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Gulf Views: Toward a Better Understanding of Viewshed Scope in Hedonic Property Models

Paul Hindsley
Eckert College

Stuart E. Hamilton
College of William and Mary

O. Ashton Morgan
Appalachian State University

Department of Economics
Appalachian State University
Boone, NC 28608
Phone: (828) 262-6123
Fax: (828) 262-6105
www.business.appstate.edu/economics

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Abstract

This study examines the influence of Gulf of Mexico views on residential home sales prices in Pinellas County, Florida. We utilize Light Detection and Ranging (lidar) data to construct four continuous measures of Gulf of Mexico views – the total view, the maximum view segment, the mean view segment, and proximity to view content. Our results illustrate that residential property owners have a higher marginal willingness-to-pay for larger total views and larger continuous view segments. Results also indicate that the proximity of homes to the view content influences view valuations.

Introduction

The flow of services from recreational and aesthetic amenities plays a contributing role in people's residential property choices. Consequently, these amenities influence high population densities in the amenity rich, coastal United States. In fact, when compared to other locations, a disproportionate number of people in the U.S. live on or near the coast. For example, roughly 35% of the US population lives within shore-adjacent US coastal counties – an area representing only 17% of the total U.S. land area .[1] While people have long been drawn to the coast, a lack of explicit markets for many coastal resources complicates our understanding of the how the flow of these services impact residential decisions. One way researchers have approached the challenge of valuing local environmental amenities is through the use of residential property transactions, via hedonic property models. In this paper, we use the hedonic framework to assess the influence of coastal view amenities, or viewsheds, on residential home prices.

In the valuation of viewsheds, researchers should make a concerted effort to communicate the specific view characteristics their analyses capture. Bourassa, Hoesli, and Sun

(2004) discuss the failure of numerous studies to fully characterize their view measures. As an extension of their discussion, we differentiate the objective constituent components of a view into view content, scope, orientation, and content distance. These components capture the content of an individual home's viewshed (view content), the magnitude or size of a view (view scope), the direction of the existing view in relation to the home's spatial orientation (view orientation), and the distance to the relevant view content influencing the homebuyer's purchasing decision (content distance).

Our study investigates the influence of a Gulf of Mexico view on home prices in Pinellas County, Florida. We focus on two constituent components of a Gulf of Mexico view, scope and content distance. Utilizing Light Detection and Ranging (lidar) data, we construct a continuous measure of view that accounts for natural and man-made obstructions. By identifying each continuous swath of view as a view segment, we then examine three different ways in which the scope of a coastal view, in degrees, could be measured in a hedonic framework – the total view, the largest or maximum view segment, and the arithmetic mean of all view segments. In addition, we also study one type of content distance view measure. Finally, we estimate the marginal willingness-to-pay for these viewshed components.

Our general findings suggest that lidar-based view measures allow for significant flexibility in understanding the influence of view scope on sales prices. Households assign higher marginal valuations to their largest continuous view segment when compared to their total view. Of the three measures, we find the highest point estimates are associated with marginal increases in mean view, but this measure also captures the greatest uncertainty, as represented by the widest confidence intervals in marginal willingness-to-pay (MWTP). Last, our results indicate that content distance does influence point estimates of MWTP.

Background

Numerous studies have examined the aesthetic value of views within the hedonic framework. Over time, viewshed measures have become increasingly precise. Early research commonly captured property views by utilizing discrete variables, either through a single dummy variable, which acted as a proxy to infer the existence of a view of a resource, or through the use of a view scale, which is a type of subjective view measure, requiring a number of dummy variables to represent the quality of a view (Bensen et al. 1995; Pompe and Reinhart 1995; Bond et al. 2002; Bourassa et al 2004).[2] Other studies also examined the role of distance on the value of views (Bensen et al. 1995; Tyrväinen and Miettnen; Bourassa et al. 2004).[3] The typical finding across these studies is that view amenities positively impact property values and the implicit value of a view decreases with increasing distance from a resource.

While these findings provided initial insight into the premium homeowners will pay for the view of an adjacent resource, the methods used to capture views in the hedonic property function had distinct limitations. First, constructing a view measure usually required physical inspection of the property, either by the researchers themselves or via household surveys. As such, these measures tend to suffer from the subjective nature of the researcher-derived view classification. The inclusion of dummy variables also limits the precision of these measures. In addition, the laborious nature of quantifying views within the hedonic framework meant that relevant studies were often characterized by a small sample of properties.

More recent studies have utilized advances in Geographic Information Systems (GIS) to generate view measures. These studies generate continuous view measures which provide significant improvements in precision when compared to the previous binary indicators or subjective view measures (Lake et al. 1998; Din et al. 2001; and Patterson and Boyle 2002). Most recently, researchers have captured the three-dimensional characteristics of viewsheds through the use of lidar (Bin et al 2008, Morgan and Hamilton 2011) and remote sensing (Cavailhes et al 2009).

Bin et al. (2008) use lidar data to construct a continuous measure of view which takes into account natural and man-made obstructions. Bin et al. were initially unable to separately identify view amenities, shoreline access, and flood risk because of the high correlation among these amenities & disamenities. Motivated by the need to disentangle these spatially integrated housing characteristics, they include a continuous viewshed measure within their specification. This inclusion enabled separate identification of coastal amenities and risk within the hedonic price function. Using data from North Carolina coastal communities, they estimate a spatial autoregressive hedonic model and calculate that households are willing to pay an average of $995 for a one-degree increase in the view of the Atlantic Ocean. They argue that failure to appropriately incorporate view may bias estimates of other highly correlated environmental variables, such as access to coastal amenities.

For non-coastal markets, numerous studies have considered a variety of landscape types observable from properties (Lake et al. 1998; Din et al. 2001; Patterson and Boyle 2002).[4] Patterson and Boyle (2002) include variables representing land use/cover features (development, agriculture, forests, and surface water) and find that views of developed areas and forests detract from sales prices, while visible agricultural land and water have no statistical effect. Similarly, Cavailhes et al. (2009) develop a three-dimensional viewshed for properties in Dijon, France by integrating remote sensing data into a GIS-based model. Their model incorporates a variety of landscape types and, by relying on a few underlying assumptions, accounts for potential view obstructions. Their results indicate that content distance does influence property valuations, such that content within tens of meters of a property has the greatest influence.

Our study captures conditions where properties' view contents focus on an expanse of water, specifically the Gulf of Mexico. While this type of analysis captures a somewhat homogenous view content, other objective components of view are likely to differ greatly among properties. For example, one property may have a larger than average total view (measured in degrees) but due to vegetation and man-made obstructions, it is comprised of the aggregation of a number of smaller individual view segments. Conversely, a property may have a smaller than average total view which includes one large view segment. Other factors may influence perceived view quality, such as the location of obstructions and the orientation of view segments. These types of examples help motivate the need to better understand the objective constituents of views.

Site Area and Data

We obtained real estate sales data from the Pinellas County property appraiser's office for Pinellas County, Florida between the years 2000 and 2006. Pinellas County lies on a 280 square mile peninsula separating Tampa Bay and the Gulf of Mexico. This county is highly urbanized, with 944,000 permanent residents and approximately 5 million visitors per year (Pinellas County Coastal Management 2009). Our study focuses on four barrier islands lining the Gulf of Mexico (Clearwater Beach Island, Long Key, Sand Key, Treasure Island), on which there are 10 municipalities. Figure 1 provides a map of our study area. From figure 1, Area A comprises the municipality of Clearwater Beach, and consists of 170 properties. Area B encompasses the municipalities of Belleaire Beach, Belleair Shore, and Indian Rocks Beach, with 260 properties, while the remaining municipalities of Madeira Beach, North Redington Beach, Redington Beach, Redington Shores, St Pete Beach and Treasure Island are contained within Area C and have 651 properties in our sample.

