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The Value of Dune Width in Avalon, New Jersey: A Hedonic Pricing Analysis

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Abstract
Previous research on the economics of coastal housing markets has proven that housing values along the east coast of the United States capitalize on the attributes of local beaches. These recent studies document two important findings: that beach width positively affects coastal property values and that there is a proximity effect, in which distance from the beach plays a significant role in the capitalization of local beach attributes. This paper builds upon these findings to explore the influence that dune width has on coastal property values in Avalon, New Jersey. I hypothesize that as dune width increases, local property values in Avalon will also increase due to the protection that dunes provide; however, the increasing property values will also be affected by their proximity to the beach. My findings support this hypothesis because the property values in Avalon, New Jersey increase as dune width increases, but the effect dune width has on property values decreases as the distance from the beach increases.

Keywords
Dune width, Beach Width, Hedonic, Non-market valuation, Climate change

Cover Page Footnote
I am very grateful to Craig Worton, an Avalon real estate broker for his assistance with this research and providing data for the hedonic analysis. I would also like to thank Professor Sahan Dissanayake for his guidance throughout this research paper.

1. Introduction

The shoreline along the east coast of the United States is a highly dynamic environment that is constantly changing due to weather fluctuations associated with climate change, ocean currents, waves, and rising sea levels. Individuals who reside in these coastal communities are feeling an increase in inclement weather as well as gradual erosion of the shoreline. In fact, it has been estimated that 80-90% of sand beaches in the United States are receding (Gopalakrishnan, Smith, Slott, and Murray 2010). Beach erosion and rising sea levels have been a concern for beach managers and environmental activists along the east coast for decades, however, natural resource economists have just recently begun studying the effects that beach width and other forms of beach protection have on coastal communities.

The most utilized forms of beach protection along the coast are hardened structures, the presence of dunes, and beach nourishment. Hardened structures, such as jetties and sea walls, are man-made constructions that work by blocking the ocean current and waves. However, the use of hardened structures has decreased in recent years because they have been proven to worsen erosion in neighboring regions as well as their high cost (Gopalakrishnan, et al. 2010). The presence of dunes is another form of protection from the ocean. Dunes are a risen area of predominantly untouched vegetation that acts as a protective buffer between the inland community and the ocean. While dunes are beneficial for this reason, a potential negative attribute of dunes is that they can be perceived as unsightly and can decrease aesthetic benefits of oceanfront homes. In communities where dunes are present, it is usually illegal to tamper with dunes in any way. Finally, beach nourishment is the process of restoring a beach by adding more sand to areas of erosion so that beach width either increases or remains unchanged. Beach nourishment provides storm protection without negatively impacting neighboring regions, while also providing recreational benefits from a wider beach.

Many recent studies have been conducted that indicate beach width positively affects coastal property values. Most notably, Gopalakrishnan, Smith, Slott, and Murray (2010) discovered that beach width should be an endogenous variable in the presence of beach nourishment, which resulted in beach width having a much larger effect on property values than other studies found before them. Simply put, beach width positively effects nearby property values. This makes intuitive sense because a wider beach provides greater protection from storms and erosion, as well as recreational benefits. In this paper, I use a similar price hedonic analysis as Gopalakrishnan, et al. (2010) to explore the relationship between coastal property values and dune width in Avalon, New Jersey. The main differences between dune width and beach width are that dune width does not provide any recreational benefit because it remains completely untouched aside from very occasional nourishment; therefore, dune width will be treated as an exogenous variable in this paper. Dune width also differs from beach width because dune width could be perceived negatively as it increases a property's distance from the beach and may decrease ocean views.

The goal of this paper is to explore the influence that dune width has on coastal property values in Avalon, New Jersey. The paper will attempt to answer if homebuyers prefer larger dunes that provide protection to their home, or smaller dunes so that they are closer to the beach and have a more aesthetically pleasing view of the ocean. These preference decisions among homebuyers will most likely be driven by factors such as environmental knowledge in regards to climate change, expectations of change in the future environment, financial market conditions, personal risk preferences, and wealth (Landry and Hindsley 2011).

