conservationists seeking to ensure marsh migration—considering both the probability that marsh will migrate onto particular areas in the future and the probability that private landowners might (in the absence of preservation) prevent marsh migration from occurring. Yet while there are many published biophysical models that can be used to predict the probability that marshes will migrate onto particular areas of coastal land as a function of specific land characteristics,[4] there are (to the knowledge of the authors) no existing models that enable conservationists to predict the cost of purchasing land suitable for marsh migration, as influenced by the same characteristics. In the absence of such systematic information, any planning for marsh conservation must rely on information that is unlikely to provide accurate insight into the future cost of land purchases.

The importance of understanding land price patterns is magnified by the fact that land attributes that are highly valued in conservation land may (or may not) be correlated with higher land prices. In general, one would expect undeveloped land prices to be influenced most heavily by market forces related to future development – often the value of land for potential residential development (e.g., Cunningham, 2006; Geoghegan, 2002; Heimlich and Anderson, 2001;

[4] See, for example, (Donnelly and Bertness, 2001; Fagherazzi et al., 2013; Gedan et al., 2009; Kennish, 2001; Kirwan et al., 2016a; Osland et al., 2016; Pethick, 2001; Stralberg et al., 2011).

Machado et al., 2006; Nordman, 2007; Papka, 2006; Plantinga and Miller, 2001). The attributes associated with land that have high potential development value, however, are not necessarily the same attributes associated with land that has high conservation value. A more formal understanding of price patterns observed in the undeveloped land market could enable conservationists to identify opportunities wherein features that are highly valued for conservation purposes are negatively related (or unrelated) to the market price of land (i.e., have a negative or insignificant implicit price)—enabling land purchases to obtain greater "bang for the buck" in terms of conservation benefits per dollar spent (Ando et al. 1998). This is particularly important in areas where development pressures are high, leading to higher costs per acre for conservation purchases in general (Armsworth et al., 2006; Claggett et al., 2004).

Although there is some work that seeks to model the price of undeveloped land purchase and preservation, this work provides minimal insight into land purchases for marsh migration. Published hedonic models used to forecast prices for undeveloped or conservation land have been primarily targeted at agricultural land (Larkin et al., 2005; Lynch and Lovell, 2002; Papka, 2006) or purchases already made by public conservation organizations (Larkin et al., 2005; Loomis et al., 2004; Lynch and Lovell, 2002; Nordman, 2007; Papka, 2006). Hedonic price analyses of open-space lands have been conducted using data from land sales (Larkin et al., 2005), easement payments for development rights (Lynch and Lovell, 2002; Nordman, 2007; Papka, 2006), or both (Loomis et al., 2004).[5] Most of this literature reflects the "public hedonic" approach of Loomis et al. (2004). Other examples include Nordman (2007), Larkin et al. (2005) and Papka (2006). These models are distinguished by a focus only on parcels purchased or eased by particular public or private organizations—that is, the models only address patterns in prices

[5] In addition, some analyses of optimal preservation targeting include supporting models of land preservation costs, although model details are often missing from published documents (Ando and Mallory, 2012; Babcock et al., 1997; Duke et al., 2014; Mallory and Ando, 2014; Polasky et al., 2001).

for land *already* purchased for preservation.[6]

Although models such as these can provide relevant information for some types of policy decisions (e.g., for agricultural preservation activity), they are of limited use when seeking to predict the future market cost of land purchases for other types of conservation. For example, hedonic models of agricultural land prices provide no direct insight into the types of non-agricultural land frequently targeted by conservation organizations. Price forecasts of "public hedonic" models, in contrast, are confounded by the prior parcel selection processes applied by the studied public conservation organizations, and hence may provide biased forecasts of general market price patterns encountered by conservationists in general. Specific to the current application, there are no models designed to quantify variations in undeveloped land prices associated with attributes relevant to salt marsh migration. In the absence of such estimates, conservation decision-makers must rely on less formal and systematic means to forecast future land conservation costs.

3. A hedonic model of undeveloped land prices

The theory and practice of hedonic modeling is grounded in decades of work, with seminal work such as that of Rosen (1974). As methods for these models are the subject of a mature literature (Taylor, 2017), we summarize only essential elements here. We emphasize, however, that the primary purpose of the illustrated model is *prediction* of parcel purchase prices under alternative circumstances, not hypothesis testing or welfare analysis. This distinguishes the model from

[6] As such, these models are well suited to characterizing preservation priorities revealed by the past land preservation activities of conservation organizations. However, because these models are limited to the analysis of purchases made by specific conservation organizations, the results cannot be used to forecast future market prices of undeveloped land in general. For example, in the present study area, past conservation by the Nature Conservancy and other organizations has been guided by multiple priorities beyond marsh migration, such as the protection of particular types of bird habitat (Bruce and Crichton 2014). The resulting purchases do not provide a representative perspective on the cost of preserving land for other purposes, including marsh migration.

common hedonic pricing models that emphasize the latter two goals. Although the structure of the underlying model is analogous, the focus on prediction implies a different emphasis in model specification and interpretation of econometric results.[7]

Within the standard hedonic property value model, land is differentiated by its characteristics which determine market price through interactions of buyers and sellers (Freeman et al., 2014). This relationship can be represented in simple, stylized form as:

$$P_h = P(z_{1h}, z_{2h}, \dots, z_{nh}) \tag{1}$$

where P_h is the sale price of undeveloped parcel h, and z_{ih} is the level of characteristic i related to the parcel. The characteristics commonly included in hedonic studies of land price include neighborhood characteristics (e.g., accessibility to the central business district, accessibility to parks), and environmental characteristics (e.g., land cover, whether the property is waterfront). Unlike hedonic price models based on residential housing sales, structural/housing characteristics are not included in undeveloped land models (because there are no structures).

A coastal hedonic model of land for salt marsh conservation includes environmental characteristics that influence marsh migration suitability. These include features such as coastal distance, elevation, the presence of wetland, land cover, and connectivity. All else equal, marsh migration is more likely with shorter coastal distances, lower elevation levels,[8] a larger presence of wetland, and higher levels of connectivity (e.g., being near larger amounts of forestland). Although these features may or may not influence land price in a systematic way, they are directly relevant to the types of purchases that would be made for marsh conservation. Hence, any systematic responsiveness of land purchase prices to these attributes will be relevant when

[7] Boyle and Wooldridge (2018) provide a detailed discussion of this issue within the context of meta-analysis.
[8] The suitability of land for marsh migration depends on elevation relative to sea level, among other factors. In general, lower land elevations are better suited to marsh migration, but only up to a certain threshold at which marshes "drown" (Duran et al. 2019).

seeking to predict the price of land suitable for future salt marsh migration. Simply put, because the primary objective is to predict the cost of land with characteristics required for future marsh migration, it is necessary to include those characteristics in the model.

In addition, the model recognizes that most purchases of (and demand for) undeveloped land will *not* be made for conservation purposes, but rather for development purposes. As such, the model also includes variables of the type included in traditional hedonic models of coastal residential land prices (excluding variables describing built structures), such as distances to highways (Atreya et al., 2016; Bin et al., 2008).

