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THE EFFECT OF LAKE WATER QUALITY AND WIND TURBINES ON RHODE ISLAND PROPERTY SALES PRICE

Susan Shim Gorelick
University of Rhode Island, ssgorelick@gmail.com

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AND WIND TURBINES

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SUSAN SHIM GORELICK

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SUSAN SHIM GORELICK

APPROVED:

Dissertation Committee

Major Advisor James Opaluch

Corey Lang

Gavino Puggioni

Dean of the Graduate School

Nasser H. Zawia

UNIVERSITY OF RHODE ISLAND

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ABSTRACT

This dissertation uses the hedonic pricing model to study the impact of lake water quality and wind turbines on Rhode Island house sales prices. The first two manuscripts are on lake water quality and use RI house sales transactions from 1988-2012. The third studies wind turbines using RI house sales transactions from 2000-2013. The first study shows that good lake water quality increases lakefront property price premium. It also shows that environmental amenities, such as forests, substitute for lake amenity as the property's distance from the lake increases. The second lake water quality study incorporates time variables to examine how environmental amenity values change over time. The results show that property price premium associated with good lake water quality does not change as it is constant in proportion to housing prices with short term economic fluctuations. The third study shows that wind turbines have a negative and significant impact on housing prices. However, this is highly location specific and varies with neighborhood demographics. All three studies have policy implications which are discussed in detail in the manuscripts below.

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I dedicate this dissertation to the endearing memory of

My mother,

Gye-Ryeon Veronica Pyeon Shim,

who embraced her life with zest and perseverance

and lived it to the fullest.

Preface

This dissertation is in manuscript format.

Manuscript 1: The Impact of Lake Water Quality on Rhode Island Property Values

Manuscript 2: Environmental Amenity Value Changes over Time

Manuscript 3: The Impact of Wind Turbines on Rhode Island Residential Property Value

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MANUSCRIPT – 1

The Impact of Lake Water Quality on Rhode Island Property Values

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Susan Shim Gorelick

Environment and Natural Resource Economics, University of Rhode Island,

Kingston, RI, USA

ABSTRACT

This study uses hedonic price model to assess the impact of lake water quality on Rhode Island property sales price premium with chlorophyll concentration as the lake water quality indicator. Edge effect of lakefront properties is positive and significant, though the threshold distance for its effect is small. Distance differentiation beyond the lakefront cut-off threshold shows that forest amenity substitutes for lake water quality as the distance increases. Lake size effect is significant in interaction term with good lake water quality, and has a positive correlation as lake size increases. Potential capitalizations into lakefront property sales prices based upon level of lake water quality are estimated using a single lake as well as all Rhode Island lakes scenarios. The improvement only from marginally poor to good water quality shows significant potential benefits. The findings from this study on homeowner preference for lake water quality provide important information for RI policymakers.

INTRODUCTION

Lake water quality impacts both consumptive and non-consumptive uses by the surrounding community (Wilson and Carpenter, 1999; Millennium Ecosystem Assessment Report, who.int 2005). Federal and state governments have allocated substantial annual investments to preserve and improve its integrity through surface water management (U.S. EPA). Despite that, sixty six percent of lakes and reservoirs in the United States were classified as impaired for one or more of their designated uses in 2009 (Walsh et. 2011). Since Rhode Island has over two hundred sizeable lakes[1], maintenance of lake water quality is important to Rhode Island communities.

This study uses chlorophyll concentration as a water quality indicator to examine the impact of lake water quality on surrounding property sales prices. Close proximity to an environmental amenity is generally incorporated as a property sales price premium from which amenity value of lake proximity can be quantified. As part of the assessment of natural amenities' effect on property sales prices, the study selects forests in the vicinity of lakes as an additional environmental amenity to examine the significance to non-consumptive amenity value by nearby property owners.

DEVELOPMENT OF HEDONIC MODELS

Hedonic pricing models have been used for characterizing the prices of competitively traded goods comprised of heterogeneous sets of characteristics. Housing market is most commonly used for environmental hedonic models because of common spatial factors

[1] These lakes are larger than 10 acres in size and tracked by RI DEM.

such as location of houses and their surrounding environmental attributes. A given housing unit is best characterized as consisting of a bundle of attributes that in aggregate describe the structure itself, the land upon which it is built, and the relevant location characteristics. The hedonic approach attempts to separate the internal property attributes (baths, bedrooms, square feet, etc.) from the public and private good attributes associated with location. For example, hedonic pricing model identifies a premium paid for houses located near desirable environmental amenities, according to the premise that price is determined by both internal characteristics of the good being sold and external factors such as many environmental externalities (Freeman, 2003). In this study, the environmental amenity (lake water quality) is a characteristic, a non-market good, and the market good is a house.

PREVIOUS STUDIES

The existing empirical research with hedonic price model to determine the value of water quality is fairly limited in contrast to the abundant literature on other environmental goods such as air quality. Although degradation of either water or air quality may adversely impact nearby property values (Walsh et al. 2011), the limited literature on water quality is may be due to the lack of consistent and accurate water quality data available to homeowners (Kashian et al. 2010). In addition, the latent and idiosyncratic nature of water quality poses a challenge to find an appropriate water quality indicator (Legget et al. 2000).

Secchi Disk Measurement (SDM) is a relatively easy measurement method which is based on visibility, and is a frequently used water quality indicator (Epp and Al-Ani, 1979; Boyle et al, 1999; Michael, Boyle and Bouchard, 2000). It has been used alone or in combination with other indicators (Poor et al. 2001; Boyle et al. 1999). Multiple water quality indicators are explored as well. For example, Walsh et al (2009) compare five routinely available water quality measurements: total nitrogen (TN), total phosphorous (TP), chlorophyll (CLR), the tropic state index (TSI), and Secchi Disk Measurement (SDM). The first three of these indicators are used by the Environmental Protection Agency (EPA) for nationwide classification of lakes. Walsh et al find that the first four indicators have a negative and significant effect on prices of waterfront properties: the higher the level of nutrients, the more degraded the water quality, thus decreased waterfront property values. In addition, different water quality indicators yield substantially different benefit estimates. Ideally a combination of these indicators would be justified by the complexity of lake water chemistry since "the changes in SDM are valued for aesthetic and visual appeal while improvements in the other indicators can be valued for a more holistic ecosystem" (Kashian et al. 2010).

Properties in close proximity to environmental amenities are a consistent focus for hedonic environmental studies; lake water quality study is no exception. One of early studies uses subjective qualitative water quality ratings (poor, moderate, and good) to examine the correlation between lakefront property prices and water quality of artificial lakes in Wisconsin (David, 1968). Her findings show a correlation between subjective water quality ratings and lakefront property prices, but studies utilizing objective measures of water quality are more useful (e.g., Leggett and Bockstael, 2000; Kashian et al. 2010). Changes in objective measures can potentially be forecast to estimate benefits associated with policy changes. It may not be possible to do the same for subjective measures.

A study using 39 objective measures in Lake Michigan finds that lakefront property prices are capitalized into property sales prices by observable water quality measures (Brashares, 1985). Other studies with an assortment of multiple water quality indicators on riverfront properties report a similar relationship (Epp and Al-Ani, 1979; Legget and Bockstael, 2000). Young and Teti (1984) examined the degraded water quality in St. Albans Bay, Vermont to find that properties closest to the degraded Bay suffered the most and are consistent with the findings from studies on water quality improvement (Michael, Boyle and Bouchard, 2000, and Poor et al., 2001). Some studies combined Hedonic model with a survey based approach. For example, Boyle et al (1999) combined hedonic method and survey of 500 homeowners in proximity to thirty three lakes in Maine and found the similar correlation between water quality and property pricing.

The distance effect of water quality on property price is another common focus of lake amenity studies. One study estimates the marginal amenity value from the difference between within and outside of a 2000 ft. distance threshold (Lansford and Jones, 1995). Their findings demonstrate that the marginal value trend for the lake water level per foot diminishes with distance from the lake to non-significance beyond the threshold. A comparison study shows that water quality amenity value benefits non-lakefront as well as lakefront properties (Walsh et al., 2011). Another distance differentiation study suggests that other landscape attributes become important and may replace lake amenity beyond its distance threshold (Palmquist and Fulcher, 2006).

Some studies have found that lake water quality is highly susceptible to the types of landscape attributes in the vicinity of the lake. For instance, lake water quality correlates with the number of homes surrounding the lake and homeowners' land use practices (Leggett et al., 2000). High housing density is a common source of excess nutrients that exacerbate lake eutrophication. The size of agricultural land and distance from lakes have a significant impact on lake water quality, and this reflects on property values (Bolitzer et al., 2000). An ambient water quality study shows residential development near lakes has a significant effect on lake water quality (Epp et al., 1979). They also find that there may be a threshold effect, such that there is little or no benefit to marginal improvements in water quality for houses in proximity to water bodies of very poor quality water, whereas housing prices are sensitive to water quality improvement for those adjacent to higher quality water. The latter study's findings relating to both consumptive and non-consumptive water use can help lake management policymakers prioritize the lakes that need improvement.

The direct correlation between lake use and lake water quality has elicited many studies to develop management policy. The study by David (1968) on lakefront property values that became a guide for public lake management is followed by many others. Studies have found that homeowners' preference for lakes vary with the types of recreational services available (Boxall et al., 2003; Kaplan,1985; Whitehead et al.,1991; and Poor et al.,2001). Larger lakes can accommodate recreation activities such as boating, canoeing, swimming, fishing, and trails whereas small lakes provide mainly aesthetic benefits (Young et al., 1984). Lakes with boating as the main recreation service may require different water quality criterion compared to lakes with primarily swimming. Homeowners' preference for recreation use may have significant management policy implication.

Designated uses are the core classification criteria defined by the EPA and regulated against lake water quality. While criterion level of each water quality is objectively measured, subjective measures based on the individual designated users' perception and preference are reflected in their property values.

The hedonic method is based on the assumption that consumers have complete knowledge of or information on the goods they are purchasing and incorporate this information into their buying decision (Freeman, 2003). Yet, individuals' preference and perception vary vastly based on population demographics and affects their buying decisions. While swimmers would prefer a lake with high transparency, recreational anglers value a lake of higher trophic level for better fish habitat (Hoyer et al. 2004). One study showcases the importance of perception with a lake discolored dark brown with tannic acid. Property values were negatively affected by this subjective aesthetic quality (Steinnes, 1992).

Discrepancy between perceived and actual water quality has been a persistent topic with hedonic lake studies. Consider the study by Poor et al. (2001) "Objective versus Subjective Measures of Water Clarity in Hedonic Property Value Models". They compare Secchi Disk Measurement (SDM) data from the Maine Department of EPA with a mail survey of shoreline residents as a subjective measure of lake water quality and find that both have a similar trend but did not converge. A similar study finds subjective and objective variables to be significant with implicit price estimates (Michael, Boyle and Bouchard, 2000). They issue the caveat that the significance of subjective variables based on public perception may undermine the importance of objective measures and influence management policy if the statistic analysis includes both objective and subjective measures. For example, a major challenge arises when there is a direct disparity between objective and subjective measures. Clearer water may appear safer to drink, but could have higher level of toxins because there may be less organic matter for which toxins to adhere to, and thereby precipitate as sediment.

Limitations and Challenges of Hedonic Price Model (HPM)

As is true of all statistically-based analyses with non-experimental data, the hedonic approach faces potential challenges associated with omitted variables, endogeneity, and spatial dependence or autocorrelation. In this study, characteristics of the house, property and the neighborhood are the control variables to reduce possibilities of omitted variables. This study also uses interactive terms along with local fixed effects to address these issues. At a larger scale, fixed effects can be applied at the Census block, block group, county or even individual lake level. Using fixed effects requires that the variables included in the regression vary over time at the specific level the fixed effects are applied. For this study, chlorophyll concentration measurements at 99 lakes over 1988-2011 span provide the requisite variations.

APPROACH OF THIS STUDY

This study tests the following hypotheses:

(1) The amenity value associated with lake water quality differs for lakefront properties versus non-lakefront properties*, ceteris paribus.*

(2) The amenity value of lake size is affected by lake water quality*, ceteris paribus.*

(3) Other environmental amenity values become more prominent for properties that are more distant from the lake*, ceteris paribus.*

This study emulates the distance differential study by Lansford and Jones (1995) with modification of replacing lake water levels that were used in their study to determine amenity value with lake water quality of this study. This study also examines the inference by Palmquist et al. (2006) that as lake amenity values diminish with increased distance from the lake, other environmental attributes become important. The additional environmental amenity used in this study is forests. This study is analogous to Walsh et al. (2011) as it analyzes a large number of property sales transactions and man-made lakes. Both studies also use logarithmic functional forms and interactions terms in hedonic models to explore the water quality effect differentiation between lakefront and non-lake front properties. The high population density and large number of property sales transactions in Rhode Island makes the hedonic model an ideal tool for this study.

STUDY AREA: Rhode Island Single Family Homes near RI Lakes

This study quantifies how lake water quality affects property sales prices for single family homes within 5 miles of Rhode Island lakes. Rhode Island's landscape encompasses more than 5,000 lakes, ponds and reservoirs covering a total of 20,749 acres. In contrast to the convention of lakes being larger than ponds, in RI historically both terms are used to name water bodies regardless of the size. Henceforth, all three types of water bodies are referred as lakes. Most RI lakes are man-made impoundments resulting from the construction of dams of varying sizes and type on rivers or streams. Seventy percent of these lakes are 50 acres or less in size. RI Department of Environmental Management (RIDEM, henceforth)[2] currently tracks 237 freshwater lakes over 10 acres in size that cover 18,845 acres. Ninety nine of these lakes are monitored by the University of Rhode Island Watershed Watch program (URIWW, henceforth) with 151 monitoring stations. This study includes 97,352 single family home sales transactions during 1988-2012 within 5 miles of these 99 lakes. FIGURE 1 depicts these lakes. URIWW monitored lakes are a subgroup of RIDEM monitored lakes. These are denoted with *lakeID* in addition to being color-coded. Two hundred thirty seven lakes monitored by RIDEM comprise of both blue coded lakes and URIWW *lakeID*'s in FIGURE 1.

[2] http://www.dem.ri.gov/bayteam/index.htm

DATA OVERVIEW

This study combines Rhode Island property sales transactions[3] and chlorophyll concentration data[4] with geographic information from Rhode Island Geographic Information System (RIGIS) to estimate the effect of lake water quality on housing prices. Both Rhode Island property sales transactions and lake water quality data are from the same 1988-2012 database.

House Sales Transaction Data

This study uses a dataset of nearly 380,000 Rhode Island property sales transactions from 1988 to 2012 and extracts the subset of 188,711 single family home sales transactions. Not all lakes have chlorophyll concentration measurements, so a dummy variable is used to designate the 97,352 property sales transactions within 5 miles to the nearest lake with chlorophyll concentration measurements. The extracted house sales transaction dataset comprises 53 variables that include the house sales price (dependent variable) and a set of house characteristics (e.g., number of bedrooms, lot size, exterior condition of house, etc) and geographic information variables such as longitude, latitude, Census block and Census tract numbers. Only those house characteristics that were significant from the preliminary data analysis are used for this study. Those are number of total rooms, bedrooms, bathrooms, fireplaces, lot size, living area, exterior condition of the house, and

[3] I would like to thank and acknowledge Alan Pasnik of the Warren Group for his generosity with housing data that made this study possible.
[4] www.uri.edu/ce/wq/ww/. My sincere thanks to Linda Green, Elizabeth Herron and all volunteer monitors of URIWW for their expertise information and the water quality data that helped this study to its fruition.

the age of the house. The house sale observations with price of only greater than $40,000and properties with house structures are included as valid sales.[5]

Descriptive Statistics

TABLE 1 lists the descriptive statistics of properties with sales transaction near the lakes with chlorophyll concentration. The average house sales price is adjusted to the second quarter of 2010 Rhode Island housing price index[6].

Chlorophyll concentration dataset

Since 1988, the University of Rhode Island has coordinated a volunteer-based lake monitoring program through the URI Watershed Watch program. This program is the primary source of ambient water quality data on lakes in RI. Since 1999, the RIDEM Office of Water Resources has provided funding to URIWW to support and expand the program. Trained volunteers collect water samples weekly from their monitoring sites from May through October. Sample analysis is performed in URI laboratories. The resulting data is used by RIDEM to assess water quality conditions in over 75% of the lake acreage in the state. Water quality parameters measured in the URIWW lake monitoring program include: water clarity (secchi depth), water depth, temperature, dissolved oxygen (deep sites), pH, alkalinity, chlorophyll, total and dissolved phosphorus, total nitrate, ammonium, nitrogen, chloride and pathogens.

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[5] This cut-off price is used in other hedonic studies (e.g., Walsh et al., 2011).

[6] www.research.stlouisfed.org/fred2/series/RISTHPI

Chlorophyll concentration is chosen for this study because it provides a good overall measure of lake water quality status, especially when excess nutrients are a key water quality issue (Boyer et al., 2009). Protecting lake water quality by mitigating eutrophication from excess nutrients as a result of human land use is a major challenge in Rhode Island.[7] Chlorophyll concentration is categorized in four conventionally used trophic levels according to the range of concentration in increasing order: oligotrophic, mesotrophic, eutrophic and hypereutrophic. For this study, a dummy variable, *goodWQ* is defined as one for oligotrophic and mesotrophic levels, equivalent of chlorophyll concentration less than 7 ppm, and zero otherwise.

FIGURE 2 depicts the annual average chlorophyll concentration trend of all RI lakes with chlorophyll measurements for the study period. The gradual increase in chlorophyll concentration with over time mirrors eutrophication, the natural aging process of lakes and its exacerbation by extra nutrients from surrounding anthropogenic land uses (Boyer et al., 2009). TABLE 1 shows that the average chlorophyll concentration with this sample is 16.76 ppm, eutrophic level which indicates the lakes in this study are in their mature stage and are more susceptible to impairment. TABLE 2 supports this observation with the highest number of transactions in the eutrophic level (40,631 or 41.74%).

[7] *www.**uri**.edu/ce/wq/ww/*

GIS dataset

The location of a house is a major determinant of its value (Bourassa, 2006; Theriault et al. 2003). The market value of a house can be expected to reflect nearby environmental amenities, and the effect on housing price is expected to decline with distance to the environmental amenity (David, 1968; Walsh, 2009)[8]. This location dependent externality is important for lake water quality management plans. This study uses ArcGIS software to determine the distance between a property and its nearest lake. The unique RI address locator from RIGIS based on Emergency 911 structure coordinates is used to geocode locations of all the houses with sales transactions and the longitudes and latitudes that came with the housing dataset are corrected accordingly. Their locations are further verified with intersecting with RI Census shape files using ArcGIS Intersect (Overlay) Tool.

The distance between a home with sales transaction and its nearest lake is determined using the NEAR ArcTool. Shape files of open space from RI conservation land, and forests from RI land use are obtained from RIGIS. The ArcMap Focal Cell Tool is used to determine the distance to open space and forests within 0.25 miles to the nearest lake, following the rasterization of these amenities in 30m x30m pixels. Therefore, the number of pixels is directly proportional to the surface area of respective amenity to the homes: the higher number of pixels, the larger surface area of and the closer to any of these amenities. Raster to Focal Cell option rather than NEAR tool is a choice of application on these amenities because of their natural contiguity and overlap among themselves near

[8] Although this is a general consensus, it might not be true for all environmental amenities. For some environmental attributes such as farmlands may be amenity or disamenity, we might want to be close, but not too close.

lakes as shown in FIGURE 3. Both panels show the same area with RI shoreline lakes, all RIDEM lakes which includes URIWW lakes. The top panel is a map of forests and agricultural land and the bottom panel open space conserved in the state and local levels. Only forest is chosen as an additional environmental amenity in the vicinity of lakes for this study.

All datasets are merged using ESRI ArcView GIS software 10.1 and statistical software STATA 12. Both open source software R and statistical software STATA 12 are used for data management in which all distances are calculated and tabulated for estimation, and data analysis.

ESTIMATION OF HEDONIC PRICE FUNCTION

Functional Forms and Model Selections

This study uses the logarithmic functional form. It is shown that econometric models for the equilibrium price function perform best when all variables are included in the model but that simpler functional form using a linear, log-linear specification performed best in the presence of omitted variable (Cropper et al., 1988). Logarithmic and semi-logarithmic functional forms which represent the elasticity in percentage render easier interpretations. Linear and squared terms were tested for primary living area, age and lot size because theory and empirical results suggest nonlinearities in valuing these characteristics.

Following tests of alternative specifications, this model is selected:

$$ln\ (Price_{ijt}) = \lambda_t + \alpha_j + \gamma_k + \sigma_i + \beta_0 + \sum\beta_1 X_{ij} + \beta_2\, lakefront_{ik} + \beta_3\, llakeft_k + \beta_4 lforest_i + \beta_5\, lacre_{ik} + \beta_6 lakefront_{ik} {*} goodWQ_{ikt} + \beta_7\, llakeft_k {*} goodWQ_{ikt} + \beta_8\, llakeft_k {*} lforest_i + \beta_9\, lacre_{ik} {*} goodWQ_{ikt} + \varepsilon_{ijt}, \quad [1]$$

where $Price_{ijt}$ represents the price of the property i adjusted to the second quarter of year 2010 RI housing price index. λ_t represents a year-quarter fixed effects; α_j denotes the Census tract fixed effects; γ_k denotes lake fixed effect; σ_i denotes bedroom fixed effects; $goodWQ_{ikt}$ is a dummy variable for the oligotrophic and mesotrophic levels of water quality. X_{ij} represents the house characteristics variables such as living area, number of total rooms, number of bathrooms, exterior condition of the house, number of bedrooms, living area and the age of the house, etc. The variable *lakefront* is a dummy variable for lakefront properties and defined as properties within 100 meters from the lakeshore[9]. *llakeft* is a logarithmic distance in ft. between a property and its nearest lake with chlorophyll measurement. *lforest* and *lacre* are logarithmic forest, and lake surface area respectively in square meters within 0.25 miles from a property, and ε_{ijt}, is error term.

RESULTS

TABLE 4 shows that lakefront properties have a positive and significant effect on house sales prices.[10] Lakefront main effect increases house sales price by 4.74% and its interaction term with good water quality increases the sales price by an additional 2.28%.

[9] This distance is commonly used to define lakefront in other studies (e.g. Walsh et al. 2011).

[10] Regression results for control variables are summarized in TABLE A and the results from OLS regressions in TABLEs B and C respectively in Appendix.

Based on the mean house sales price ($263,348), this is equivalent to a premium of $18,487 in combined effect of lakefront property and good lake water quality. The edge effect of lakefront properties declines rapidly beyond a cut-off distance as observed in other studies (Brown and Pollakowski, 1977; Landford and Jones, 1995). The main effect of natural logarithmic proximity to the lake in ft. variable, *llakeft,* is not significant. Its interaction term with water quality, *llakeft*goodWQ* is negative and significant as -0.894% . Its negative net effect indicates that house sales prices decrease as the distance between a property and its nearest lake increases when water quality is good.

TABLE 4 shows that the natural logarithmic forest surface area has a positive and significant impact on house sales price (0.45%) in its interaction term with lake distance, *lforest*llakeft*. This trend is opposite to that of lake water quality and lake distance interaction term, *llakeft*goodWQ*, and indicates that forests substitute for lake amenity values as the distance between a property and its nearest lake increases. This observation corroborates the findings from other studies (e.g., Palmquist and Fulcher, 2006).