Pinellas County's barrier islands are roughly 35 miles in length. Up until the mid-20th century, the Pinellas County barrier islands experienced significant dredge-and-fill activities on the back barrier bays (Pinellas County Coastal Management 2009). These dredge-and-fill activities greatly increased the total number of lots as well as the water access through an intricate series of canals (see figure 2). As a result, many of the single family homes sold during the 2000-2006 period are found on the backsides of these islands. In our dataset, 62% of homes have either access to a back barrier bay via canals or are found on the back barrier bays; in contrast, only 1.5% of the homes are considered Gulf front. The average home is 2157 feet from the Gulf of Mexico.

We adjust sales prices for inflation and normalized them to 2006 values. Table 1 provides summary statistics for housing sales prices as well as other variables relevant to the empirical analysis. After accounting for missing values and irregular observations, 1081 properties were collected from the 2000 to 2006 time period. All 1081 properties are designated as having homestead exemptions by the Pinellas County Property Appraiser's office, meaning all homes are primary residences. The average normalized sales price for properties within this period was $475,400. The average residential property in this sample is 38 years of age, 2803 square feet in size, and has a lot size of 8036 square feet. The Pinellas County Property Appraiser's office does not collect information on the number of bathrooms or bedrooms, but it does collect information on the number of bathroom water connections. In this application, a water connection refers to a sink, tub, shower, or bidet. The average home in this dataset has just over 7 fixtures, which is approximately 2 bathrooms.

Lidar data was obtained from the Florida Department of Emergency Management. The lidar flight occurred between 7/6/2007 and 8/10/2007. The vertical accuracy of the lidar elevation data meets the NSSDA DTM requirement of .9.14cm at the 95% confidence level and was verified using field survey by an independent survey. For each property we construct four lidar-derived viewshed measures that account for natural and man-made features on the landscape including all structures, sand dunes, trees, other vegetation, etc. The first viewshed measure is a Gulf side *individual property's view angle* (IPVA°) as defined by Hamilton & Morgan (2010). The IPVA° is constructed for all 1081 properties in the study areas resulting in 777 homes with Gulf of Mexico views. The IPVA° measures a home's view of the Gulf of Mexico in degrees assuming an observer location in the highest living level of the home. For example, on a two level home the observer is placed at the approximate height of the second level. Figure 3 provides a schematic detailing the IPVA° from two different properties in the sample. The property on the left is an inland property with a large IPVA that constitutes two large view segments of differing sizes. On the right is a Gulf-front property with a large IPVA consisting of one large single view segment. A theoretical maximum of approximately 180 degrees exists for this measure due to the almost linear nature of the Gulf shoreline in this area. It is shown that buyers prefer an increased IPVA° of the desirable amenity (Bin et al. 2008, Morgan and Hamilton 2011).

Our second viewshed measure examines each property's largest view segment of the IPVA°. The IPVA° measure was divided into segments with a minimum possible segment of 0° and a maximum of 180°. Each property was then assigned the number of segments occurring and attributes that summarize the minimum, maximum, mean and standard deviation of its view segments. We surmise that two properties may exhibit an equivalent overall view of the shoreline but due to obstructions, the size of segments in each property's viewshed differs. We hypothesize that homebuyers prefer large continuous view segments as opposed to small individual view segments. Our third measure of view scope utilizes the arithmetic mean of each property's view segments. It is our hypothesis that homebuyers not only prefer properties with one large view segment, but they also prefer larger view segments on average. Last, we measure the influence of distance on a property's view measure (content distance) by interacting our continuous view measure with dummy variables representing distances to the Gulf shoreline.

Empirical Model

Hedonic property models are predicated on the theory that the prices of heterogeneous goods reflect the component values of those goods' characteristics (Rosen 1974). As such, price differentials reflect these component values. Hedonic property models utilize observations on property values to infer the values of home characteristics. This theory allows researchers to estimate values for non-marketed characteristics such as environmental quality. When we assume a fixed housing supply where prices are demand determined, the equilibrium hedonic price function is

$$P = P(\boldsymbol{S},\boldsymbol{N},\boldsymbol{E}), \quad (1)$$

where P represents the price of a unit, which is a function of vectors of structural (S), neighborhood (N), and environmental (E) characteristics. Because housing supply is assumed to be fixed in the short run, the hedonic price function arises as the consequence of bidding by home buyers. Assuming the hedonic price function is continuously differentiable, Rosen (1974) postulated that the first derivative of equation (1) with respect to any continuous attribute results in an average household's marginal willingness to pay for an additional unit of that attribute.

In the last twenty years, the hedonic literature has begun to place a growing emphasis on spatial dependence in residential housing markets (Dubin 1988; Anselin and Bera 1998; Kim, Phipps, and Anselin 2003). Traditional estimation methods often fail to account for spatial autocorrelation, even with the inclusion of location-based indicators. Often home prices will cluster according to spatial characteristics. In some cases, the prices may be spatially clustered due to unobserved neighborhood characteristics such as school quality or crime rates. In other cases, structural characteristics of adjacent homes may be reflected in sales prices. Failure to account for spatial dependence can violate the assumption of uncorrelated error terms and lead to biased and inefficient coefficient estimates.

Regression diagnostics based on Ordinary Least Squares (OLS) estimation procedures tests suggest the presence of spatial autocorrelation. We estimate the hedonic price function with a log-linear specification. Lagrange Multiplier (LM) test statistics suggest the use of a spatial simultaneous autoregressive lag model.[5] The formal spatial lag model is

$$P = \rho WP + \beta S + \delta N + \theta E + \varepsilon \quad (2)$$

where P is an $i \times 1$ vector of residential sales prices for i observations, ρ is a spatial autoregressive coefficient, W is an $i \times i$ spatial weights matrix, β is an $s \times 1$ vector of structural variable coefficients, S is an $i \times s$ matrix of observations on structural home variables, δ is an $n \times 1$ vector of neighborhood variable coefficients, N is an $i \times n$ matrix of observations on neighborhood variables, θ is an $e \times 1$ vector of environmental variable coefficients, E is an $i \times e$ matrix of observations on environmental variables, and ε is an $i \times 1$ vector of independent and identically distributed random error terms. In equation 2, the spatial autoregressive coefficient, ρ, reflects the average influence of neighboring properties on sample home prices.

In the spatial lag model, marginal changes in housing characteristics must reflect the spatial spillovers or diffusions represented by ρWP. This means that spatially relevant characteristics can directly influence the price of a house in question while also indirectly influencing the price of neighboring properties. Kim, Phipps, and Anselin (2003) recommend estimating marginal effects in spatial lag models with the inclusion of a spatial multiplier, $1/(1-\rho)$. In our study, we are interested in estimating the marginal willingness-to-pay for view amenities. Given our log-linear specification, we measure the MWTP for a Gulf of Mexico view with $\theta_{view} \cdot P \cdot \left(1/(1-\rho)\right)$. All reported values of MWTP are computed with mean home sales prices. We use the Krinksy and Robb (1986) parametric bootstrap procedure with 5000 draws from a multivariate normal distribution to generate confidence intervals for MWTP.

