A hedonic pricing method to estimate value of waterfront in the Gulf of Mexico

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Abstract

Open spaces, including waterfront areas, are publicly-or-privately owned landscapes that provide numerous benefits and services such as opportunities for recreational activities, ecological benefits, and economic development. However, with rapidly growing populations, development pressure on these areas has been increasing, often leading to conflicts between proposed land uses. Information on the monetary value of environmental amenities provided by these spaces would help decision makers account for their importance to quality of life. This study estimated the monetary value associated with waterfronts using the hedonic pricing method (HPM) and real estate sales data for the coastal cities of Mobile and Daphne in Alabama, USA. The price of houses sold during 2001 to 2015 was used as the dependent variable and house structural and neighborhood attributes and presence of environmental amenities served as independent variables. Results showed that coastal residents considered proximity to waterfronts as one of the most important factors when buying a house and paid higher prices for houses located near most waterfront types. In Mobile, marginal implicit prices of proximity to waterfronts ranged from $2,490 to $3,530 per km, whereas in Daphne, the price ranged from $9,250 to $15,460 per km. Findings can help guide future decisions related to development of coastal areas, land-use planning, urban forestry, and open space preservation by balancing opportunities for urban and commercial development as well as providing public access to open space environmental amenities with close proximity to residential areas.

Keywords: Ecosystem services, land-use planning, marginal implicit price, multiple listing service data, real estate, waterfront

1.1 Introduction

Open spaces are publicly-or-privately owned landscapes that are partially or completely covered with vegetation or water (Allen Klaiber & Phaneuf, 2010; Bolitzer & Netusil, 2000). Open spaces can be developed (e.g., a city recreational park) or undeveloped (e.g., an exurban woodland). With increases in population and urbanization, damage to and loss of waterfront open spaces have been extensive. Yet, due to their environmental, economic, and cultural benefits, waterfront open spaces remain an integral part of urban landscapes. The challenges city planners and elected officials face in managing urban sprawl and protecting waterfronts often relate to the lack of monetary estimates of waterfront values that would help prioritize preservation versus other land uses. Proponents of open space planning call for preservation of waterfronts based on location, availability, and suitability, including mitigating forest fragmentation through hubs, links, and corridors. Valuation analyses such as this study help identify and gauge the importance of these areas, and may be preferable to the current approach of arbitrarily preserving leftover land, which is not necessarily the open space that provides the highest benefits to the community.

The benefits of open space to human welfare have been extensively discussed within diverse research areas. For example, open spaces provide many services including recreational opportunities, scenic views, and mitigation of negative externalities such as pollution and congestion associated with development (Irwin, 2002). In addition, open spaces provide ecological benefits such as wildlife habitat, air and water quality improvement, and urban heat island reduction; economic benefits such as increased real estate values and improved local economies; and other health and socio-cultural benefits such as places to exercise and socialize (Anderson & West, 2006; Brander & Koetse, 2011; Hakim et al., 1999; Lowry, 1967; Nowak, Crane, & Stevens, 2006). Therefore, protection of open spaces should be considered in residential and commercial planning decisions to enhance environmental, cultural, and economic values of adjacent areas.

With an increase in population and urbanization, many open space areas have been lost to commercial and residential developments (McDonald, Forman, & Kareiva, 2010; Schuyt, 2005). In terms of U.S. forest land alone, approximately 4.0 million hectares of land were converted to development during 1982 to 1997 and an additional 9.0 million hectares are projected to be developed by 2030 (Alig & Plantinga, 2004). Impacts of such disturbances are not only felt locally where rapid development occurs, but are also transported to distant locations via air and water pollution (Faulkner, 2004). For example, habitat fragmentation as a result of urban sprawl induces edge effects resulting in a loss of connectivity between habitats and, therefore, restricts movement of species, leading some species to a threatened status and others to possible extinction (Faulkner, 2004).Thus, findings showed that loss of open space was highly correlated with population growth.

With an increase in population, demand for open space and its benefits has also been increasing, making preservation of open space an important policy and social issue. There have been numerous initiatives at national, state, and local levels to preserve and protect open space (Bengston, Fletcher, & Nelson, 2004). For example, in 2007 the U.S. Forest Service has developed an Open Space Conservation Strategy to help conserve open spaces (USDA, 2007). Tax policies are examples of other initiatives implemented to support open space conservation and promote ecosystem service markets (Bengston, Fletcher, & Nelson, 2004). Similarly, voters in 21 states approved funds of over $3 billion for open space conservation in 2016 (Trust for Public Land 2016). Such spending suggests the importance of open space to communities.

However, this spending presents only a partial estimate of the extent of benefits that open space provides (McConnell & Walls, 2005). Thus, knowing the total economic value of open space will help in formulating public policy to retain waterfront open space and guide future land conservation and development decisions.

Estimating a total value of open space is difficult because it considers both market and nonmarket goods and services (McConnell & Walls, 2005). In contrast to crops and timber, nonmarket goods such as clean air and aesthetic values are not directly traded in the market and it is therefore challenging to estimate their monetary value (McConnell & Walls, 2005). If nonmarket goods and services can be quantified in monetary terms, their value can be compared with and possibly outweigh market values such as urban development (Boyer & Polasky, 2004). Monetary valuation helps to identify types of open space that have the greatest importance to residents (i.e., consumers), compare relative values of these open spaces with other land uses, and facilitate more informed policy decisions pertaining to their conservation and development.

Various methods have been developed by economists to estimate the monetary value of nonmarket goods and services. The most common methods used in nonmarket valuation include the contingent valuation method (CVM), the travel cost method (TCM), and the hedonic pricing method (HPM). This study employed the HPM, which is a revealed preference method, and utilized real estate market transaction data to estimate the monetary value of waterfront properties. HPM relies on information from property purchase behavior to infer values for environmental amenities. This approach assumes that property price, such as a house price, is a function of structural, neighborhood, and environmental attributes.