The resulting model can be represented in simple form as:

$$P_h = P(N_h,\ C_h,\ M_h) \tag{2}$$

where N_h is a vector of neighborhood characteristics, C_h is a vector of other characteristics unrelated to marsh migration suitability (e.g., acreage, overlay and base zoning, etc.) but nonetheless relevant to parcel demand, and M_h is a vector of marshland suitability characteristics including features such as coastal distance, elevation, presence of wetland, and ecological connectivity (e.g., to existing salt marsh habitat). Here, the focus of the analysis is placed on the marginal implicit prices of characteristics related to marsh migration suitability, with the goal of predicting the cost of land suitable for marsh migration under sea-level rise. These implicit prices reflect the marginal effect of land characteristics on prices paid for that land in the study area.

Although we expect some of the variables in vector M_h to influence land prices, we expect others to have no discernible impact. This is because there is no intuitive reason for (some types of) variables influencing suitability for marsh migration to have major impacts on the prices of undeveloped land sold primarily for residential development purposes. However, given the emphasis of the model on land cost prediction (rather than hypothesis testing, per se), possible reductions in model efficiency due to the inclusion of potentially irrelevant variables (e.g., due to multicollinearity) is not a primary concern.

Various econometric specifications are used for contemporary hedonic modeling, and theory provides no unequivocal guidance as to the structure of these functions (Cropper et al., 1988; Taylor, 2017). Hence, specifications are generally chosen based on anticipated properties of the price function within specific applications, together with empirical performance of the model on available data. Nonlinear functions are generally preferred, as linear price functions imply unrealistic properties for most applications (Taylor, 2017).

Here, we apply a double-log functional specification of (2),

$$\ln(P_h) = \beta_0 + \beta_{N1}\ln(N_{1h}) + \beta_{N2}N_{2h} + \beta_{C1}\ln(C_{1h}) + \beta_{C2}C_{2h} + \beta_{M1}\ln(M_{1h}) + \beta_{M2}M_{2h} + \varepsilon_h \,, \quad (3)$$

where the subscript 1 denotes variables within vectors N_h, C_h, and M_h measured in continuous form (along with associated parameters), subscript 2 denotes similar variables measured in discrete or categorical form, and ε_h is an independent random error term related to undeveloped parcel h. Simply put, independent variables are included as natural logs for non-categorical continuous variables, and linearly for discrete and categorical variables. The latter two categories include a set of spatial and temporal covariates expected to influence the sales price of undeveloped land, including the proportion of different land cover types on each parcel (e.g., agricultural, forest). The properties of such functions and the resulting implicit prices are well-known (Johnston et al., 2001; Taylor, 2017). Specifications of this type are common in the hedonic pricing literature, given advantages that include the capacity to accommodate positive or negative nonlinear price effects and the implicit constraint that land price is zero when parcel size is zero. They can also accommodate zero values for discrete and categorical variables without the need of for ad hoc adjustments. Finally, non-linear forms such as this also have the advantage of performing well in terms of approximating the true underlying implicit prices in the face of omitted variable bias (Cropper et al., 1988).

4. Data and empirical model

Data for the analysis were drawn from Accomack and Northampton Counties, two counties on Virginia's Eastern Shore. These counties were selected because of their proximity to the Virginia Coast Reserve Long-Term Ecological Research, and due to the substantial wetland and salt marsh conservation activity by both governmental institutions and NGOs (e.g., The Virginia Land Conservation Foundation, The Nature Conservancy, Virginia Eastern Shore Land Trust, and The Chesapeake Bay Foundation) in the area (Duran et al., 2019).

The data were constructed from a comprehensive, original database including all sales of undeveloped land in the two counties between January 2014 and June 2017, inclusive. The original property sales information included data such as the sales date, sale price, seller and buyer information, county location and tax map identification numbers. These data were supplemented using information from multiple sources, including the Accomack 2016 Biennial Assessment, Accomack and Northampton Counties' GIS[9] data layers, and the Virginia Tax Parcels Map Service.[10]

The data were screened in several ways to ensure that they include only arms-length sales at true market values, were not affected by "package deals" in which multiple parcels are sold together, and only cover the type of parcels of sufficient size for conservation purposes. Screening of this type is ubiquitous in hedonic modeling to avoid bias due to the inclusion of

[9] http://gis.vgsi.com/northamptonva/, http://northampton.mapsdirect.net/Account/Logon#, http://accomack.mapsdirect.net/Account/Logon

[10] https://vgin.maps.arcgis.com/home/index.html

parcels not sold at regular market prices or that are not relevant for the model to be estimated.[11] Specifically, (1) vacancy was verified by checking for a zero-improvement value, (2) buyer and seller information was verified to eliminate sales that were not at arms-length (avoiding the inclusion of transactions where land is sold at less than market value), (3) sales of multiple, nonadjacent parcels purchased at a single price were dropped[12], and (4) parcels under four acres in size were not included because local conservation agencies do not typically consider parcels of this size for purchase and preservation.[13,14] Accordingly, the model is best interpreted as predicting the market purchase price of parcels of the size relevant for conservation purposes. This process led to a total database of 222 observations used for model estimation. The size and location of each parcel relative to current salt marsh are illustrated in Figure 1.[15]

[11] Taylor (2017) provides additional discussion of this topic, including why screens of this type are necessary to obtain unbiased results.

[12] Since these observations were rare (only 2% of the original raw data), and had no discernable pattern in their variables, the potential for bias (e.g., in model cost predictions or in the standard errors of independent variables) was negligible. Furthermore, the model produced consistent results with the inclusion of these observations.

[13] The original raw data included 1,241 observations. Filtering the data according to (1) and (2) led to the removal of 112 observations (9%). Filtering according to (3), led to the removal of an additional 23 observations (2%). Lastly, filtering the data according to (4), led to the removal of 884 observations (71%).

[14] This is based on personal communications with local conservation organizations, together with data provided by The Nature Conservancy's GIS manager, showing the sizes of all preserved land in the Eastern Shore of Virginia. None of these parcels were smaller than 4 acres in size.

[15] These salt marsh habitats are taken from the National Wetland Inventory and includes all marine and estuarine intertidal wetlands as defined in the Cowardin et al. 1979 classification system.