Results

Construction of the spatial weights matrix plays a key role in capturing the unobserved spatial characteristics that contribute to spatial dependence. We follow suggestions by Anselin and Bera (1998) in the construction of our spatial weights. After experimenting with different weight matrices, we choose a row standardized weighting scheme where neighbors are defined with a distance cutoff. The distance cutoff defines the extent of spatial spillover within the study area. We use a spatial weighting matrix that identifies properties within 1640 feet. All properties outside 1640 feet are treated as zero elements in the weighting matrix.

In our investigation of the influence of view scope, we estimate three primary model specifications with the log of sales prices used as the dependent variable. Table 2 provides the Maximum Likelihood estimation results for three hedonic property models. In each model, we address heteroskedasticity by estimating robust standard errors.[6] Each model differs only in how it represents our primary variable of interest, scope for a Gulf of Mexico view. As such, we refer to these model specifications as the total visibility model, the maximum visibility model, and the mean visibility model.

We estimate numerous specifications and found the primary results robust to alternative functional forms. In each case, significant spatial autoregressive coefficients indicate the presence of spatial dependence. In each model, we include year and island fixed effects. The year fixed effects are statistically significant at the 1% level in all four model specifications. With one exception, the island fixed effects do not have statistically significant coefficient estimates.

Among the other variables included are a quadratic specification for home area (square feet/1000), property area (square feet/1000), and distance to the Gulf shoreline (hundred foot increments) in order to account for potential non-linear effects. The distance to the Gulf shoreline plays an important role in our specification because it controls for differences between local amenities associated with the Gulf of Mexico. Distance captures ecosystem services, such as recreation, that need to be identified separately from view. The total and mean visibility models provide evidence that homebuyers prefer homes closer to the Gulf, but the influence diminishes with increased distance.

Other variables included in each specification are the number of bathroom water connections, the distance to downtown Tampa, a Census tract level variable depicting the percentage of households with members over 60 years of age, a Census tract level variable depicting the percentage of houses rented, and a variety of indicator variables depicting structural and spatial characteristics, including two Pinellas County property assessor variables depicting superior and excellent home condition, homes with a custom interior finish, homes with decks, pools, a variable depicting sound front homes with no dock or boatlift, soundfront homes with docks only, and soundfront homes with both docks and boatlifts. The inclusion of three soundfront dummy variables allows our estimation procedures to capture the influence of docks and boatlifts; otherwise, the high correlation between the dock, boatlift, and sound front variables would lead to concerns over multicollinearity. While some coefficients are not statistically significant, all coefficients exhibit the expected signs.

Table 2 presents the results from the three view scope models. First, the total visibility model incorporates a view measure that captures the total Gulf of Mexico view for properties (GULF_IPVA) in degrees. This measure aggregates all view segments in a home's view with a theoretical minimum of 0 degrees and a maximum of 180 degrees. The coefficient estimates indicate that the total Gulf of Mexico view for a property has a positive effect on property values with significance at the 1% level.

Next, the maximum visibility model incorporates a view measure that captures the largest Gulf of Mexico view segment for properties in degrees. Our results indicate that the maximum Gulf of Mexico view for a property has a positive effect on property values at the 1% level. Our final measure, the mean visibility of the Gulf of Mexico, represents the average of all view segments for a property. Mean visibility has a positive impact on property valuations at the 1% level. Each view measure coefficient coincides with our hypothesis that homebuyers prefer large views and large view segments.

In addition to view scope, we also estimate seven models capturing varying magnitudes of content distance. We retain our previous total visibility model specification, with the exception of our content distance measures. In order to capture content distance, we create indicator variables based on different distances from the Gulf of Mexico. Table 3 depicts the results of these estimation procedures.[7] The seven measures represent a sensitivity analysis for content distance in that they estimate the influence of interacting different distance bands (1500 ft, 1000 ft, 900 ft, 800 ft, 700 ft, 600 ft, and 500 ft) with our total visibility measure. For example, our model that uses 1500 ft distance bands is specified to include two variables that interact distance-based indicator variables with the Gulf IPVA measure. The first distance based indicator variable represents homes within 1500 feet of the Gulf of Mexico and the second represents homes between 1500 and 3000 feet of the Gulf. These measures are meant to capture the total views for the homes within different distance bands. In general, as the distance band closest to the Gulf of Mexico get smaller in size, the coefficient gets larger. This indicates that content distance does influence price.

MWTP estimates for our Gulf of Mexico visibility measures can be found in Table 4. We estimate standard errors using the Krinsky-Robb method, where 5000 random variables are computed from our parameter estimates (Krinsky and Robb 1986). In the total visibility model, MWTP for total visibility is $1300 per degree of view (95% Confidence Interval: $706 - $1894. MWTP for maximum visibility is $2015 per degree of view (95% Confidence Interval: $1266 - $2765). MWTP for mean visibility is $2881 per degree of view (95% Confidence Interval: $884 - $4879). Figure 4 provides graphical depictions of MWTP for total, maximum, and mean visibility.

Table 4 also provides MWTP estimates for our content distance measures. We compute measures for the distance band closest to the Gulf of Mexico. We use the total visibility model for all properties as a point of comparison. When we constrain total visibility to the first 1500 feet, MWTP for total visibility is $1324 per degree of view (95% Confidence Interval: $725 - $1922), only slightly higher than the measure with no distance constraints. We generally observe an increase in MWTP as the size of the distance band decreases. In the smallest distance band, 500 feet, MWTP for total visibility is $1901 per degree of view (95% Confidence Interval: $1150 - $2651). Figure 5 provides graphical depictions of MWTP for total visibility within each distance band.

Discussion/Conclusions

While the scholarly literature on hedonic property models has established the positive/negative values of numerous local environmental amenities/disamenities, from amenities such as beach width (Landry and Hindsley 2011, Gopalakrishnan et al. 2011) to disamenities such as flood risk (Bin and Polasky 2004, Bin et al 2008), appropriately capturing and measuring the value of a property's view has proven to be difficult. Recent advances in GIS techniques have enabled continuous and replicable measures of view which supersede previously subjective classifications. In this study, we attempt to add to the existing literature by examining two specific view components: scope and content distance. We provide more precise insight into the valuation of these view components. Results suggest that households' valuation of different types of view scope and content distance follow our preconceived hypotheses. These findings are consistent with our expectation that homebuyers not only prefer larger total views, but also larger continuous view segments. Results also indicate that distance to the view content also influences homebuyers' purchasing decisions.

The first measure of view, total visibility, picks up the total view for a property. The MWTP point estimate for total ocean visibility of $1300 per degree of view is comparable to the MWTP of $995 per degree view that Bin et al. (2008) estimated for North Carolina properties. In this study, the valuation of view amenities per degree has a higher dollar value, but the average home price is also greater in our sample.

In addition to our total visibility model, we also created a content distance measure by interacting total visibility with distance-based indicator variables. In general, we find that homes in closer proximity to the Gulf of Mexico have higher per degree view valuations. Our findings indicate that content distance does in fact influence the assessment of views. It is difficult to make a direct comparison to other studies due to differences in view content. Our study only targets one type of view, while other studies investigating content distance account for more heterogeneous views for adjacent viewscapes. Both Bensen et al. (1998) and Bourassa et al. (2004) interact distance with view quality dummy variables and find that distance negatively influences the valuation of a view. Cavailhes et al. (2009) find a similar relationship between distance and view content. They create a continuous measure that accounts for view type within adjacent areas through the use of remote sensing.