HPM is a commonly-used method in quantifying the monetary value of nonmarket benefits, such as those provided by waterfront open spaces (Morancho, 2003). For example, Acharya and Bennett (2001), Irwin (2002), Anderson and West (2006), and Poudyal et al. (2009) used HPM to quantify the monetary value of nonmarket benefits provided by open space in different parts of the U.S. Findings from these studies suggested that proximity to open space was positively associated with property values. The HPM has also been used previously to estimate the value of selected waterfront properties adjacent to lakes and reservoirs, rivers and streams, and oceans (Brown & Pollakowski, 1977; Costanza et al., 2006; Knetsch, 1964; Mahan, Polasky & Adams, 2000; Young & Teti, 1984). For example, Mahan et al. (2000) used HPM to estimate the monetary value of a wetland in Portland, Oregon and reported that wetland characteristics related to its size and distance to an urban area were related with the value of nearby residential properties. The study reported that a one-acre increase in wetland area was associated with an increase of nearby house values by $24.39. Similarly, decreasing distance between residences and wetlands by 1,000 feet increased property values by $436.17. A similar study by Bin (2005) found that moving 1,000 feet closer to the nearest river increased property value by $3,750, whereas Costanza et al. (2006) estimated that sale prices for houses within 300 feet of a beach ranged from $81,000 to $194,000 higher than for houses located further away, suggesting beach proximity had a positive impact on house values. Some of the other recent studies related to waterfronts are summarized in Table 1.

Most previous studies either quantified values of individual waterfront types such as lakes, beaches, and wetlands or treated them as a composite good. However, values may vary across different types of open space (McConnell & Walls, 2005). Valuing different waterfront types as a composite good thus may not be useful to practitioners. To address this limitation, our study estimated monetary values of different waterfront types such as bays, rivers, streams, bayous, and other water bodies in a single HPM model to facilitate the comparison of their monetary values and relative importance to coastal residents. Thus, the study provides useful insights on the monetary value of specific waterfront types and helps to analyze the effect of different land use options. The study used 13,903 house sale records obtained from a multiple listing service (MLS) to estimate marginal implicit prices of proximity to different waterfront types in two coastal cities near the Gulf of Mexico: Mobile and Daphne, Alabama, U.S. Findings have several policy implications related to maximizing net benefits of waterfront access and can be used to facilitate informed planning decisions regarding waterfront open space preservation and alternative development as well as financial and tax decisions related to waterfront open space conservation.

Table 1. Summary of the recent hedonic studies related to a monetary valuation of waterfronts.

Waterfront type	Author and year	Study site/ location	Analysis method	Finding(s)
Waterbody	Cho et al., 2010	Southern U.S.	Spatial model	Water view was associated with a house price increase of 26%.
Watercourse	MacDonald et al., 2010	Adelaide, South Australia	OLS	A 1-meter increase in distance from a property to a watercourse was associated with a price decrease of AU$24.
Seashore	Damigos & Anyfantis. 2011	Athens, Greece	Fuzzy Delphi method	Sea view related to dwelling price increase of 21% to 65%, with the most likely price premium of 34%.
Lake	Wen et al, 2012	Hangzhou, China	OLS	A 1% increase in distance to a lake translated to a price decrease of 0.24%.
River	Tapsuwan et al., 2012	Murray-Darling Basin, South Australia	OLS	For an average house located 1 km away from a river, decreasing a distance to a river to 0.50 km was associated with a house price increase of AU$245,000.
River and coast line	Gibbons et al., 2013	England specifically and Great Britain to a lesser extent	OLS	A 1-km increase in distance to river and coastline related to a house price decrease of 0.93% and 0.14%, respectively.
Stream, canal, and waterbody	Larson & Perrings, 2013	Phoenix, Arizona	OLS and spatial lag model	A 1% increase in distance to stream, canal, and waterbody was associated with a house price decrease of 0.002%, 0.008%, and 0.008% in OLS model and <0.001%, 0.002%, and 0.006% in a spatial lag model, respectively.
Lake	Pandit et al., 2013	Perth, Western Australia	OLS and spatial model	A 1% increase in distance to a park with lake related to a price decrease of 0.03% (OLS) and 0.02% (spatial model).
Waterbody	Kolbe & Wustemann, 2014	Cologne, Germany	OLS	A 1% increase in the size of a waterbody within a 500-meter buffer translated to a price increase of 0.16%.
Waterbody	Cohen et al, 2015	Connecticut	OLS and GWR	Relationship insignificant in OLS, whereas a 1% increase in distance to a waterbody related to a house price decrease of 0.027% in the GWR model.
Surf break (oceanfront)	Scorse et al., 2015	Santa Cruz, California, U.S.	OLS	Ocean view was associated with a house price increase of $957,000. A house located next to a surf break was valued at $106,000 more than a house located 1 mile away.
River	Tapsuwan et al., 2015	Murray-Darling Basin, South Australia	OLS and spatial model	Within 3-km buffer, 1-km increase in distance to a river was associated with a price decrease of AU$2,414.

Note: OLS stands for ordinary least square; GWR stands for geographically weighted regression.

1.2 Material and methods

1.2.1 Study area

The study area consists of the city limits of Mobile and Daphne in Alabama, U.S. (Figure 1). Both cities are adjacent to Mobile Bay and are less than 65 miles to the Gulf of Mexico. Dog River, Fish River, Fowl River, Mobile River, and Spanish River are some of the largest rivers in the study area, with Mobile Bay and D'Olive Bay serving as popular tourist destinations.

Of Mobile's total area (466 km^2), 44.74% is commercially and residentially developed, while 19.36% is covered by wetlands (Homer et al. 2015). Despite a 2.05% decrease in population from 2000 to 2010, the number of housing units increased by 3.17% (U.S. Census Bureau 2012). During 2000-2010, the number of households remained relatively flat (+0.65%) and a median household income increased by 17.84%, suggesting an increasing housing demand.

Of the 45.24 km^2 within Daphne's city limits, 3.18 km^2 are water area, most of which lies in Mobile Bay (U.S. Census Bureau 2012). The city area is 50.56% in residential and commercial development, whereas 8.74% is covered by wetlands (Homer et al. 2015). As of 2010, the population of Daphne was 21,570, which represented a 30.09% increase since 2000 with a corresponding 40.03% increase in housing units (U.S. Census Bureau 2012). The number of households increased by 35.44%, whereas a median household income increased by 13.76%. Thus, the fast rate of growth in housing units suggested an increasing loss of open space due to land development.