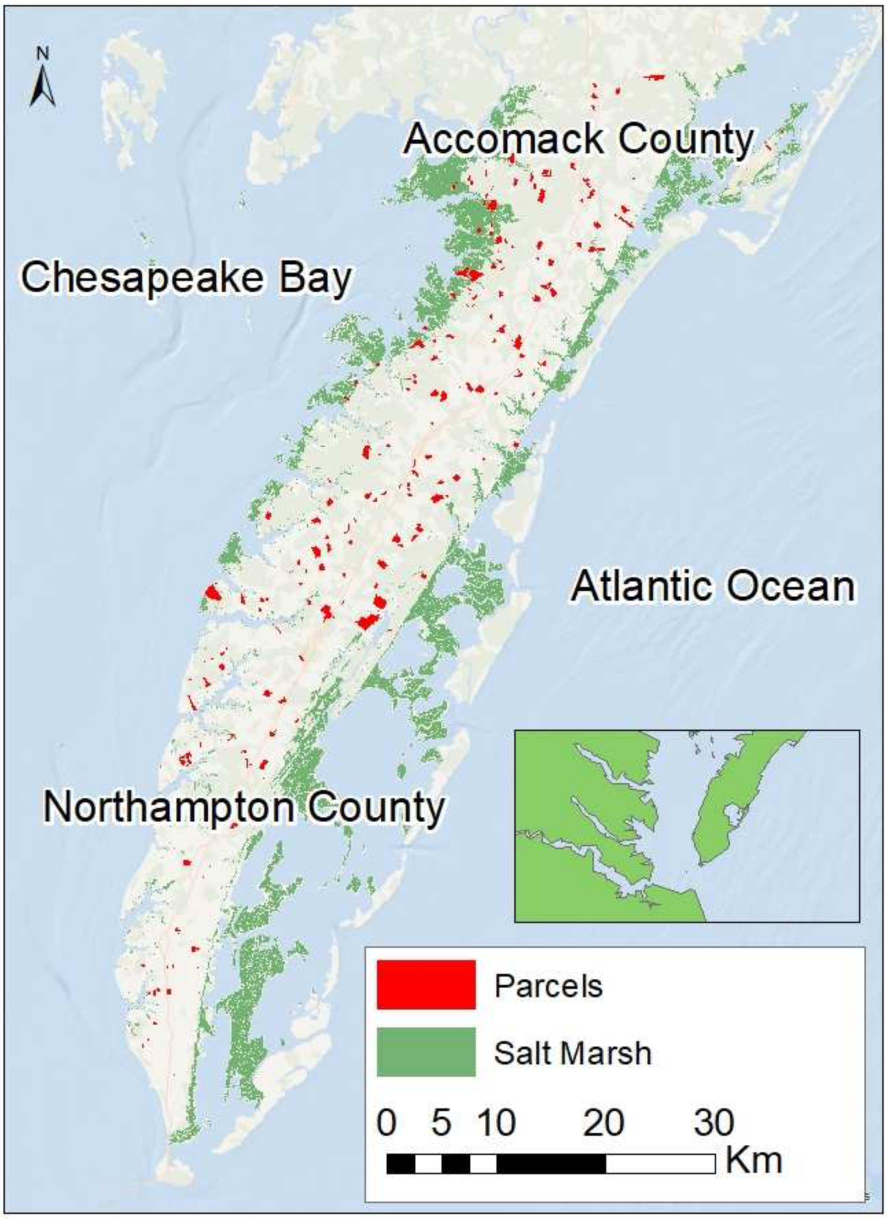

Figure 1. Map of Accomack and Northampton Counties with current salt marsh and sample observations.

Price data were adjusted to 2017 USD ($).[16] All data relating to topographical features and distances were measured in ArcGIS using data layers identified above. These data include land cover percentages, a waterfront indicator, distance to commercial and industrial districts, parcel elevation, coastal distances, an indicator for parcels located in areas suitable for planting salt marsh, and connectivity measures.[17] Variables in the model are summarized by Table 1.

Table 1

Variable description and summary statistics.

Variable	Description	Min	Max	Mean	Std. Dev.
adjsaleprice	Sales price adjusted to 2017$	1,548.81	1,132,422	149,990	183,421
acreage	Parcel size measured in acres	5	326.5	40.24	50.06
agricultural	Binary variable that takes a value of 1 for agricultural base zoning, and 0 otherwise	0	1	0.784	0.413
floodhazardist	Binary variable that takes a value of 1 for flood hazard overlay district zoning, and 0 otherwise	0	1	0.311	0.464
airportdist	Binary variable that takes a value of 1 for airport overlay district zoning, and 0 otherwise	0	1	0.108	0.311
barrenland	Percentage of the parcel classified as barren land	0	100.00	2.376	8.079
devopenspace	Percentage of parcel classified as	0	54.64	0.747	4.055

[16] Prices were deflated using the Bureau of Labor Statistic's Historical Consumer Price Index. https://www.bls.gov/cpi/tables/historical-cpi-u-201709.pdf

[17] Data layers for conservation land are taken from the Virginia Department of Conservation and Recreation which includes easements and land in private and public protective management. This is overlaid with land cover data from the 2011 National Land Cover Database.

	developed – open space				
forestland	Percentage of parcel classified as forestland	0	100.00	38.74	34.02
wetland	Percentage of parcel classified as wetland	0	96.63	7.349	17.86
farmland	Percentage of parcel classified as farmland	0	100.00	50.19	36.49
waterfront	Binary variable that takes a value of 1 for waterfront property, and 0 otherwise	0	1	0.0541	0.227
farmdist	Distance from the parcel centroid to the nearest farm measured in meters	0	12,543	1,899	2,055
airdist	Distance from the parcel centroid to the nearest major airport measured in meters	1,026	57,157	22,998	13,443
elevation	The midpoint between the highest and lowest elevation points on the parcel measured in meters	0.100	15.40	6.549	4.424
hwydist	Distance from the parcel centroid to U.S. Highway 13 measured in meters	34.61	16,911	3,948	3,021
coastaldist	Distance from the parcel centroid to the coast measured in meters	29.02	5,437	1,503	1,249
marshplant[a]	Binary variable that takes a value of 1 if the property is within 50 meters of an area suitable for planting salt marsh, and 0 otherwise	0	1	0.221	0.416

cons_farm50m	The percentage of conserved farmland relative to all land within 50 meters of the parcel edge	0	68.60	1.814	8.997
cons_for50m	The percentage of conserved forestland relative to all land within 50 meters of the parcel edge	0	20.92	0.552	2.484
cons_wet50m	The percentage of conserved wetland relative to all land within 50 meters of the parcel edge	0	76.74	1.678	8.369
uncon_farm50m	The percentage of non-conserved farmland relative to all land within 50 meters of the parcel edge	0	100.00	36.80	30.13
uncon_for50m	The percentage of non-conserved forestland relative to all land within 50 meters of the parcel edge	0	83.13	12.59	18.09
uncon_wet50m	The percentage of non-conserved wetland relative to all land within 50 meters of the parcel edge	0	100.00	34.63	32.44

[a] Based on bathymetric measurements from the VIMS. A 1-meter bathymetric contour is used to determine if the nearshore is suitable for marsh planting. If the contour is outside 10 meters of the shoreline then it is considered 'shallow' and suitable for marsh planting.

Of the variables described in Table 1, those addressing suitability for salt marsh planting (*marshplant*) and ecological connectivity (*cons_farm50mm, cons_for50m, cons_wet50m, uncon_farm50m, uncon_for50m, uncon_wet50m*) warrant additional explanation. With regard to the former, parcels located in areas where salt marsh can be planted are considered to be likely areas for marsh migration, since they are in an environment that already supports or can support future salt marsh habitats. These parcels are defined as those within 50 meters of the shore and where the water's depth is sufficiently shallow, reflecting the type of land where most marshes are found in the Southeastern United States (Minello et al., 2012).[18]

Ecological connectivity is defined here as the quantity of surrounding undeveloped land, and has been shown by Kirwan et al. (2016b) to have significant implications for marsh migration potential. This is incorporated into the model using six variables that measure the percentage of conserved and non-conserved forestland, farmland, and wetland within 50 meters of each parcel's edge. We differentiate connectivity measures by conserved and non-conserved land types, because marsh migration is a slow process and its likelihood of occurring may increase when near conserved land that is less likely to be developed in the future (e.g., is already preserved). Lastly, conserved and non-conserved land near the parcel may have different impacts on its price. Although the study uses sales of undeveloped land, factors influencing the price of developed land may also be relevant here since the land may have been purchased for future development. Past literature has shown conserved open space to have a much larger positive impact on nearby developed land than non-conserved open space (Geoghegan, 2002; Irwin, 2002; Yoo and Ready, 2016).