The maximum visibility measure represents the largest view segment in a property's viewshed. Two homes with equal measures of total view in degrees could have views comprised of different quantity and sized view segments. We hypothesize that homeowners prefer large view segments to small segments. As a consequence, we surmise that, all else equal, a view with fewer large segments would be preferred to one with more numerous small segments. Our total view measure does not allow us to identify these differences. We utilize the maximum visibility measure to test this hypothesis. Our findings show that households have a greater willingness-to-pay for a marginal change in their maximum view segment than their total visibility. This clearly suggests that home buyers consider multiple dimensions of view scope when making purchasing decisions. Homebuyers not only prefer larger total views, but also larger continuous views.

The final view type represents the mean visibility of each property. In comparison to the other two view scope measures, estimates associated with mean visibility offer less precision. The mean visibility measure is represented by an average of all view segments. This measure does indicate that homebuyers' prefer larger view segments on average; however, each individual average value can represent numerous combinations of different sized view segments. For example, one property may have four view segments (in degrees of 40, 10, 5, and 5) compared to a property with just two (in degrees of 20 and 10). While both have a mean visibility of 15 degrees, clear differences exist in the variance of segment size. This uncertainty manifests itself as a larger standard error in MWTP. The interpretation of this value is also more obscure. While a marginal increase in total and maximum visibility truly represents a one degree increase, the true value of a marginal increase in mean visibility is dependent on the number of view segments. As the number of segments increase, the absolute change associated with a marginal increase also increases. This increases the variance of MWTP and makes it difficult to directly compare the MWTP value of mean visibility with either total or maximum visibility.

GIS techniques have allowed us to measure the continuous characteristics of a coastal view within a hedonic property model. Our findings provide a promising look at the influence of scope on household valuations for viewsheds. These valuations coincide with our preconceived hypotheses related to view scope in that homeowners prefer not only larger total Gulf of Mexico views, as seen in previous studies (Bin et al. 2998; Morgan and Hamilton 2011), but also larger continuous view segments. In its present form, our viewshed method does not account for different types of view content or view orientation. Future research is needed to integrate heterogeneous view content and specificity of orientation with lidar-based viewshed measures.

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Tables and Figures

Table 1: Summary Statistics

Variable	Mean	Std Dev	Min	Max
Price	475400	424266	50000	6540000
Clearwater (1,0)	0.16	0.36	0	1
Long Key (1,0)	0.07	0.25	0	1
Sand Key (1,0)	0.59	0.49	0	1
Treasure Island (1,0)	0.19	0.39	0	1
Year2000 (1,0)	0.15	0.36	0	1
Year2001 (1,0)	0.16	0.37	0	1
Year2002 (1,0)	0.17	0.38	0	1
Year2003 (1,0)	0.15	0.36	0	1
Year2004 (1,0)	0.16	0.37	0	1
Year2005 (1,0)	0.12	0.33	0	1
Year2006 (1,0)	0.08	0.27	0	1
Home Area	2803	1350.95	688	11611
Property Area	8036	3120	1394	40119
Stories	1.2	0.43	1	4
Bathroom Water Connections	7.5	3.22	3	30
Superior (1,0)	0.02	0.14	0	1
Excellent (1,0)	0.06	0.23	0	1
Custom Finish (1,0)	0.16	0.36	0	1
Bay Front (1,0)	0.62	0.48	0	1
Dock (1,0)	0.61	0.49	0	1
Boatlift (1,0)	0.51	0.50	0	1
Deck (1,0)	0.86	0.35	0	1
Pool (1,0)	0.46	0.50	0	1
Distance to Gulf (feet)	2157	1377.6	50	6028
Distance to Tampa (miles)	46.3	1.79	42.04	49.58
Percent White*	0.97	0.004	0.97	0.99
Percent of Homes Rented*	0.31	0.1	0.15	0.54
Percent of Households with Individuals 60+ *	0.48	0.09	0.34	0.63
Total Gulf Visibility (degrees)	26.29	502.5	0	177
Max Gulf Visibility (degrees)	13.75	34.18	0	176.15
Mean Gulf Visibility (degrees)	3.53	15.12	0	175.27

***Data Collected from 2000 Census Tracts**

Table 2: Spatial Lag Estimation Results for the Total, Maximum, and Mean Visibility Models

	Total Visibility Model		Maximum Visibility Model		Mean Visibility Model	
Variable	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Constant	1.381 [b]	0.54349	1.5254 [a]	0.53756	1.8213 [a]	0.53337
Sold in 2001	0.1969 [a]	0.03266	0.1808 [a]	0.03222	0.1858 [a]	0.03212
Sold in 2002	0.3227 [a]	0.0363	0.3103 [a]	0.03573	0.3282 [a]	0.03559
Sold in 2003	0.4882 [a]	0.03482	0.4812 [a]	0.03395	0.4883 [a]	0.03374
Sold in 2004	0.6606 [a]	0.03577	0.6487 [a]	0.03521	0.6491 [a]	0.03474
Sold in 2005	0.8932 [a]	0.04171	0.8842 [a]	0.04107	0.9002 [a]	0.04126
Sold in 2006	0.9633 [a]	0.05187	0.9522 [a]	0.05137	0.9575 [a]	0.05109
LONG KEY	-0.0932	0.06311	-0.1070 [c]	0.06256	-0.0890	0.06239
SAND KEY	-0.0665	0.05598	-0.0835	0.05500	-0.0724	0.05435
TREASURE ISLAND	-0.1143	0.08042	-0.1277	0.07992	-0.0861	0.07866
Total housing square footage	0.2127 [a]	0.04565	0.2200 [a]	0.04214	0.2657 [a]	0.04209
Total housing square footage ^2	-0.0173 [a]	0.00517	-0.0185 [a]	0.00476	-0.0207 [a]	0.00473
Bathroom water connections	0.0182 [a]	0.00647	0.0180 [a]	0.00629	0.0194 [a]	0.00629
Total Lot square footage	0.0399 [b]	0.0200	0.0404 [b]	0.01938	0.0275	0.01921
Total Lot square footage ^2	-0.0004	0.00086	-0.0005	0.00083	-0.0002	0.00081
Superior Quality	0.4400 [a]	0.15112	0.4638 [a]	0.13966	0.4096 [a]	0.14339
Excellent Quality	0.1613 [a]	0.06076	0.1575 [a]	0.05986	0.1781 [a]	0.06318
Custom Finish	0.0768 [c]	0.0396	0.0699 [c]	0.03924	0.0912 [b]	0.03926
Pool	0.0374	0.02565	0.0372	0.02558	0.0420	0.02572
Deck	0.0612 [c]	0.03601	0.0740 [b]	0.03618	0.0758 [b]	0.03632
Soundfront Only	0.3471 [b]	0.13958	0.3478 [b]	0.14461	0.3436 [b]	0.14409
Soundfront (with Dock)	0.5425 [a]	0.04872	0.5435 [a]	0.04863	0.5394 [a]	0.04874
Soundfront (with Dock & Boatlift)	0.5406 [a]	0.03535	0.5416 [a]	0.03506	0.5375 [a]	0.03475
Distance To Gulf	-0.0097 [b]	0.00442	-0.0064	0.00428	-0.011 [b]	0.00431
Distance To Gulf^2	0.0002 [a]	0.00007	0.0001 [b]	0.00006	0.0002 [a]	0.00007
Distance To Tampa	-0.0079	0.0173	-0.011	0.01721	-0.0199	0.01697
Percent of Households with Residents over age 60	0.4694	0.42383	0.4598	0.42409	0.6198	0.41701
Percent of Houses that are rented	0.6093	0.41704	0.5949	0.41553	0.7313 [c]	0.41086
Gulf IPVA	0.0023 [a]	0.00051				
Maximum Visibility			0.0036 [a]	0.00061		
Mean Visibility					0.0052 [a]	0.0018
Rho	0.1431	0.04785	0.1413	0.04725	0.15004	0.048105
Log Likelihood	-401.394		-386.628		-394.8173	
Akaike Info Criterion	864.79		835.26		853.63	
Observations	1081		1081		1081	