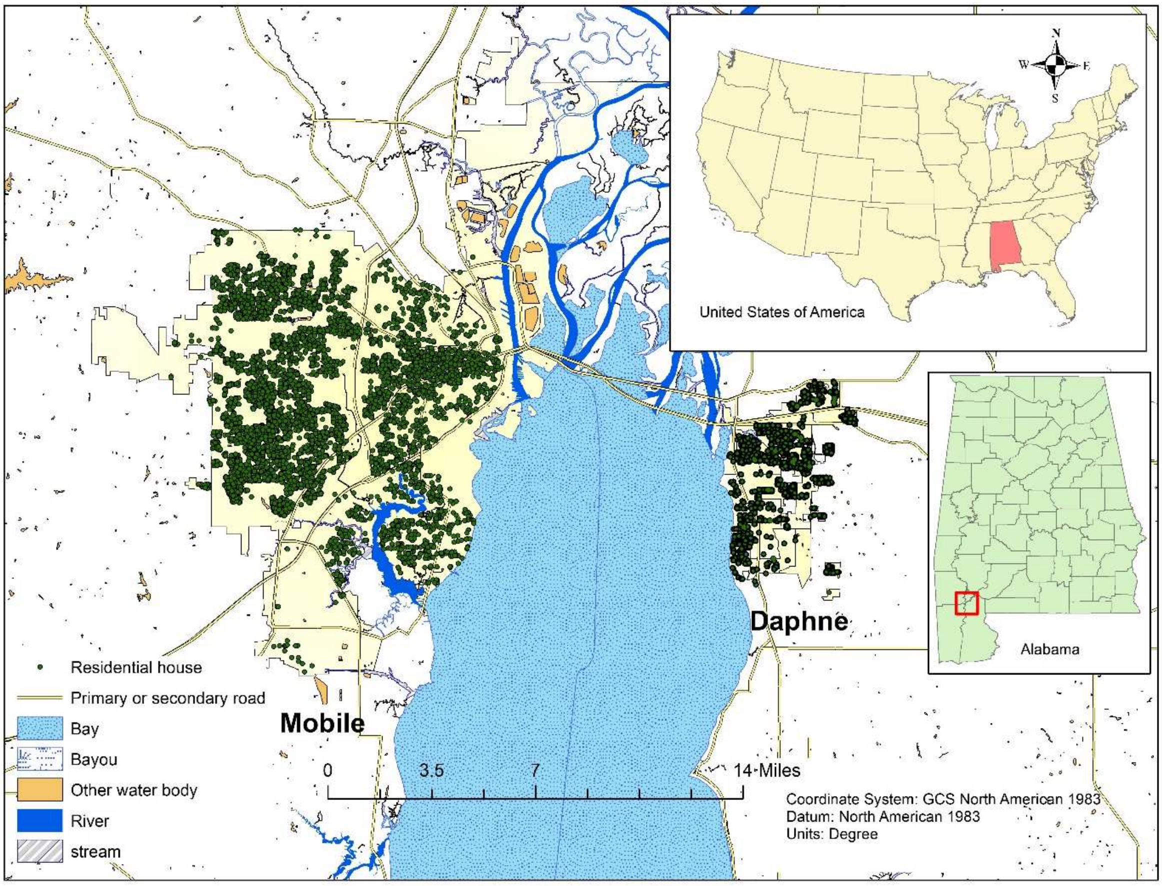

Figure 1. Study area in the Gulf of Mexico: Mobile (Left) and Daphne (Right), Alabama, U.S.

1.2.2 Data collection

MLS data were obtained from Gulf Coast Multiple Listing Service, Inc. The MLS dataset included complete information on house prices and their structural characteristics. Data were drawn for the period 2001 to 2015. Data from 2001 was used because it was the earliest data available. During the study period, the study area experienced certain events that might affect the house prices. For example, Mississippi and Alabama experienced devastating losses due to extreme weather events such as Hurricane Ivan in 2004 and Hurricanes Dennis, Rita, Wilma and Katrina in 2005. More than 275,000 housing units were lost in Mississippi and Alabama due to hurricanes Katrina, Rita, and Wilma (MASGC, 2012). Thus, using housing data for an extended period helped control for these market fluctuations by averaging their effects.

1.2.3 Data preparation

Houses marked as unsold in the MLS dataset were omitted from the analysis. As the house data were not georeferenced, the dataset was transformed to a Geographic Information System (GIS) format to facilitate geospatial analysis. The location of each sold house was geocoded in ArcMap using an Alabama address locator obtained from the TIGER/Line geodatabase maintained by the U.S. Census Bureau. A total of 15,463 house records were matched for Mobile and 3,748 house records for Daphne. However, 5,018 house records from Mobile and 290 from Daphne did not have complete information about house structural characteristics and, therefore, were not used in the study. The final dataset contained 10,445 house sale records for Mobile and 3,458 sale records for Daphne, resulting in a total of 13,903 records for both cities. House prices were then expressed in 2010 U.S. dollars using housing price index obtained from Federal Housing Finance Agency (FHFA 2017) to control for inflation and real estate market fluctuations, and to be comparable with neighborhood data for the 2010 Decennial Census.

A trend in housing prices for Mobile and Daphne expressed in 2010 U.S. dollars is illustrated in Figure 2. During 2000-2015, housing prices in Daphne were relatively higher than in Mobile with prices increasing until 2007 and then falling sharply. The global economic recession and sharp decline in housing starts were the major reasons for this downturn (Mian & Sufi, 2010). Mobile followed a similar trend as Daphne in terms of housing prices. An average housing price in Daphne was approximately $200,000, whereas in Mobile it was $150,000.

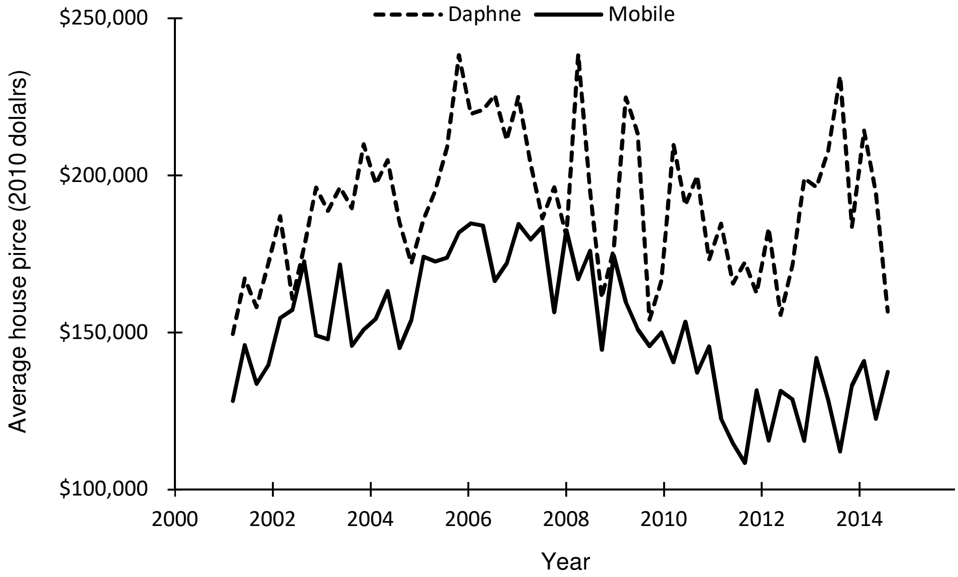

Figure 2. Average house prices in Daphne and Mobile, U.S. during 2001-2015.