2. Motivations and Literature Review

The motivation behind this topic stems from the negative effects associated with the intensified weather patterns and rising sea levels around the world. A particular example that relates to this paper is Hurricane Sandy, which was extremely detrimental along the New Jersey and New York coastline in 2012. While Hurricane Sandy devastated the majority of that region, Avalon remained relatively unscathed and many attribute this outcome to the protection from high dunes along its coast. "The high dunes stretch from 40th to 59th Streets, offering not only hurricane protection to island residents but also a home to hundreds of species of birds and animals" (*Protect Avalon's Dunes, Inc.*). This stretch of high dunes is a result of forward-looking individuals from the mid-1900's that chose dune preservation over development in this section of Avalon. As Brian Reynolds, the Chairman of The Avalon Borough Environmental Commission explains, "The Borough of Avalon has long realized that the dunes are important for public safety and the protection of property. The Borough is also proud to claim one of the few examples of a mature maritime forest to be found between Virginia and Massachusetts" (Reynolds 2010). Avalon's high dunes are extremely unique along the east coast as they are a mostly undeveloped stretch of sandy grassland and woods that stand up to 16.5 yards high above the beachfront and reach as far as 400 yards wide. Along the entire coast of Avalon, dune width varies from approximately 40 yards to 400 yards, which is exactly why this unique beach town is ideal to explore the influence that dune width has on its coastal property values.

While it has been proven that beach width positively affects coastal property values because of the protection that a wider beach provides, dune width has never been explored in a similar manner. Despite this, there is still an abundance of non-economic literature that indicates individuals do positively value more protective dunes, particularly after Hurricane Sandy.

The Asbury Park Press, a northern New Jersey news outlet, published an article in 2015 titled, *Sandy Study: Not All Dunes Worked*. The author, Todd Bates, writes about how some individuals continue to loathe dunes, despite the clear advantages that wide dunes provide for the entire community. In reference to the findings of a dune study that was conducted by the Coastal Research Center at Richard Stockton College of NJ, Bates explains, "[Hurricane] Sandy caused the greatest damage in communities with nonexistent dunes, low beaches and dunes or narrow beaches. Setbacks for new structures landward of secondary dunes, or adhering to elevation standards for homes, also averted damages." (Bates 2015). MaryAnn Spoto also speaks to this point in her NJ.com article regarding the effectiveness of dunes during Hurricane Sandy: "One thing everyone agrees on: Where the dunes were high and wide, there was little if any damage to the homes and businesses behind them. The most destruction, they said, came to the towns with low, narrow dunes" (Spoto 2012). There may not be much economic data on the protection that dunes provide, but it appears that many individuals recognize their importance.

Another example that dune width does positively influence property value can be elicited from protests that occurred in 2006 to protect Avalon's dunes. The construction of an extremely large home within the high dunes sparked the protests, and the following quote illustrates how much the local Avalon community values the wide dunes: "'We have these historic dunes that are unique to Avalon, and my personal feeling is that when you take one shovelful of sand out of them, you are negatively affecting the entire infrastructure,' Avalon Borough Councilman Dave Ellenberg said. 'We have to do whatever we can to preserve them'" (Urgo 2006).

Previous economic research on coastal housing markets has indicated that housing values capitalize on the attributes of local beaches. While there have been no studies done on the effect of dune width on coastal housing markets, the aforementioned literature indicates that some individuals do prefer wide dunes. This paper will explore the effect that dune width has on coastal property values by building upon recent studies that indicate beach width positively affects coastal property values (Gopalakrishnan, et al. 2010) and that there is a proximity effect in which distance from the beach plays a significant role in the capitalization of these local beach attributes (Landry and Allen 2014).

3. Data Selection and Manipulation

I constructed a dataset that combines real estate data with beach attribute data. I collected sales records for 749 residential properties that spanned from 9th Street to 80th Street, which includes every street along the Avalon coast that is protected by dunes. These records were obtained from Craig Worton, an Avalon real estate broker. The data ranges from 2010 to 2015, and during my analysis I only included the most recent transaction if the property had been sold more than once in that timeframe. I also created yearly dummy variables to control for time of sale and heterogeneity across the five-year time period. The real estate data includes property characteristics such as the number of bedrooms, full bathrooms, lavatories (half bathrooms), sale price, sale date, and the type of property; which is either a single-family home, condominium, or townhouse. In the analysis I also distinguish how many blocks each home is from the dune entrance and if that street has direct beach access or not; I used the ordinal housing numbers to identify what block each property was located on. Finally, I used the measuring tool on Google Earth to measure the dune width on each street using a straight-line measurement from the dune entrance to the end of the dune vegetation.