Lake size is usually included only as an interaction term in regressions because lakes do not change their size. Accordingly, the interpretation of its coefficient as an independent variable warrants a caveat that it may overestimate the significance (Walsh et al., 2011). TABLE 3 is a summary of house sales transaction distribution by lake size. Looking at all single family homes and those near lakes with chlorophyll measurements, the largest number of sales transactions occurs near lakes between 10 and 50 acres in size. TABLE

4 shows that the lake size variable, the logarithmic surface area of lakes in square meters, *lacre,* does not have a significant main effect. However, its interaction term with good lake water quality has positive significant effect on house sales price (1.17%). The fact that good lake water quality has a positive effect on the lake size amenity value is consistent with findings from other studies (e.g. Walsh et al. 2011). These lake size observations may be related to the variety of recreational services that larger lakes offer if water quality is adequate to support those activities.

POLICY ANALYSIS

This study's results are applied to hypothetical water quality improvement policies encompassing all RI lakes. Three scenarios are explored: (1) a single lake with poor (eutrophic) water quality, (2) all Rhode Island lakes with poor (eutrophic) water quality, and (3) all Rhode Island lakes with the combination of poor (eutrophic) and extremely poor (hypereutrophic) water quality. In scenario 1, FIGURE 4 depicts the 85 acre, medium sized lake named Warwick Pond. This lake has poor (eutrophic) water quality and 2,311 property sales transactions, 152 of which are lakefront. TABLE 5A shows that Warwick Pond is one of 26 eutrophic lakes with chlorophyll measurement.

For scenarios 2 and 3, the all RI lake hypothetical policies, *goodWQ* in the model [1] above is replaced with a vector of three trophic levels (good, poor and extremely poor) for additional regression. This differentiates non-good water quality into poor and extremely poor. TABLE 5B extrapolates data for lakes with chlorophyll measurements to all RI lakes, showing both lakefront and all transactions.

TABLE 6 lists non-good lake water quality variables to estimate the total change in lakefront property sales prices if the lake were to switch from non-good to good water quality.[11] Two non-good water quality levels include poor (eutrophic chlorophyll concentration 7.2 to 35 ppm) and extremely poor (hypereutrophic chlorophyll concentration greater than 35 ppm). The reference water quality level is good water quality, which includes oligotrophic chlorophyll concentration (less than 2.6 ppm) and mesotrophic chlorophyll concentration (2.6 to 7.2 ppm). The lakefront interaction term with poor (eutrophic) quality is significant and is negative, it reduces lakefront property sales prices by 3%. The interaction term with extremely poor (hypereutrophic) water quality is not significant. This is likely due to the small number of observations, with only 230 lakefront property transactions near 5 extremely poor lakes.

TABLE 7 summarizes potential change in property sales prices for all lakefront properties if the lake water quality were to improve. Estimates are done using four different scenarios: one with a single lake with poor (eutrophic) water quality and the two others with all RI lakes that have either poor or extremely poor (hypereutrophic) water quality. The first three scenarios include lakefront properties with sales transactions. The fourth scenario uses all RI lakefront properties acquired from RIGIS Emergency 911 structures. The aggregate change in transaction price is estimated at $950,000 for 152 lakefront properties around a single lake. The aggregate change in transaction price is estimated at $9.6 million if all RI lakes with poor water quality were improved to good. The aggregate change in transaction price is estimated at $1.5 million if all RI lakes with extremely poor quality were improved to good. This yields over $11 million if all RI

[11] Regression results for control variables are summarized in TABLE D of Appendix.

lakes with both poor and extremely poor water quality were improved. If all RIDEM lakes with non-good water quality (either eutrophic or hypereutrophic) improved their water quality to good water quality, those RI lakefront properties both with and without sales transactions would benefit from $23 million increase in total property values. These estimations are based on annual average chlorophyll concentrations from 1988-2012 and projected to all Rhode Island lakes.

CONCLUSION

Good lake water quality is an environmental amenity, as evidenced by its positive impact on neighboring property sales prices. The amenity edge effect on lakefront properties is only for close proximity, likely due to the latent nature of lake water quality. Forest amenities substitute for lake water quality as distance increases, which is consistent with the findings from other studies (e.g. Walsh et al., 2011; Palmquist et al. 2006). Since good lake water quality benefits non-lakefront as well as lakefront properties as shown by edge effect and amenity substitution, the scope of lake water quality management needs to extend beyond the lakefront. Taking into consideration the recreational services that different size lakes may offer, along with homeowners' willingness to pay for recreational services, lake size is another important consideration to incorporate into lake water quality management policy. The estimation of potential increase in lakefront property sales prices shows that the improvement from poor (eutrophic) to good water quality is significant while the improvement from extremely poor (hypereutrophic) to good is not statistically significant. These results are consistent with the findings from other studies (e.g. Epp et. al, 1979) and can help policymakers prioritize the lakes that need improvement.

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TABLE 1 | *Descriptive Statistics of Variables of Interest for Observations near the lakes with Chlorophyll measurements*

Variable	***Description***	***No. of observations***	***Mean***	***Standard Deviation***	***Min.***	***Max.***
adjprice	sale price adjusted to 2010 RI HPI	97,352	$263,348	$232,796	$31,502.	$27,900,000
lotsize	lot size of property in square ft.	97,314	15,522.88	38,822.05	0.02	2,657,160
livingarea	living area in square ft.	96,989	1,565.49	717.42	112	15,838
totrooms	no. of total rooms	96,840	6.28	1.55	1	27
bedrooms	no. of bedrooms	93,936	3.03	0.79	1	14
bathrooms	no. of bathrooms	96,983	1.52	0.67	1	9
numfireplace	no. of fireplace	97,352	0.34	0.57	0	8
age	age of the house	96,983	56.4	33.6	2	343
extcon	exterior condition of the house	96,884	5.45	0.97	1	11
lforest	Logarithmic surface forest land use area within 0.25 mile from a property	96,873	11.24	0.83	8.66	12.7
lake_mi	distance to the nearest lake from the property with sale transaction	97,352	0.9	0.63	0	3.63
chlr	chlorophyll concentration in ppm.	97,352	16.76	17.5	0.2	225.1
acres	lake surface size in acres	97,352	86.89	123.25	6.37	1,051.18
year_quarter	Year quarters are numbered from 1988 first quarter as 1 to the first quarter of 2012 as 96	97,352	51.47	24.95	3	97

TABLE 2 | *Property Sales Transactions by Trophic Level*

Trophic level	Chlorophyll Concentration	Frequency	Percent
Oligotrophic	< 2.6 ppm	17,277	17.75
Mesotrophic	2.6 to 7.2 ppm	28,448	29.22
Eutrophic	7.2 to 35 ppm	40,631	41.74
Hypereutrophic	> 35 ppm	10,996	11.30
TOTAL		97,352	100

TABLE 3 | *Single Family Home Sales Transactions by Lake Size*

Lake Size (acres)	All observations		With Chlorophyll	
	Frequency	Percent	Frequency	Percent
10 and less	29,617	15.69	4,935	5.07
10 and 50	100,638	53.33	47,768	49.06
50 and 100	29,244	15.5	25,041	25.72
100 and 200	15,053	7.98	10,666	10.96
greater than 200	14,159	7.5	8,942	9.19
TOTAL	188711	100	97,352	100

TABLE 4| *Environmental Amenity Variables of Interest*

Variable	Description	Estimate	Std_Error	t_value	Pr(>|t|)	
lakefront	property within 100 meter from lake	0.0474	0.0097	4.864	0.00	***
lforest	logarithmic forest area within 0.25 mile	-0.0349	0.0237	-1.473	0.1408	
lacre	logarithmic lake surface area	-0.0168	0.0195	-0.863	0.3882	
llakeft	logarithmic distance between a property and its nearest lake in ft.	-0.0009	0.0044	-0.194	0.8461	
goodWQ	lake water quality dummy variable: one for oligo- and mesotrophic levels	0.3029	0.1474	2.055	0.0399	*
Interaction Variable						
lakefront	**goodWQ*	0.02275	0.0125	1.816	0.0693	.
llakeft	**goodWQ*	-0.0089	0.0027	-3.33	0.0009	***
lforest	**llakeft*	0.0044	0.0021	2.15	0.0316	*
lacre	**goodWQ*	0.0117	0.0054	2.194	0.0282	*
Observations		97,352				
R squared		0.6856				
Fixed Effects:		Year-Quarter, Census Tract and Lake ID				

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1; the number 0.00 denotes number less than 10^{-6}; and TABLE A in Appendix lists complete regression variables.

TABLE 5A |*Water Quality by Lakes with Chlorophyll measurements*

Water Quality	Trophic Level	No. of lakes	Total Transactions	No. of Lakefront Properties	Mean CHLR conc.	Stand Dev
good	Oligotrophic	28	17,222	1,076	1.66	0.53
	Mesotrophic	35	29,183	1,153	4.88	1.29
poor	Eutrophic	26	39,926	856	15.9	7.19
extremely poor	Hypereutrophic	5	11,009	230	53.097	13.98
Total		94	97,340	3,315		

TABLE 5B |*Lakefront Property Distribution by Lake Water Quality levels*

Water Quality level		With Property Sales Transaction				All RI properties E911 structures	
		Lakes with Chlorophyll	total	All RIDEM Lakes	total	All RI properties	total
Good (oligotrophic)	goodWQ	1,075	2,138	1,398	2,780	2,956	5,878
Good (mesotrophic)		1,063		1,382		2,923	
Poor (eutrophic)	non-good WQ	947	1,177	1,232	1,531	2,604	3,236
Extremely Poor (hypereutrophic)		230		299		632	
Total		3,315		4,311		9,114	

TABLE 6 | *Environmental Amenity Variables of Interest(Non-Good Water Quality)*

Variable	*Description*	*Estimate*	*Std_Error*	*t_value*	*Pr(>|t|)*	
lakefront	property within 100 meter from lake	0.0692	0.00854	8.106	0.00	***
lforest	logarithmic forest area within 0.25 mile	-0.00976	0.0197	-0.494	0.621065	
lacre	logarithmic lake surface area	0.00999	0.00449	2.226	0.026013	*
llakeft	logarithmic distance between a property and its nearest lake in ft.	-0.0344	0.0249	-1.382	0.16686	
Interaction Term Variables						
lakefront	** poor (eutrophic)*	-0.03	0.0135	-2.224	0.026134	*
	** extremely poor (hypereutrophic)*	0.00893	0.0218	0.409	0.682358	
llakeft	** poor (eutrophic)*	0.00994	0.00279	3.562	0.000369	***
	** extremely poor (hypereutrophic)*	0.000736	0.00524	0.14	0.888349	
lforest	**llakeft*	0.00364	0.00209	1.736	0.08254	.
lacre	** poor (eutrophic)*	-0.0138	0.00573	-2.411	0.015922	*
	** extremely poor (hypereutrophic)*	-0.000779	0.00881	-0.088	0.929503	
Observations		97,352				
R squared		0.6856				
Fixed Effects:		Year-Quarter, Census Tract and Lake ID				

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1; the number 0.00 denotes numbers less than 10^{-6}; and TABLE B in Appendix lists complete regression variables.

TABLE 7 | *Total Change in Lakefront Property Sales Prices with Improved Water Quality*

	RI DEM lakes with Property Sales Transaction				***All RIDEM Lakes E-911 Structures***
	LakeID 2346 (Warwick Pond)	***All RIDEM Lakes***			
Water Quality Level	*A single lake with Eutrophic (Poor) Quality*	*Eutrophic (Poor) Quality*	*HyperEutrophic (Extremely Poor) Quality*	*Non-good water quality (Both eutrophic and hypereutrophic)*	Non-good water Quality
No. of Lakefront properties	152	1,232	299	1531	3,236
Average Lakefront Property Sales Price	$209,340	$258,664	$251,148	$257,195	$257,195
Coefficient	0.03	0.03	Not significant	0.028	0.028
Total change in Lakefront Property Sales Prices with improved water quality	$954,589	$9,560,224	$1,465,230	$11,025,453	$23,303,963

FIGURE 1| *RIDEM & URIWW monitored lakes*

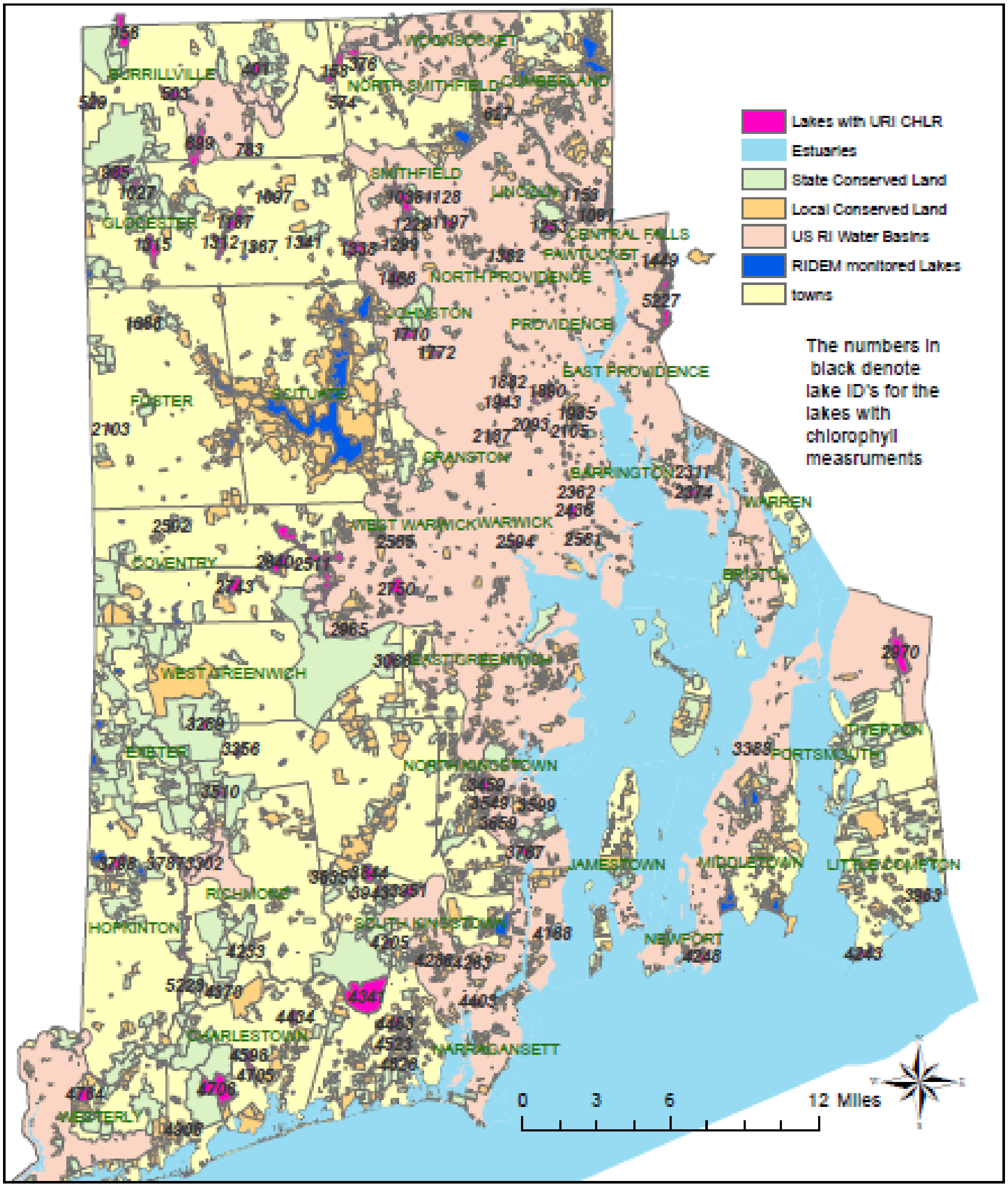


FIGURE 2 |*Annual Mean Chlorophyll concentration of all RI Lakes,1988-2011*

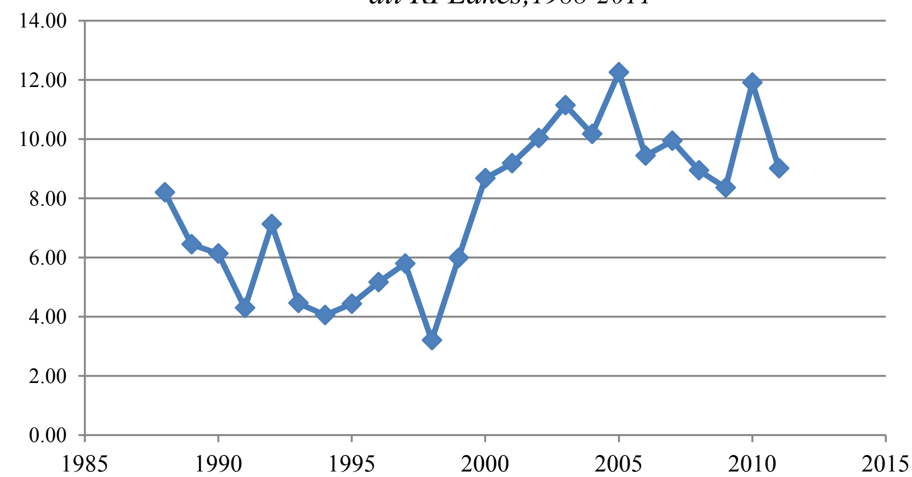


FIGURE 3 | *Natural Amenities nearby RI Shoreline Lakes*

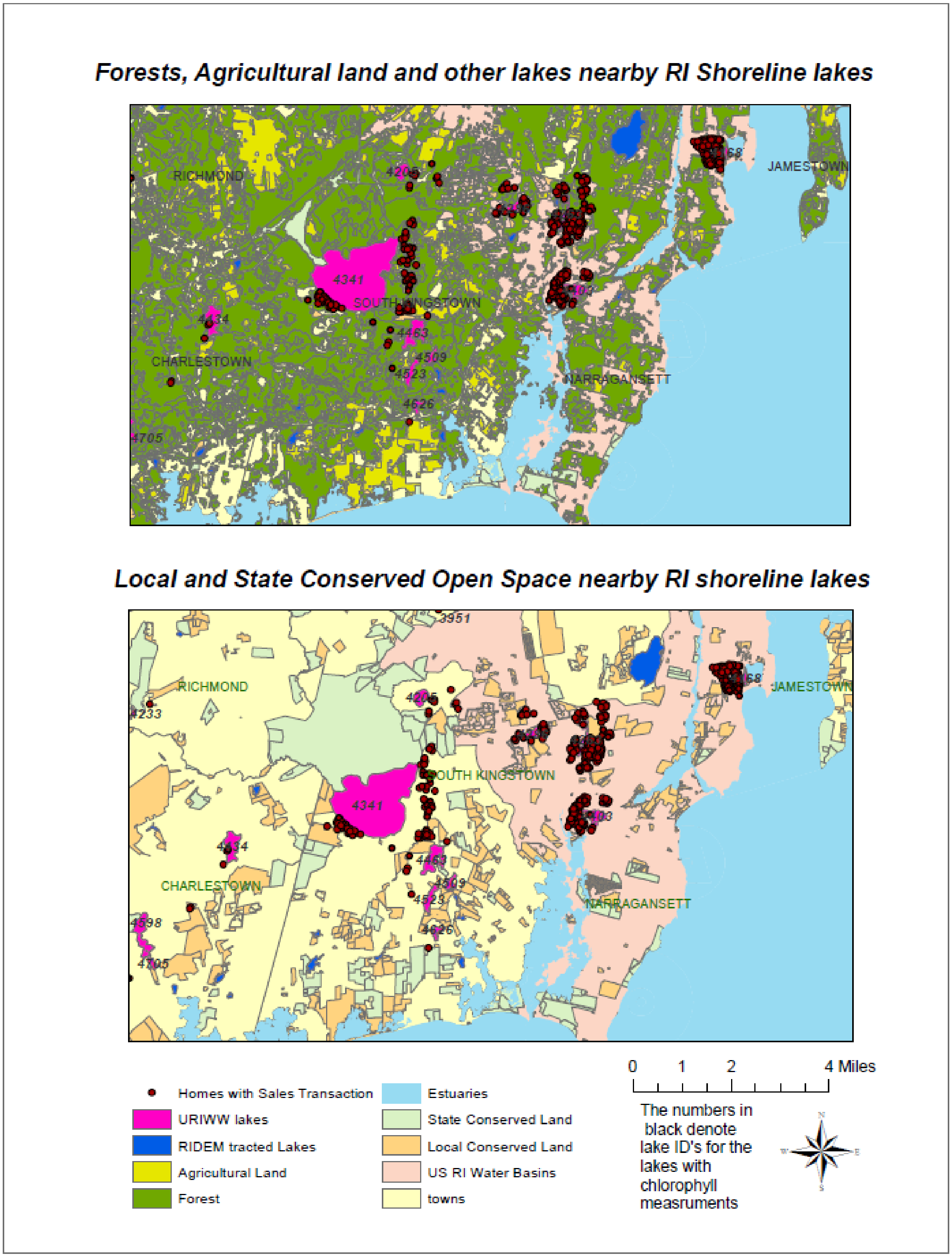
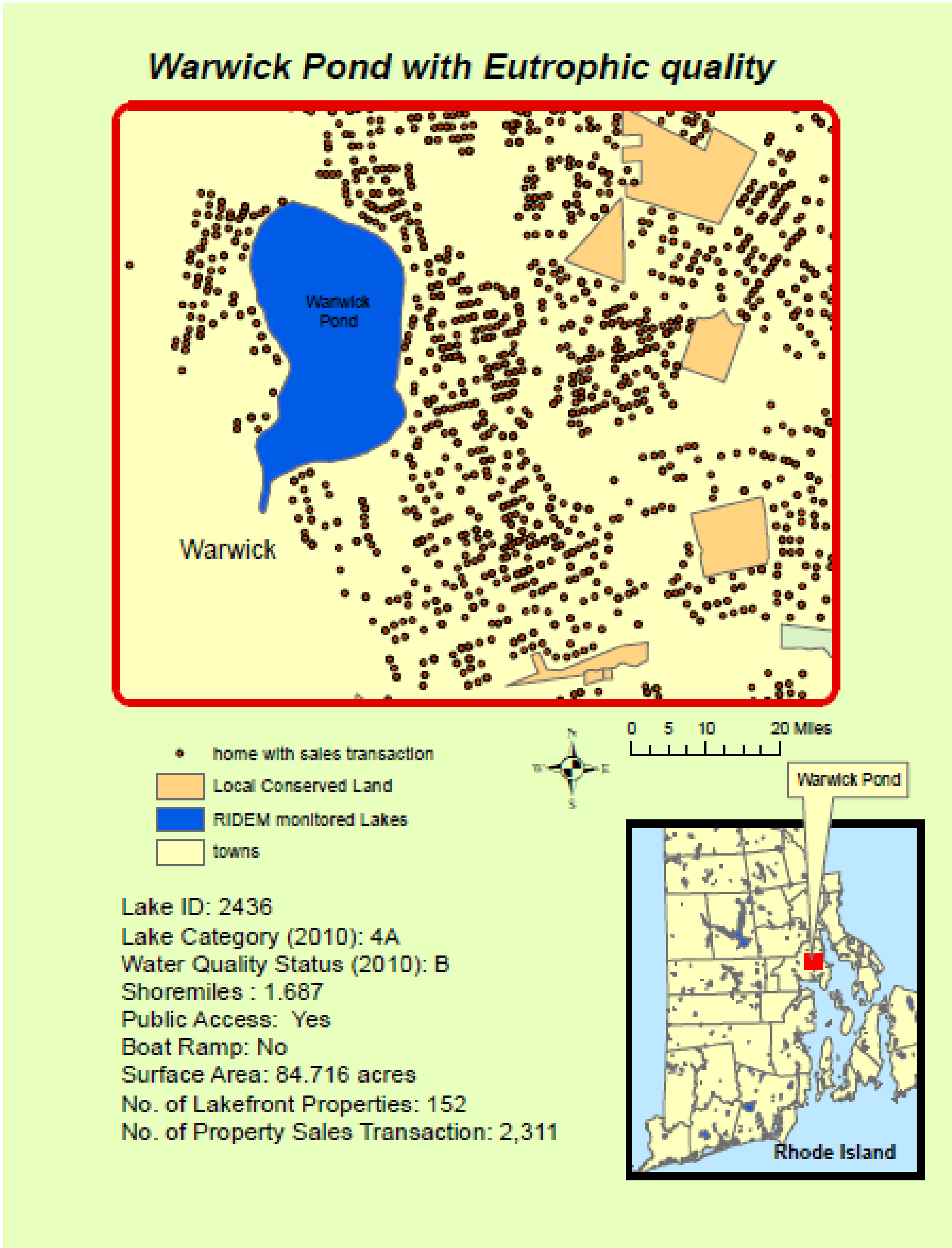