Geospatial data such as location of regional airports, primary and secondary roads, railroads, parks, waterfront types, shopping centers, hospitals, and schools were obtained from the TIGER/Line database maintained by the U.S. Census Bureau and open data sources including usa.com, data.gov, expertGPS, and City of Mobile. Euclidean distances from a sold house to the nearest geospatial features were computed using a proximity tool of ArcMap 10.3.1.

1.2.4 Econometric model

The HPM is a widely used nonmarket valuation technique. According to the model, goods and services can be viewed as bundles of attributes (McConnell & Walls 2005). For instance, a house is characterized by many structural attributes affecting its price, such as age, size, number of bedrooms, bathrooms, and presence of a garage. Additionally, a house price might be affected by environmental attributes such as proximity to waterfronts and public parks on waterfronts, and neighborhood attributes such as proximity to schools, shopping centers, and hospitals (McConnell & Walls, 2005). Buyers often value the presence of environmental amenities and neighborhood attributes and are willing to pay higher prices for houses up to a point where the marginal cost of access to or being close to such amenities equals their marginal benefits (Flores, 2003). Even though consumers do not purchase such amenities directly, their values to consumers are reflected in how much they paid for the houses (Taylor, 2003). Homebuyers thus buy a bundle of house attributes (structural, neighborhood, and environmental) when they buy a property (Lancaster 1966). As a result, the total property sale price is a function of market and nonmarket attributes that characterize the house: $P_h=(Z)$. A particular house can be described by its structural, locational, and environmental attributes represented as $Z=(Z_1,Z_2, \ldots\ldots Z_n)$, where $i=1, 2\ldots n$ represents the types of attributes associated with a property and P stands for the hedonic price function. Price of a house is thus a function of vector Z.

The implicit price of any attribute characterizing the house is conceived as a partial derivative of the hedonic price function (Morancho, 2003). It is called an implicit price because the price is implicit in the total house price and represents the marginal price of an attribute characterizing the house (Taylor, 2003). However, the attribute is not purchased directly; rather, its monetary value is revealed through the price a buyer pays for the house, of which a particular attribute is a part. Mathematically, an implicit price of a specific house attribute, keeping other characteristics constant, can be expressed as:

$$P_{Z_i}(Z_i,Z_{i-1})=\frac{\partial P(Z)}{\partial Z_i} \tag{1}$$

where Z_i is vector of house attributes.

An ordinary least squares (OLS) regression model was used to estimate marginal implicit prices of structural, neighborhood, and environmental attributes associated with houses in

Mobile and Daphne, U.S. Several model types were tested including simple linear mode, reciprocal, logarithmic, and logarithmic reciprocal based on goodness of fit (R^2). Finally, a semi-log model was selected as represented in Equation 2. A separate HPM model was developed for each city because the housing markets may differ between the cities, while houses in a particular city may share similar structural and neighborhood attributes. Sales price was used as the dependent variable. Independent variables included house structural, neighborhood, and environmental attributes.

$$ln\, H_i = \beta_0 + \sum \beta_j S_{ij} + \sum \beta_k N_{ik} + \sum \beta_l E_{il} + \varepsilon_i \qquad (2)$$

where lnH_i is the natural log of the i^{th} house price (2010 U.S. dollars), S_{ij} represents the j^{th} house's structural attributes, N_{ik} stands for the k^{th} neighborhood attributes, E_{il} represents the l^{th}environmental attributes, β's are the corresponding parameters to be estimated, and ε_i is the error term.

Descriptions of the three groups of independent variables used in the study reflecting structural, neighborhood, and environmental attributes are presented in Table 2. Structural attributes included the number of bedrooms and full bathrooms; house age at sale; presence of a garage, fire-place, and porch; and square footage of the house. Neighborhood attributes were further categorized into two groups of variables: socioeconomic attributes and government/municipal/locational services. Socioeconomic attributes included population density, percentage of families below the poverty line, median income, median resident age, percentage of vacant houses, and percentage of houses used for recreational or seasonal purposes. These variables were selected to reflect the level of development, economic condition, and prosperity of the neighborhood. These data were collected at the Census Block Group level. Government/municipal/locational services included distance-based variables representing house's proximity to the nearest public school, active railroad, primary or secondary road, hospital, airport, and shopping center.

Environmental attributes included variables representing a house's proximity to the nearest waterfront such as river, stream (creek, branch, and fork), bay, bayou, and other water bodies (lake, pond, reservoir, and lagoon). Streams were defined as natural flowing waterways with an intricate network of interlacing channels, artificial waterways constructed to transport water (e.g., to irrigate or drain land), and natural or artificial waterways to connect two or more bodies of water or for watercraft transportation (U.S. Census Bureau, 2018). In Mobile, an average distance to the nearest stream was approximately 3 km. Some of the streams/creeks included Rabbit, Threemile, Chicksaw, and Black Creek. Similarly, in Daphne an average distance to the nearest stream/creek was about 2.5 km. D'Olive Creek is one of the most popular creeks in Daphne. Rivers included natural flowing waterways that did not contain the characteristics of streams (U.S. Census Bureau, 2018). An average distance from a residential property to a river was approximately 6 km. Mobile, Tensaw, Spanish, and Dog River were some of the rivers included in the analysis. Bays included bodies of water partially surrounded by land (U.S. Census Bureau, 2018). An average distance to a bay in Mobile was 9 km, whereas in Daphne it was 3 km. Mobile, Polecat, Delvan, and D'Olive Bay are examples of bays included in the model. Bayous included slowly moving water and marshy land. Environmental attributes also included proximity to the nearest public park. An average distance to a bayou was 8 km and Black, Sara, Big Canot, Catfish, Alligator, Greenwood, Rattlesnake, and Shell bayous are examples of bayous found in Mobile. Other water bodies included lakes, reservoirs, and lagoons. An average distance to nearest other waterbodies in Mobile and Daphne was approximately 1 km (Table 2).