Dependent variable is natural log of sales price. Superscripts a,b, and c denote significance at the .01, .05, and .1 level

Table 3: Spatial Lag Estimation Results for the Total Visibility when Limited to Distance Bands Note to Reviewers: Full Results in Appendix

Variable	Coefficient	Std.Err	Log Lik.	AIC	Percent of Sample in Distance Band
Total View	0.0234 [a]	0.00051	-401.39	864.79	100%
1500ft Threshold	0.0239 [a]	0.00044	-400.08	864.16	38%
1000ft Threshold	0.0264 [a]	0.00055	-398.55	863.09	24%
900ft Threshold	0.0274 [a]	0.00056	-397.25	860.51	21%
800ft Threshold	0.0265 [a]	0.00056	-397.99	861.98	17%
700ft Threshold	0.0272 [a]	0.00061	-396.85	859.7	13%
600ft Threshold	0.0312 [a]	0.00059	-392.97	851.94	10%
500ft Threshold	0.0340 [a]	0.00063	-388.39	842.77	7%

Dependent variable is natural log of sales price. Superscripts a,b, and c denote significance at the .01, .05, and .1 level

Table 4: Spatial Lag Estimation Results for the Total Visibility when Limited to Distance Bands

	Primary Models			Total Visibility Models with Distance Bands						
	Mean Visibility	Max Visibility	Total Visibility	1500ft	1000ft	900ft	800ft	700ft	600ft	500ft
Upper Bound	$4,879	$2,765	$1,894	$1,922	$2,108	$2,176	$2,131	$2,230	$2,422	$2,651
Mean	$2,881	$2,015	$1,300	$1,324	$1,461	$1,511	$1,464	$1,498	$1,713	$1,901
Lower Bound	$884	$1,266	$706	$725	$815	$847	$797	$767	$1,004	$1,150

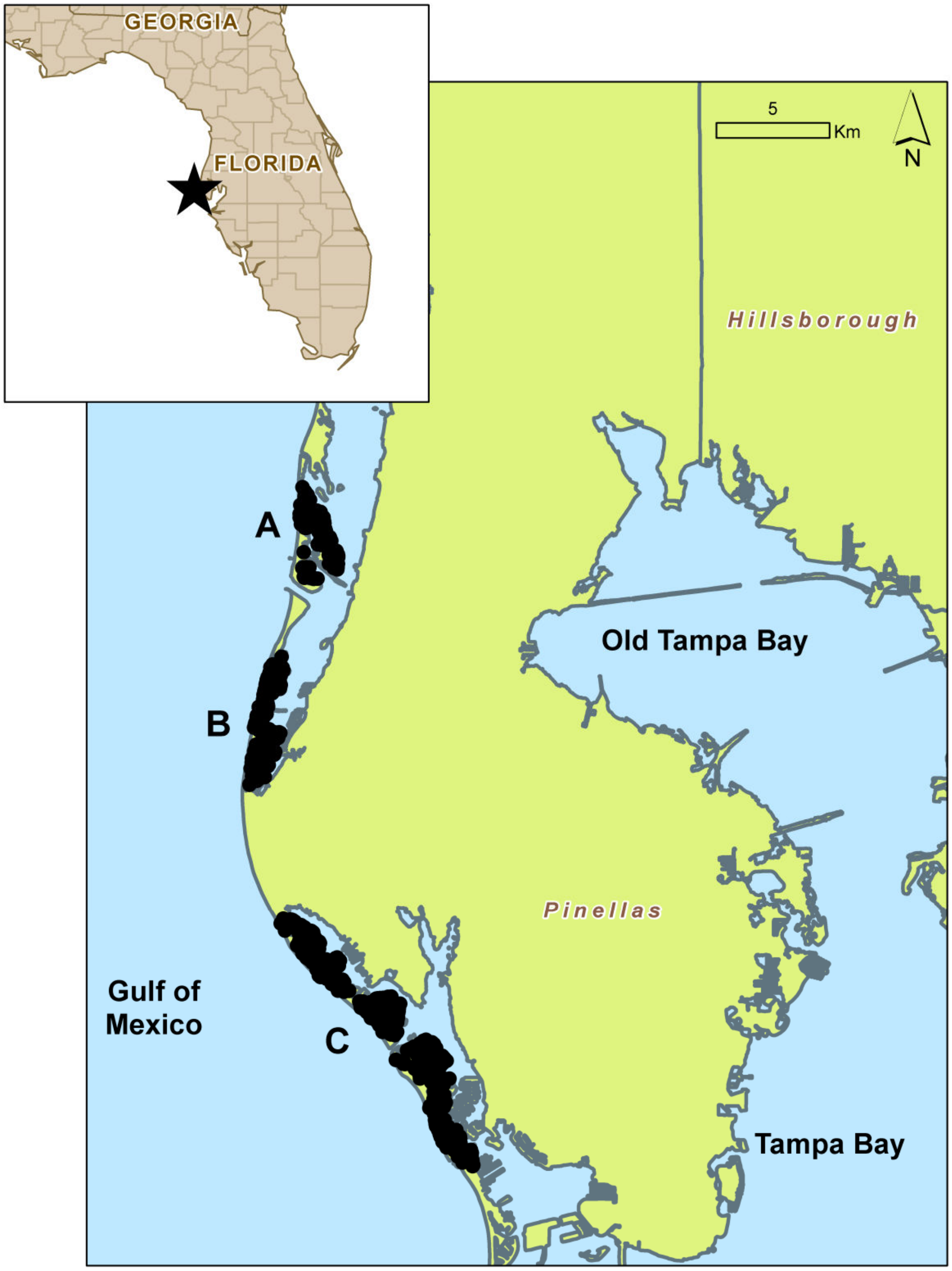

Figure 1 Map of Study Area (Pinellas County Barrier Islands)

Figure 2 An Example of Complex Back-Barrier Shorelines as a Consequence of Dredge-and-Fill Activities