FIGURE 4 | *A Single Lake for Policy Analysis*



APPENDIX

TABLE A | *Full list of Regression Variables for TABLE 4*

Variable	*Description*	*Estimate*	*Std_Error*	*t_value*	*Pr(>|t|)*	
(Intercept)		105.5	9.623	10.965	0.00	***
House Characteristic Variables						
bathrooms	no. of bathrooms	0.0471	0.0018	26.11	0.00	***
lotacre	lot size in acres	0.0105	0.0005	19.448	0.00	***
numfirepl	no. of fireplace	0.0773	0.0021	37.658	0.00	***
age	age of the house	-0.0019	3..262e-5	-58.155	0.00	***
Exterior Condition of House (relative to (extcon 1):poor condition)						
factor(extcon)3	extr. con.: above average	0.2817	0.0114	24.755	0.00	***
livingarea	living area in square ft.	0.0002	2.296e-6	98.454	0.00	***
longitude		0.2206	0.1197	1.843	0.0653	.
latitude		-1.875	0.1268	-14.785	0.00	***
Household and Neighborhood Characteristics						
medhinc2	median household income	0.0055	0.0010	5.359	0.00	***
popD2	population density	-0.0075	0.0003	-23.481	0.00	***
pNHWhite2	% non-Hispanic White population	0.0721	0.0115	6.26	0.00	***
p65plus2	% 65 yr. & older population	0.1115	0.0117	9.557	0.00	***
aveHH	average household size	0.0010	0.0035	0.273	0.78	
pFamHH2	% family household	0.0962	0.0104	9.236	0.00	***
pOOHU2	% owner occupied housing units	0.0584	0.0067	8.666	0.00	***
Environmental Amenity Variables of Interest						
lakefront	property within 100 meter from lake	0.0474	0.0097	4.864	0.00	***
lforest	logarithmic forest area within 0.25 mile	-0.0349	0.0237	-1.473	0.1408	
lacre	logarithmic lake surface area	-0.0168	0.0195	-0.863	0.3882	
llakeft	logarithmic distance between a property and its nearest lake in ft.	-0.0009	0.0044	-0.194	0.8461	
goodWQ	lake water quality dummy variable: one for oligo- and mesotrophic levels	0.3029	0.1474	2.055	0.0399	*
Interaction Variable						
lakefront	**goodWQ*	0.02275	0.0125	1.816	0.0693	.

llakeft	**goodWQ*	-0.0089	0.0027	-3.33	0.0009	***
lforest	**llakeft*	0.0044	0.0021	2.15	0.0316	*
lacre	**goodWQ*	0.0117	0.0054	2.194	0.0282	*
Observations		97,352				
R squared		0.6856				
Fixed Effects:		Year-Quarter, Census Tract and Lake ID				

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1; and 0.00 denotes numbers less than 10

TABLE B | *Full Regression Variables for TABLE 6 (Non-Good Water Quality)*

Variable	*Description*	*Estimate*	*Std_Error*	*t_value*	*Pr(>|t|)*	
(Intercept)		105.5	9.624	10.967	0.00	***
House Characteristic Variables						
bathrooms	no. of bathrooms	0.01815	0.001042	17.417	0.00	***
lotacre	lot size in acres	0.04705	0.001802	26.111	0.00	***
numfirepl	no. of fireplace	0.07729	0.002052	37.656	0.00	***
age	age of the house	-0.001897	0.00003262	-58.151	0.00	***
Exterior Condition of House (relative to (extcon 1): poor condition)						
extcon 2	average	0.1034	0.005959	17.348	0.00	***
extcon3	above average	0.2818	0.01138	24.755	0.00	***
livingarea	living area in square ft.	0.000226	0.000002296	98.426	0.00	***
lotacre	lot size in acres	0.0103	0.0006	19.454	0.00	***
longitude		0.2205	0.1197	1.842	0.065408	.
latitude		-1.875	0.1268	-14.787	0.00	***
Household and Neighborhood Characteristics						
medhinc2	median household income	0.005529	0.001032	5.357	0.00	***
popD2	population density	-0.007509	0.0003198	-23.48	0.00	***
pNHWhite2	% non-Hispanic White population	0.07212	0.01152	6.261	0.00	***
p65plus2	% 65 yr. & older population	0.1115	0.01166	9.556	0.00	***
aveHH	average household size	0.0009672	0.003543	0.273	0.78	
pFamHH2	% family household	0.09617	0.01041	9.235	0.00	***
pOOHU2	% owner occupied housing units	0.0584	0.006741	8.664	0.00	***
Environmental Amenity Variables of Interest						
lakefront	property within 100 meter from lake	0.0692	0.00854	8.106	0	***
lforest	logarithmic forest area within 0.25 mile	-0.00976	0.0197	-0.494	0.621065	
lacre	logarithmic lake surface area	0.00999	0.00449	2.226	0.026013	*
llakeft	logarithmic distance between a property and its nearest lake in ft.	-0.0344	0.0249	-1.382	0.16686	
Interaction Variable						

lakefront	** poor (eutrophic)*	-0.03	0.0135	-2.224	0.026134	*
	** extremely poor (hypereutrophic)*	0.00893	0.0218	0.409	0.682358	
llakeft	** poor (eutrophic)*	0.00994	0.00279	3.562	0.000369	***
	** extremely poor (hypereutrophic)*	0.000736	0.00524	0.14	0.888349	
lforest	**llakeft*	0.00364	0.00209	1.736	0.08254	.
lacre	** poor (eutrophic)*	-0.0138	0.00573	-2.411	0.015922	*
	** extremely poor (hypereutrophic)*	-0.000779	0.00881	-0.088	0.929503	
Observations		97,352				
R squared		0.6856				
Fixed Effects:		Year-Quarter, Census Tract and Lake ID				

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1; and the number 0.00 denotes numbers less than 10^{-6}.

MANUSCRIPT – 2

Environmental Amenity Value Changes over Time

(Intended to publish in

Land Economics)

Susan Shim Gorelick

Environment and Natural Resource Economics, University of Rhode Island,

Kingston, RI, USA

ABSTRACT

This study examines how the housing price premium associated with environmental amenities change over time. House sales transactions data in Rhode Island from 1988 through 2012 are combined with water quality data for Rhode Island lakes to estimate the price premium associated with water quality. The study assesses changes in values over time using two continuous variables, the Rhode Island Current Condition Index (RICCI) and a time trend. A statistically non-significant and positive interaction term between the time trend variable, number of days and lake water quality indicates that the amenity value of water quality is constant over the study period. Non-significant interaction term between economic condition indicator RICCI and lake water quality indicates that the amenity value is constant in percent terms across economic cycles. The findings from this study bear policy implications regarding amenity values for environmental management planning.

INTRODUCTION

Economists commonly estimate values for environmental amenities at a point in time, using approaches such as stated preference surveys and travel cost approach. These estimates are often used to guide government policy. Unfortunately, values estimated at a particular point in time may mislead policy that affects environmental amenities in other time periods. For example, a policy might conserve an environmental amenity such as habitat for an indefinite period, while the estimated amenity values may have been based on a study carried out at some particular point in the past. If amenity values increase over time, then we will underestimate their value if we use an estimate from a snapshot in the past.

Similarly, estimated values may vary over time depending upon circumstances specific to the particular time period. People's willingness to support environmental programs may decline during periods of economic downturn, and may increase during periods of economic boom. As a consequence, a study carried out at a particular point in time may mislead policy if the study is carried out at a point in time when economic conditions are extremely strong (or weak). Therefore, it is important to understand the degree of sensitivity of amenity value estimates to time. If we find that amenity value estimates are very sensitive on relatively short time scales, it may be important to adjust amenity value estimates to provide policy guidance. In contrast, if we find that amenity values are robust over time, then there is less need to consider methods for correcting amenity values.

This study examines the sensitivity of estimated environmental values over time within the context of a case study of the amenity value of water quality in Rhode Island lakes. The hedonic model is used with data for Rhode Island house sales transactions from 1988 through 2012 to estimate the price premium associated with the lake water quality over this time period. Sensitivity of the price premium over time is estimated using two time-related variables – a simple time trend, a logarithmic number of days, based on the house sales transaction date, and the Rhode Island Current Conditions Index (RICCI), a monthly indicator that details the current state of the Rhode Island economy, based on the behavior of key economic indicators.

Hedonic pricing model is a revealed preference valuation method that models a heterogeneous composite of both market and non-market goods in several bundles. Its popular application in environmental studies is rooted in its structural form which allows the separation of the non-market environmental amenities from market goods with market price from which the value of nonmarket goods can be potentially estimated. As both housing market prices and environmental amenity values change dynamically over time, understanding their change over time and the degree of sensitivity of amenity value estimates to time can be essential to making informed policy and planning decisions (e.g. lake water quality management). With over 200 sizable[1] lakes, Rhode Island places great importance on maintaining their integrity. The results of this study can help shape environmental protection policy.

[1] Only the lakes of 10 acres or more are tracked by RI DEM.

PREVIOUS STUDIES

Hedonic pricing model quantifies environmental amenity value revealed through the property sales price premium for an environmental amenity in its proximity. This is based on the premise that environmental amenities behave as normal goods. Clean air quality is commonly used in literature to test the hypothesis that environment amenity is a normal good. There is a negative correlation of air pollution intensity by nitrogen and sulfur compounds with income per capita across the U.S regions (Bruneau and Eschevarria, 2003). Looking at another amenity, property owners in proximity to lakes having higher levels of human capital (the proxy being the shares of college graduates) also suggests that environmental amenity is a normal good (Stephens and Patridge, 2012). Overall, the findings are consistent with the theory that environmental amenities are normal or superior goods.

In general, one would expect income to be an important factor in determining environmental amenity values (Antle et al.,1995; Barbier, 1997; Yandle et al., 2002). An open question is the extent to which time scale matters. Changes in income over the long term can have different effects on environmental amenity values compared with short term fluctuations in income. Friedman's permanent income hypothesis suggests that values are not expected to be very sensitive to short term volatility in income. Taken to an extreme, the permanent income hypothesis could imply that people anticipate long term income increases, and this anticipation may be reflected in environmental amenity values. As a result, environmental amenity values may not be very sensitive even to long term income changes. In contrast, if households behave myopically, one might expect to find the value of environmental amenities to vary with short run changes in income. This provides a rationale for testing the statistical significance of both long term income trends and short term fluctuations in revealed values for environmental amenities.

Real estate plays an integral role in the economy.[2] The real estate recession and boom cycles trend is a good indicator of economic health. It is generally considered that during weak economic conditions consumers are forced to alter their financial decision making with different spending patterns (Shahid, 2008). Since real estate is a large portion of the typical consumer's expenditure, economic conditions affect spending patterns related to both disposable income and larger, long-term financial assets (Stein, 1995). Furthermore, environmental amenities are often considered to be luxury goods. Since change in demand for environmental amenities to be more than proportionate to income changes, the study of how economic cycles affect environmental amenity value warrants an analysis of both demand elasticity for environmental amenities as well as income elasticity (Martinez-Alier, 1994; Bruneau et al, 2003).

The concept that the demand for environmental amenities is sensitive to changes in income underlines the Environmental Kuznets Curve (EKC). Under the EKC, environmental quality decreases with increasing income until a threshold income level is reached, after which environmental quality improves with income level (Barbier, 1997). This result is based on the notion that if environmental quality is a luxury good, then

[2] www.useconomy.about.com, "The slowness in the housing sector is an important headwind that is impeding the pace of economic recovery." (www.frbatlanta.org/news/speeches/110511_lackhart.cfm).

demand for environmental quality increases as incomes get sufficiently high. (Antle and Heidebrink, 1995).

Numerous studies explore EKC in broad, global perspectives (e.g. Stern et al 1996). A more recent study focusing on a specific environmental amenity assesses the income elasticity demand for environmental quality in Sweden using recreational services as an environmental quality indicator (Ghalwash, 2008). It confirms that recreational services are a luxury good. The study also includes other traditional groups of goods for the analysis of how the income elasticities for these composite goods change over time. It finds that income elasticities for traditional goods are stable over time and are mirrored in consumer preferences for expenditure on specific commodities, such as recreational services.

There are a handful of studies on income elasticity of demand in the context of housing market. The hedonic study by Dorsey et al. (2010) indexes property sales transactions in the Los Angeles and San Diego metropolitan areas between 2000 and 2008 by zip codes. It shows that the intensity of the real estate boom-bust cycle varies greatly across zip codes and price-tiers in a pattern consistent with increased foreclosure activity in low price-tier zip code areas. A similar correlation is observed in Rhode Island, as shown in the Rhode Island Multiple List Services (MLS)[3] quarterly reports. Properties in low price-tier zip codes have more days of listing and proportionally larger fall in sales price during a recession compared to properties in high price-tier zip codes. Rental properties

[3] http://www.riliving.com/About-Rhode-Island/HomeSales/Index.aspx

encompass a large portion of the housing market in Rhode Island. Rental property booking trends mirror property sales trends during boom-recession cycles: those in high price-tier areas are affected less by boom-recession fluctuations.[4]

Peoples' willingness to pay (WTP) to support environmental programs may also be expected to vary with economic conditions. However, there are few studies on the impact of economic conditions on consumer spending pattern for non-market goods, such as environmental amenities, in comparison with studies for market goods. One of these is by Cho et al (2011), following their earlier study on temporal and spatial effects on open space (Cho et al. 2009a). In both studies they use open space as an environmental amenity. They examine how the amenity value of open space, (developed versus forest-open space) during the 2000-2006 real estate booms differs from the subsequent 2008 recession. They find that the environmental amenity is a normal good, as marginal implicit values decreased during recession and increased during boom. A study examining the relationship between county per capita income and toxic pollutants using a Kuznets Curve model (Rupasingha et al., 2004) corroborates the findings of Cho et al. (2009a, 2011). Other studies using different environmental attributes also show environmental amenity as a normal good: the value of a greenbelt in Seoul changed with the recession-boom cycle (Lee and Linneman, 1998); undeveloped land in proximity to vacant land has a higher value during boom cycles (Smith et al., 2002); and an analysis of data from the 1970's and 1980's shows that consumer marginal willingness to pay for

[4] http://www.providencejournal.com/business/content/20110513-things-are-looking-up-for-summer-rentals-in-rhode-island.ece

improved air quality was lower during the 1981-82 recession (Chay and Greenstone, 2004).

HYPOTHESES OF THIS STUDY

(i) Environmental amenity values change over time. This study will determine whether these values increase in conjunction with improved economic conditions over a continuous time horizon.

(ii) Environmental amenity value changes vary depending upon the time scale, whether they are short term fluctuations or long term trends. This study is designed to test whether lake water quality impacts house sales price premium more during upward versus downward economic conditions.

(iii) Environmental amenities are luxury goods. Using edge effect of lake water quality on lakefront properties as the environmental amenity, fluctuations in economic condition is expected to affect the price premium of lake front properties more than non-lakefront properties.

The first two hypotheses mirror Environmental Kuznets Curve that models demand for environmental quality depends upon income. Two explanations to consider: exogenous changes in environmental values and environmental values increase over time with income, with the latter more likely to show a response to economic cycles. In addition, response to economic condition is more about the time scale of sensitivity to income changes. One argument would be that current income matters. A second argument would be like a "permanent income hypothesis", which could be a speculative effect or a smoothing over time that prices don't respond to current income because there is an expectation that prices will rebound in the future. The third hypothesis is based on the premise that environmental amenities behave as normal goods and economic conditions influence consumers differently in accordance with their financial status. If environmental quality is a luxury good, one would expect the price premium to be more sensitive to fluctuations in income. The hypotheses test time sensitivity of environmental amenity values in the context of RI lake water quality in response to short term economic conditions using the Rhode Island Current Condition Index (RICCI), and to long term time trend using a liner number of days.

OVERVIEW OF STUDY AREA and DATA

Rhode Island's landscape encompasses more than 5,000 lakes covering 20,749 acres. Seventy percent of these lakes are 50 acres or less in size. RI Department of Environmental Management (RIDEM)[5] tracks 237 freshwater lakes with size greater than 10 acres, covering 18,845 acres. Ninety nine of these lakes are monitored by the University of Rhode Island Watershed Watch program (URIWW) with 151 monitoring stations. This study includes Rhode Island sales transaction of properties within 0.5 miles of the nearest of the 99 monitored lakes.

Rhode Island property sales transactions and lake water quality data from 1988-2012 are combined to estimate the effect of lake water quality on housing prices. This study comprises four datasets: A general time variable and Rhode Island Current Conditions

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[5] http://www.dem.ri.gov/bayteam/index.htm

index (RICCI); house sales transactions from the Warren group;[6] chlorophyll concentration measurements from URI WW[7]; and geographic information from Rhode Island Geographic Information System (RIGIS).

A simple time trend variable and RI Current Conditions Index (RICCI)

A simple time trend variable, *Ldays* is a natural logarithmic function of house sales date in number of days with January 1, 1988 as the base date. All house sales transaction prices are adjusted to the second quarter of 2010 from quarterly adjusted Rhode Island Housing Price Index, obtained from Economic Research[8] for the 1988-2012. This is a subsection of North East Regional Case-Shiller housing price index which is based on a repeat-sale method. FIGURE 1A shows its time series trend and FIGURE 1B is a quarter-year percent change trend. In FIGURE 1B, housing market recessions and booms are labeled with red and green lines respectively. These are based on the prominent percent changes that are more than one percent in magnitude and/or with the duration more than two quarter periods. Since housing market trend usually lags that of overall economy, especially during recession,[9] Rhode Island Current Condition Index (CCI)[10] is used as continuous proxy of economic conditions and as one of time trend variable regressors for this study.

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[6] I would like to acknowledge and thank Alan Pasnik of the Warren Group for the housing data which made this study possible.

[7] *www.uri.edu/ce/wq/ww/*

[8] www.research.stlouisfed.org/fred2/series/RISTHPI

[9] "..the real estate sector will lag an otherwise improving economy", www.frbtlanta.org/news/speeches/110511_lockhart.cfm.

[10] I would like to thank Dr. Len Lardaro of University of Rhode Island for the permission to use the information from his website, http://www.llardaro.com/current.htm

Rhode Island CCI is a monthly indicator of the present state of the Rhode Island economy. It follows the twelve key economic indicators pertaining to housing, retail sales, fiscal pressures, the employment situation, and labor supply as follows: Government employment; Employment services jobs; Retail sales; University of Michigan U.S. Consumer Sentiment index; Single-Unit housing permits; Private service-producing employment; Manufacturing man-hours; Average hourly manufacturing wage; Seasonally adjusted unemployment rate; Resident labor force; New initial claims for unemployment insurance; and Unemployment insurance regular benefit exhaustions. The CCI ranges from 0 when no indicators improved compared to year-earlier levels to 100 when all twelve indicators show improvement. The values above 50, the "neutral" value indicate that the RI economy is expanding, while values below 50 indicate contraction (http://www.llardaro.com/current.htm). FIGURE's 2A and 2B depict the trend of annual RICCI values.

House Sales Transaction Data

This study extracts Rhode Island single family home sales transactions, a subset of 188,711 from a dataset of 380,000 observations with various types of property sales transactions that span from 1988 to 2012. The housing dataset comprises 53 variables that include the house sales price (dependent variable), all house characteristics (explanatory variables), and GIS (Geographic Information System) variables such as longitude and latitude. Only those house characteristic variables that were significant from the preliminary data analysis are used for this study. Those include number of total rooms, number of bathrooms, number of fireplaces, living area, exterior condition of the house, and the age of the house. The house sale observations with price of only greater than $40,000[11] and properties with house structures are included as valid sales[12]. Not all lakes have chlorophyll concentration measurements, so a dummy variable is used to designate the 97,352 property sales transactions nearest to the lakes with chlorophyll concentration measurement within 5 miles.[13] The further reduced dataset of 32,914 single family homes within 0.5 miles from their nearest lakes are extracted and they include 3,315 single family lakefront properties. The cut-off proximity for lakefront property is 100 meters from its nearest study lake.

Chlorophyll concentration dataset

Since 1988, the University of Rhode Island has coordinated a volunteer-based lake monitoring program through the URI Watershed Watch (URIWW) program.[14] This program is the primary source of ambient water quality data on lakes in RI. Watershed Watch trains volunteers to collect samples seasonally from May through October at a total of 99 water bodies in Rhode Island. Sample analysis is performed in URI laboratories. Water quality parameters measured in the URIWW lake monitoring program include: water clarity (secchi depth), water depth, temperature, dissolved oxygen (deep sites), pH, alkalinity, chlorophyll, total and dissolved phosphorus, total nitrate, ammonium –nitrogen, chloride and pathogens.

[11] This cutoff amount was used in other hedonic studies such as Walsh et al. 2011.

[12] The transactions occurred with the same sale year were considered as duplicates and dropped.

[13] Even though the 5 mile-cutoff was set, the maximum proximity is 3.6 miles due to the prevalence of RI lakes.

[14] I would like to thank and acknowledge Linda Green and Elizabeth Herron of URI WW, and all URI WW volunteer monitors for the water quality data and their time and devotion.

Chlorophyll concentration is chosen for this study because of its visual manifestation of lake water quality status. It also serves as a good summary measure of water quality in Rhode Island lakes that simplifies the complex idiosyncratic nature of lake chemistry and serves as a trophic-level proxy. Chlorophyll concentration is a key water quality measure that reflects eutrophication levels of lakes. Overall, chlorophyll concentration is a good holistic measure, particularly when excess nutrients are a primary water quality issue (Boyer et al., 2009). Protecting lake water quality by mitigating eutrophication is a major challenge in Rhode Island.[15] Chlorophyll concentration is categorized in four conventionally used trophic levels according to the range of concentration in increasing order: oligotrophic, mesotrophic, eutrophic and hyper-eutrophic. The chlorophyll concentration unit of microgram per liter is equivalent to parts per million, ppm. For this study, a dummy variable, *goodWQ* is defined as one for oligotrophic and mesotrophic levels, equivalent of chlorophyll concentration less than 7 ppm, and zero otherwise. FIGURE 3 depicts the annual average chlorophyll concentration trend of all RI lakes with chlorophyll measurements for the study period. The gradual increase in chlorophyll concentration with over time mirrors eutrophication, the natural aging process of lakes and its exacerbation by extra nutrients from surrounding anthropogenic land uses (Boyer et al., 2009).

<u>Geographic Information System (GIS) dataset</u>

The location of a house is a major determinant of its value (Bourassa, 2006; Theriault et al. 2003). The market value of a house can be expected to reflect nearby environmental

[15] *www.uri.edu/ce/wq/ww/*

amenities. Typically, one would expect that properties in closer proximity to the amenity will have a larger effect, the larger the effect sales price (David, 1968; Walsh, 2011)[16]. This location dependent externality distribution is important for lake water quality management plans. Accordingly the GIS is instrumental for this study. The unique RI address locator from Rhode Island Geographic Information System (RIGIS) based on Emergency 9-1-1 structure coordinates is used to geocode locations of all the houses with sales transaction and the longitudes and latitudes associated with the housing dataset are corrected accordingly. Their locations are further verified with an intersect tool with RI Census shape files using ArcGIS Intersect (Overlay) Tool.