The HPM usually suffers from heteroscedasticity and multicollinearity problems (Poudyal et al., 2009; H. A. Sander & Polasky, 2009; H. Sander, Polasky, & Haight, 2010) and, therefore, this model was tested for heteroscedasticity and multicollinearity. The presence of heteroscedasticity was tested for using White's test at a 5% significance level (Greene, 2012). If heteroscedasticity existed, robust standard errors (heteroscedasticity-consistent standard errors) were used to test parameter significance. Variance inflation factor (VIF) was used to test the model for the presence of multicollinearity (Greene, 2012). Variables with a VIF value greater than 10 were regarded as problematic and were omitted from the model.

Some of the independent variables were transformed to logarithmic, square, and product forms as some of the variables required non-linear specification (Taylor, 2003). Thus, the final model consisted of logarithmically-transformed variables for house price, square footage, population density, income, and all distance-related variables, whereas all other variables were not transformed. Effects of environmental attributes on house prices were measured by six variables in Mobile and four variables in Daphne because Daphne lacked rivers and bayous within the city limits. In addition, Daphne lacked some neighborhood attributes such as airports and hospitals within the city limits. Thus, the final models consisted of 24 variables for Mobile and 20 variables for Daphne.

Table 2. Definition and descriptive statistics of variables used to quantify the monetary value of waterfront in Mobile and Daphne, Alabama, U.S.

Variables	Definitions	Mobile		Daphne	
		Mean	Std. Dev.	Mean	Std. Dev.
Dependent variable					
House price[a]	House sales price (thousand U.S.$)	155.74	134.48	196.06	137.74
Structural attributes					
Bedrooms	Number of bedrooms	3.26	0.73	3.43	0.64
Full bathrooms	Number of full bathrooms	1.98	0.68	2.27	0.58
Stories	Number of stories	1.20	0.39	1.18	0.57
Garage	Dummy variable: 1 if the house had a garage, 0 otherwise	0.63	0.48	0.93	0.26
Fireplace	Dummy variable: 1 if the house had a fireplace, 0 otherwise	0.65	0.48	0.84	0.36
Porch	Dummy variable: 1 if the house had porch, 0 otherwise	0.80	0.40	0.90	0.30
Area[a]	Square footage of the house (thousand)	1.94	0.81	2.16	0.70
House age	House age at the date of sale	72.01	270.22	15.62	13.13
Neighborhood attributes					
Population density[ab]	Number of people per square mile (thousand)	2.77	1.44	1.31	0.97
Poverty[b]	Percentage of families below the poverty line	11.50	11.45	6.52	4.96
Vacancy[b]	Percentage of vacant houses	8.56	4.79	10.94	2.97
Recreational[b]	Percentage of houses used for seasonal, recreational, or occasional purposes	0.41	0.42	1.44	1.07
Median age[b]	Median age of residents	38.26	5.97	39.96	4.37
Income[ab]	Median household income (thousand $)	52.49	21.25	70.26	22.92
Airport[a]	Distance to the nearest airport	5.53	1.87	NA	NA
Hospitals[a]	Distance to the nearest hospital	4.15	2.50	NA	NA
Railroad[a]	Distance to the nearest active railroad	3.08	2.12	14.81	1.53
Road[a]	Distance to the nearest primary or secondary road	2.18	1.80	1.06	0.74
School[a]	Distance to the nearest public school	1.41	0.96	1.61	0.71
Shopping[a]	Distance to the nearest shopping center	1.01	0.74	2.74	1.31
Environmental amenities					
Park[a]	Distance to the nearest public park	0.87	0.62	1.79	1.15
Stream[a]	Distance to the nearest stream	2.77	1.37	2.45	1.75
River[a]	Distance to the nearest river	6.02	3.28	NA	NA
Bay[a]	Distance to the nearest bay	9.29	3.94	3.01	1.62
Bayou[a]	Distance to the nearest bayou	8.09	3.21	NA	NA
Water[a]	Distance to the nearest other water body	1.22	0.60	1.57	0.73

Note: [a] represents a log-transformed variable. [b] represents a value reported at a census block group level. Distance-related variables were measured in thousand meters (m) from the house location to the nearest corresponding feature. NA indicates that a variable was not applicable.

1.3 Results

White's test indicated the presence of heteroscedasticity at a 5% significance level and, therefore, robust standard errors were used in the analysis. The VIFs for variables in both models were not greater than 10, indicating multicollinearity was not a major concern in the model, except for house age and its squared term. However, these two variables were not omitted from the models because using a squared term permits a nonlinear relation between age and house price and these two variables have been commonly used in most previous HPM studies (e.g. Troy & Grove, 2008; Poudyal et al., 2009; Nilsson, 2014). In addition, multicollinearity resulting from the use of a squared term does not affect the probability values of the variable and does not have adverse effect on the model (Allison, 2012; Morrissey & House, 2018; Pokharel 2019). The Housman test indicated that the model did not suffer from endogeneity. Coefficients of determination (R^2) were 0.67 and 0.78 for Mobile and Daphne models, respectively (Table 3). These findings indicated that independent variables included in the models accounted for 67.00% and 78.00% of the variation in house prices for Mobile and Daphne, respectively. The F-statistics for the models were 840.3 ($p < 0.001$) (Mobile) and 569.19 ($p < 0.000$) (Daphne) suggesting that the models fit the data better than models with an intercept only.

Table 3. Estimates from hedonic price method (HPM) models used to estimate the monetary value of waterfront in Mobile and Daphne, Alabama, U.S.