Upon compiling all of the above variables, a few variables were transformed to create a model of better fit. The first data manipulation was to take the natural logarithm of sale price and dune width. The intuition behind transforming dune width is that it is assumed to be a non-linear variable, meaning that individuals may prefer wider dunes until a certain point. This also means that the relationship between dune width and sale price is elastic if they are both transformed when comparing them. The second data manipulation I conducted was to square the number of bedrooms, full bathrooms, and lavatories. The purpose behind this manipulation is that I want to account for a quadratic relationship between these explanatory variables and the sale price because there is an assumed non-linear increase in sale price as these explanatory variables increase. Table 1 includes variable descriptions and summary statistics of variables used.

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Price	748	1,222,000	920,066	145,000	12,400,000
Bedrooms	748	4.153743	1.214217	0	9
Full Bathrooms	748	2.897059	1.318732	1	9
Lavatories	748	.4679144	.6254636	0	5
Property Type Dummy	748	.6350267	.4817448	0	1
Beach Access Dummy	748	.9131016	.2818746	0	1
Dune Width	748	112.0327	87.56689	38.25	429
Distance to Beach	748	2.707219	1.260501	1	5

4. Methods

A hedonic pricing model was used to estimate the value of dune width that is capitalized in property values in Avalon, New Jersey. The sale price of property i in location j (P_{ij}) is a function of property characteristics (X_{ij}), location-specific dummy variables (L_j), time-specific dummy variables (T_{ij}), distance from the beach (D_{ij}), and dune width at that property location (W_{ij}). The model can be seen below:

$$\ln(P_{ij}) = \beta_1 X_{ij} + \beta_2 L_j + \beta_3 T_{ij} + \beta_4 W_{ij} + \beta_5 D_{ij} W_{ij} + \varepsilon$$

where X_{ij} is a vector of property characteristics of the property i in location j including number of bedrooms, number of full bathrooms, number of lavatories (half bathrooms), and a dummy variable for the type of property (=1 if single family home/=0 if condominium or townhouse). The location-specific dummy variable (L_j) is beach access (=1 if there is a path through the dune on that street/=0 if not). The time-specific dummy variables (T_{ij}) identify the year each property was sold. An interaction term of distance to the beach and dune width was also created ($D_{ij}W_{ij}$) to identify the effect dune with has on property values based on distance to the beach. The next step is to estimate this model to discover the value of dune width by running an ordinary least squares (OLS) regression, while also taking the proximity effect into account.

5. Results and Discussion

The results of the initial regressions are presented in Table 2. Two OLS regressions with different specifications of dune width were run to explore the different outcomes and find the most accurate model. The dependent variable in each model is the natural log of the sale price, but they both differ by the way dune width is specified. Additionally, this set of regressions only includes properties within three blocks from the beach, which is approximately 600 yards (200 yards per block).

All of the property characteristic coefficients in both models have the expected sign. The number of bedrooms, bathrooms, and lavatories all have positive coefficients and are all significant at the 1% level in each model. The coefficient on single-family homes is also positive and significant at the 1% level of significance, indicating that the value of single-family homes is greater than condominiums and townhomes. Finally, the coefficient on beach access is positive and significant at the 1% level in both models as well, which indicates that properties with direct beach access on their street have greater value than properties that do not.

Model (1) is a semi-log specification where the explanatory variables for dune width and the interaction term between dune width and distance from beach are not transformed. In this model, the coefficient on dune width is positive while the coefficient on the interaction term of distance and dune width is negative, both at the 1% level of significance. The combination of these coefficients indicates that the positive effect of dune width on property value is significant, but the dune width effect decreases as the distance from the ocean increases, which is known as the proximity effect. Specifically, the interpretation of Model (1) for an oceanfront property is that a one-yard increase in dune width is associated with approximately a 0.213% increase in property value. It is important to specify that this is the conclusion for an oceanfront property specifically because the effect will slightly decrease as you move further from the beach due to the proximity effect indicated by the interaction term.