As shown in Table 1, the average adjusted sale price for undeveloped land (*adjsaleprice*) in the study area was $149,990 in 2017 USD, with a standard deviation of $183,421. The acreage (*acreage*) for an average parcel was 40.24, with a maximum of 326.5. The dominant land covers were forest (*forestland*) and farmland (*farmland*), at 39 and 50 percent of total mean land cover, respectively. Parcels had a mean elevation (*elevation*) of 6.5 meters, ranging from 0.1 to 15.4

[18] 'Sufficiently shallow' uses the Virginia Institute of Marine Science's Shoreline Management Model's definition which includes areas where the water has a depth of 1 meter further than 10 meters from the shoreline (Berman et al., 2011; Berman et al., 2016).

meters. This is relevant here, because elevation is one of the primary factors determining marsh migration potential (Kirwan et al., 2016a; Kirwan et al., 2016b). Mean coastal distance (*coastaldist*) was 1,503 meters. This is also salient, because only parcels that are relatively close to the coast are able to support salt marsh migration. Only 22 percent of parcels were within 50 meters of an area suitable for planting salt marsh (*marshplant*). Lastly, the average percentage of conserved forestland (*cons_for50m*), farmland (*cons_farm50m*), and wetland (*cons_wet50m*) within 50 meters of the parcel was 0.6, 1.8, and 1.7, respectively.

As described above, the model is estimated using a double-log specification with the natural log of sales price, $\log(adjsaleprice)$, as the dependent variable. This specification was chosen after comparison to alternative specifications, none of which outperformed the illustrated model. Preliminary models were tested with variables included to distinguish sales year (i.e., 2014, 2015, 2016 and 2017), but these variables were dropped due to clear lack of statistical significance or other effects on the model. Spatial autocorrelation was also tested within preliminary models using univariate Moran's I error and Lagrange Multiplier tests, with these evaluations showing no sign of significant autocorrelation (Anselin, 2001). All final regressions were hence estimated using OLS with robust standard errors.[19]

5. Results

Table 2 compares results from three alternative model specifications that include different factors important to marsh migration (elevation, distance to the coast, suitability for marsh planting, and ecological connectivity). All models include measures of elevation (*elevation*), distance to the coastline (*coastaldist*), and variables characterizing proportions of the parcel in different land

[19] The model was also compared to alternative specifications with truncated distance variables, reflecting an expectation that the implicit prices of these variables may become zero beyond a certain threshold. The results from these models were virtually identical to the primary models illustrated here.

cover types (*forest, farmland, wetland*), along with other variables expected to have potential influences on property sales price (Table 1). In addition to these variables, Model Two includes *marshplant*, reflecting the capacity of the nearby land to support salt marsh habitat. Model Three includes variables reflecting the connectivity of the parcel to nearby undeveloped farmland, forestland and wetland (both preserved and unpreserved), as described above. In all cases, results for statistically significant variables comport with prior expectations derived from theory and intuition, where prior expectations exist. All models find (very close to) unit elasticity of land price with respect to parcel size, with a 1 percent increase in size leading to between a 0.977 percent and 0.991 percent increase in land price.

Table 2

Hedonic regression results.

Variables	Model One Coefficient (S.E.)	Model Two Coefficient (S.E.)	Model Three Coefficient (S.E.)
log(acreage)	0.977^{***}	0.991^{***}	0.982^{***}
	(0.0703)	(0.0728)	(0.0761)
agricultural	-0.204	-0.173	-0.0995
	(0.171)	(0.167)	(0.176)
floodhazardist	-0.0842	-0.0515	0.0285
	(0.196)	(0.201)	(0.209)
airportdist	0.726^{***}	0.766^{***}	0.757^{***}
	(0.201)	(0.204)	(0.192)
barrenland	-0.0229	-0.0199	-0.0224
	(0.0174)	(0.0174)	(0.0145)
devopenspace	-0.0421^{**}	-0.0378^{*}	-0.0385^{*}
	(0.0204)	(0.0207)	(0.0196)
forestland	-0.0245	-0.0214	-0.0242^{*}
	(0.0154)	(0.0156)	(0.0131)

wetland	-0.0313**	-0.0277*	-0.0305**
	(0.0158)	(0.0161)	(0.0137)
farmland	-0.0215	-0.0184	-0.0250*
	(0.0153)	(0.0154)	(0.0128)
waterfront	0.910***	0.976***	0.948***
	(0.268)	(0.280)	(0.288)
log(farmdist)	-0.0239**	-0.0244**	-0.0235**
	(0.0111)	(0.0111)	(0.0103)
log(airdist)	0.200**	0.200**	0.181**
	(0.0892)	(0.0897)	(0.0859)
log(hwydist)	0.195***	0.178***	0.160**
	(0.0681)	(0.0677)	(0.0720)
log(coastaldist)	-0.213**	-0.278***	-0.254***
	(0.0850)	(0.0887)	(0.0915)
log(elevation)	0.328**	0.316**	0.263*
	(0.133)	(0.133)	(0.144)
marshplant		-0.253	-0.290
		(0.181)	(0.185)
cons_farm50m			-0.00323
			(0.00911)
cons_for50m			0.0286
			(0.0189)
cons_wet50m			0.00370
			(0.00648)
uncon_farm50m			0.00706
			(0.00566)
uncon_for50m			0.00128
			(0.00670)
uncon_wet50m			-0.000166
			(0.00532)

_cons	8.157***	8.419***	8.786***
	(2.015)	(2.021)	(1.770)
N	222	222	222
R^2	0.634	0.650	0.652

*, **, *** indicate levels of significance of 0.10, 0.05, and 0.01, respectively, with standard errors shown in parenthesis.