Variables	Mobile			Daphne		
	Parameter estimates	White Std. error	VIF	Parameter estimates	White Std. error	VIF
Intercept	0.564*	0.337	0.000	4.844***	0.525	0.000
Bedrooms	-0.075***	0.021	1.764	-0.023**	0.010	2.046
Full Bathrooms	0.138***	0.011	2.504	0.087***	0.013	2.172
Garage	0.103***	0.009	1.127	0.150***	0.027	1.151
Fireplace	0.100***	0.012	1.428	0.067***	0.014	1.237
Porch	0.108***	0.012	1.097	0.058***	0.017	1.032
ln(Area)	1.043***	0.032	3.519	0.871**	0.030	3.140
House age	-0.002***	0.000	26.165	-0.006**	0.002	1.860
House age squared	0.000***	0.000	25.845	0.000	0.000	1.306
ln(Population density)	0.026**	0.011	1.811	-0.083***	0.016	8.395
Poverty	-0.005***	0.001	2.386	0.011***	0.002	1.981
Vacancy	-0.006***	0.002	1.981	-0.020***	0.003	4.544
Recreation	0.131***	0.013	1.458	-0.004	0.010	6.374
Median age	-0.004***	0.001	1.585	NA	NA	NA
ln(Income)	0.291***	0.020	2.713	0.129***	0.034	4.068
ln(Airport)	0.104***	0.016	1.936	NA	NA	NA
ln(Hospital)	-0.106***	0.012	2.495	NA	NA	NA
ln(Road)	0.022***	0.006	2.272	-0.042***	0.007	1.835
ln(School)	0.020**	0.008	1.702	0.032***	0.010	1.773
ln(Shopping centers)	-0.007	0.007	1.298	0.119***	0.018	4.431
ln(park)	-0.003	0.005	1.269	0.000	0.018	3.349
ln(Stream)	-0.026***	0.009	1.708	0.028***	0.010	4.227
ln(River)	-0.036***	0.013	4.265	NA	NA	NA
ln(Bay)	-0.036*	0.019	4.215	-0.127***	0.017	4.748
ln(Bayou)	0.070***	0.015	3.519	NA	NA	NA
ln(Water)	0.002	0.007	1.309	-0.076***	0.010	2.047
F value	840.300***			569.190***		
R^2	0.669			0.777		
Adj. R^2	0.668			0.776		
N	10445.000			3287.000		

Note: The dependent variable is ln(house price), *$p<0.10$,**$p<0.05$, ***$p<0.01$. NA indicates that a variable was not applicable to the specific model.

1.3.1 House structural and neighborhood attributes

Structural attributes had both positive and negative effects on house prices. The number of bedrooms was negatively related with house prices in both cities. An increase in the number of bedrooms by one was associated with a decrease in house prices of 7.50% ($p=0.000$) in Mobile and 2.30% ($p=0.022$) in Daphne. However, the number of full bathrooms was positively related with house prices. A garage, fireplace, or porch were positively associated with price in both cities. Similarly, square footage of a house was also positively related with house prices and the parameter estimates can be interpreted in terms of elasticity as both independent and dependent variables were log-transformed. In Mobile, a 1% increase in square footage corresponded with a 1.04% ($p<0.001$) increase in house prices, whereas in Daphne the price increase was 0.87% ($p<0.001$). House age was negatively related with house prices. A positive sign for house age squared indicated that house prices had a non-linear relationship with house age such that house prices decreased at a decreasing rate with age ($p<0.001$) in Mobile; however, the inflection point, where houses prices would begin to increase with age, was beyond a general house life span. The relationship between house age and price in Daphne was strictly decreasing.

Neighborhood variables demonstrated the relationship between locality and house prices. Population density was positively related with house prices in Mobile and negatively related in Daphne. A 1% increase in population density was associated with a 0.03% ($p=0.013$) increase in house prices in Mobile and a 0.08% ($p<0.000$) decrease in Daphne. The percentage of families with household income below the poverty line was significantly related to house prices in the two cities. In both cities, there was a negative relationship between vacancy house prices. The percentage of houses used for recreational purposes was positively related with house prices in Mobile as an increase in the number of recreational houses by 1% increased house prices by

13.10% ($p<0.001$); no such relationship was found in Daphne ($p>0.10$). Income had a positive relationship with house prices in both cities where a 1% increase in median household income was associated with 0.29% ($p<0.001$) and 0.13% ($p<0.001$) price increases in Mobile and Daphne, respectively. In Mobile, the distance to an airport was positively associated with house prices, whereas the distance to a hospital was negatively associated with house prices. The distance to the nearest primary or secondary road had a positive association with house prices in Mobile and a negative relationship in Daphne. The distance to the nearest public school was positively associated with house prices for both cities.

1.3.2 Environmental attributes

The effect of environmental amenities on house prices varied across waterfront types. Distance to the nearest public park was not related to house prices in either city. A 1% increase in distance to the nearest stream, river, or bay in Mobile was associated with a decrease in house prices of 0.03% ($p=0.003$), 0.04% ($p=0.004$), and 0.04% ($p=0.058$), respectively. The distance to the nearest bayou was positively related with house prices in Mobile where a 1% increase in distance reflected an increase in house prices of 0.07% ($p<0.001$). Distance to other water bodies was not related to house prices in Mobile. As mentioned earlier, there were no rivers and bayous in Daphne. Thus, only distance to bays, streams and other waterbodies were measured. In Daphne, a 1% increase in the distance to the nearest bay and other water body was associated with a decrease in house prices of 0.13% ($p<0.001$) and 0.08% ($p<0.001$), respectively. However, a 1% increase in the distance to a stream increased house prices by 0.03% ($p=0.006$) in Daphne.

The marginal implicit price was calculated by taking a partial derivative of hedonic price function using Equation 1. The marginal implicit price of each statistically significant attribute was evaluated at the mean house prices of $155,744 and $196,063 in Mobile and Daphne, respectively and a distance of one mile (1609.34 meters) to each waterfront type (Table 4). The marginal implicit prices of proximity to the nearest stream were -$2.49 and $3.47 per meter in Mobile and Daphne, respectively, resulting in a price decrease of $2,490 and an increase of $3,470 for each 1-km increase in distance to a stream in Mobile and Daphne, respectively. Similarly, a marginal implicit price of proximity to a river in Mobile was -$3.46 per meter suggesting a 1-km increase in distance to a river decreased house prices by $3,460. The marginal implicit price of distance to the nearest bay was -$3.53 and -$15.46 per meter in Mobile and Daphne, respectively. This implied that a 1-km increase in distance to a bay was associated with decreases in house prices of $3,530 and $15,460 in Mobile and Daphne, respectively. The marginal implicit price of proximity to a bayou was $6.79 per meter in Mobile with a corresponding increase in house prices of $6,790 for a 1-km distance increase. Similarly, the marginal implicit price of proximity to the nearest other water body was -$9.25 per meter in Daphne and corresponded to a $9,250 decrease in house prices for a 1-km distance increase.

Table 4. A marginal implicit price of proximity to environmental attributes in Mobile and Daphne, Alabama, U.S.