Model (2) is a double-log specification, which means that all of the continuous explanatory variables are also transformed by taking their natural logarithms. Coincidentally, dune width and the interaction term of distance and dune width are the only two continuous explanatory variables in this model. Just like in Model (1), the coefficient on dune width is positive while the coefficient on the interaction term of distance and dune width is negative, both at the 1% level of significance. The overall intuition is the same for this model; however, the interpretation of the coefficients is much different because the dependent variable (sale price) and explanatory variables (dune width and the interaction term) are both transformed. When interpreting the effect that a logged explanatory variable has on a logged dependent variable, you are dealing with elasticity. Therefore, the interpretation for an oceanfront property in this model is that a one-percent increase in dune width is estimated to result in about a 0.105% increase in property value.

Overall, Model (2) appears to be a slightly more accurate model. This makes sense intuitively because one would expect sale price to experience diminishing marginal returns with respect to increases in dune width. It also makes sense statistically because r-squared and the log-likelihood are both larger in Model (2), while the error sum of squares and root mean squared error (Root MSE) are smaller. Regardless, these results prove the initial hypothesis that as dune width increases, local property values will also increase due to the protection that dunes provide, however, the increasing property values will also be affected by their proximity to the beach.

The proximity effect is verified in the regressions above in Table 2, but it is also important explore how the estimates might change by eliminating properties that were furthest from the beach. Therefore, the regressions presented in Table 3 only include properties within two blocks from the beach, which is approximately 400 yards. It is also worth noting that there are only two blocks of properties along most of Avalon's high dunes, so this may create more accurate estimates for Avalon specifically.

Just as before, Model (1) is a semi-log specification and Model (2) is a double-log specification. All of the property characteristic coefficients still have the expected sign and remain statistically significant. The number of full bathrooms became slightly less significant in both models and the beach access dummy variable decreased its significance in Model 1, but the rest of the estimates remain significant at the 1% level. The most substantial outcome from Table 3 in comparison to Table 2 is that the coefficients of dune width and the natural log of dune width increased and remained statistically significant at the 1% level. These results indicate that dune width positively effects property value to an even greater extent when you focus on a closer proximity to the beach, thus further verifying the proximity effect.

Table 2. Hedonic pricing model results (within three blocks from beach)

Dependent Variable—ln(Sale Price)

	(1)	(2)
Number of bedrooms	**0.502*****	**0.544*****
	(0.0487)	(0.0474)
Bedrooms^2	**-0.0468*****	**-0.0521*****
	(0.00571)	(0.00558)
Number of Full Bathrooms	**0.190*****	**0.166*****
	(0.0427)	(0.0411)
Full Bathrooms^2	**-0.00490**	**-0.00135**
	(0.00583)	(0.00563)
Number of Lavatories	**0.123*****	**0.128*****
	(0.0336)	(0.0323)
Lavatories^2	**0.00675**	**0.00550**
	(0.0140)	(0.0134)
Type (=1 if single family home)	**0.496*****	**0.487*****
	(0.0331)	(0.0315)
Beach Access (=1 if yes)	**0.149*****	**0.187*****
	(0.0559)	(0.0483)
Dune Width (yards)	**0.00223*****	
	(0.000335)	
Distance x Width (yards)	**-0.00107*****	
	(0.000139)	
ln(Dune Width)		**0.110*****
		(0.0261)
Distance x ln(Width)		**-0.0365*****
		(0.00354)
Constant	**11.63*****	**11.41*****
	(0.104)	(0.161)
Yearly Sale Dummies	**Included**	**Included**
Observations	542	542
Log lik.	-54.08	-32.00
R-Squared	0.8200	0.8340

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The yearly dummy variables in the regressions above control for time of sale and heterogeneity across the five-year sample, therefore, they somewhat account for the changes in the housing market that occurred after Hurricane Sandy. But to test the effect of Hurricane Sandy even further, two semi-log regressions are run in Table 4 below where Model (1) only includes property sales in Avalon before Hurricane

Sandy occurred and Model (2) only includes property sales afterwards. The regressions include all property sales regardless of the distance from the beach to investigate the effect Hurricane Sandy had on the entire Avalon real estate market. The yearly dummy variables were not included to avoid collinearity issues.