All datasets are merged using ESRI ArcView GIS software 10.1 and statistical software STATA 12. Both open source software R and statistical software STATA 12 are used for data management and for the hedonic price function estimation that is used to specify the effect of water quality on sales prices.

ENVIRONMENTAL AMENITY AS SUPERIOR GOOD

There are two types of goods in relation to consumer's income: inferior goods and normal goods. FIGURE 4 shows how demand for each type of good behaves with change in income. Demand for inferior goods decreases (from Q to Q_3) as consumer's income increases (from I_1 to I_2). Thus, the income elasticity is negative. The income elasticity for normal goods is positive since demand increases (from Q to Q_1) as consumer's income rises (from I_1 to I_2). An extreme form of normal good is superior good. Superior

[16] Although this is a general consensus, it might not be true for all environmental amenities. For some amenities such as farmland or forest, we might want to be close, but not too close.

goods make up a larger proportion of consumption (from Q to Q_2) as income rises (from I_1 to I_2), thus a superior good's income elasticity is both positive and greater than 1. A superior good is said to be a luxury good if it is not purchased at all below a certain level of income. Superior good and luxury good are also normal goods, but a normal good is not necessarily a superior good or a luxury good (Mankiw, 2007).

The bell shape of Environmental Kuznets Curve (EKC) in FIGURE 5 models the hypothesized relationship between environmental quality and income (Barbier, 1997) and it becomes a luxury good at higher levels of income (Antle and Heidebrink, 1995). The demand relationship determines income elasticity, which in turn determines whether a normal good is a necessity or a luxury. Income elasticity may vary with income, but not necessarily. And a good may be a necessity (strictly positive) at all income levels while another good may be a luxury good at all income levels.

Consider a simple example with two goods, X and Y, where X is a superior good and Y is an inferior good as below:

$$\mathbf{x^* = X(p_x, p_y, I)\ ;\ \ y^* = X(p_x, p_y, I)\ ,}$$

where both x* and y* are the optima demand for respective normal goods, and p is price of good in subscripts. I, the income constraint is defined as $I = p_x x + p_y y$. FIGURE 6A demonstrates the changes in income from I_1 to I_2 and vice versa, ceteris paribus prices and preferences (utility function), shift the budget constraint parallel, thus X_1 to X_2 and Y_1 to Y_2, and vice versa. For normal goods, as income increases from I_1 to I_2, demand increases from X_1 to X_2. If income elasticity of demand for X is greater than 1 as shown, then normal good X is a superior good. The decreased demand for good Y from Y_1 to Y_2 as income increases from I_1 to I_2 indicates that good Y is an inferior good. FIGURE 6B is another Engel Curve that shows how demand for normal good y changes as income changes, ceteris paribus, in which y is a function of income, f(I).

Now, suppose these two normal goods are differentiated as luxury and necessity good as shown in FIGURE 7. Q* is optima quantity of good demand and it is a function of income, f (I). For normal goods, $\frac{\partial Q*}{\partial I} \geq 0$, or $f_I \geq 0$. Curves may bend up for luxury goods ($f_{II} > 0$) so that income elasticity is greater than 1, and down for necessities ($f_{II} < 0$) with income elasticity less than 1. This holds when income is above the threshold so that non-zero quantities of the luxury goods are purchased. Income elasticity is zero for the luxury good when income is strictly below the threshold. Both necessity and luxury goods have a positive income elasticity, these two curves intersect at the threshold income level, I_T. Demand for luxury good will decline by more than demand for necessity good below I_T. By definition, the derivative of demand for the luxury good with respect to income is greater than derivative for other normal good (necessity good). Environmental amenity is a luxury good. We would expect that the price premium for high environmental quality will decline in down economic times, and the degree with which economic conditions impact income levels would mirror environmental amenity values.

DEVELOPMENT OF HEDONIC PRICE MODELS

Hedonic pricing models have been used for estimating the values of competitively traded heterogeneous goods. Under appropriate conditions, the hedonic model allows one to identify the contribution that characteristics make to the market price of heterogeneous market goods (Freeman, 2003). Housing market is most commonly used for environmental hedonic models because of common spatial factors such as location of houses and their surrounding environmental attributes. In the context of housing market, characteristics include the structural characteristics of the properties (bathrooms, bedrooms, lot size, etc.) and non-structural characteristics associated with the location, including environmental characteristics. The hedonic model's structural form that internal property characteristics can be decomposed from other non-structural attributes associated with location is the attractive feature for its popular application to study environmental attributes. For example, a hedonic pricing model identifies a premium paid for houses located near desirable environmental amenities, according to the premise that price is determined by both internal characteristics of the good being sold such as structural characteristics of a house, and external factors such as environmental externalities (Freeman, 2003). The environmental amenity of interest in this study (lake water quality) is a non-market characteristic, and the house is the associated market good.

Limitations and Challenges of Hedonic Pricing Model (HPM)

As is true of all statistically-based analyses with non-experimental data, the hedonic approach faces potential challenges associated with omitted variables, endogeneity, and spatial dependence or autocorrelation. In this study, characteristics of the house, property and the neighborhood are the control variables to reduce possibilities of omitted variables. Endogeniety, spatial dependence, and autocorrelation error can be addressed with fixed effects applied at a specified geographic range (Kuminoff, Parmeter, and Pope, 2010). This study uses interactive terms along with local fixed effects to address these issues. Variation between the explanatory variables is measured within the scale of the fixed effects so if we are measuring proximity to various amenities using Census tract, the variation that would otherwise be present between individual parcels is lost. Using fixed effects requires that the variables included in the regression vary over time at the specific level the fixed effects are applied. Chlorophyll concentration measurements over 1988-2011 span provide the requisite variations.

Estimation of the Hedonic Price Function

Functional Forms and Model Selections

Since the house sale price is in logarithmic functional form, semi-logarithmic equation is used as functional form in this study. Log-log function form renders easier interpretation of coefficient. Linear and squared terms were tested primarily for living area, age and lot size, but only linear function forms are used for these variables. Numerous trials with functional transformation and model selections render the following equation:

$$ln\,(Price_{ijt}) = \lambda_t + \alpha_j + \gamma_k + \sigma_i + \beta_0 + \sum \beta_1 X_{ij} + \beta_2\, lakefront_k{*}goodWQ_{ikt} + \beta_3\, lakefront_k{*}goodWQ_{ikt}{*}\,RICCI_{ij} + \beta_4\, lakefront_k{*}goodWQ_{ikt}{*}\,days_i + \varepsilon_{jt},$$

where $Price_{ijt}$ represents the price of the property i adjusted to the second quarter of year 2010 using the RI housing price index. λ_t represents a year-quarter fixed effects; α_j denotes the Census tract fixed effects; γ_k denotes lake fixed effect; σ_i denotes bedroom fixed effects; $goodWQ_{ikt}$ is a dummy variable for the oligotrophic and mesotrophic levels of water quality. X_{ij} represents the house characteristics variables such as living area, number of total rooms, number of bathrooms, exterior condition of the house, number of bedrooms, living area and the age of the house, etc. The variable *lakefront* is a dummy variable for lakefront properties and defined as properties within 100 meters from the lakeshore.[17] *RICCI* is Rhode Island Current Condition Index and used as Rhode Island economic condition indicator. Its 0-100 range is converted to percentile for better comparable unit magnitude. *days* is a linear continuous time variable. It is defined as logarithmic number of days converted from property sales transaction date. ε_{ijt}, is error term.

RESULTS

TABLE 1 shows the coefficient estimates for key variables using house sales transactions for properties within 0.5 mile to the nearest lake, with those within 100 meters identified as lakefront properties.[18] Main effects show lakefront is significant among the variables of interest. The interaction term between lakefront property and good lake water quality, *lakefront**goodWQ* indicates how lakefront property prices are affected by water quality. The interaction term between lakefront, water quality and *days, lakefront**goodWQ* *days* indicates how the water quality effect on property prices changes over time. The coefficient of interaction between lakefront property and good lake water quality, *lakefront* **goodWQ* is positive, but not statistically significant at the + 1.95% level. The coefficient of interaction between lakefront property, good lake water quality and *days,*

[17] This distance is commonly used to define lakefront in other studies (e.g. Walsh et al. 2011).
[18] The regression results of respective control variables are in TABLES A and B of Appendix.

*lakefront*goodWQ**day200* is also positive and not statistically significant at the 0.0662 % level. The other time variable RICCI exhibits the same trend, but with negative and not significant coefficient. This indicates that the water quality effect does not change over time. These non-significant coefficients indicate that we cannot reject the hypothesis that amenity value for lake water quality is constant in percentage terms over varying economic conditions and over time.

Lake water quality is significant only in small distance between a property and its nearest lake, this includes lakefront properties. Looking at the environmental amenity of good water quality as a superior good, the demand for lakefront properties should increase more than proportionately when income increases. However, the non-significant interaction terms both *lakefront *goodWQ*** days and *lakefront *goodWQ**RICCI* suggest that price premium for water quality for lakefront properties[19] is constant in proportion to housing prices. For example, if housing prices increase by 20%, so does amenity value as it stays constant in percentage terms to economic conditions on short time scales. This suggests that people are not myopic on these time scales (months to a couple of years) and this notion warrants a further investigation in future studies.

TABLE 6 is an assortment of various time interval dummies used for robustness test. Three interval dummies are selected from a larger pool of intervals: five 5-year, three 8-year, and two 12-year. All show non-significant interaction terms with *lakefront*goodWQ*. This is consistent with what is observed both with the discrete time variable in this study, RICCI and the continuous linear time variable, *days*. This suggests

[19] Descriptive Statistics of Demographic Variables of lakefront and non-lakefront properties are tabulated in TABLEs 2 and 3.

that price premium for water quality for lakefront properties is constant in proportion to housing prices.

CONCLUSION

This study assesses how environmental values vary over time, as reflected in the environmental price premium on houses near Rhode Island lakes. The study considers two different time scales: short term variability associated with economic cycles, as reflected in the Rhode Island Current Condition Index (RICCI), and longer term variability as reflected by a time trend over a 24-year period from 1988-2012. Two continuous variables are used to assess lake amenity value changes over the 1988-2012 study period. Rhode Island Current Condition Index (RICCI) provides annual data over a continuum.

We find that short term economic fluctuations do not have a statistically significant effect on environmental price premium, but rather amenity values are constant in percentage terms with respect to short term economic conditions. This study also shows that environmental amenity values stay constant over a continuous time horizon, which shows amenity value is constant in percentage terms across economic condition fluctuations and over time. Housing market is a leading engine of the U.S. economy.[20] Using hedonic pricing model to analyze environmental amenity value can show the impact of economic cycles on communities' willingness to pay to preserve the environment. Studies such as

[20] www.useconomy.about.com

this can guide policymakers to focus on data over a continuum rather than being misled by data that only reflects snapshots in time.

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TABLE 1 | *Environmental Amenity Variables of Interest*

Variable	*Description*	*Estimate*	*Std_Error*	*t_value*	*Pr(>|t|)*	
goodWQ	chlorophyll less than 7.0 ppm	-0.0374	0.0279	-1.342	0.1797	
lakefront	property within 100 meter from lake	-0.0073	0.0274	-0.268	0.7886	
days	number of days	0.0194	0.0052	3.696	0.000219	***
RICCI	RI Current Condition Index	-0.0051	0.0201	-0.256	0.7982	
Interaction Variable						
lakefront	**goodWQ*	0.0311	0.0347	0.897	0.37	
	**days (x1000)*	0.0590	0.3341	0.177	0.8598	
	**RICCI*	0.0503	0.0358	1.404	0.1603	
goodWQ	**days (x1000)*	0.0448	0.1301	0.344	0.7306	
	**RICCI (x1000)*	-0.0756	13.75	-0.005	0.9956	
lakefront	**goodWQ **day(x1000)*	0.6621	0.4246	1.56	0.1189	
	**goodWQ **RICCI*	-0.0331	0.0451	-0.734	0.4629	
Observations		32,914				
R squared		0.6083				
Fixed Effects:		Year-Quarter, Census Tract and Lake ID				

Level of Significance codes: 0 ‘***’ 0.001’ 0.01 ‘*’0.05 ‘.’0.1 ‘ ’1

Complete regression variables are summarize in TABLE A in Appendix

TABLE 2 | *Demographic Variables of Lakefront vs. Non-Lakefront Properties*

Variable	*Description*	*Lakefront*		*Non-Lakefront*	
		Mean	*Standard Deviation*	*Mean*	*Standard Deviation*
medhinc	median household income	$67,970.00	$11,211.00	$62,833.00	$12,494.00
f2smedhinc	factor to the state median income	1.21	0.20	1.12	0.22
popD	population density	3037.72	3066.38	58744.40	5509.18
pop18plusD	population density of 18 yrs & older	2433.12	2393.94	4484.70	4009.62
pNHWhite	percent non-Hispanic White population	94.27	10.44	87.24	19.26
p65plus	percent 65 yr. & older population	15.05	9.80	14.17	9.46
popHH	total household population	156.63	189.76	123.10	150.74
aveHH	average household size	2.50	0.42	2.65	0.46
pFamHH	percent family household	69.59	14.17	72.11	14.09
pVacSeason	percent seasonal vacancy	37.82	37.41	15.18	29.05
pOOHU	percent owner occupied housing units	83.65	15.83	80.73	19.81
totHH	total housing unit	62.45	73.64	47.64	60.77
pVacant	percent vacancy	9.78	10.90	6.04	7.72
observations		3,315		29,599	

TABLE 3 | *Variables of Interest for Lakefront vs. Non-Lakefront Properties*

Variable	***Description***	***Lakefront Properties***		***Non-Lakefront Properties***	
		Mean	***Standard Deviation***	***Mean***	***Standard Deviation***
adjprice	sale price adjusted to 2010 RI HPI	$245,709.00	$159,555.00	$232,489.00	$224,443.00
livingarea	living area in square ft.	1414.07	619.79	1458.71	571.52
totrooms	no. of total rooms	5.59	1.48	6.14	1.40
bedrooms	no. of bedrooms	2.67	0.79	2.97	0.73
bathrooms	no. of bathrooms	1.49	0.64	1.43	0.61
numfireplace	no. of fireplace	0.36	0.56	0.27	0.52
age	age of the house	54.39	27.39	58.05	31.23
extcon	exterior condition of the house	5.54	1.06	5.39	0.90
lforest	log of surface area of forest land use	11.84	0.73	11.27	0.78
lake_mi	distance to the nearest lake from the property with sale transaction	0.03	0.02	0.28	0.12
chlr	chlorophyll concentration in ppm.	10.60	13.79	19.00	19.90
year_quarter	Year quarters are numbered from 1988 first quarter as 1 to the first quarter of 2012 as 96	52.24	24.97	51.49	25.07
observations		3,315		29,599	

TABLE 4| *Robustness Check with Different Discrete Time Interval Dummies*

5 intervals (5years)		**F0: 1988-1992**	**F1: 1993-1997**	**F2:1998 -2002**	**F3: 2003-2007**	**F4: 2008-2012**
		base	-0.4381 (0.11)***	-0.0561 (0.101)	-0.1661 (0.0973).	-0.9494 (0.1143)***
Interaction with	**lakefront**	-0.0229	0.0623	0.102	0.0352	0.0921
	*goodWQ**	(0.0259)	(0.0336).	(0.0320)**	(0.0317)	(0.0363)*

3 intervals (8years)		**S0:1988-1995**	**S1:1996-2003**	**S2: 2004 -2012**
		base	0.0209 (0.0799)	-0.3876 (0.0815)***
Interaction with	**lakefront**	-0.0035	0.0657	0.0412
	*goodWQ**	(0.0194)	(0.0247)**	(0.0251).

2 intervals (12years)		**H0: 1988-2000**	**H: 2001-2012**
		base	-0.3671 (0.0646)***
Interaction with	**lakefront**	0.0273	0.0171
	*goodWQ**	(0.0151).	(0.0196)

Signif. codes: 0 '***'0.001 '**'0.01 '*' 0.05 '.'0.1 ' ' 1

FIGURE 1A |*Rhode Island Housing Price Index*

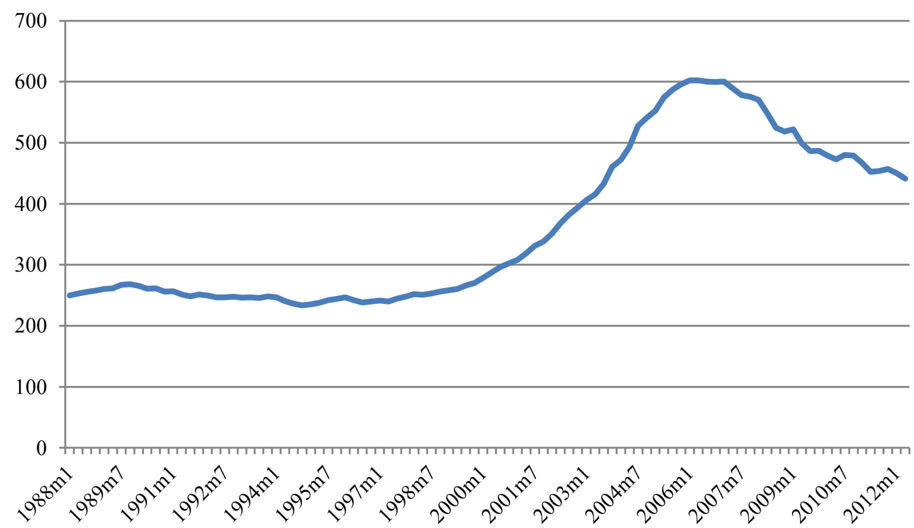


FIGURE 1B |*Rhode Island Housing Market Trend 1988-2012*

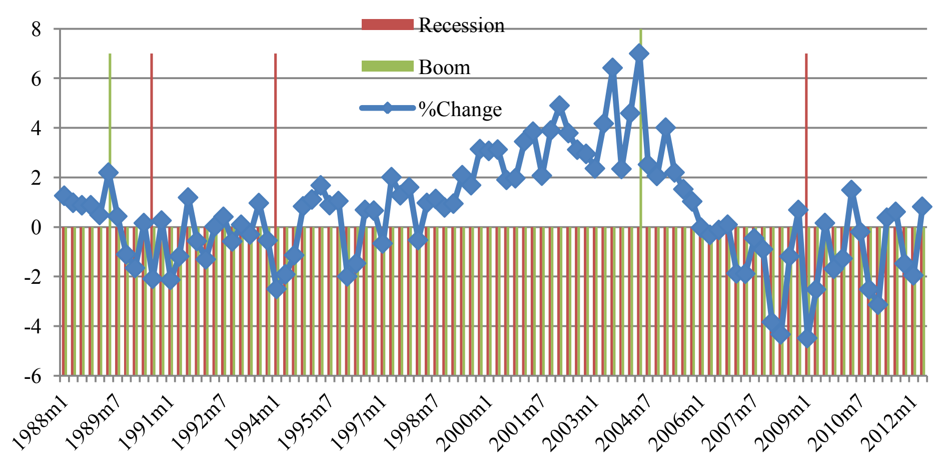


FIGURE 2A |*Historical Annual CCI Values*

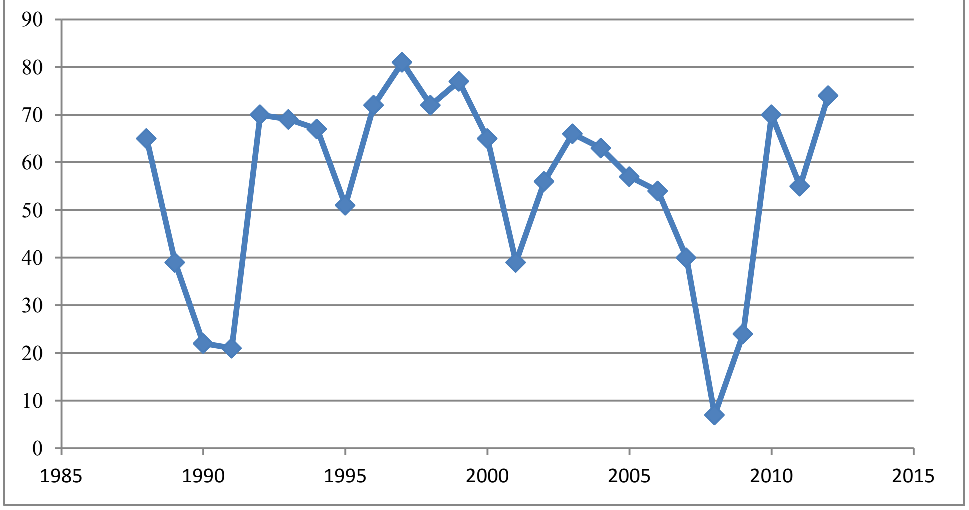
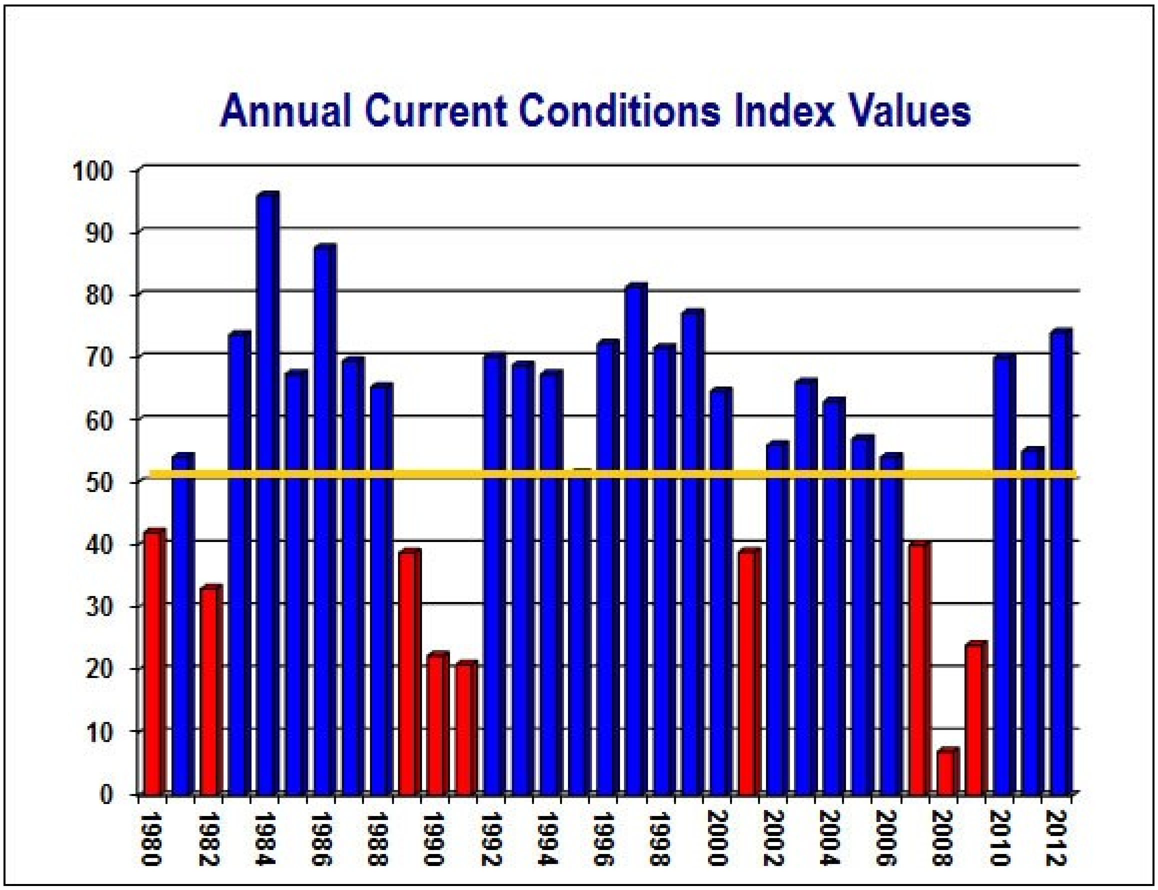


FIGURE 2B | *Annual CCI Values**



*from http://www.llardaro.com/current.htm with the permission from Dr. Lardaro.