Variables	Parameter estimates		Marginal implicit price ($ per km)	
	Mobile	Daphne	Mobile	Daphne
Distance to bay	-0.036	-0.127	-3,530	-15,460
Distance to river	-0.036	NA	-3,460	NA
Distance to stream	-0.026	0.028	-2,490	3,470
Distance to other water bodies	NS	-0.076	NS	-9,250
Distance to bayous	0.070	NA	6,790	NA

Note: NA indicates that a variable was not applicable; NS indicates that a variable was statistically not significant

The relationships between distances to various waterfront types and house prices, holding all other variables constant, are presented in Figure 3. A downward sloping relationship implied that houses located nearer to a given waterfront type sold at higher prices than those located farther away, whereas an upward slope suggested that houses farther away from a specified waterfront type sold at higher prices. In Mobile, the relationship was downward sloping for bays, rivers, and streams and upward sloping for bayous. In Daphne, the relationships for streams was upward sloping, whereas bays and other water bodies were downward sloping. A downward sloping relation implied that houses in Mobile located near a bay, river, or stream sold at higher prices than those farther away. Similarly, houses near bays and other water bodies sold at higher prices in Daphne. However, in the case of bayous in Mobile and streams in Daphne, houses located farther away sold at higher prices.

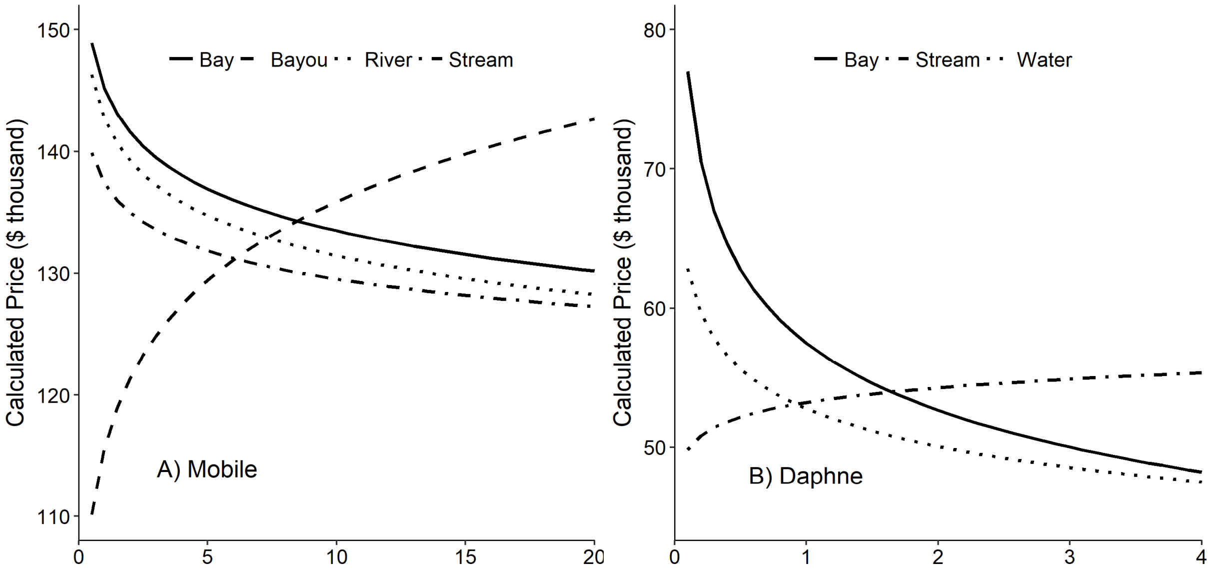

Figure 3. Relationships between house prices and distance to various waterfront types in Alabama, U.S.: A) Mobile, B) Daphne.

1.4 Discussion

Structural, neighborhood, and environmental attributes were critical factors considered in residential home purchases. With the exception of number of bedrooms, all structural variables included in the analysis had a positive and statistically significant association with house prices. A negative relationship of the bedroom number with house prices possibly indicated that buyers preferred a less fragmented interior space (Bowman, Thompson, & Colletti, 2009). It could also be that people place more value on the relative size of bedrooms than on number of rooms. The mean numbers of bedrooms for both cities were greater than the average number of bedrooms in the U.S. (U.S. Census Bureau, 2017). Only about 20% of people in the U.S. prefer more than three bedrooms and as a result, additional number of bedrooms had negative impact on house prices. The relationships of other structural variables (full bathroom number; presence of a garage, fireplaces, and porches; house square footage, and age) with house prices were consistent with a number of hedonic studies (e.g., Bolitzer and Netusil 2000, Geoghegan 2002; Poudyal et al. 2009; Sander et al. 2010). While most house structural attributes were associated with higher house prices, consistent with other studies, house age was linked with lower house prices. For example, Bolitzer and Netusil (2000), Poudyal et al. (2009), and Sander et al. (2010) found a drop from 0.2% to 0.7% in house prices for each one year increase in a house age. However, a house price may have a nonlinear relationship with its age. For instance, Sander et al. (2010) reported a decrease in house price up to 88 years and an increase afterwards. Thus, a level of structural improvements such as number of full bathrooms, presence of a garage, and house living area were significant factors in determining a house value.

Most neighborhood attributes affected house prices, yet the coefficient signs differed between some Mobile and Daphne attributes. For instance, population density was positively related with house prices in Mobile and negatively related in Daphne. Geoghegan et al. (2003) stated that population density could have two opposite effects on house prices. On one hand, population density can be regarded as a measure of congestion and thus a negative externality. On the other hand, it can serve as a proxy for density of other goods and services that can attract people and therefore increase house prices. The mean population density in Mobile was more than double that of Daphne suggesting a higher demand of other goods and services such as shopping centers and recreationally-used houses. Similarly, distance to the nearest primary or secondary road had a positive association to house prices in Mobile and negative relationship in Daphne. A possible explanation for this relationship might be that Mobile is characterized by substantial industrial and commercial development and, therefore, residents chose to live close to nearby roads for easy and quick access to their work places. However, Daphne is characterized mostly by residential development and people may consider nearby roads as a negative externality because of noise and pollution. The percentage of vacant houses was negatively related with house prices in both cities. Poudyal et al. (2009) and Klaiber and Phaneuf (2010) also reported that house prices decreased as the percentage of vacancies increased. A possible explanation for this trend might be that consumers view increases in the percentage of vacant houses as a safety issue, an unpleasant living environment, and/or a health hazard resulting in a negative impacts on house prices (Heynen, Perkins, & Roy, 2006; Woolle & Rose, 2004). In addition, the presence of vacant houses might be an indication of house oversupply resulting in decreased house prices. Thus, neighborhood attributes played an important role in determining residential property values and required market analysis before arriving at fair market value of any residential property.