All models find statistically significant variations in land price associated with *elevation* and *coastaldist*—variables with primary importance for marsh migration. Higher prices are associated with parcels that are at higher elevation and closer to the coastline. Model Three finds significant variations in price associated with the proportions of different land cover types on the parcel (*forest*, *farmland*, *wetland*). Only wetland proportion is significant in Models One and Two, with the other two variables narrowly missing significance at the 10 percent level. Land cover is potentially important for conservation in the present context, as private landowners might be more prone to prevent farmland from becoming salt marsh (e.g., via armoring or topographical alterations) compared to forest. Unpreserved forestland may hence be more likely to remain unarmored by landowners, so that marshes can migrate onto that land irrespective of its preservation status. As a result, conservation additionality for marsh migration may be greater on farmland than on other land types (Duran et al., 2019).[20]

However, not all variables relevant to marsh migration are shown to influence parcel price. Results in Model Two find no significant impact associated with proximity to areas suitable for planting salt marsh. This is an expected result, as there is no clear reason why land purchasers (other than marsh conservationists) would attend to the ecological suitability of a parcel for salt marsh plants, *ceteris paribus*. Similarly, Model Three results find no significant effects associated with the six connectivity variables (*cons_farm50m, cons_for50m,*

[20] Regional conservation also focuses heavily on the preservation of undeveloped farmland and forestland for marsh migration (Bruce and Crichton, 2014).

cons_wet50m, uncon_farm50m, uncon_for50m, uncon_wet50m). This result is robust across multiple specifications of these variables tested in alternative preliminary models. Given these results, we use the results of Model One for subsequent analysis concerning implications for the predicted cost of land conservation to support marsh transgression.

5.1. Patterns in land conservation costs

Model results can be used to characterize the effect of factors relevant to marsh migration potential on land conservation costs. For illustration, we focus here on the effect of three types of variables that are potentially important for marsh migration and local preservation decisions: (a) distance from the coastline, (b) parcel elevation, and (c) land cover type. Regarding coastal distance, parcel price decreases by 0.213 percent for each 1 percent increase in distance. Price increases by 0.328 percent for each 1 percent increase in elevation, such that parcels with lower elevation levels (and usually better suited to marsh migration) command lower prices. Finally, a 1 percent increase in the proportion of wetland on the parcel leads to a 3.13 percent reduction in price. Proportions of forest- and farmland on the parcel have no statistically significant effect at standard levels (p-values are 0.12 and 0.16) but are included for completeness.

Additional insight into the magnitude of these effects may be obtained by considering mean implicit prices, reflecting estimated marginal price changes associated with each variable. We illustrate these effects for a parcel with mean characteristics shown in Table 1. For example, elevation has a mean positive implicit price of $75.08 per centimeter, reflecting a premium paid for land at higher elevation. Hence, land that is less highly valued in the market based on (lower) elevation is often more valuable for marsh conservation purposes. Coastal distance has a negative implicit price of $20.12 per meter, reflecting a premium for land closer to the coast. In this case, land that commands a higher price on the market is the same type of land required for marsh conservation purposes. Lastly, we find a negative implicit price of $6.04 for each percentage point increase of wetland on the parcel. This indicates that parcels with a greater presence of current wetland, and hence, that are potentially more valuable for current marsh conservation purposes, command a price discount.

5.2. Simulating the cost of land for marsh migration under alternative sea-level rise scenarios

Results in Table 2 may also be used to predict the expected cost of different types of land conservation suitable for marsh migration, reflecting combined effects of the factors discussed above. As shown below, the price of land purchased to promote future marsh migration can vary substantially across space, and hence as a function of different sea-level rise scenarios (which will cause different areas to be suitable for marsh migration). Given uncertainty regarding future sea-level rise, we demonstrate such patterns using "optimistic" and "pessimistic" sea-level rise scenarios by 2100.[21] Figures 2 and 3 show the location of predicted salt marsh habitats under each scenario, as predicted using previously developed Sea Level and Marsh Migration (SLAMM) model results for the region (Clough et al., 2018). These figures show the variation that can exist in the location of land that may have salt marsh in the future, under alternative sea-level rise scenarios.

[21] The sea level rise scenarios and predicted locations of future salt marsh habitats in 2100 are taken from The Nature Conservancy, based on a Sea Level and Marsh Migration (SLAMM) model. The optimistic scenario predicts marsh locations under a 0.71-meter sea level rise and the pessimistic scenario predicts locations under a 2.71-meter sea level rise.

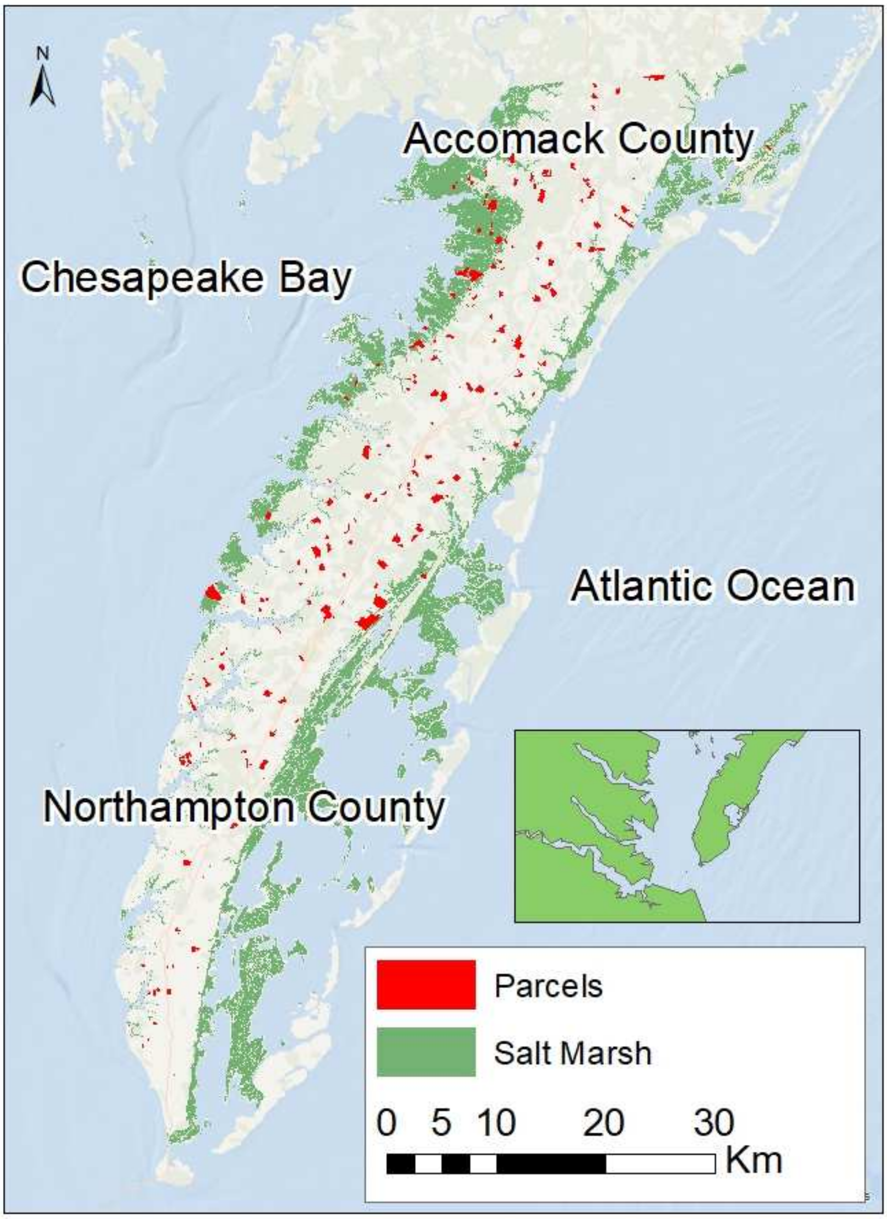

Figure 2. Predicted salt marsh habitats in the year 2100 under a low sea level rise scenario.