FIGURE 3 |*Annual Mean Chlorophyll concentration of URI Watershed Watch monitored RI Lakes,1988-2011*

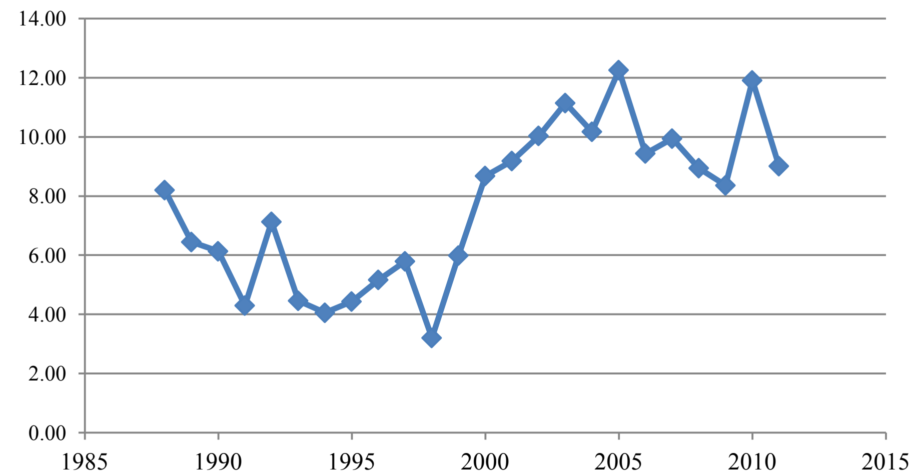


FIGURE 4 | *Demand for Normal, Superior, and Inferior goods with Income Change*

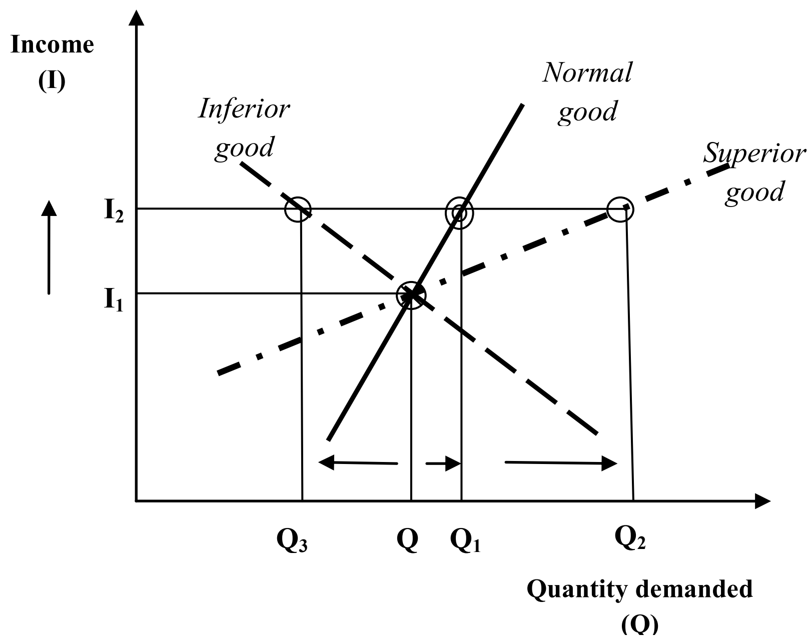


FIGURE 5 | *Environmental Kuznets Curve*

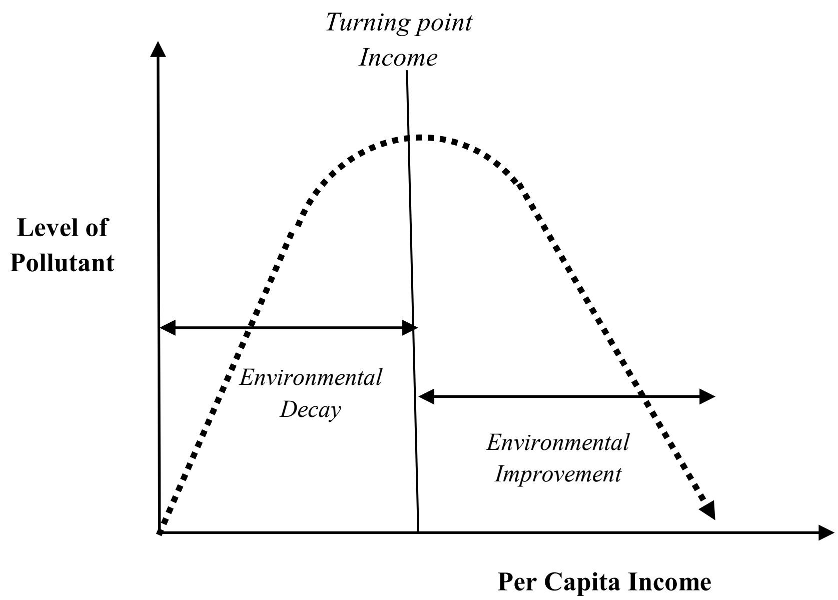


FIGURE 6A | *Demand for Two Goods with Income Constraint*

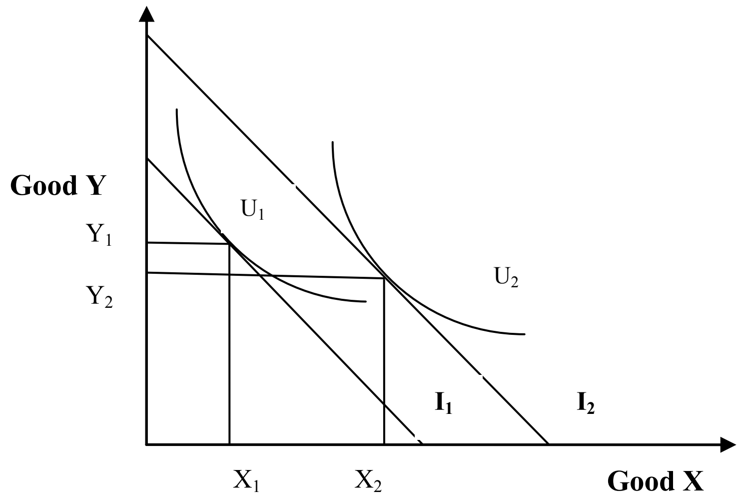


FIGURE 6B | *Engel Curve with Income (I) Changes, Ceteris Paribus*

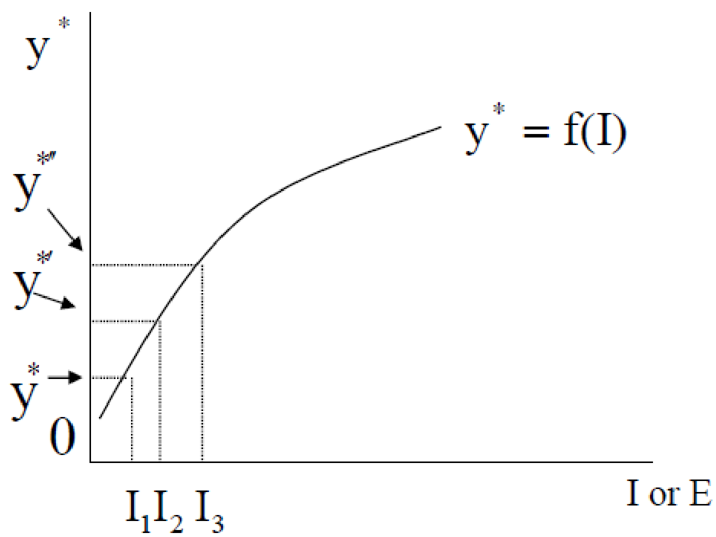
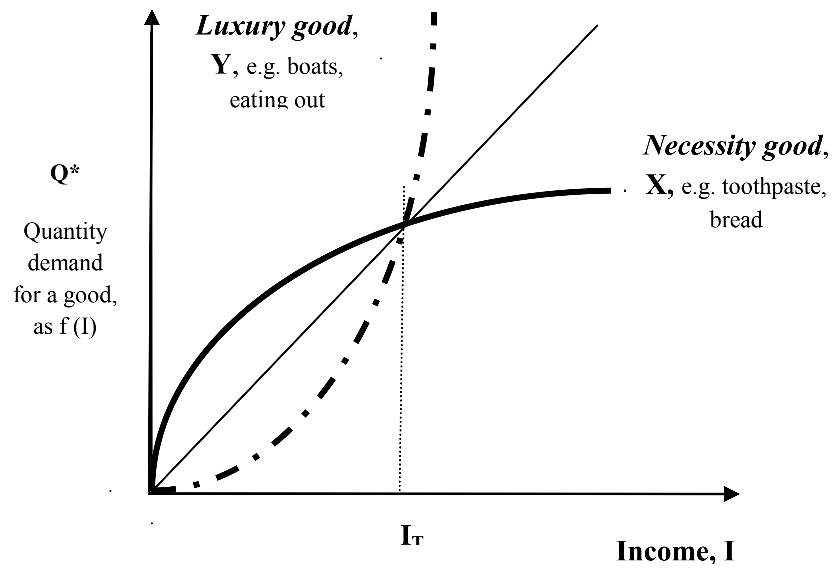


FIGURE 7 | *Luxury Good vs. Necessity Good*



Appendix

TABLE A | *Complete Regression Results for TABLE 1*

Variable	*Description*	*Estimate*	*Std_Error*	*t_value*	*Pr(>|t|)*	
Dependent Variable : Log of Property Sales Price adjusted to RIHPI 2010 3rd quarter						
Variable of Interest						
Intercept		10.43	0.1725	60.496	0.00^	***
goodWQ	chlorophyll less than 7.0 ppm	-0.0374	0.0279	-1.342	0.1797	
lakefront	property within 100 meter from lake	-0.0073	0.0274	-0.268	0.7886	
days	number of days	0.0194	0.0052	3.696	0.000219	***
RICCI	RI Current Condtion Index	-0.0051	0.0201	-0.256	0.7982	
Interaction Term Variables of Interest						
lakefront	**goodWQ*	0.0311	0.0347	0.897	0.37	
	**days (x1000)*	0.0590	0.3341	0.177	0.8598	
	**RICCI*	0.0503	0.0358	1.404	0.1603	
goodWQ	**days (x1000)*	0.0448	0.1301	0.344	0.7306	
	**RICCI (x1000)*	-0.0756	13.75	-0.005	0.9956	
lakefront	**goodWQ **day(x1000)*	0.6621	0.4246	1.56	0.1189	
	**goodWQ **RICCI*	-0.0331	0.0451	-0.734	0.4629	
House Characteristic Variables						
totrooms	no. of total rooms	0.02019	0.001753	11.516	0.00	***
bathrooms	no. of bathrooms	0.04366	0.00304	14.361	0.00	***
numfirepl	no. of fireplace	0.07342	0.003432	21.395	0.00	***
age	age of the house	-0.002091	0.00005483	-38.132	0.00	***
Exterior Condition of House (relative to (extcon 1):poor condition)						
(extcon)2	extr. con. of house: average	0.09685	0.01004	9.644	0.00	***
(extcon)3	extr. con.: above average	0.1952	0.02121	9.204	0.00	***
livingarea	living area in sqaure ft.	0.0002042	0.000004159	49.088	0.00	***
lotacre	lot size in acres	0.01122	0.001052	10.667	0.00	***
Household and Neighborhood Characteristics						
medhinc2	median household income	0.008472	0.001988	4.261	0.0000204	***
popD2	population density	-0.006714	0.0005263	-12.758	0.00	***

pNHWhite2	% non-Hispanic White population	0.133	0.01788	7.437	0.00	***
p65plus2	% 65 yr. & older population	0.1202	0.01842	6.524	0.00	***
aveHH	average household size	0.0127	0.005715	2.222	0.026304	*
pFamHH2	% family household	0.06398	0.01676	3.817	0.000135	***
pOOHU2	% owner occupied housing units	0.02188	0.01072	2.042	0.041209	*
Observations		32,914				
R squared		0.6083				
Fixed Effects:		Year-Quarter, Census Tract, and Lake ID				

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1; 0.00 indicates number less than 10e-6

MANUSCRIPT – 3

The Impact of Wind Turbines on Rhode Island Residential Property Values

(Intended to publish in

Journal of Real Estate Research)

Susan Shim Gorelick

Environment and Natural Resource Economics, University of Rhode Island,

Kingston, RI, USA

ABSTRACT

This study employs the hedonic price model to examine the impact of Rhode Island wind turbines on property sales price in terms of view and proximity. Since RI communities are heterogeneous, residential demographics and regional fixed effects are used to properly identify the impact of wind turbines on property prices. Community attitudinal effect is examined with announcement and construction timelines of wind turbine development. The difference-in-differences estimations with fixed effects show that the view of wind turbines has no significant impact. The interaction term between proximity and the time periods of wind turbine development shows that both post announcement and post construction have statistically significant positive impact on property sales price with a smaller positive post construction effect than post announcement. This result indicates that wind turbines are sited in locations that have lower property values. The findings from this study show that demographic attributes are important when considering wind energy site selection and lay the groundwork for further study as more post construction observations become available with the maturity of wind energy development.

INTRODUCTION

Wind energy is among the fastest growing renewable energy sources (Devine-Wright, 2005; Global Wind Energy Council, 2008) and is expected to grow at an accelerating pace to meet the Unite State's goal of 20% electricity from wind energy by 2030 (U.S. DOE, 2008). This momentum encompasses approximately 3,000 additional wind facilities to be sited, along with the expectation that they will expand from the conventional wind farms in rural areas to more urban residential areas (Cellik et al. 2007; Gao Y.F. et al. 2012)). A 2008 MIT survey on energy shows that nearly 75% of the public in the U.S. either support or strongly support the siting of wind energy facility within 25 miles of their homes (Ansolabehere and Konisky, 2009). Although this is far greater support than for coal, natural gas, and nuclear facilities[1] (Bidwell, 2013), the high public support rating for wind energy is not without some concerns. These concerns range from endangerment of wildlife (Devine-Wright, 2005; Kuvlesky et al. 2007) to potential detrimental effects on human health (Nina Pierpont, MD, 2008; Colby et al. 2009).

Because the fear of potential adverse effects of wind turbines on nearby property values has been among the most important concerns (e.g., Bond, 2010), the siting of wind turbines has been an extremely contentious issue. The hedonic method is a promising approach for identifying the extent to which housing prices are affected by nearby wind turbines.

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[1] Green house gas (GHS) emission estimate process called 'harmonization' shows that wind energy is similar to other renewable and nuclear energy and much lower than fossil fuel in total life cycle GHS emissions. http://www.nrel.gov/analysis/sustain_lca_wind.html

Appropriate market definition and scale are prerequisite for effective hedonic analysis; housing market is no exception (Dorsey et al, 2010). Incorporating residential demographics into hedonic model is necessary because of Rhode Island's high housing density and town heterogeneity in a single housing market. Although disproportionate externality for properties in close proximity to wind turbines is not addressed, this study's use of residential demographics helps understand community attitude towards wind turbines.

The potential negative impact on local property owners has been classified into three stigma categories: scenic vista, nuisance, and area (Hoen et al., 2009, 2011). Scenic vista stigma results from adverse effect and/or obstruction of views from a property. For example, a wind turbine might adversely affect an otherwise pristine ocean view. Since a scenic view is considered a premium attribute for property value, scenic vista stigma has been commonly examined in hedonic studies of wind energy (e.g., Dent, P. and S. Sims, 2007; Sims et al. 2008; Hoen et al. 2009, 2011). Nuisance stigma includes noise, infrasonic vibration, and shadow flicker. Nuisance stigma primarily impacts homeowners within a small proximity as they bear disproportioned externality (Pierpont, 2008; Colby et al. 2009; Heintzelman and Tuttle, 2011).

Area stigma includes the perception that the community is an industrial location. This is the most subjective of the three forms of stigma and could be the most far reaching, as this brings the concern from an individual property owner perspective to that of the wider community (Heintzelman and Tuttle, 2011). For this most subjective form of stigma, inclusion of area demographics would enhance understanding of wind turbine effect on community attitude and location impact. This study's combination of residential demographics and RI's unique geographical features helps examine all three stigmas and guide wind energy development.

PREVIOIUS RESEARCH

Parallel to the rapid growth of wind energy development, many studies of wind energy have emerged. Since the potential negative impact by wind energy development on its nearby property values has been a common concern, hedonic method is an appropriate analysis tool to assess the significance of the impact by wind energy development and the role of perception by homeowners at the community level.

The location of and view from a property influence the premium value of a property (Bourassa et al, 2004). Accordingly, proximity and view have been commonly used to examine the three stigmas: area, scenic vista, and nuisance. Most hedonic studies of wind energy have been on rural areas with a limited number of property sales transactions. Many showed non-significance of wind energy facilities, possibly related to the limited number of observations. Some studies compensate this size limitation by using multiple housing markets incorporating several regions or states (Sterzinger et al., 2003). The proximity study by Sterzinger et al. combines different regions to increase the number of observations. Their Renewable Energy Policy Report (REPP, 2003) analyzed about 25,000 property transactions in the U.S. to assess area stigma. Their comparison between within and beyond the 5 mile threshold does not conclude a negative impact on property value within 5 miles. Hoen and Wiser (2011) studied property values within 7 miles of wind turbines at four wind energy projects between 2006 and 2010. Their results were not statistically significant in relation to the effect on property values. An additional study by Hoen et al. (2011) encompassing ten different U.S. states also finds no significant impact by wind farms on property values. A single-region study with a small number of observations and closer proximity on scenic vista stigma by Sims et al. (2008) examines 201 residential sales transactions in Cornwall, UK. They use 0.5 mile proximity to a 16 turbine wind farm and did not find significant impact with respect to the view, but the data suggested that view approached significance more than other comparison variables.

Nuisance stigma such as shadow flicker, sound, and vibration is pertinent to homeowners in close proximity to wind turbines. Both nuisance and scenic vista stigmas were investigated in the study by Dent, P. and S. Sims (2007) with 919 transactions for homes within five miles of two wind facilities in Cornwell, UK. Despite initial evidence that there was an effect, their further investigation reveals other factors that were more significant than the presence of a wind farm. It was not differentiable from their study whether it is due to the small size of the transactions in close proximity or the impact of the effect. Another study that analyzes scenic vista stigma with 280 residential transactions of homes near a wind facility in Madison County, NY finds no evidence that view of turbines significantly affects home sales prices (Hoen et al., 2006).

The development timeline of wind energy is introduced to examine the anticipatory effect on homeowners' perception of wind energy and post construction effect in the studies (Hoen et al. 2009, 2011). These studies render a comprehensive approach by combining spatial and temporal components in the process. Discrete proximity increments and their interaction terms with wind turbine development timeline show that the impact of wind turbines is not statistically significant to nearby property values. They also find that home sales prices within a mile of the turbines more than two years prior to the facilities' announcement and those that sold in later periods (e.g. post announcement or post construction) are statistically indistinguishable (Hoen et al, 2011).

Numerous attitudinal studies on how wind energy development is perceived at the community level have also emerged. Most of these surveys are either simple format or use extensive empirical stated preference method, look at off-shore wind turbines, and show mixed results. Ladenburg et al. (2007) in Denmark use choice experiments to estimate the willingness to pay for visual disamenities related to prospective offshore wind facilities. Their valuation scenario comprises the location of 720 offshore wind turbines in farms at different distance increments from the shore, relative to an 8 km (approximately 5 miles) baseline. They find that the average willingness to pay (WTP) increased proportionally as the wind facility distance from shore increased. In addition, their results reveal that WTP varies significantly depending on the age of respondents and their experience with offshore wind farms. This demonstrates the importance of understanding the demographics of homeowners and stakeholders.

The subjective nature of attitudinal studies makes them helpful when examining wind turbine effect on area stigma. One survey study by Goldman (2006) finds no evidence of area stigma from a survey of local residents conducted after the wind facilities were erected. Yet, another study finds limited evidence of these stigmas (Bond, 2008). The results from her surveys of public attitudes towards the construction of proposed wind farms indicate that although the overall respondents think of wind farms in positive terms with proximity as an important determinant factor, 38% of the respondents would pay 1% - 9% less for their property due to the presence of a nearby wind farm. The large distance between properties to the wind farms in both study areas impose limitation on the significance of the results. Also, the author cautions generalization of these results since resident attitudes can be highly location-specific.

The correlation between how wind energy is perceived at the community level and wind energy development timeline is an important component in understanding its acceptance by communities. Homeowners' attitudes before and after wind energy facility construction are examined in two separate studies in the U.K. by Khatri (2004) and Warren et al. (2005). The findings from both studies suggest that when wind farm development is first announced, property prices may decline, but prices are likely to recover after the wind farms are in operation and communities learn more about the benefits of wind development. Similarly, Wolsink (1989) and Palmer (1997) examine public attitude in relation to wind energy development timeline. They find that local residents' attitude towards wind power is at its lowest during the planning stage, but nearly returns to the pre-announcement levels after the facilities are built. Studies by

Devine-Wright (2004) and Thayer and Freeman (1987) show mixed results, but emphasize the importance of understanding local community perceptions.

Many studies reveal that wind energy facilities are *predicted* to negatively impact property values pre-construction (Khatri, 2004; Firestone, Kempton, and Krueger, 2007; Kielisch, 2009), but negative impact largely dissipates post construction (Sterzinger, Beck, and Kostiuk, 2003; Hoen, 2006; Poletti, 2007). Further study of wind turbine post construction effect is hindered by the fact that wind development is still in its early stage with a relatively small number of property sales transactions. Some studies look for supporting data from research on facilities that are "similar" to wind turbines. Attitudinal studies of high voltage overhead transmission lines (HVOTL) show statistically significant negative impact on the price of properties in close proximity (Bond and Hopkin, 2000; Des Rosiers, 2002). Given the longer timeline of HVOTL facilities, these results can be used to supplement house sales transaction data in relation to wind turbines. HVOTL data may provide supporting information for potential post construction effects of wind turbines.

APPROACH OF THIS STUDY

This study uses an extensive data set focusing on residential communities in close proximity with single high capacity wind turbines. Much of the literature used large-scale wind farms sited primarily in rural areas with relatively sparse property sales transaction observations. Wind turbines in Rhode Island are primarily located near residential areas virtually by necessity because of the state's small size and high population density. This provides the setting for more close proximity property sales transactions. This study analyzes house transaction data with respect to location and demographic specific nature in relation to twelve wind turbines in seven different towns in a single housing market. The single wind turbines in this study vary in size, but are industrial scale with capacity beyond typical residential electricity usage. The study investigates the potential negative impact of wind turbines on nearby property values, with residential demographics as control variables.

This study draws from the approach by Hoen et al. (2006; 2007; 2009; 2011) for the purpose of proximity and view analysis. The studies by Hoen et al. are chosen because of their comprehensive approach to spatial and temporal components. This study's large dataset of house sales transactions in close proximity to wind turbines in a single housing market that provides appropriate scale and definition of housing market within one state complements Hoen et al.'s[2] and other studies in rural areas with sparse transaction observations.