Table 3. Hedonic pricing model results (within two blocks from beach)
Dependent Variable—ln(Sale Price)

	(1)	(2)
Number of bedrooms	**0.545*** **	**0.593*** **
	(0.0556)	(0.0549)
Bedrooms^2	**-0.0512*** **	**-0.0568*** **
	(0.00658)	(0.00649)
Number of Full Bathrooms	**0.135** **	**0.117** **
	(0.0540)	(0.0521)
Full Bathrooms^2	**0.00276**	**0.00535**
	(0.00720)	(0.00695)
Number of Lavatories	**0.136*** **	**0.119*** **
	(0.0410)	(0.0397)
Lavatories^2	**-0.00504**	**-0.000435**
	(0.0156)	(0.0150)
Type (=1 if single family home)	**0.565*** **	**0.554*** **
	(0.0480)	(0.0464)
Beach Access (=1 if yes)	**0.114**	**0.194*** **
	(0.0706)	(0.0612)
Dune Width (yards)	**0.00314*** **	
	(0.000600)	
Distance x Width (yards)	**-0.00176*** **	
	(0.000283)	
ln(Dune Width)		**0.165*** **
		(0.0395)
Distance x ln(Width)		**-0.0617*** **
		(0.00748)
Constant	**11.86*** **	**11.46*** **
	(0.127)	(0.212)
Yearly Sale Dummies	**Included**	**Included**
Observations	367	367
Log lik.	-49.68	-37.16
R-Squared	0.8340	0.8449

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In Model (1), most of the property characteristic coefficients have the expected sign and are statistically significant except for the number of lavatories and the beach access dummy variable. The coefficient for the number of lavatories is negative, which is unexpected, but it is also extremely insignificant. The beach access dummy variable has the expected positive sign, but it is only significant at the 16% level. In Model (2), all of the property characteristic coefficients have the expected sign and are statistically significant. The explanations of the expected sign of each coefficient are the same as described earlier in this section.

Table 4. Before Hurricane Sandy versus after Hurricane Sandy
Dependent Variable—ln(Sale Price)

	(1) Before Sandy	(2) After Sandy
Number of bedrooms	**0.392*** **	**0.424*** **
	(0.0839)	(0.0586)
Bedrooms^2	**-0.0362*** **	**-0.0381*** **
	(0.0103)	(0.00689)
Number of Full Bathrooms	**0.310*** **	**0.265*** **
	(0.0601)	(0.0563)
Full Bathrooms^2	**-0.0178* **	**-0.0137* **
	(0.00919)	(0.00758)
Number of Lavatories	**-0.0337**	**0.0927** **
	(0.0547)	(0.0427)
Lavatories^2	**0.122*** **	**0.00234**
	(0.0320)	(0.0166)
Type (=1 if single family home)	**0.486*** **	**0.487*** **
	(0.0342)	(0.0401)
Beach Access (=1 if yes)	**0.112**	**0.152* **
	(0.0798)	(0.0804)
Dune Width (yards)	**0.00116*** **	**0.00145*** **
	(0.000336)	(0.000372)
Distance x Width (yards)	**-0.000336*** **	**-0.000578*** **
	(0.000109)	(0.000132)
Constant	**11.64*** **	**11.69*** **
	(0.157)	(0.131)
Observations	389	359
Log lik.	-41.81	-68.73
R-Squared	0.7805	0.7828

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The most substantial outcome in Table 4 when comparing Model (1) and Model (2) is that the coefficients of both the dune width and the interaction term increased and remained statistically significant after Hurricane Sandy occurred. The same outcome occurs when running a double-log specification, which is not displayed below. The results in Table 4 demonstrate that the effect dune width has on property values increased after Hurricane Sandy, which reveals an increased preference for wider dunes among homebuyers post-Hurricane Sandy.

6. Conclusion

Rising sea levels and weather fluctuations associated with climate change are a growing concern among residents of coastal communities. This increased concern has recently influenced natural resource economists to start studying the economic implications of the highly dynamic shoreline. While economists have concluded that local beach attributes are capitalized in coastal housing markets, the effect that dune width has on local property values has never been examined before this. According to estimates from this paper, the value of dune width in Avalon, New Jersey is capitalized positively in the housing market, and that effect increased after Hurricane Sandy.

Although Avalon's high dunes are extremely unique along the east coast, these findings could still be useful to dune conservation policies as they highlight the importance of dune protection if it is available. Additionally, these results may be somewhat telling of a future increase in coastal property values in beach towns with wide dunes as homebuyers become more aware and concerned about climate change issues along the coast.

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