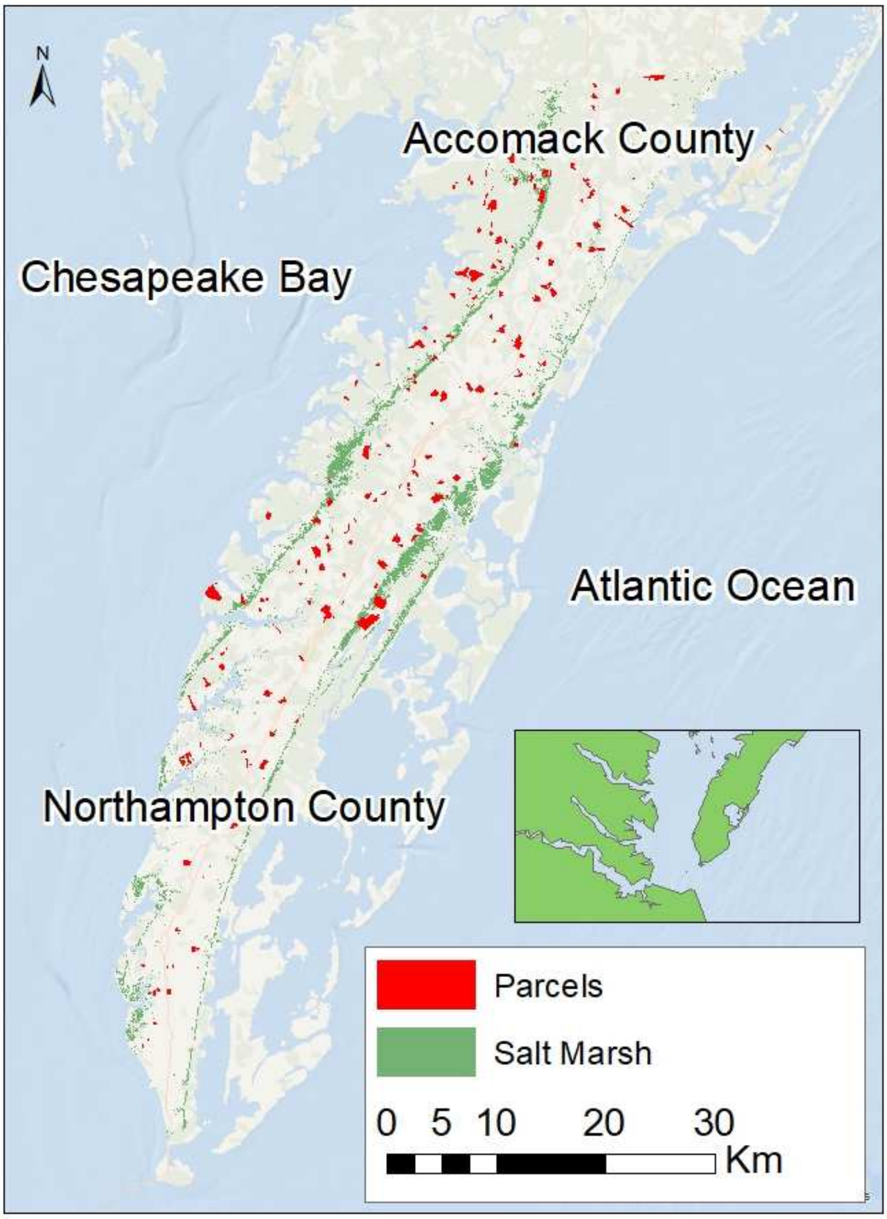

Figure 3. Predicted salt marsh habitats in the year 2100 under a high sea level rise scenario.

Under the optimistic sea-level rise scenario, many of the predicted salt marsh locations are relatively close to today's coastline (Figure 2). In contrast, under the pessimistic scenario, many of these habitats are pushed inland and are smaller in size (Figure 3). These predictions are based on current land use and cover, assuming that no actions are taken to develop or armor current undeveloped lands. However, in the absence of conservation, landowners may take actions to prevent these areas from becoming marsh, such that land conservation is required to ensure that land remains available for marsh migration (Duran et al. 2019; Runting et al., 2017).

Model results demonstrate how predicted conservation costs vary depending on one's expectations concerning future sea-level rise. Figures 4 and 5 show the predicted price per acre for land that is expected to become salt marsh under the two scenarios, for a small illustrative area in Accomack County.[22] These results illustrate the predicted cost of preserving this land via fee-simple purchase. The figures reveal significant differences (both within and across each scenario) in the location and predicted price of land suitable for marsh migration, even when focusing on a small section of the Eastern Shore. In Figure 4, under the optimistic scenario, the average predicted price per acre is $4,735 for land suitable for marsh migration, with a standard deviation of $10,188. Land relatively close to the coast (within 100 meters) is predicted to cost, on average, $9,836 an acre, but predicted costs for all land, regardless of its distance from the coast, typically range between $1,084 and $8,883 per acre (when comparing predicted costs in the 10th and 90th percentiles).[23] In Figure 5, under the pessimistic scenario, due to the higher elevation the mean predicted price per acre is higher at $4,913 with a standard deviation of $9,362. Both scenarios illustrate the wide range in predicted prices for transgression zone purchases and suggest that cost-efficiencies can be achieved through careful targeting of these purchases to identify land that is simultaneously low cost and at high probability of becoming

[22] Square cells 1 acre in size are created over areas that are predicted to have salt marsh under each scenario. Model One results are used to predict the price in each cell.
[23] In rare cases (0.3 percent of the total acreage), predicted costs are over $100,000 an acre near the coast.

marsh under the anticipated sea-level rise scenario.