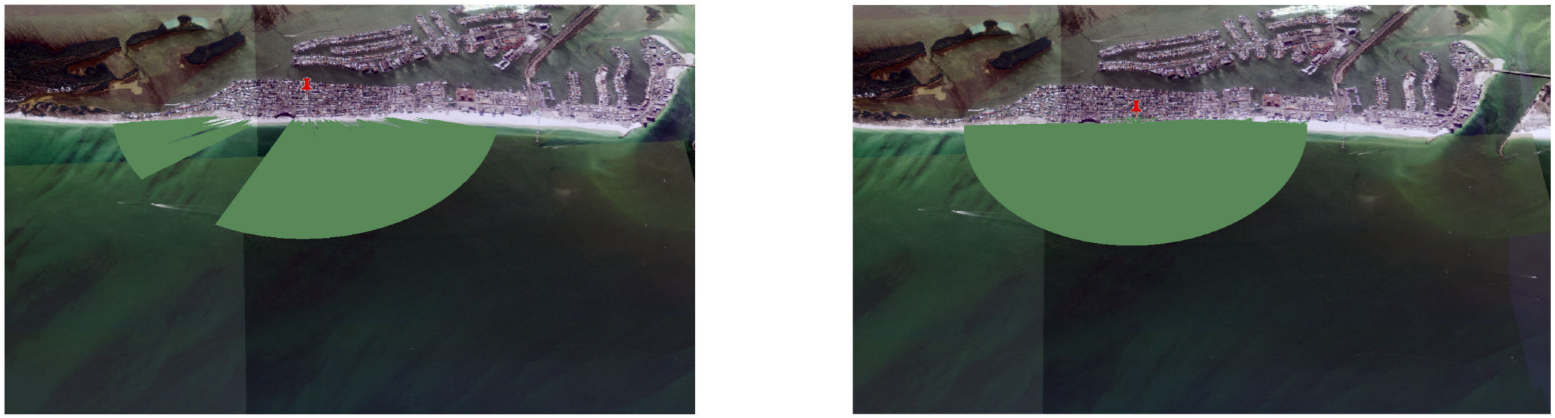

Figure 3 Differing Viewshed Schematics

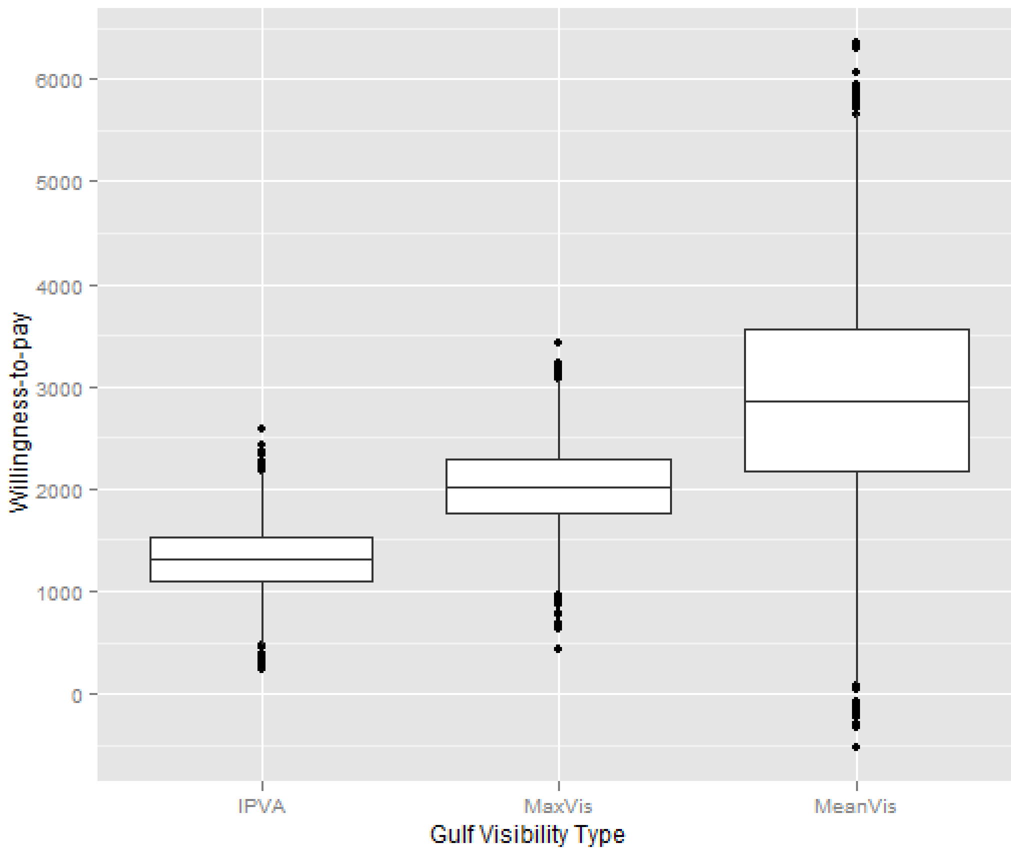

Figure 4 Distribution of MWTP for Total Visibility (IPVA), Maximum Visibility (MaxVis), and Mean Visibility (MeanVis). The Krinsky-Robb procedure is used with 5000 draws from a multivariate normal distribution.

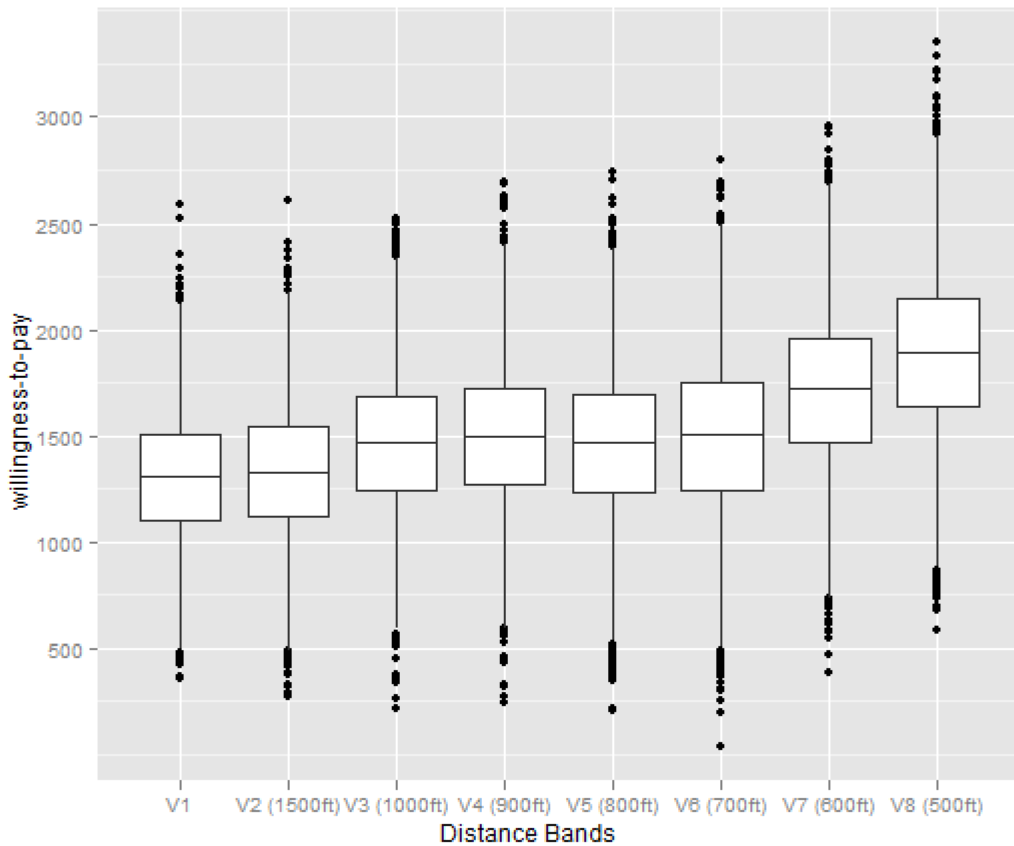

Figure 5 Distribution of MWTP for Total Visibility (IPVA) when controlling for content distance. Total visibility (V1) for the entire sample is compared to different cutoff distances (V2-V8). The Krinsky-Robb procedure is used with 5000 draws from a multivariate normal distribution.