STUDY AREAS

This study includes twelve single wind turbines sited in seven Rhode Island towns as shown in FIGURE 1. Minimum wind turbine energy capacity of 100 kilo-Watts (kW) is chosen for the study: four 100 kW, one 250 kW, one 275 kW, one 660 kW and five 1.5 Mega-Watts (MW). This is based on the assumption that wind turbines less than 100 kW

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[2] I would like to acknowledge and thank Ben Hoen for his helpful insights graciously given through numerous email correspondences. My sincere gratitude also goes to Jason Brown whose expertise in spatial economics was helpful although this manuscript does not include that component.

would have qualitatively smaller, if any, impact. 1.5 MW is currently the highest capacity wind turbine in Rhode Island. The specifications of the wind turbines in this study are tabulated in TABLE 3. They are all single wind turbines, including the three 1.5 MW wind turbines that are in one location in Providence (PR1, PR2 and PR3). FIGURE 5 shows the twelve individual wind turbines with the three in Portsmouth aggregated as PTS.

The towns with existing wind turbines are grouped into six study regions: (1) Providence (PRV) with three 1.5 MW wind turbines (PR1, PR2 and PR3); (2) Warwick (WAR) with two 100 kW wind turbines, one at New England Institute of Technology campus (NET) and the other at Shalom nursing home complex (SHA); (3) North Kingstown (NKS) with one 1.5 MW; (4) Narragansett (NRG) with one 100 kW; (5) Tiverton (TVR) with one 275 kW; (6) Aquidneck Island (AQD) comprised of Portsmouth High School (PHS) with one 1.5 MW, Portsmouth Abbey boarding school campus (PAB) with one 660 kW, Hodge Badger's complex site in Portsmouth (PHB) with one 250 kW and Aquidneck Corporation Park in Middletown (MDT) with one 100 kW wind turbine. Thus, Aquidneck Island area (AQD) encompasses the largest number of wind turbines in Rhode Island with a diverse range of energy capacity. FIGURE 6 depicts these six regions.

The distribution of total and post construction property sales transactions within 5 miles to the nearest wind turbine is summarized by six proximity increments in TABLE 4: less than 0.33 mile, 0.34 to 0.66 mile, 0.67 to 1 mile, 1 to 2 miles, 2 to 3 miles, and 3 to 5 miles. There are 5,235 transactions within one mile, 665 of which are post construction.

TABLE 5 summarizes the timeline based on the development announcement and construction dates. Most were constructed recently which explains why out of the 69,768 total transactions within 5 miles, only 8,371 are post construction. The recent construction dates in TABLE 3 corroborate the brevity of wind development in Rhode Island: six of twelve were constructed in 2012; two in 2011; three in 2009; and one in 2006. The distribution of all transactions within 5 miles to the nearest wind turbine is tabulated in TALBE 6 by both proximity and timeline increments.

Despite being the smallest state, RI features thirty nine unique towns with diverse demographics. The median household income and population density of seven Rhode Island towns with the existing wind turbines in this study are depicted in FIGURE 2 and FIGURE 3 respectively. They show an inverse correlation between the median household income and population density. These and other demographics statistics are further detailed in the TABLE 8 series. TABLE 8A's summary of complete demographics of all observations within 5 miles and TABLE 8B-E's individual wind turbines sorted in three aggregates mirror the same observations in FIGUREs 2 and 3.

The variable "*Factor to State Median HH (Household) income*" is the ratio between the median income of household occupying properties near the respective wind turbine and the state median household income and serves as an income profile proxy. As shown in TABLE 8E, Providence (PRV) with three 1.5 MW wind turbines (PR1, PR2 and PR3) has the lowest median household income, thus lowest factor to the state median household income (0.891); Warwick (WAR) with two wind turbines in separate locations

(NET and SHA), both 100 kW follows with the factor to the state median household income of 1.06; Tiverton (TVR) with 1.16; Narragansett (NRG) and aggregated towns on Aquidneck Island (AQD), each with 1.23; and North Kingstown (NKS) with 1.51. It is important to note that the towns on Aquidneck Island, Portsmouth and Middletown have the range of 1.26 to 1.51 factor to the state median household income as shown in TABLE 8B. *NKS* shown in TABLE 8B and *MDT* shown TABLE 8D both have the highest factor of 1.51 which implies 51% above the state median household income.

Each of the subsequent TABLE's 8B-D has the descriptive statistics of all observations within 5 miles (*All SFH within 5 miles*) in the first column as a comparison reference. Each wind turbine on Aquidneck Island shown in TABLE 8D showed a higher factor individually and in aggregate than the remainder of the observations. Percent non-Hispanic White population and the percent owner occupied housing unit show a proportional correlation with the factor to the state median household income while the population density shows an inverse correlation.

DATASETS

Property Sales Transaction Data

This study uses the extensive RI house sales transaction dataset which comprise 69,768 single family properties that spans from January 1, 2000 to February 28, 2013 within 5 miles of existing wind turbines. The single family properties are extracted from 335,436 transactions of all types of properties, 169,267 of which are residential properties for the selected time series. This portion of time series is chosen because the first wind turbine in Rhode Island at Portsmouth Abbey was erected in 2006. Thus, it covers roughly the same number of years prior to and following construction of wind turbines within the state. This process reduces the number of sales transactions further to 123,424 after eliminating duplicate transactions and properties with sales price less than $40,000.[3] To focus on current housing characteristics and mitigate potential estimation bias if a house was remodeled or a property split into two or more properties, multiple sales transactions within six months for the same property were considered duplicates and dropped.

The final dataset of 69,768 single family homes with sales transactions have fully populated "core" house characteristics data (lot size in acres, number of bathrooms, bedrooms, fireplace, year built and the exterior condition of the house), sales price, sales date, home addresses, latitudes and longitudes, assessed property values, and tax amount. The single family homes comprise 72 percent of total residential transactions as shown in FIGURE 4. The descriptive statistics of house characteristics are summarized in TABLEs 9A and B. House sale prices are adjusted to the second quarter of 2010 Rhode Island Housing Price Index. The exterior condition is categorized in eleven levels from 1 being "unsound" to 11 "excellent", thus the mean value of 5.38 is between categories 5 ("average") and 6 ("average-good"). These are collapsed into three categories for the estimation model shown in the next section: below average, *extcon1*; average, *extcon2*; and above average, *extcon3*. Below average, *extcon1* is used as the reference category. Lot size in acres is used as a categorical variable to control house characteristics.

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[3] This cut-off amount is from other hedonic study literature in which it ranges from 10,000 and 40,000.

There is concern in the literature that not all property transactions are "arm-length" transactions. For example, some properties are sold within a family for a nominal price to satisfy legal requirements for ownership transfer. In these cases, sales price does not reflect true market value. As a consequence, transactions at anomalously low prices are commonly excluded from hedonic analysis. This study excluding observations with sales price less than $40,000, similar to Hoen et al., 2009, 2011; Walsh et al. 2011. Lot size in acres is used as one of the fixed effects. Only single family residential property transactions within 5 miles to the nearest wind turbines are used for the analysis.

Geographical Information System Data

GIS data from Rhode Island Geographic Information System (RIGIS) were used to calculate the distance between each house with a transaction and its closest wind turbine. House locations were geocoded using ArcGIS geocoding tool with RIGIS address locator which is based on Emergency 9-1-1 structures.[4] Buffer proximity rings around the wind turbines combined with house locations were used to identify properties within each proximity increment of thirds of a mile (less than 0.33 mile; 0.34 to 0.66 mile; 0.67 to 1 mile), then 1 to 2, 2 to 3 and 3 to 5 miles. These are used for field data collections for *view* and *% residential* (or *vista*) variables. The geocoded addresses were also used for verifying and correcting the original longitudes and latitudes that came with the dataset. RI 2010 Census information from RIGIS was used to verify Census tracts and blocks. Using ArcMap NEAR tool, each transaction was assigned a unique distance (*dist_mi*) defined as the distance between the home and its nearest wind turbine at the time of sale.

[4] This geocoding locator is available at http://www.euc.uri.edu/rigis/.

The empirical modeling uses actual distance both as a continuous variable (*dist_mi:* distance between each property and its nearest wind turbine in miles.) and a vector of six discrete distance increments.

<u>View and % Residential (or Vista) Variables from Field Data collection</u>

The view of the wind turbine from a particular property is likely to be a significant factor in determining the effect on the property sales transaction prices. Although ArcTool software program has a viewshed tool, field data collection for *view* variable became necessary because the software could not take into account obstruction by nearby trees or neighboring houses (Hoen et al., 2009). Field data comprised of scenic vista in terms of percent residential versus industrial and view of the wind turbines were collected from site visits to each home in the post construction sample.

To ensure the consistency in rating, field data collection was conducted by the same individual on a house-by-house basis during the spring of 2013. Each of the houses within 3 mile proximity was visited. However, only the views from those properties within 0.5 mile proximity were photographed. For the properties outside 0.5 mile proximity, pictures were only taken if there was a view of the wind turbine. The distribution of viewshed by proximity increments is summarized in TABLE 12. Out of 69,768 post construction properties with a sales transaction, 134 have a view of a wind turbine. This constitutes 0.2% of all post construction observations.
These two qualitative measures were based on the categories defined by Hoen et al. (2009, 2011) and modified for RI context of this study. Field data for three additional

variables, "contrast" to supplement the vista and "viewnow" and "viewseason" were collected to differentiate the view by season, particularly tree foliage. However, the model selection process with various combinations of these variables, and the benefit of parsimony with variables for better modeling led only view and vista variables with modifications to be included in the final model. These potential variables are based on the presence of wind turbine view, but since only 0.2% of post construction properties have wind turbine view, this would not be expected to have a substantial impact. Since the degree of industrialization and residential development in neighborhoods showed more discernible correlation, they were incorporated into the *vista* variable as *% residential*.

There are a handful studies that conducted field data collection for view and vista variables to examine scenic vista stigma (Dent and Sims, 2007; Sims et al., 2008; Kielisch, 2009; Hoen et al., 2009, 2011). They were drawn on the landscape-quality rating system developed by Buhyoff et al. (1994) and dubbed as Q-sort to differentiate the degree of sorting between two extreme ends (least vs. most). It categorizes by sorting the photographs of landscapes concerned in odd numbered groups, usually five groups as optimal: two for each extreme end and one for the middle reference point. There was 75-85% consistency categorizing photographs of the field landscapes between those personnel that were and were not involved with field data collection (Torres-Sibillea, 2009).

The view ranking system consists of five categories: (1) *NO VIEW* (2) *MINOR*; (3) *MODERATE*; (4) *SUBSTANTIAL*; and (5) *EXTREME,* similar to Hoen et al (2011). The view variable incorporates both proximity and the percent portion of wind turbine profile. For each view measure, three rubrics were used as reference for maximum consistency: scope of view from a property; the viewer angle of the view of wind turbine; and the degree of contrast between wind turbine and its surrounding objects. Combination of these rubrics is categorized by five levels with *view 0* for no view as base category: *view 1*, minor view with less than 33% of the view scope; *view 2*, moderate view between 34% and 66% of view scope; *view 3*, substantial view between 67 and 80%; and *view 4*, extreme view above 80% of the view scope. The angle of the view is kept between 0 to 90 degrees of viewer's waist height as plane of zero and the viewer at standing position. The view scope ranges from 0 to 180 degrees with viewer's left shoulder to her right shoulder. View categories are described in TABLE 10 and sample photographs are indexed in Appendix A.

A rating for the quality of the scenic vista (*vista*) from each property was also collected because view and vista are expected to be correlated. Properties with a premium vista are more likely to have a wide viewing angle for the view of wind turbines. In order to accommodate the high housing density inherent in a residential setting, the degree of urbanization in terms of percent commerce and municipal utility facilities in the neighborhood is integrated in the ranking. The lower number of vista indicates the higher percent of industrialization or commerce and less residential neighborhood. Five categories defined by Hoen et al. (2009, 2011) are modified to six categories to incorporate the percent residential for this study: *(1) POOR, 10% Residential; (2) BELOW AVERAGE, 25% Residential; (2.5) ALMOST AVERAGE, 40% Residential; (3)*

AVERAGE, 55% Residential; (4) ABOVE AVERAGE, 70% Residential; and (5) PREMIUM, 90% Residential. Vista categories are described in TABLE 11 and sample photographs are indexed in Appendix B. Observations from the *vista (or % residential*) field data collection indicate high correlation between percent residential in neighborhoods and the distance to coastline and high voltage overhead transmission lines (HVOTL). FIGURE 7A shows coastlines and HVOTL near wind turbines. Both coastline (*ocean_mi*) and high voltage overhead transmission lines (*hvotl_mi*) show more consistent correlation than % residential. They are also better quantitative indicators to which neighborhoods are residential or industrial compared to using % residential. The final estimation model includes both as control variables in lieu of including *vista or % residential* as regressors. Since view and vista are correlated, the vista component is accounted for in the view variable in the model (Hoen et al. 2009).

DEVELOPMENT OF HEDONIC MODELS

Hedonic pricing models have been used for characterizing the prices of competitively traded heterogeneous goods in numerous bundles. Hedonic consumer price index for appliances is a good example. Housing market is most commonly used for environmental hedonic models because of common spatial factors, such as location of houses and their surrounding environmental attributes. A given housing unit is best characterized as consisting of a bundle of attributes that in aggregation describe the structure itself, the land upon which it is built, and the relevant spatial characteristics. In addition, the hedonic approach can separate the internal property attributes (baths, bedrooms, square feet, etc.) from the public and private good attributes associated with location. For example, a hedonic pricing model identifies a premium paid for houses located near desirable environmental amenities, according to the premise that price is determined by both internal characteristics of the good being sold such as structural characteristics of a house and external factors such as environmental externalities (Freeman, 2003). In this study, the environmental amenity (proximity to wind turbine) is the non-market good characteristic, while the house is the market good.

A generic hedonic price function for housing market is a linear regression comprised of house sales price in most cases as a dependent variable and an array of numerous explanatory variables, grouped in the three main bundles as below:

House Price = *f* (HC, NC, EA),

where HC is the set of structural house characteristics, NC is neighborhood characteristics and EA is environmental amenities.

House characteristics include number of bedrooms, number of floors, lot size, square footage of living area, number of fireplaces, type of heating system, type of exterior material and general condition among other things. Neighborhood characteristics usually include school quality, crime rate, and municipal services such as fire station, town police, and demographics of neighbors. Environmental amenities include presence or absence of a nearby park, farm, river or stream, open space, and lakes. Environmental disamenities might include air pollution, industrial facilities and landfills.

Hedonic price model is a revealed preference method through which an implicit marginal willingness to pay (MWTP) for a good can be estimated from consumers' selection behavior. It is a bid function within the supply and demand curves of a market in which the value of non-marginal characteristic changes within the context of the hedonic price function and the marginal bid function.[5] Hence, hedonic price model is a reduced form of equation that entails two stages. The first stage is a multivariable linear regression to observe the hedonic price function in a market to measure the slope of a characteristic of interest. The second stage uses this slope as a price of the characteristic to determine the demand for that characteristic. This is an important step because how much price changes when the characteristic of interest changes by one unit is the marginal price of that characteristic, which represents the marginal value, not the incremental value for a finite change in the characteristic. For example, if the marginal value of distance diminishes, using the estimate from the hedonic price function will overstate the WTP for a change in distance for a distance increase, and understate WTP for a distance decrease.

Limitations and Challenges of Hedonic Price Model (HPM)

In order to accurately estimate the effects of the wind turbines on home values with HPM, it is important to address three empirical issues embedded within the hedonic model: omitted variables, endogeneity, and spatial dependence or autocorrelation. There are many factors that co-determine the house price and many of these factors are unobservable, therefore not included for the analyses. If any of the unobserved factors are also correlated with included factors, then the resulting coefficient estimates will be biased due to omitted variables. Endogeneity bias arises when the values of the dependent and one or more independent variables are co-determined. For example, if the wind turbine is developed in the neighborhood of lower value properties and the presence of wind turbine lowers property values, we have endogeneity.

[5] "Because our interest is the value of characteristics to home buyers which is demand side of a market, there is no need to formally model supply side of a market" (Freeman, 2003 p. 356).

Endogeniety, spatial dependence or autocorrelation error and omitted variable bias can be corrected with fixed effects applied at a specified geographic range (Kuminoff, Parmeter, and Pope, 2010) and difference in differences estimation approach. At the most precise level, these fixed effects will occur at parcel level in terms of lot size in acres of the property. This study uses interactive terms along with local fixed effects to address these issues (Greenstone and Gayer, 2009). At a larger scale, fixed effects can be applied at Census block, block group, county or Census tract. This study uses Census Tract and region as spatial fixed effects for the difference-in-difference estimation. Year-quarterly is used as temporal fixed effects.

ESTIMATION OF HEDONIC PRICE FUNTION

<u>Functional Forms and Model Selections</u>

This study uses the logarithmic functional form. It is shown that econometric models for the equilibrium price function perform best when all variables are included in the model but that simpler functional form using a linear, log-linear specification performed best in the presence of omitted variable (Cropper et al., 1988). Logarithmic and semi-logarithmic functional forms which represent the elasticity in percentage render easier interpretations. Linear and squared terms were tested for primary living area, age and lot size because theory and empirical results suggest nonlinearities in valuing these characteristics. However, for the purpose of determining the correlation of proximity to the nearest wind turbine, a linear form for the continuous distance variable is used, following the convention using a log-linear specification for log of sales price.

Following numerous trials with functional transformation, these two models [3] and [4] are selected:

$$ln\ (adj.Price_{ijt}) = \lambda_t + \alpha_j + \beta_0 + \sum\beta_1 X_{ij} + \sum\beta_2 N_{ij} +$$

$$\beta_3\, dist\_mi_{ikt} + \beta_4(dist\_mi_{ikt}) * \sum(timeperiod_{ik}) +$$

$$\sum\beta_5(view_{ikt}) + \sum\beta_6(view_{ikt}) * (dist\_mi_{it}) +$$

$$B_7(ocean\_mi_{ikt}) + \beta_8(hvotl_{ikt}) + \varepsilon_{jt},\ [3]$$

$$ln\ (adj.Price_{ijt}) = \lambda_t + \alpha_j + \beta_0 + \sum\beta_1 X_{ij} + \sum\beta_2 N_{ij} +$$

$$\sum\beta_3\, diswt_{ikt} + \sum \beta_4\ (diswt_{ikt}) * \sum(timeperiod_{ik}) +$$

$$\sum\beta_5(view_{ikt}) + \sum\beta_6(diswt_{ikt}) * \sum(view_{ikt}) +$$

$$B_7(ocean\_mi_{ikt}) + \beta_8(hvotl_{ikt}) + \varepsilon_{jt},\ [4]$$

where $adjP_{ijt}$ represents the price of the property *i* adjusted to the 2nd quarter of 2010 RI housing price index in the fixed effects group *j* at time *t*; λ_t represents the year-quarter fixed effects; α_j denotes the census tract fixed effects; $dist\_mi_{ikt}$ variable is the linear continuous distance in miles between a particular property and its nearest wind turbine. $diswt_{ikt}$ is a vector of six discrete distance increments with a base of 3-5 mile increment. X_{ij} represents the house characteristics variables such as living area, number of total rooms, number of bathrooms, exterior condition of the house, number of bedrooms, lot size and the age of the house, etc. N_{ij} represents neighborhood control variables of socioeconomic demographics of neighbors. The variable $timeperiod_k$ are timeline variables: pre announcement (*PA*), post announcement and preconstruction (*PAPC*), and post construction (*PC*). Pre-announcement (*PA*) is the reference category for time period. $(dist\_mi_{ikt})*(timeperiod_{ik})$ is an interaction term between linear continuous distance in miles and timeline variables. $(dist\_mi_{it})*(view_{ikt})$ is an interaction term between continuous distance and a vector of view in four categories; the same holds for the discrete distance variable, $diswt_{ikt}$. $ocean\_mi_{ikt}$ is a linear continuous distance between a property and its nearest coastline in miles. $hvotl\_mi_{ikt}$ is a linear continuous distance between a property and its nearest high voltage overhead transmission lines. ε_{jt} is fixed effects error term.

DIFFERENCE-IN-DIFFERENCES ESTIMATION

The difference-in-differences (DID, henceforth) estimator has become a popular identification approach in recent literature (e.g., Bertrand et al, 2004), although it has a long history in analysis of variance.[6] It attempts to mimic random assignment of treatment and "comparison" (or control) sample by applying two-way fixed effects model: cross section and time fixed effects on pooled cross section data as of this study. Accordingly, it requires four points of observations with two time periods (before and after the treatment) and two groups (treatment and control). One approach is DID without regression which simply takes the mean value of each group's outcome before and after treatment and then calculate the "DID" of the means. We can get the same result with DID with regression which allows us to add regression controls, if needed. The regression framework that might pick up the effects of other factors that changed around the time of treatment is the attractive feature for its recent application popularity

[6] Econometric Analysis of Cross Section and Panel Data, Second Edition by Jeffrey M. Wooldridge, p.148

because it uses a control group to “difference out” these confounding factors and isolate the treatment effect. Hence, the coefficient on the interaction term of two fixed effects in the regression framework is the treatment effect. And the overall effect is a coefficient sum of interaction term and its respective individual variables. In this study, the coefficient on the interaction term between logarithmic continuous distance between a property and its nearest wind turbine and time periods (pre announcement, post announcement and post construction) is the treatment effect – the impact by wind turbine on the property values of the nearest properties.

RESULTS

<u>Development Anticipatory and Post Construction Impact by Wind Turbines</u>

Wind turbine impact in terms of development timeline is explored with both linear continuous distance in TABLE 1, and six discrete distance increments in TABLE 2. Each table includes one model for all observations, A11(1) and one for observations near only the big wind turbines, Big (2). Big wind turbines in this group have energy capacity 660 kW and greater. Pre announcement is the reference time period in both TABLEs 1 and 2. Accordingly, the coefficient of 0.0317 on the main effect of distance in miles between a property and its nearest wind turbine, *dist_mi* tells us how property values change with distance from the wind turbine before the announcement of wind turbine development. Its positive sign suggests that wind turbines are located in the neighborhood with lower property values, and not that wind turbines have a negative effect on property price. The wind turbines in Providence (PRV) and Warwick (WAR) areas are good examples. Property prices get higher as properties are further away from the waste treatment plants adjacent to PRV wind turbines, and from the major interstate high way adjacent WAR turbines.

The negative sign of interaction term between distance and post announcement-pre construction, *dist_mi*PAPC,* indicates that distance results in a smaller increase in property values after the announcement of wind turbine development (+0.0317 – 0.0072 = 0.0245). The reduced magnitude of *dist_mi* from its main effect, 0.0317 to 0.0245 of interaction term suggests that the announcement at that distance from the wind turbine has less of an adverse effect on property price. The interaction term between distance and post construction, *dist_mi*PC* is negative and larger in absolute value (+ 0.0317-0.0121 = 0.0196). This suggests distance from the wind turbines has an even smaller effect after wind turbine construction: from 0.0317 during pre announcement (*PA*), 0.0245 post announcement (*PAPC*) to 0.0196 after construction (*PC*). Overall, it indicates that wind turbines are sited in locations that have lower property values and that the reduction in value per unit of distance is smaller after announcement and even smaller still after construction. In other words, wind turbines have a positive impact on property price. Big (2), the properties near the big wind turbines show a similar trend with slight magnitude deviations. Its larger absolute value magnitude of interaction between distance and post construction, *dist_mi*PC,* (+0.0317 -0.0261 = 0.0056) results in even smaller effect than all properties, All (1) of 0.0196. This may be due to the location of big wind turbines and the number of observations. PRV has three of five wind turbines included in this group, and the most number of post construction observations.

The analysis with discrete distance increments in TABLE 2 shows the same general result. The negative coefficients on main effect distance variables, pre announcement of wind turbine development, suggest that properties values near wind turbines are lower than properties further from wind turbines. Mostly positive coefficients of distance and time period interactions indicate the wind turbine impact is smaller in absolute value after announcement or construction of wind turbines. The only exceptions are *1-2 miles *PAPC* for Big (2) and *0.67-1 mles*PAPC* for both All (1) and Big (2), which warrant investigation in further study.