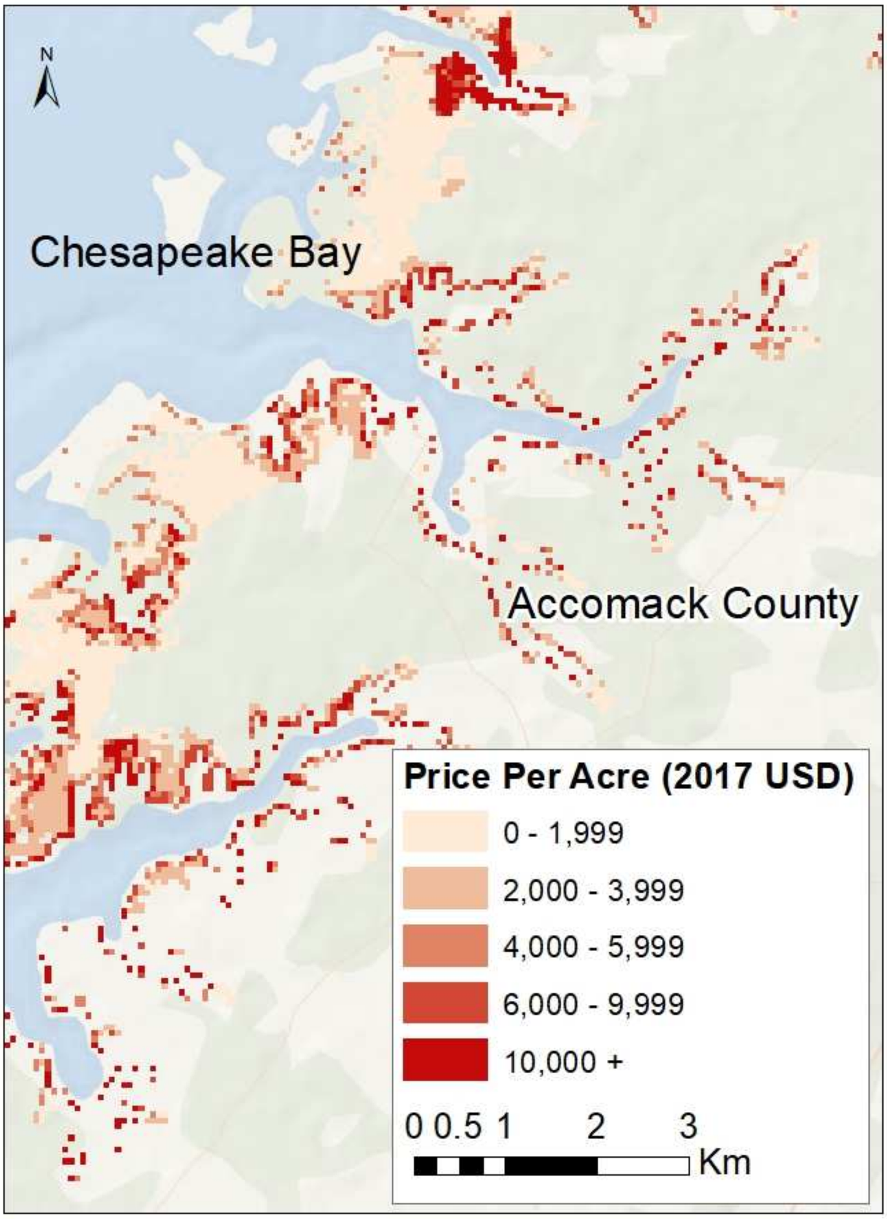

Figure 4. Predicted price per acre for transgression zones in the year 2100 under a low sea level rise scenario.

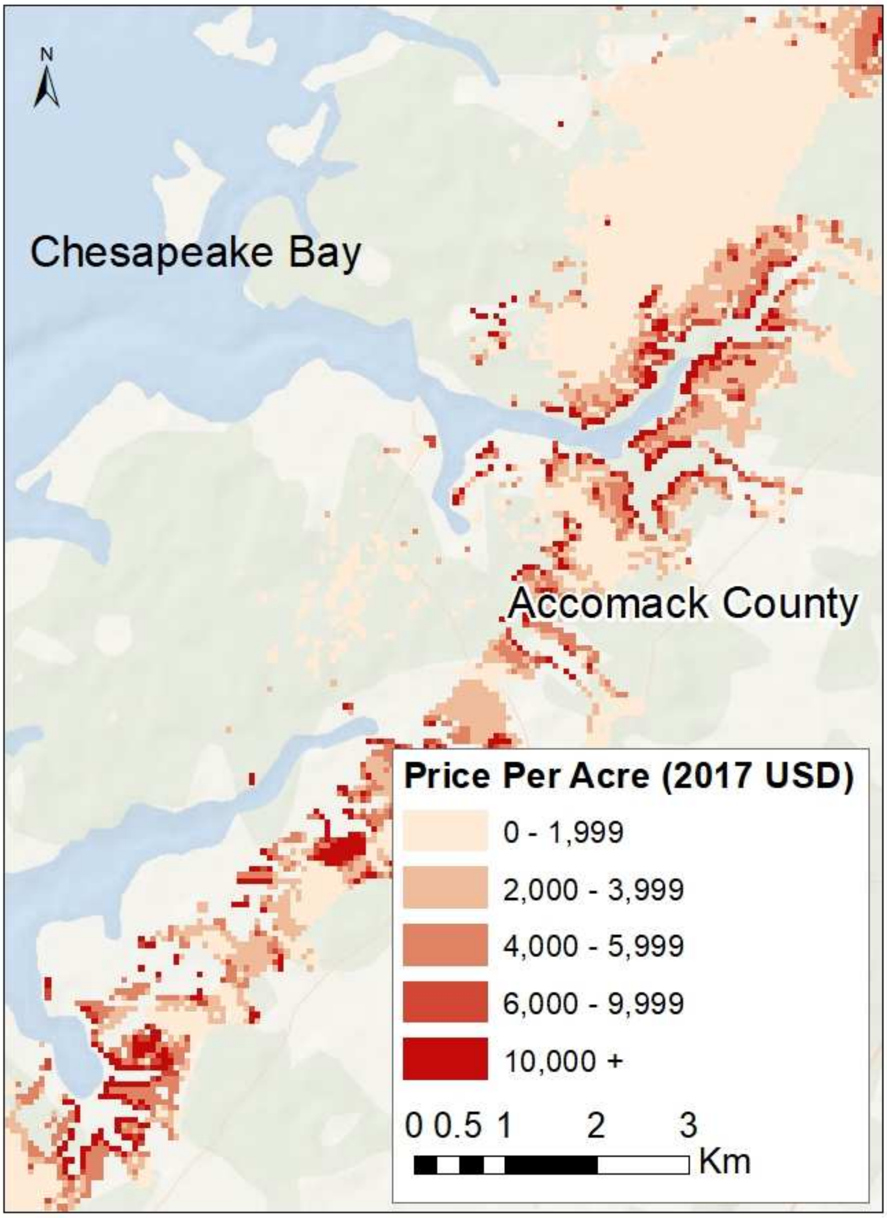

Figure 5. Predicted price per acre for transgression zones in the year 2100 under a high sea level rise scenario.

Predicted land price variations such as these also suggest that expectations drawn solely from mean land prices (or other simplified proxies) can lead to misguided understanding of the cost of land preservation suitable for future marsh migration. These concerns can be illustrated by comparing model predictions of land cost to simpler proxy measures that conservationists might use to predict these costs in the absence of targeted model results such as these.

Consider, for example, a case in which a conservation organization wishes to target particular parcels of land for purchase and preservation in the areas projected to support marsh migration under the alternative sea-level rise scenarios shown in Figures 2 and 3. Unless those parcels are already on the market, there is no direct way to observe their prices. To predict those prices for planning purposes, reasonable simple proxies for these costs (in the absence of hedonic model results) might be the average sales price of all undeveloped parcels in the region, or the average sales price of undeveloped parcels of particular types (e.g., farm, forest) that are the same as those desired for conservation.

Table 3 shows illustrative results for the optimistic and pessimistic sea-level rise scenarios considered above, for all vacant parcels and parcels that are primarily (greater than 75 percent) forestland and farmland within the areas predicted to become marsh under the two SLAMM sea-level rise scenarios (the optimistic and pessimistic scenarios introduced above). Results for each scenario are shown in a different column. To simulate results in Table 3, we first identify all parcels in the hedonic model dataset (and for which price information is hence available) that are within the predicted marsh migration area, according to SLAMM results. For illustrative purposes, we assume that these are the parcels targeted for potential preservation. The goal of the simulation exercise is to compare hedonic model predictions of these costs to predictions that could be obtained through simpler proxy measures. We conduct the same exercise for parcels that are primarily farm- and forestland. For farm and forest parcels, we compare hedonic model predictions to simpler proxy measures drawn from parcels of similar types (i.e., mostly farm and mostly forest).