Footnotes

1. These 2008 estimates are available for download from the National Ocean Economics Program < http://www.oceaneconomics.org>.

2. For example, Bensen et al. 1998 use four dummies for view (full, superior partial, good partial, and poor partial) to measure the impact of ocean, lake, and mountain views on property prices in Bellingham, Washington. Bourassa et al. (2004) use narrow, medium, and wide indicators of view to indicate the quality of a lake view on property values in Auckland, New Zealand.

3. Bensen et al. (1995) find that the premium for a full view (68%) for properties 0.1 miles from the coast falls to 31% at 2 miles away. Bourassa et al. (2004) estimate a "wide view" property premium of 59% at the coastline, falling to 14% at 2,000 meters from the coast.

4. For example, Lake et al. (1998) analyze the visual impacts of road development on property prices. Using GIS to construct a Digital Terrain Model that measures the viewshed from each property in a sample of homes in Glasgow, Scotland, they find homes with roads visible from the front of the property have lower average property prices by 2.5 percent. Din et al. (2001) use GIS to estimate the influence of visible land area on property valuations.

5. Robust Lagrange Multiplier tests shows the spatial lag model as preferred to the spatial error model in the Total and Mean Visibility Models. While the spatial error model is preferred for the Mean Visibility Model, comparisons using AIC reveal little benefit to

the spatial lag. We utilize the spatial lag model for consistency. Spatial error dependence (Total Visibility Model: $\chi2$ = 1.097; p-value = 0.295; Max Visibility: $\chi2$ = 1.445; p-value = 0.229; Mean Visibility: $\chi2$ = 5.028; p-value = 0.02494) vs spatial dependence (Total Visibility Model: $\chi2$ = 5.171; p-value = 0.023; Max Visibility: $\chi2$ = 4.939; p-value = 0.026; Mean Visibility: $\chi2$ = 3.703; p-value = 0.054).

6. We conduct the Breusch-Pagan test for heteroskedasticity for the Total Visibility ($\chi2$ = 80.181; p-value = 6.272e-07), Maximum Visibility ($\chi2$ = 73.490; p-value = 5.970e-06), and Mean Visibility ($\chi2$ = 79.050; p-value 9.240e-07.

7. Table 3 represents a condensed table summarizing seven content distance estimation procedures. Complete results are available upon request. **Note to Reviewers: Complete results found in Appendix.**

Appendix: Estimation Results for Distance Cut-off Models

	No Threshold		1500ft Threshold	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Constant	1.3810 [b]	0.54349	1.3653 [b]	0.54259
Sold in 2001	0.1969 [a]	0.03266	0.193 [a]	0.03263
Sold in 2002	0.3227 [a]	0.0363	0.3198 [a]	0.03624
Sold in 2003	0.4882 [a]	0.03482	0.4862 [a]	0.03489
Sold in 2004	0.6606 [a]	0.03577	0.658 [a]	0.03569
Sold in 2005	0.8932 [a]	0.04171	0.8896 [a]	0.04181
Sold in 2006	0.9633 [a]	0.05187	0.9579 [a]	0.05162
LONG KEY	-0.0932	0.06311	-0.1	0.06308
SAND KEY	-0.0665	0.05598	-0.0701	0.05604
TREASURE ISLAND	-0.1143	0.08042	-0.1214	0.08052
Total housing square footage	0.2127 [a]	0.04565	0.2168 [a]	0.04565
Total housing square footage ^2	-0.0173 [a]	0.00517	-0.0174 [a]	0.00518
Bathroom water connections	0.0182 [a]	0.00647	0.0186 [a]	0.00638
Total Lot square footage	0.0399 [b]	0.002	0.0386 [c]	0.02003
Total Lot square footage ^2	-0.0004	0.00086	-0.0004	0.00086
Superior Quality	0.440 [a]	0.15112	0.4518 [a]	0.15333
Excellent Quality	0.1613 [a]	0.06076	0.1710 [a]	0.06062
Custom Finish	0.0768 [c]	0.0396	0.0823 [b]	0.0394
Pool	0.0374	0.02565	0.037	0.02564
Deck	0.0612 [c]	0.03601	0.0615 [c]	0.03624
Soundfront Only	0.3471 [b]	0.13958	0.3464 [b]	0.13958
Soundfront (with Dock)	0.5425 [a]	0.04872	0.5375 [a]	0.04858
Soundfront (with Dock & Boatlift)	0.5406 [a]	0.03535	0.5362 [a]	0.03537
Distance To Gulf	-0.0097 [b]	0.00442	-0.0083 [c]	0.00444
Distance To Gulf^2	0.0002 [a]	0.00007	0.0002 [a]	0.00007
Distance To Tampa	-0.0079	0.0173	-0.0072	0.01724
Percent of Households with Residents over age 60	0.4694	0.42383	0.4458	0.42398
Percent of Houses that are rented	0.6093	0.41704	0.5762	0.41804
Gulf IPVA	0.0023 [a]	0.00051		0.00052
0-1500ft Distance			0.0024 [a]	0.00052
1500-3000ft Distance			0.0021 [a]	0.00068
Rho	0.1431	0.04785	0.1422	0.047773
Log Likelihood	-401.3935		-400.0808	
Akaike Info Criterion	864.79		864.16	
Observations	1081		1081	

Dependent variable is natural log of sales price. Superscripts a,b, and c denote significance at the .01, .05, and .1 level

	1000ft Threshold		900ft Threshold	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Constant	1.3986 [a]	0.53757	1.4613 [a]	0.53685
Sold in 2001	0.1918 [a]	0.03269	0.1894 [a]	0.03238
Sold in 2002	0.3172 [a]	0.03616	0.3145 [a]	0.03598
Sold in 2003	0.4834 [a]	0.0347	0.4818 [a]	0.03447
Sold in 2004	0.6546 [a]	0.03568	0.6515 [a]	0.03551
Sold in 2005	0.8889 [a]	0.0418	0.8869 [a]	0.04166
Sold in 2006	0.9549 [a]	0.05168	0.9561 [a]	0.05173
LONG KEY	-0.1003	0.063	-0.1043 [c]	0.06279
SAND KEY	-0.0753	0.0556	-0.0803	0.05484
TREASURE ISLAND	-0.1244	0.07993	-0.126	0.07977
Total housing square footage	0.2214 [a]	0.04566	0.2186 [a]	0.04395
Total housing square footage ^2	-0.0177 [a]	0.00518	-0.0169 [a]	0.00498
Bathroom water connections	0.0186 [a]	0.00638	0.0189 [a]	0.00636
Total Lot square footage	0.0377 [c]	0.02004	0.0364 [c]	0.01927
Total Lot square footage ^2	-0.0004	0.00087	-0.0004	0.00083
Superior Quality	0.4651 [a]	0.14959	0.4497 [a]	0.14685
Excellent Quality	0.1701 [a]	0.0606	0.1757 [a]	0.06104
Custom Finish	0.0855 [b]	0.0395	0.0871 [b]	0.04002
Pool	0.0394	0.02571	0.0409	0.02563
Deck	0.0626 [c]	0.0361	0.0643 [c]	0.03612
Soundfront Only	0.3552 [b]	0.14136	0.3585 [b]	0.14089
Soundfront (with Dock)	0.541 [a]	0.04841	0.544 [a]	0.04806
Soundfront (with Dock & Boatlift)	0.5384 [a]	0.03511	0.5417 [a]	0.03501
Distance To Gulf	-0.0061	0.00457	-0.0049	0.0045
Distance To Gulf^2	0.0002 [b]	0.00007	0.0001 [c]	0.00007
Distance To Tampa	-0.0084	0.01713	-0.0094	0.01716
Percent of Households with Residents over age 60	0.4478	0.42014	0.4516	0.42057
Percent of Houses that are rented	0.578	0.41272	0.5733	0.41235
0-1000ft Distance	0.0026 [a]	0.00055		
1000-2000ft Distance	0.0018 [a]	0.00055		
2000-3000ft Distance	0.0012	0.00107		
0-900ft Distance			0.0027 [a]	0.00055
900-1800ft Distance			0.0016 [a]	0.00061
1800-2700ft Distance			0.0008	0.00086
Rho	0.1422	0.04816	0.1373	0.04782
Log Likelihood	-398.55		-397.25	
Akaike Info Criterion	863.09		860.51	
Observations	1081		1081	