As shorelines provide more wind sources for wind turbines, most of the wind turbines in RI are sited near coastline. Also for the efficient transmission of electricity from wind turbines and inter-connector, it is conducive to site wind turbine near electricity facilities. This is consistent with the observation during field data collection that most wind turbines are located near town utility facilities if not HVOTL. Findings from this study are consistent with the report by Lang et al. (2013)[7] that used the same housing dataset and site-visit data. However, the inclusion of both *ocean_mi* and *hvotl_mi* as control variables in this study complements the OER report by providing statistical significance.

To explore the post construction effect further and to supplement the brevity of post construction observations, the observations near high voltage overhead transmission lines (HVOTL) are examined. The same properties within 5 miles to the nearest wind turbines

[7] I would like to thank RI Office of Energy Resources for funding this project and Coastal Institute of University of Rhode Island for the acquisition of housing data.

are used to determine the nearest distance to HVOTL, *hvotl_mi*. The relevant locations of HVOTL to the wind turbines in this study are shown in FIGURE 7A. The time series with mean property sales price in three proximity increments to HVOTL: less than 2 miles, between 2 and 4 miles and greater than 4 miles are shown in FIGURE 7B. All three proximity increments have a similar trend. In fact, the first two proximity increments less than 4 miles are almost identical. The greater than 4 mile proximity increment fluctuates more with the housing market post HVOTL construction trend for all three proximity increments during 13 years. With the assumption that HVOTLs anticipate the similar potential negative effect as wind turbines as observed in other studies, the findings from FIGURE 7B can be inferred that post construction impact of wind turbine would eventually die out. Thus, it would be plausible to conclude that post construction effect, if any existed, will most likely phase out as observed in other studies (Sterzinger, Beck, and Kostiuk, 2003; Khatri, 2004; Warren et al., 2005; Hoen, 2006; Poletti, 2007).

View and Proximity impact by Wind Turbines

TABLEs 7, 7A and 7B with interaction terms between viewshed and distance either in linear continuous (TABLE 7) or discrete increments (7B) show that the view impact by wind turbines is not significant. This may be due to high housing density which is generally associated with more obstructed views of wind turbine. In addition, since there were a small number of post construction observations, this warrants further study when more post construction observations are available.

CONCLUSION

This study shows no evidence that wind turbines have negative effect on property values. If anything, the results show that distance to wind turbines has a statistically significant and positive impact during both pre announcement development and post construction in the magnitude of 2.45% and 1.96% respectively. The distance from the wind turbines has an even smaller effect after wind turbine construction: from 3.17% during pre announcement (*PA*), 2.45% post announcement (*PAPC*) to 1.96% after construction (*PC*). Overall, wind turbines have a positive impact on property price. This finding is consistent in both linear distance and discrete distance analyses. However, anomalous deviation in two discrete bands in discrete distance analysis suggests further investigation. DID estimates with discrete distance bands are based on the premise that property values in the 3-5 mile reference band are not affected by wind turbines. This is a common premise in multi-state wind farm hedonic studies. Since Rhode Island's numerous small towns are heterogeneous, further study using regional multiple comparisons may be considered.

Location-specific homeowner demographics influence the integration of new technology in society. It is important to include homeowners' concerns in decision making for wind energy development (Cowell et al., 2011). This study's use of residential demographics helps assess the impact of wind turbines on property sales prices, and provides a better understanding of community acceptance of wind energy facilities. It became clear through interviews and correspondence with RI town planners, and attendance at multiple stakeholders meetings, that transparency during the wind energy development process affects community acceptance. This is consistent with the discrete distance DID estimates and observation distribution by six different regions shown in TABLEs 4 and 5. Towns with the most transparency have positive or less negative impact by wind turbines on property sales prices during both post announcement and post construction periods; towns with the least transparency have negative or more negative impact and attitude towards wind turbines.

More communities considering wind energy development would mean more diverse development timelines. The heterogeneity of wind energy development in this study broaches the need for differentiable wind energy policies to accommodate wind turbines at different stages of development. For example, zoning ordinance for siting at an initial stage of development may encompass different policy implication from long-term plans for maintaining established wind turbines. A 1.5 MW wind turbine at Portsmouth High School (PHS) was operating for 39 months prior to going out of operation for over a year. Despite the fact that it is out of operation, the community has accepted its presence as reflected in the town's effort to repair it. Interviews with Rhode Island town planners[8] with existing wind turbines show the process of wind energy development at the community level is as important as its outcome. Towns with existing wind turbines are working to accommodate different stages of wind turbine development.

[8] I would like to thank all of the town planners and town clerks for their time answering my many questions, especially, Gary Gump from Portsmouth whose leading effort to revive the Portsmouth High School wind turbine to operating status is commendable.

The findings from this study impart a useful lesson for RI wind energy development. Site selection should address demographic attributes, as well as physical attributes, such as quality of the wind resource and distance to housing units. The results from this study can be expanded upon once more post construction observation data is available. This work is paramount to guide wind energy development policy and may be applicable to other renewable energy sources.

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TABLE 1 | *Wind Turbine Development Impact in Continuous Distance*

Variables		**All (3)**	**Big (4)**
dist_mi		0.0317 (0.0033)***	0.0212 (0.0056)***
Timeperiod (relative to PA: pre announcement)			
PAPC		-0.0028 (0.0113)	-0.0360 (0.0167)*
PC		0.0156 (0.0139)	-0.0024 (0.0265)
Difference-in-Differences			
dist_mi	*PAPC*	-0.0072 (0.0029)*	0.0016 (0.0036)
	PC	-0.0121 (0.0035)***	-0.0261 (0.0066)***
Observations		*67,768*	*34,058*
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*			
R-Squared		*0.6275*	*0.6536*

^Lot size is categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement. Complete regression variables are summarized in TABLE A for All(1) and B for Big (2) in Appendix C

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1

TABLE 2 | *Wind Turbine Development Impact in Discrete Distance Increments*

Variables		**All** (1)	**Big** (2)
Distance (relative to 3-5 miles)			
2-3 miles		-0.02341 (0.0059)***	-0.0203 (0.0094)*
1-2 miles		-0.06713 (0.0081)***	-0.0438 (0.0139)**
0.67-1 miles		-0.0955 (0.0114)***	-0.0672 (0.0196)***
0.34-0.66 miles		-0.1409 (0.0134)***	-0.103 (0.0257)***
0-0.33 miles		-0.1603 (0.02402)***	-0.0587 (0.0455)
Timeperiod (relative to PA: pre announcement)			
PAPC		-0.03355 (0.0086)***	-0.0337 (0.0146)*
PC		-0.03238 (0.0115)**	-0.1076 (0.0250)***
Difference-in-Differences			
2-3 miles	*PAPC*	0.0190 (0.0087)*	0.0231 (0.0106)*
	PC	0.0080 (0.0100)	0.0785 (0.0188)***
1-2 miles	*PAPC*	0.01425 (0.0103)	-0.0061 (0.0125)
	PC	0.0299 (0.0116)**	0.0375 (0.0226).
0.67-1 miles	*PAPC*	-0.01012 (0.0185)	-0.0782 (0.0254)**
	PC	0.0811 (0.0202)***	0.0681 (0.0394).
0.34-0.66 miles	*PAPC*	0.08257 (0.0226)***	0.0477 (0.0311)
	PC	0.0675 (0.0284)*	0.1037 (0.0480)*
0-0.33 miles	*PAPC*	0.0620 (0.0494)	0.0058 (0.0675)
	PC	-0.0356	-0.0745

		(0.0843)	(0.1092)
Observations		*67,768*	*34,058*
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*			
R-Squared		*0.6279*	*0.654*
^Lot size is categorical variable to control house characteristics. ^Lot size is categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement. Complete regression variables are summarized in TABLE in Appendix			

Level of Significance codes: 0 ‘***’ 0.001’ 0.01 ‘*’0.05 ‘.’0.1 ‘ ’1

TABLE 3 | *Specifications of RI Wind Turbines*

Code	Location	System Size	Height (ft)	Blade Diameter (ft)	Announcement Date	Construction Date	Total Transactions
MDT	**Middletown** Aquidneck Corporate Park	100 kW	157	69	13-Apr-09	9-Oct-09	80237
NET	**Warwick** New England Tech	100 kW	157	69	9-Oct-08	6-Aug-09	79987
NKS	**North Kingstown** Green	1.5 MW	424	285	15-Sep-09	18-Oct-12	81980
NRG	**Narraganset t** Fishermen's Memorial	100 kW	157	68	7-Jul-09	19-Sep-11	81031
PAB	**Portsmouth** Abby	660 kW	240	123	15-Dec-04	27-Mar-06	77502
PHB	**Portsmouth** Hodges Badge	250 kW	197	88	14-May-09	4-Jan-12	81144
PHS*	**Portsmouth** High School	1.5 MW	336	252	15-Apr-06	1-Mar-09	79283
PVD	**Providence** NBC x3	1.5 MW	360	270	26-Sep-07	23-Jan-12	80912
SHA	**Warwick** Shalom Housing	100 kW	157	69	6-Aug-09	2-Feb-11	80833
TVR	**Tiverton** Sandywoods Farm	275 kW	180	100	18-Jul-06	23-Mar-12	80187

* This wind turbine at Portsmouth High School has been out of operation since July 18th, 2012 due to its gear failure after 39 month-operation.

TABLE 4 | *Property Sales Transaction Distribution by Region and Proximity Increment*

REG	***Description & Location***	***Observations***	***< 0.33 mile***	***0.33 to 0.66***	***0.66 to 1***	***1 to 2***	***2 to 3***	***3 to 5***	***TOTAL***
1	*PR1, PR2, PR3*	Post Construction	8	22	48	248	482	934	1,742
PRV	*Providence*	All	94	374	674	4,247	6,790	13,947	26,126
2	*NET, SHA*	Post Construction	6	31	89	707	1,563	2,170	4,566
WAR	*Warwick*	All	61	315	667	3,771	8,098	12,341	25,253
3	*NKS*	Post Construction	1	0	2	16	30	67	116
NKS	*North Kingstown*	All	6	65	184	703	1,555	3,070	5,583
4	*NRG*	Post Construction	8	21	33	50	41	165	318
NRG	*Narragansett*	All	77	221	267	443	387	1,673	3,068
5	*PHS, PAB, PHB, MDT*	Post Construction	26	145	217	518	298	368	1,572
AQD	*Aquidneck Island*	All	136	739	1,152	2,740	1,810	1,540	8,117
6	*TVR*	Post Construction	1	6	1	6	10	33	57
TVR	*Tiverton*	All	5	89	109	236	274	908	1,621
TOTAL		Post Construction	50	225	390	1,545	2,424	3,737	8,371
		All	379	1,803	3,053	12,140	18,914	33,479	69,768

TABLE 5 | *Sales Transaction Distribution by Development Time period*

REG	***Region***	***Pre Announcement***	***Post Announcement***	***Post Construction***	***TOTAL***
1 PRV	*Providence*	17,105	7,279	1,742	26,126
2 WAR	*Warwick*	18,855	1,832	4,566	25,253
3 NKS	*North Kingstown*	4,449	1,018	116	5,583
4 NRG	*Narragansett*	2,338	412	318	3,068
5 AQD	*Aquidneck Island*	5,700	845	1,572	8,117
6 TVR	*Tiverton*	969	595	57	1,621
TOTAL		49,416	11,981	8,371	69,768

TABLE 6 | *Single Family Home Sales Transactions by Proximity and by Timeline*

Distance Interval (miles)	*Pre Announcement*	*Post Announcement*	*Post Construction*	**TOTAL**
0 to 0.33	267	62	50	379
0.34 to 0.66	1,253	325	225	1,803
0.67 to 1	2,193	470	390	3,053
1 to 2	8,661	1,934	1,545	12,140
2 to 3	13,432	3,058	2,424	18,914
3 to 5	23,610	6,132	3,737	33,479
TOTAL	49,416	11,981	8,371	69,768

TABLE 7 | *View Impact of Wind Turbines in Continuous distance*

Variables		**All**	**Big**
relative to "no" view		(1)	(2)
minor		-0.3012 (0.3483)	-3.463 (86.72)
moderate		-0.0938 (0.3093)	- -
high		0.0764 (0.1891)	-0.1095 (0.3642)
extreme		0.0088 (0.2894)	0.1232 (0.3344)
dist_mi		0.0317 (0.0033)***	0.0212 (0.0056)***
Interaction Terms			
dist_mi	*minor*	0.3522 (0.4335)	3.044 (75.87)
	moderate	0.2942 (0.3503)	- -
	high	-0.4058 (0.3385)	-0.2582 (0.4335)
	extreme	-0.1437 (0.9113)	-0.6023 (1.001)
Observations		*67,768*	*34,058*
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*			
R-Squared		*0.6275*	*0.6536*

^Lot size in acres is a categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement. Complete regression variables are summarized in TABLE A for All (1) and B for Big(2) in Appendix C.

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1

TABLE 7A | *View Impact by Wind Turbines in Six Discrete Distance Increments(1/2)*

Variables	**All**	**Big**
relative to "no" view	(1)	(2)
minor	-0.09717 (0.1982)	0.0044 (0.244)
moderate	-0.0859 (0.3971)	NA
high	0.0867 (0.1742)	0.0863 (0.3688)
extreme	0.0149 (0.1163)	-0.0235 (0.1601)
Distance (relative to 3-5 miles)		
2-3 miles	-0.02341 (0.0059)***	-0.0203 (0.0094)*
1-2 miles	-0.06713 (0.0081)***	-0.0438 (0.0139)**
0.67-1 miles	-0.0955 (0.0114)***	-0.0672 (0.0196)***
0.34-0.66 miles	-0.1409 (0.0134)***	-0.103 (0.0257)***
0-0.33 miles	-0.1603 (0.02402)***	-0.0587 (0.0455)
Observations	*67,768*	*34,058*
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*		
R-Squared	*0.6279*	*0.654*

^Lot size in acres is a categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement. Complete regression variables are summarized in TABLE C for All (1) and TABLE D for Big (2) in Appendix.

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1

TABLE 7B | *View Impact by Wind Turbines in Six Discrete Distance Increments(2/2)*

Variables		**All**	**Big**
Interaction Terms		(1)	(2)
Distance (relative to 3-5 miles)			
extreme	*2-3 miles*	NA	NA
	1-2 miles	NA	NA
	0.67-1 miles	0.0713 (0.361)	0.1645 (0.3739)
	0.34-0.66 miles	-0.021 (0.1926)	-0.1091 (0.2349)
	0-0.33 miles	NA	NA
high	*2-3 miles*	NA	NA
	1-2 miles	-0.4918 (0.3839)	-0.4804 (0.5042)
	0.67-1 miles	NA	NA
	0.34-0.66 miles	-0.2237 (0.2634)	-0.5915 (0.5047)
	0-0.33 miles	NA	NA
moderate	*2-3 miles*	NA	NA
	1-2 miles	0.4393 (0.4656)	NA
	0.67-1 miles	0.1529 (0.5242)	NA
	0.34-0.66 miles	0.2041 (0.3664)	NA
	0-0.33 miles	NA	NA
minor	*2-3 miles*	NA	NA

	1-2 miles	0.1567 (0.313)	NA
	0.67-1 miles	NA	NA
	0.34-0.66 miles	NA	NA
	0-0.33 miles	NA	NA
Observations		*67,768*	*34,058*
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*			
R-Squared		*0.6279*	*0.654*

^Lot size in acres is a categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement. Complete regression variables are summarized in TABLE in Appendix.

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1

TABLE 8 A | *Demographic Statistics of Single Family Homes within 5 miles*

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Median Household Income	69768	$59,572	14,759	38,922	102,550
Factor to State Median Household Income	69768	1.06	0.26	0.7	1.83
Population Density	69768	6529	5802	0	82376
Population of 18 & older	69768	5034	4270	0	81723
% Non-Hispanic White	69677	85.9	20.6	0	100
% 65 years and older	69680	14.65	9.92	0	100
Average Household size	69768	2.57	0.5	0	7
% Family Household	69677	68.58	16.04	0	100
% Married with Children under 18	69592	30.19	15.27	0	100
% Owner Occupied Housing Unit	69677	76.33	22.3	0	100
% Vacancy	69696	7.94	9.86	0	100
% Seasonal Vacancy	51087	20.82	32.87	0	100

TABLE 8B | *Demographic Statistics of Single Family Homes near 1.5 MW Wind Turbine*

Variable	All SFH within 5 miles	PR1	PR2	PR3	NKS
Median Household Income	$59,572.45 ($14,758.6)	$ 56,717.79 ($ 12,249.34)	$ 59,609.79 ($ 20,082.99)	$ 41,406.00 ($ 5,768.94)	$ 84,608.93 ($ 10,041.29)
Factor to State Median Household income	1.06 (0.26)	1.0115 (0.217)	1.063 (0.359)	0.743 (0.101)	1.51 (0.18)
Population Density	6529 (5802)	9821 (5708)	6155 (3328)	12990 (7234)	1616 (1661)
Population of 18 & older	5034 (4270)	7484 (4075)	4858 (2655)	9666 (5057)	1228 (1289)
% Non-Hispanic White	85.9 20.6	75.42 (24.71)	90.62 (10.31)	62.31 (29.46)	95.43 (4.93)
% 65 years and older	14.65 (9.92)	12.60 (8.64)	16.50 (9.27)	11.91 (9.25)	12.89 (8.84)
Average Household size	2.57 (0.5)	2.63 (0.51)	2.52 (0.39)	2.70 (0.60)	2.76 (0.48)
% Family Household	68.58 (16.04)	67.36 (14.13)	70.37 (14.15)	65.78 (16.16)	78.85 (14.58)
% Married with Children under 18	30.19 (15.27)	29.04 (14.35)	30.93 (15.65)	29.35 (14.29)	38.66 (16.73)
% Owner Occupied Housing Unit	76.33 (22.3)	73.46 (20.77)	80.91 (19.51)	60.88 (24.78)	88.60 (14.14)
% Vacancy	7.97 (9.86)	7.10 (7.60)	4.88 (5.45)	9.04 (8.36)	5.56 (6.62)
% Seasonal Vacancy	20.82 (32.87)	8.49 (22.84)	12.08 (25.74)	5.48 (17.44)	25.91 (32.20)
Observations	69,768	7,839	5,488	12,799	5583

TABLE 8C | *Demographic Statistics of Single Family Homes near Small Wind Turbine*

Variable	***All SFH within 5 miles***	***NET (100 kW)***	***SHA (100 kW)***	***NRG (100 kW)***	***TVR (275 kW)***
Median Household Income	$59,572.45	$ 59,415.04	$ 59,889.25	$ 69,319.81	$ 64,767.40
	($14,758.6)	($ 875.59)	($ 10,164.90)	($ 5,053.56)	($ 5,609.33)
Factor to State Median Household Income	1.06	1.06	1.068	1.234	1.16
	(0.26)	(0.02)	(0.184)	(0.09)	(0.10)
Population Density	6529	5363	3987	2253	2213
	(5802)	(2608)	(2872)	(1798)	(2118)
Population of 18 & older	5034	4239	3116	1903	1776
	(4270)	(2030)	(2203)	(1558)	(1668)
% Non-Hispanic White	85.9	92.79	94.71	95.42	97.51
	20.6	(7.55)	(5.80)	(6.24)	(3.39)
% 65 years and older	14.65	15.46	14.60	18.44	17.72
	(9.92)	(9.66)	(9.22)	(12.71)	(10.21)
Average Household size	2.57	2.52	2.59	2.40	2.48
	(0.5)	(0.42)	(0.45)	(0.49)	(0.38)
% Family Household	68.58	68.90	72.09	58.05	72.95
	(16.04)	(14.06)	(15.18)	(18.47)	(10.49)
% Married with Children under 18	30.19	28.74	32.15	23.55	28.83
	(15.27)	(14.39)	(15.17)	(16.93)	(12.68)
% Owner Occupied Housing Unit	76.33	83.32	83.74	69.27	85.18
	(22.3)	(17.84)	(20.13)	(21.66)	(12.90)
% Vacancy	7.97	5.48	5.16	23.96	6.60
	(9.86)	(6.51)	(6.42)	(20.30)	(6.18)
% Seasonal Vacancy	20.82	14.02	16.79	70.41	23.84
	(32.87)	(28.21)	(28.12)	(34.23)	(38.76)
Observations	69,768	13,346	11,907	3,068	1,621

TABLE 8D | *Demographic Statistics of Single Family Homes near Aquidneck Island Wind Turbines*

Variable	*All SFH within 5 miles*	*PHS(1.5 MW)*	*PAB(660kW)*	*PHB (250 kW)*	*MDT (100 kW)*
Median Household Income	$59,572.45	$ 70,642.03	$ 76,500.00	$ 76,101.95	$ 84,608.93
	($14,758.6)	($ 6120.99)	($ 0)	($ 6,953.48)	($ 10,041.29)
Factor to State Median Household Income	1.06	1.26	1.37	1.36	1.51
	(0.26)	(0.02)	(0)	(0.13)	(0.18)
Population Density	6529	4074	1852	1775	1616
	(5802)	(3583)	(958)	(1527)	(1661)
Population of 18 & older	5034	3274	1328	1296	1228
	(4270)	(2847)	(604)	(1103)	(1289)
% Non-Hispanic White	85.9	96.41	95.68	93.59	95.43
	20.6	(5.94)	(5.15)	(9.65)	(4.93)
% 65 years and older	14.65	18.55	17.96	15.34	12.89
	(9.92)	(11.87)	(13.01)	(9.55)	(8.84)
Average Household size	2.57	2.37	2.74	2.66	2.76
	(0.5)	(0.39)	(0.54)	(0.44)	(0.48)
% Family Household	68.58	66.26	78.98	78.00	78.85
	(16.04)	(15.32)	(18.78)	(11.77)	(14.58)
% Married with Children under 18	30.19	27.13	37.21	36.45	38.66
	(15.27)	(14.02)	(14.67)	(14.69)	(16.73)
% Owner Occupied Housing Unit	76.33	72.87	81.27	83.61	88.60
	(22.3)	(19.48)	(21.49)	(14.99)	(14.14)
% Vacancy	7.97	11.73	6.37	8.50	5.56
	(9.86)	(11.87)	(5.93)	(12.58)	(6.62)
% Seasonal Vacancy	20.82	39.65	38.11	42.29	25.91
	(32.87)	(36.66)	(40.62)	(37.37)	(32.20)
Observations	69,768	13,346	265	1,359	1,621

TABLE 8E | *Demographic Statistics of Consolidated WT Groups*

Variable	*All SFH within 5 miles*	*Providence (PR1, PR2 & PR3)*	*Warwick (NET & SHA)*	*Aquidneck (PHS, PAB, PHB & MDT)*
Median Household Income	$59,572.45 ($14,758.60)	$ 49824.11 ($14667.08)	$ 59,638.63 ($ 7,012.69)	$ 68,801.18 ($ 8,833.77)
Factor to State MHInc	1.06 (0.26)	0.891 (0.260)	1.06 (0.127)	1.23 (0.158)
Population Density	6529 (5802)	10604 (6698)	4714 (2821)	4917 (4756)
Population of 18 & older	5034 (4270)	8002 (4743)	3709 (2186)	4052 (4031)
% Non-Hispanic White	85.9 20.6	72.19 (27.44)	93.70 (6.84)	93.33 (8.75)
% 65 years and older	14.65 (9.92)	13.08 (9.25)	15.06 (9.47)	17.64 (11.39)
Average Household size	2.57 (0.5)	2.64 (0.54)	2.56 (0.43)	2.34 (0.45)
% Family Household	68.58 (16.04)	67.22 (15.26)	70.40 (14.69)	63.30 (18.17)
% Married with Children under 18	30.19 (15.27)	29.59 (14.62)	30.35 (14.86)	28.54 (15.01)
% Owner Occupied Housing Unit	76.33 (22.3)	68.86 (24.05)	83.52 (18.95)	70.42 (20.86)
% Vacancy	7.97 (9.86)	7.59 (7.77)	5.33 (6.47)	13.05 (12.97)
% Seasonal Vacancy	20.82 (32.87)	7.58 (21.00)	15.38 (28.20)	47.54 (36.50)
%Total Household Population	53.47 (69.61)	38.18 (50.88)	53.37 (71.78)	51.97 (73.61)
Observations	69,768	26,126	25,253	8,117

TABLE 9A | *Summary Statistics of House Characteristics of SFH within 5 miles*

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Price*	69768	$263,720	287,505	31,392	23,000,000
Lot size in acres	69744	0.35	0.98	0.01	110**
Living area in sq.ft.	69149	1541.3	733.7	320	18825
Total number of rooms	69375	6.3	1.6	1	27
Number of bedrooms	69455	3	0.8	1	14
Number of bathrooms	69465	1.5	0.7	1	10
Number of fireplace	69768	0.29	0.53	0	6
age of the house	69476	61.8	34.1	1	338
Condition of House Exterior	68686	5.38	0.94	1	11
Distance to WT in miles	69768	2.92	1.23	0.07	4.99
Distance to HVTL in miles	69768	1.96	2.02	0***	9.96
Year-Quarter	69768	24.7	14.7	1	53
View	69768	1.01	0.14	1	5
Vista	69768	2.49	0.11	2	5

*Price is adjusted to 2nd Quarter of 2010 RI Housing Price Index. **There are 11 observations with lot size > 25 acres. ***The zero value for distance to HVTL (or HVOTL) indicates 14 observations with values between 0.118 ft and 18.23 ft, with conversion to miles become negligible to 0. These houses are located right beneath over passing HVOTL. The number of missing values for each variable is reflected in the number of observations.