Table 3

Cost prediction comparisons [a]

	Optimistic sea-level rise scenario	Pessimistic sea-level rise scenario
Average price of all vacant land	$149,959	$188,189
Average price of forestland	$67,637	$69,276
Average price of farmland	$172,793	$177,561
Avg. |% error| using model predictions for all vacant land	72% (93%)	61% (66%)
Avg. |% error| using model predictions for forestland	110% (142%)	62% (50%)
Avg. |% error| using model predictions for farmland	37% (39%)	42% (51%)
Avg. |% error| using average price of all vacant land	477% (1,265%)	273% (351%)
Avg. |% error| using average price of forestland	518% (1,103%)	127% (184%)
Avg. |% error| using average price of farmland	195% (258%)	226% (282%)

[a] Forestland and farmland average prices and predictions are based on parcels with greater than 75% land cover in each category. The percentage errors for all vacant land parcel predictions are based on 65 parcels in the optimistic sea-level rise scenario and 61 parcels in the pessimistic sea-level rise scenario. The percentage errors for forestland and farmland parcel predictions are based on 15 and 12 parcels in the optimistic sea-level rise scenario, and 9 and 15 parcels in the pessimistic sea-level rise scenario. Standard deviations are in parenthesis.

Specifically, the first three non-heading rows of Table 3 show the average price for all vacant parcels, and for those parcels that are mostly (greater than 75 percent) forest and mostly (greater than 75 percent) farmland. Rows four through nine show the mean absolute value prediction errors and standard deviations (in parenthesis) that result if the price for each of these parcels is predicted using results from the hedonic model. That is, for each selected parcel we compare the predicted price to the actual observed price from the data and quantify the difference between the two (the prediction error) in absolute value percentage terms.

Rows ten through fifteen then show the parallel absolute value prediction errors if, instead, simple *average prices* for parcels in each category (the first three rows) are used to predict these values instead. These average prices are also drawn from the available data (Table 1), but do not rely on hedonic model results. Specifically, the average price for all undeveloped parcels in the dataset is used to predict the price for those parcels suitable for marsh migration under each sea level rise scenario (as indicated by SLAMM results). Similarly, the average price for all parcels in the data that are mostly forest is used to predict the price of forested parcels that are predicted to become marsh under each sea level rise scenario (and are hence suitable for marsh conservation purposes). The same process is implemented for farmland parcels.

Results in Table 3 demonstrate the increased accuracy made possible using results such as those presented in Table 2 to predict conservation land prices. Focusing on the optimistic sea level rise scenario in the first column, the average price for all undeveloped parcels in the data is $149,959, and the average price for parcels that are primarily forestland and farmland are $67,637 and $172,793, respectively. Rows ten through fifteen reveal large prediction errors when these simple averages are used to predict the price of land that is suitable for marsh migration conservation purposes. For example, using the average price of all vacant land to predict the price of all parcels expected to become salt marsh results in an average absolute percentage error of 477 percent with a standard deviation of 1,265 percent. The accuracy of these predictions is similarly poor when using the average price of forest- and farmland to predict the price of similar forest- and farmland expected to become salt marsh; average absolute percentage errors are 518 percent for parcels that are primarily forestland and 195 percent for parcels that are primarily farmland.

In contrast, the average absolute percentage errors that result when using the hedonic model to generate price predictions show a substantial improvement. Parallel absolute value errors are 72 percent for all vacant land, 110 percent for forestland, and 37 percent for farmland (standard deviations are also lower ranging from only 39 to 142 percent). Analogous results are found for the pessimistic sea-level rise scenario. Similar results may be generated for a variety of illustrative scenarios and alternative proxy measures, all demonstrating the increased accuracy obtained by the use of model results to predict land purchase prices for conservation, in lieu of simplified proxy measures that might be used in the absence of such results. Parallel gains in accuracy are obtained if one instead predicts errors out-of-sample using an iterative leave-one-observation-out procedure, in which hedonic model results are estimated repeatedly with one observation omitted, and results are then used to predict the price for the omitted observation.

6. Conclusion

Land preservation is often implemented for purposes such as marsh migration that influence the characteristics of land expected to provide the greatest conservation benefit. In such cases, planning for optimal or cost-effective land preservation requires an ability to forecast the cost of particular types of undeveloped land. This paper develops the first hedonic model designed to predict the fee-simple purchase price of undeveloped land purchased for purposes of marsh migration, quantifying relationships between land attributes that affect marsh migration and land price. The model further enables identification of cost-effective means to purchase land suitable for marsh migration, by considering tradeoffs that affect migration potential and market demand. This modeling objective implies the inclusion of attributes such as parcel elevation that are often excluded from hedonic analyses, along with more commonly included attributes such as distance to the coastline. These and other attributes were shown to exert a statistically significant influence on land sales price. Unlike the vast majority of hedonic models in the literature, we focus here on undeveloped rather than developed land—as the former reflects the type of land targeted for conservation to promote marsh transgression. Illustrative scenario analyses demonstrate the significant accuracy gains made possible by models of this type, when seeking to predict the cost of undeveloped land purchase prices.

As in all models of this general type, multiple caveats should be considered when interpreting results. First, the specific quantitative results shown here are applicable only to the studied area. Although we expect that analogous results may hold for other, similar areas, it is beyond the scope of the present article to consider whether and how these results might be used to predict similar patterns elsewhere. There is an established literature on environmental benefit transfer that considers the accuracy with which results of this general type may be "transferred" to other policy areas, and the methods used to do so. This is an important area for future work.

Other, more specific caveats should also be considered. For example, as with all first-stage hedonic models of this type, results should be interpreted "on the margin" based on the situation that existed from 2014 to 2017. Any significant, non-marginal departure from these conditions in the future (e.g., due to substantial land development) will affect the capacity of the model to provide accurate forecasts. Also, the presented model only forecasts the price of fee-simple land purchase, assuming that purchases for preservation are made on the open market at prevailing prices. Any departure from these prices—for example due to bargaining between conservation organizations and potential sellers, or non-arms-length sales—may lead to prices that may depart from those predicted by models of this type. Preservation costs not related to the original purchase price, such as maintenance and upkeep costs, will also be overlooked by hedonic models of this type. To the extent that these are significant, such ongoing costs must be added to predicted fee-simple acquisition costs.

These and other caveats notwithstanding, the illustrated model demonstrates the potential insight for coastal conservation planning that can be provided by models that forecast the price of undeveloped, non-agricultural land with particular characteristics. Although hedonic property value models of similar structure are ubiquitous in the literature, there is a perhaps surprising paucity of insight into parallel price patterns for undeveloped land. Insight is especially sparse for particular types of land, such as land suitable for salt marsh migration. Greater understanding of these market patterns can promote more effective planning by conservation organizations.

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