Most environmental attributes, which were the focus of this study, were related with house prices. Residents in Mobile and Daphne were willing to pay higher prices for houses in the vicinity of most waterfront types. Coefficient signs for environmental attributes were consistent with previous studies. For instance, a decrease in the distance to a wetland by 1,000 feet was related with an increase in property value of $436.17 (Bin, 2005). Similarly, Sander and Polasky (2009) reported a relatively small but statistically significant increase in house prices as distance to a lake decreased. Chen and Jim (2010) reported that a 1,000-meter increase in distance to a bay reduced house prices by 0.70%. Distance to a park was not a significant factor for house prices in either city. The reason might be that when both parks and waterfronts were available as open space, coastal residents preferred waterfronts more than parks because of their uniqueness compared to non-coastal areas (also see Mahan et al. 2000).

Some of the specific waterfront types, however, had positive coefficients indicating that residents preferred houses located away from these waterfronts. For example, distance to a bayou was positively related to price indicating that houses further away from bayous had higher selling prices. This might be because residents considered bayous as a negative externality due to their specific microclimatic effects and less appealing nature (i.e., marshy character and slowly moving water). Another explanation might be that bayous provide habitat for animals such as alligators and caimans and residents may have considered living in close vicinity to a bayou as unsafe.

In terms of waterfront types, distance to a bay had the largest marginal implicit price followed by distance to a river and a stream. This suggest that coastal residents preferred to live near a larger-sized body of water, perhaps because of more opportunities for recreation. In addition, the estimated marginal implicit prices for distance to different waterfront types were larger in Daphne than in Mobile. A possible explanation might be related to the total water coverage in each city. Only 7.04% of the area within the city limits is covered by water in Daphne in contrast to 22.62% in Mobile. Residents of Daphne thus might place a higher value on proximity to waterfronts as a scarce environmental amenity. Furthermore, the mean distance to a bay and other water bodies in Daphne was 3,008 and 1,572 meters, respectively, in comparison to 9,292 and 1,222 meters in Mobile. Thus, the marginal price of proximity to waterfronts was larger in Daphne than in Mobile because of proximity and easier access to waterfronts.

In addition, a substantial portion of the area within Mobile city limits fronting Mobile Bay and Mobile River is dedicated to the commercial/industrial activity associated with the Port of Mobile. None of these areas is zoned for residential use, whereas Daphne waterfronts are dedicated for residential use. Therefore, people who prefer waterfront living tend to choose Daphne over Mobile. The coefficient for distance to streams was positively associated with house prices in Daphne indicating that houses located farther away from streams had higher selling values. This result might well be attributed to the presence of small streams, such as Daphne, D’Olive, and Tiawasee Creeks, which flow east-west in the northern section of the city and D’Olive Bay which lies within 1,500 meters from these streams. It is possible that residents were more attracted to the bay than streams, resulting in lower house prices in proximity to streams and higher prices in proximity to the bay. Thus, value of waterfront varied based on its type. Waterfronts that were more appealing, larger sized, and in closer proximity to residential properties, such as bay and river, were valued more than ones that were smaller sized, farther away or having marshy or slowly moving water such as bayou.

It should be noted that the implicit prices estimated in this study using HPM represent only a partial component of house prices. These prices are unlikely to capture total value of waterfront because house buyers may not have perceived all the values of waterfronts such as those related to recreation, scenic views, and habitat. The estimates presented in this study reflect only the values and services captured by changes in house prices (Mahan et al., 2000). A study by Dahal et al. (2018) located in the Gulf of Mexico used contingent valuation to measure both use and nonuse values of open space. The authors estimated that coastal residents' average willingness to pay to preserve waterfront open space was $90.72 per household, which translated to an aggregated value of $10.84 million. Thus, total value of waterfront might be larger than estimated in this study. If so, then computing the total value of benefits associated with waterfront in coastal areas remains an important area for future research. Total value estimation will be important for identification of resident preferences towards open spaces and incorporation of these preferences into future land-use and urban development decisions as well as design of urban living areas.

In addition, this study examined the relationship between proximity to waterfronts by type and house prices only within the city limits. However, house prices might have been affected by proximity to waterfronts beyond the city limits and, thus, restricting the study area to within the city limits might have reduced the quantified implicit prices. Future studies should consider including attributes located outside of administrative boundaries. Doing so would better enable quantification of attributes' impacts on marginal implicit price, and provide a means to determine how far people are willing to travel to enjoy environmental services provided by open spaces. In addition, this study estimated monetary values of waterfront types by developing separate models for each city, assuming houses in a particular city shared structural and neighborhood attributes, and housing market. However, future studies might consider developing a spatial model such as a geographically weighted regression model to estimate how location affects house prices. Finally, future studies might also focus on identifying open space features people value most such as trees, shrubs, water, and grasses as well as their preferences towards natural versus manicured landscapes. This information would facilitate a more precise estimation of implicit prices associated with open space benefits, and help city planners make decisions about balancing preservation of these spaces in face of development desired by local communities.

1.5 Conclusions

The study provided insights into how different waterfront types were valued by coastal community residents based on the relationship of residential properties' structural, neighborhood, and environmental attributes with price. Distances to different waterfront types, in addition to house structural and neighborhood attributes, were factors considered by coastal residents when buying a house. With the exception of bayous in Mobile and streams in Daphne, houses near waterfronts sold at higher prices than those located farther away with house price impacts ranging from -$6,790 to $15,460 per km depending on waterfront type. Because most waterfronts were highly desired by residents, and they preferred to live in proximity to these open space areas, planners can use information from this study to formulate more effective and transparent conservation and development strategies in budget allocations and city planning.

This study has several implications. Results indicated that waterfronts had substantial positive price impacts on residential properties and affected the surrounding land market by creating new and enhancing existing land values that translated into positive economic benefits to coastal communities. Proximity to preserved waterfronts can enhance property value, if the waterfronts are not intensively developed and they are carefully integrated with the neighborhood. Estimates on monetary value will also be useful for federal income tax governing the valuation of conservation easements and other set-asides. In addition, monetary values as estimated by this study can be used in making important policy decisions such as zoning, restrictions on land use, open space through public or private initiatives, and improving local landscape and vegetation ordinances Maintaining visually appealing, usable, and easily accessible waterfronts can be an effective way to make waterfronts lively public destinations that offer not only environmental benefits, but which also create economic opportunities. With proper design and sound policies promoting waterfront open spaces, demand for their benefits will likely increase and lead to higher local tax revenues from properties and economic activities.

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