Dependent variable is natural log of sales price. Superscripts a,b, and c denote significance at the .01, .05, and .1 level

	800ft Threshold		700ft Threshold	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Constant	1.5288 [a]	0.537 [a]	1.4699	0.52742
Sold in 2001	0.1879 [a]	0.03246	0.1867 [a]	0.03245
Sold in 2002	0.3156 [a]	0.03598	0.3168 [a]	0.03623
Sold in 2003	0.4789 [a]	0.03444	0.4815 [a]	0.03425
Sold in 2004	0.6501 [a]	0.03547	0.6520 [a]	0.03531
Sold in 2005	0.8886 [a]	0.04139	0.8910 [a]	0.04162
Sold in 2006	0.9549 [a]	0.05187	0.9495 [a]	0.05198
LONG KEY	-0.0988	0.06291	-0.1056 [c]	0.06243
SAND KEY	-0.0848	0.0544	-0.0872	0.05412
TREASURE ISLAND	-0.1243	0.07896	-0.134 [c]	0.07813
Total housing square footage	0.2172 [a]	0.04382	0.2274 [a]	0.04336
Total housing square footage ^2	-0.0164 [a]	0.00498	-0.0172 [a]	0.00486
Bathroom water connections	0.0182 [a]	0.00633	0.0182 [a]	0.00632
Total Lot square footage	0.0371 [c]	0.01922	0.0368 [c]	0.01918
Total Lot square footage ^2	-0.0004	0.00083	-0.0004	0.00082
Superior Quality	0.4471 [a]	0.14714	0.4527 [a]	0.1457
Excellent Quality	0.1787 [a]	0.06076	0.1801 [a]	0.06102
Custom Finish	0.0883 [b]	0.03966	0.0772 [b]	0.03954
Pool	0.0415	0.02562	0.0378	0.0257
Deck	0.0669 [c]	0.03602	0.0641 [c]	0.03591
Soundfront Only	0.3695 [a]	0.13988	0.3619 [a]	0.13962
Soundfront (with Dock)	0.5475 [a]	0.04823	0.5439 [a]	0.04828
Soundfront (with Dock & Boatlift)	0.5453 [a]	0.03538	0.5416 [a]	0.03515
Distance To Gulf	-0.0061	0.00446	-0.0064	0.00455
Distance To Gulf^2	0.0001 [b]	0.00007	0.0001 [b]	0.00007
Distance To Tampa	-0.0111	0.01718	-0.0087	0.01675
Percent of Households with Residents over age 60	0.4714	0.41969	0.4107	0.41212
Percent of Houses that are rented	0.6035	0.41487	0.5613	0.40673
0-800ft Distance	0.0027 [a]	0.00056		
800-1600ft Distance	0.0011 [c]	0.00064		
1600-2400ft Distance	0.0016 [b]	0.00075		
0-700ft Distance			0.0027 [a]	0.00061
700-1400ft Distance			0.0011 [c]	0.00058
1400-2100ft Distance			0.002 [a]	0.0006
Rho	0.139	0.04879	0.13613	0.04768
Log Likelihood	-397.99		-396.85	
Akaike Info Criterion	861.98		859.7	
Observations	1081		1081	

Dependent variable is natural log of sales price. Superscripts a,b, and c denote significance at the .01, .05, and .1 level

Variable	600ft Threshold Coefficient	Std. Error	500ft Threshold Coefficient	Std. Error
Constant	1.5565 [a]	0.52965	1.7603 [a]	0.53521
Sold in 2001	0.1867 [a]	0.03255	0.1806 [a]	0.0326
Sold in 2002	0.3129 [a]	0.03615	0.3107 [a]	0.03614
Sold in 2003	0.4773 [a]	0.03419	0.4757 [a]	0.03381
Sold in 2004	0.6479 [a]	0.03514	0.6454 [a]	0.03519
Sold in 2005	0.8910 [a]	0.04165	0.8938 [a]	0.04135
Sold in 2006	0.9528 [a]	0.05164	0.9440 [a]	0.05175
LONG KEY	-0.1084 [c]	0.0628	-0.0939	0.06263
SAND KEY	-0.0877	0.05481	-0.0823	0.05411
TREASURE ISLAND	-0.1356 [c]	0.07954	-0.1103	0.07954
Total housing square footage	0.2306 [a]	0.04203	0.2443 [a]	0.04079
Total housing square footage ^2	-0.0175 [a]	0.00477	-0.0181 [a]	0.00454
Bathroom water connections	0.0186 [a]	0.00634	0.0188 [a]	0.00632
Total Lot square footage	0.0358 [c]	0.01881	0.0318 [c]	0.01788
Total Lot square footage ^2	-0.0004	0.0008	-0.0004	0.00075
Superior Quality	0.4362 [a]	0.14267	0.4098 [a]	0.13684
Excellent Quality	0.1763 [a]	0.0611	0.1603 [b]	0.06226
Custom Finish	0.0822 [b]	0.03964	0.0848 [c]	0.03957
Pool	0.0385	0.02574	0.0396	0.0258
Deck	0.0686 [c]	0.03599	0.0723 [b]	0.03588
Soundfront Only	0.3567 [b]	0.14147	0.3472 [b]	0.14517
Soundfront (with Dock)	0.545 [a]	0.04871	0.5446 [a]	0.0491
Soundfront (with Dock & Boatlift)	0.5429 [a]	0.03537	0.543 [a]	0.03577
Distance To Gulf	-0.0045	0.00451	-0.0051	0.00445
Distance To Gulf^2	0.0001 [c]	0.00007	0.0001 [c]	0.00007
Distance To Tampa	-0.0108	0.01697	-0.0183	0.01717
Percent of Households with Residents over age 60	0.4255	0.41914	0.5479	0.42047
Percent of Houses that are rented	0.5417	0.41113	0.6604	0.41397
0-600ft Distance	0.0031 [a]	0.00059		
600-1200ft Distance	0.0012 [c]	0.00063		
1200-1800ft Distance	0.0016 [a]	0.00061		
0-500ft Distance			0.0058 [a]	0.00063
500-1000ft Distance			0.0006	0.00063
1000-1500ft Distance			0.0008	0.00059
Rho	0.13312	0.0484	0.14951	0.04713
Log Likelihood	-392.97		-388.39	
Akaike Info Criterion	851.94		842.77	
Observations	1081		1081	

Dependent variable is natural log of sales price. Superscripts a,b, and c denote significance at the .01, .05, and .1 level