TABLE 9B | *House Characteristics Statistics of Consolidated WT Groups*

Variable	***All SFH within 5 miles***	***Providence (PR1, PR2 & PR3)***	***Warwick (NET, SHA)***	***Aquidneck (PHS, PAB, PHS, MDT)***
*Price**	$263,720 ($287,505.2)	$216,366.60 ($233,495.80)	$215,957.40 ($120,027.10)	$ 438,887.30 ($ 588,150.20)
Lot size in acres	0.35 (0.98)	0.15 (0.37)	0.29 (0.51)	0.45 (1.02)
Living area in sq.ft.	1541.3 (733.7)	1470.9 (620.4)	1389.7 (570.9)	1809.7 (1017.3)
Total number of rooms	6.3 (1.6)	6.3 (1.5)	6.0 (1.3)	6.6 (1.9)
Number of bedrooms	3 (1)	3.07 (0.86)	2.90 (0.69)	3.12 (0.91)
Number of bathrooms	1.5 (0.7)	1.34 (0.58)	1.38 (0.57)	1.82 (0.90)
Number of fireplace	0.29 (0.53)	0.25 (0.50)	.33 (0.52)	0.10 (0.36)
age of the house	61.8 (34.1)	71.8 (30.4)	57.1 (30.5)	64.8 (44.4)
Condition of House Exterior	5.38 (0.94)	5.35 (0.94)	5.26 (0.74)	5.70 (1.37)
Distance to WT in miles	2.92 (1.23)	3.10 (1.19)	3.00 (1.10)	1.98 (1.27)
Year-Quarter	24.7 (14.7)	25.1 (14.4)	24.82 (14.81)	23.65 (14.96)
View	1.01 (0.14)	.0008 (0.062)	0.0013 (0.063)	0.0354 (0.348)
Vista	2.49 (0.11)	2.49 (0.07)	2.50 (0.10)	2.49 (0.24)
Observations	69,768	26,126	25,253	8,117

TABLE 10 | *Definition of View Categories*

Category	***View***	***Definition***
View 0	No view	No view either by obstruction of other structures or by the absence of wind turbine
View 1	Minor view	The turbine is visible from this property but in very narrow view scope or angle due to many obstructions such as trees or neighboring properties. The distance between the property and the wind turbine is large.
View 2	Moderate view	The turbine is visible, but the view scope ranges from narrow to medium. There might be some obstructions but in much less degree and the distance between the property and the wind turbine is most likely a mile if not more.
View 3	Substantial view	The turbine is substantially visible from the property in a wide scope. A full profile of the turbine may be visible but not overbearing. The distance between the property and turbine is short, within a mile or less.
View 4	Extreme view	The turbine is dramatically visible to the extreme. This rating is reserved for sites that have unmistakably overwhelming presence of the wind turbine. The distance between the turbine and the property is very small.

This table is a modified version of Hoen et al. study (2011) for the RI context of this study.

TABLE 11 | *Definition of Vista and % Residential Categories*

Category	***Vista***	***% Residential***	***Definition***
Vista 1	Poor vista	10%	These vistas virtually have no aesthetic appeal. They are uncomfortable spaces for people, rendering no recreational potential. They are mostly dominated by man-made structures, not considering the wind turbine
Vista 2	Below Average vista	25%	These vistas mainly situated industrialized areas. They are not inviting spaces for people albeit not uncomfortable. Many structures are not maintained for aesthetic appeal. Man-made structures are prevalent, but not dominant. More industrialized than residential neighborhood.
Vista 2.5	Almost Average vista	40%	These vistas are of boundary between urban and suburban. They include interesting views that can be enjoyed often but only in a narrow scope due to medium housing density.
Vista 3	Average vista	55%	These vistas contain the properties relatively well maintained and convey a sense of comfortable community. They have a good balance of suburban appeal with the urban convenience.
Vista 4	Above Average vista	70%	These vistas provide inviting views for people to enjoy in a medium to wide scope due to low housing density. Properties are relatively large and well maintained.
Vista 5	Premium vista	90%	These scenic vistas provide spectacular views to enjoy free or mostly free of man-made structures. The properties are large due to very low housing density, thus only a few neighboring properties. They convey a high potential for recreation.

This table is modified from Hoen et al. study (2011) for the RI context of this study.

TABLE 12 | *Observations with View by Distance to WT*

Distance	*View*					*View Total*
	no view	*minor*	*moderate*	*substantial*	*extreme*	
less than 0.33 mile	334	0	1	14	30	45
0.34 to 0.66 miles	1,737	7	17	16	26	66
0.67 to 1 mile	3,043	0	9	0	1	10
1 to 2 miles	12,127	5	5	3	0	13
2 to 3 miles	18,914	0	0	0	0	0
3 to 5 miles	33,479	0	0	0	0	0
TOTAL	**69,634**	**12**	**32**	**33**	**57**	**134**

Figure 1| Location of RI Wind Turbines

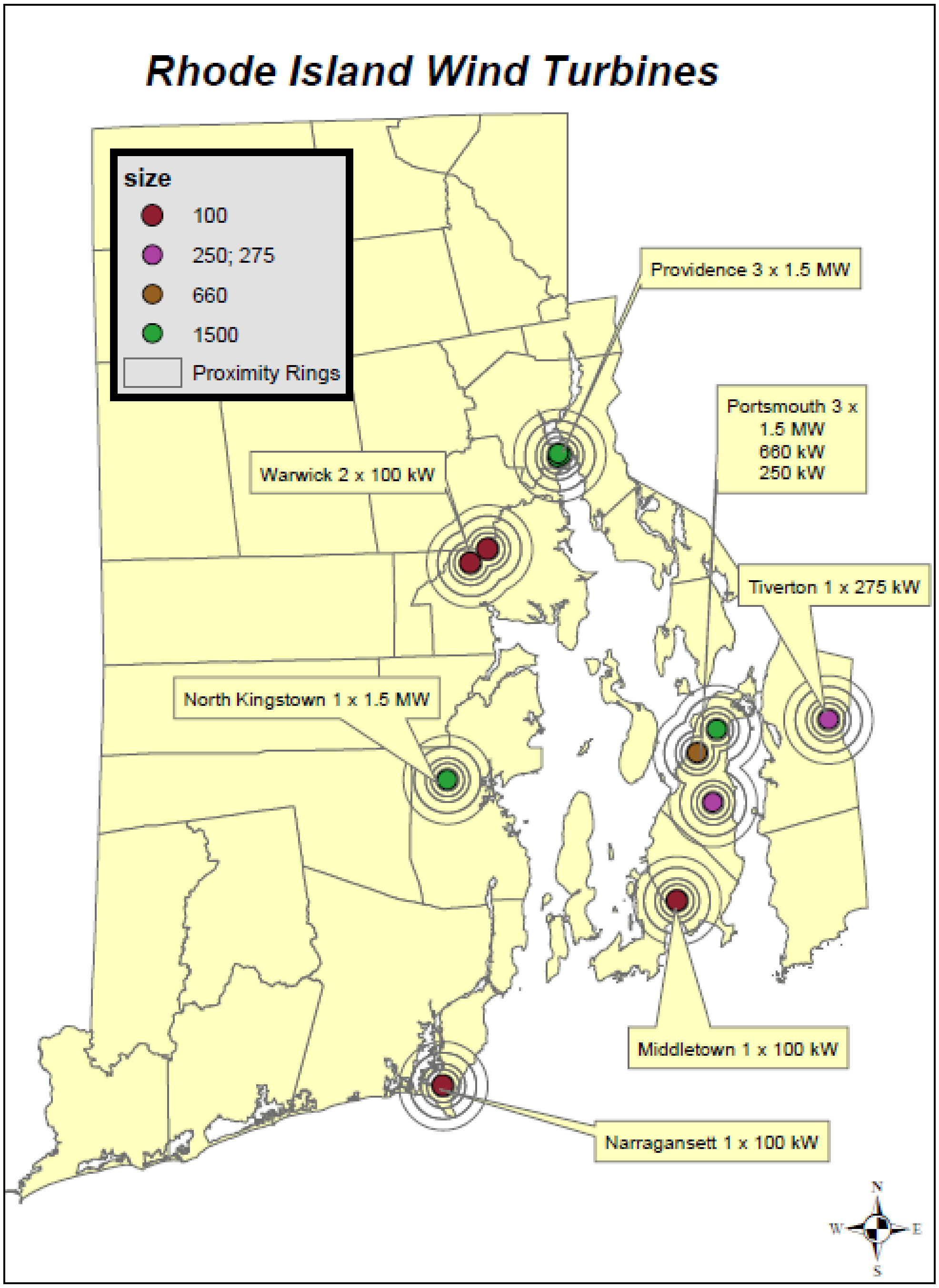


Figure 2| Distribution of RI towns' Median Household Income

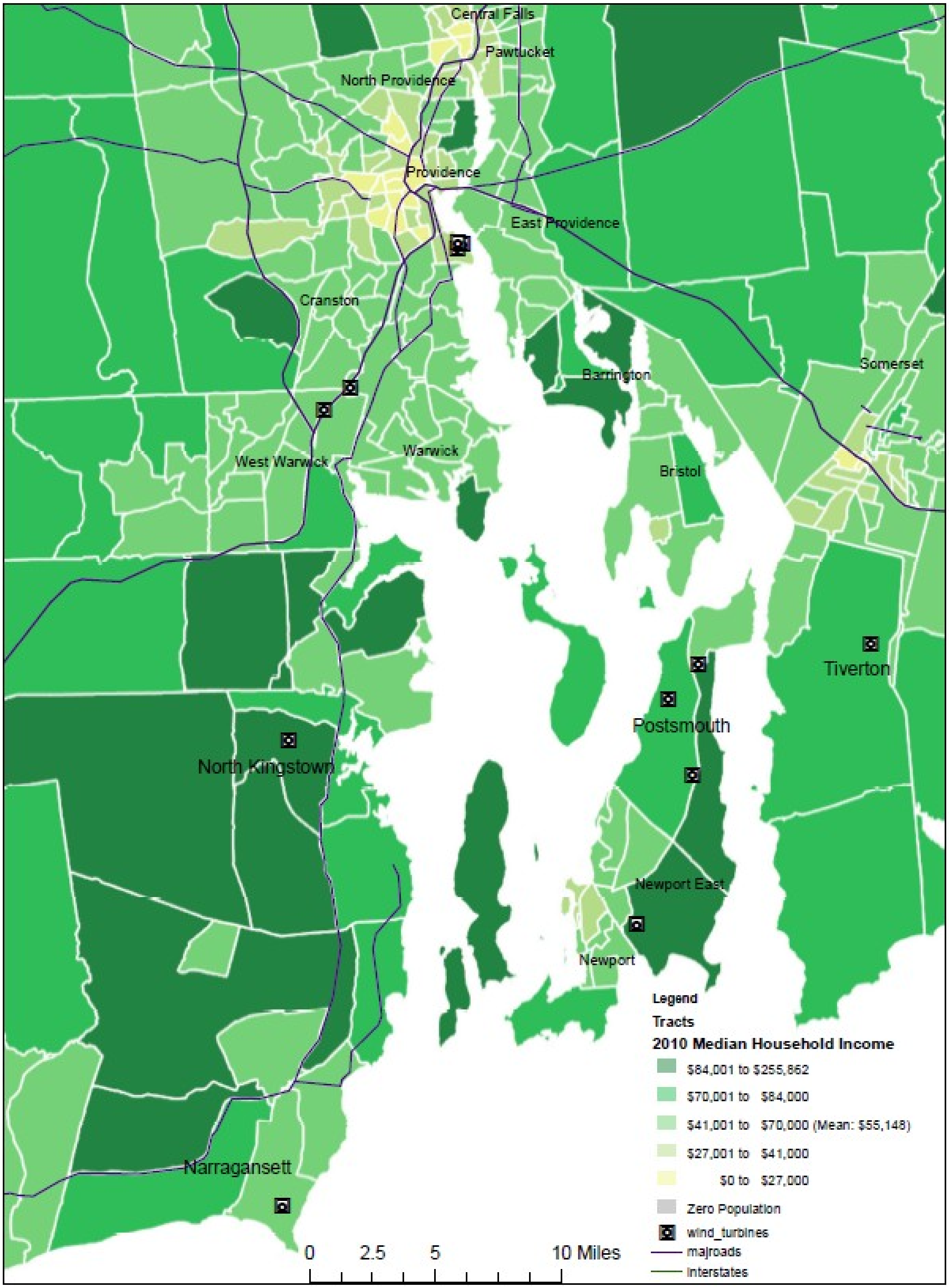


FIGURE 3| Distribution of RI towns' Population Density

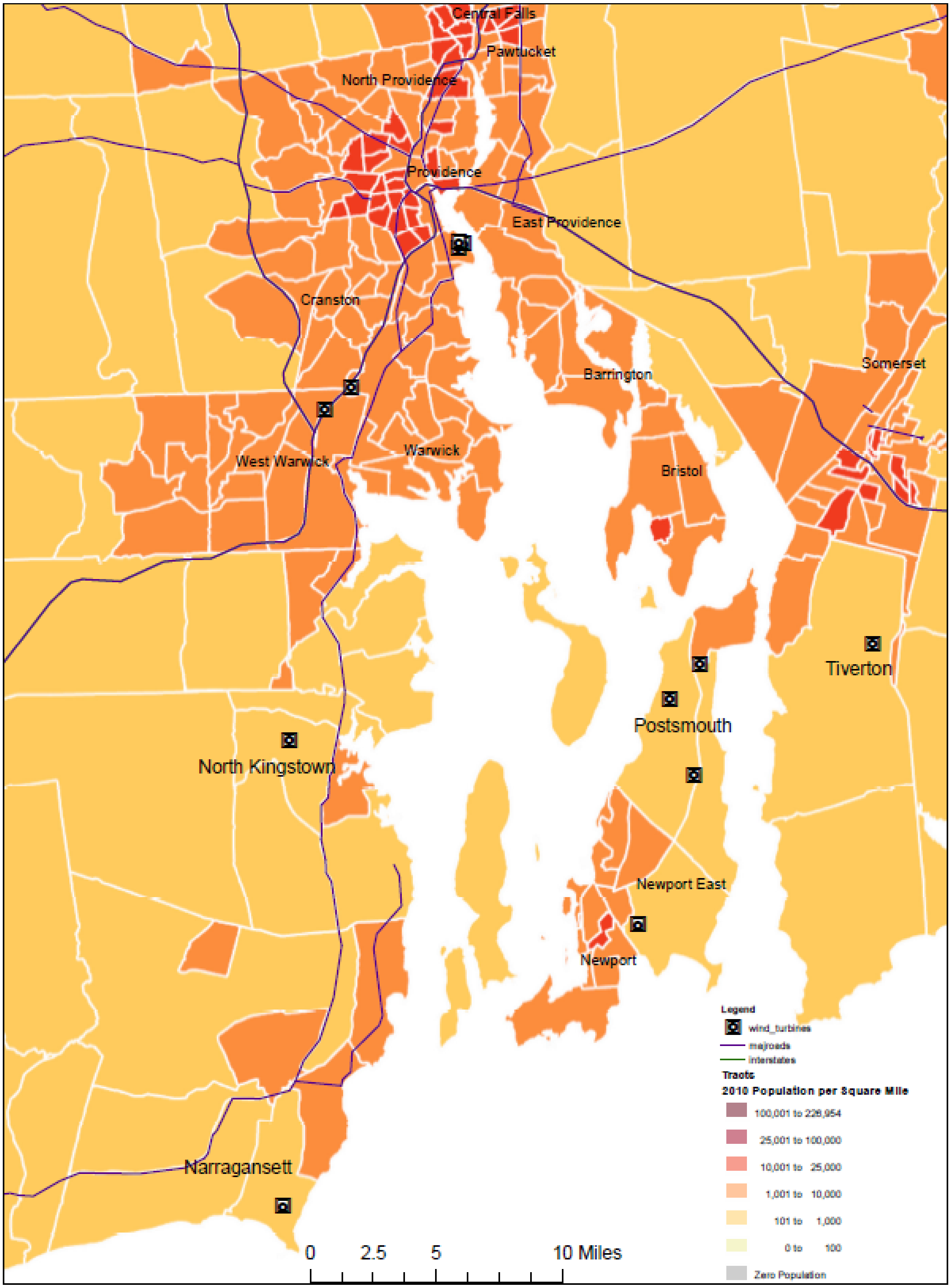


FIGURE 4 | *Distribution of RI Residential Property Types (2000-2013)*

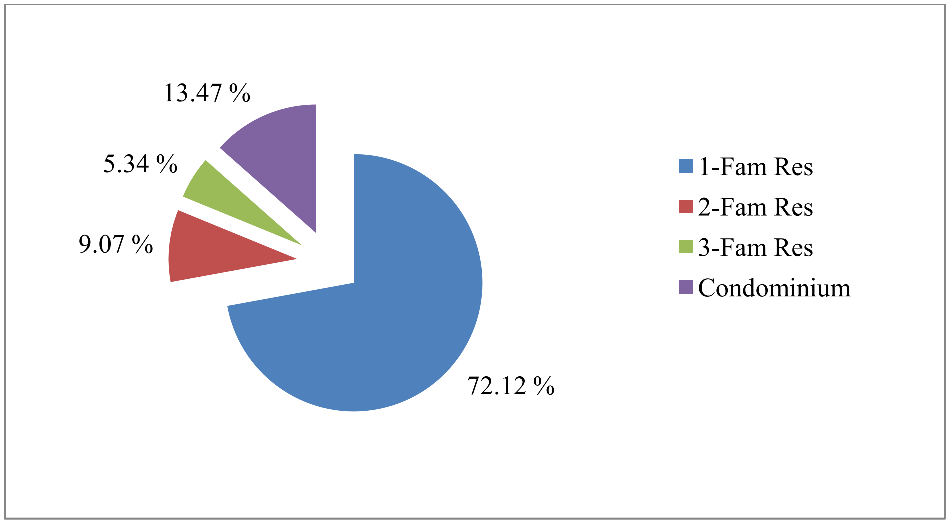


FIGURE 5 | *Distribution of Properties by Wind Turbines*

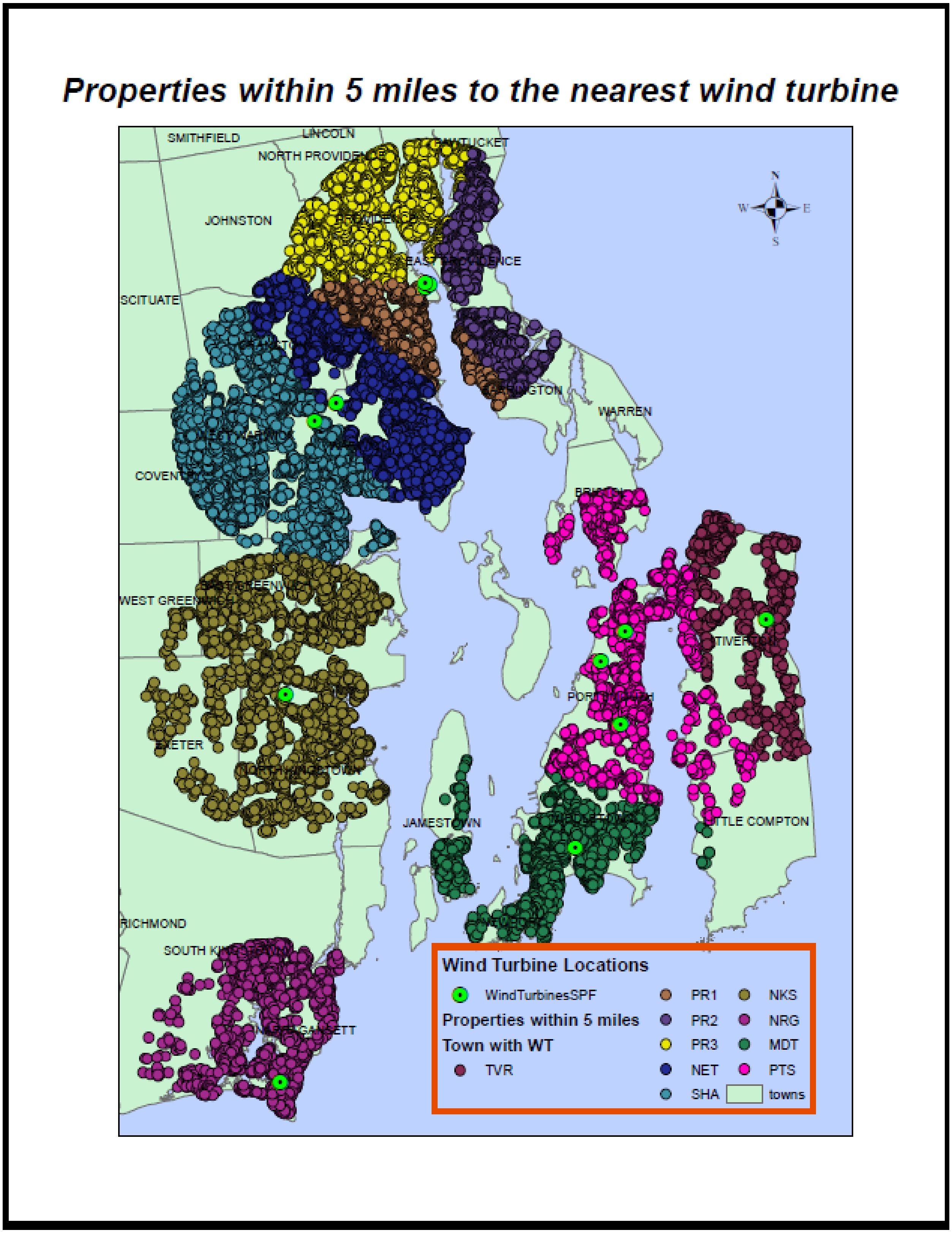


FIGURE 6 | *Single Family Homes near RI Wind Turbines in Six Regions*

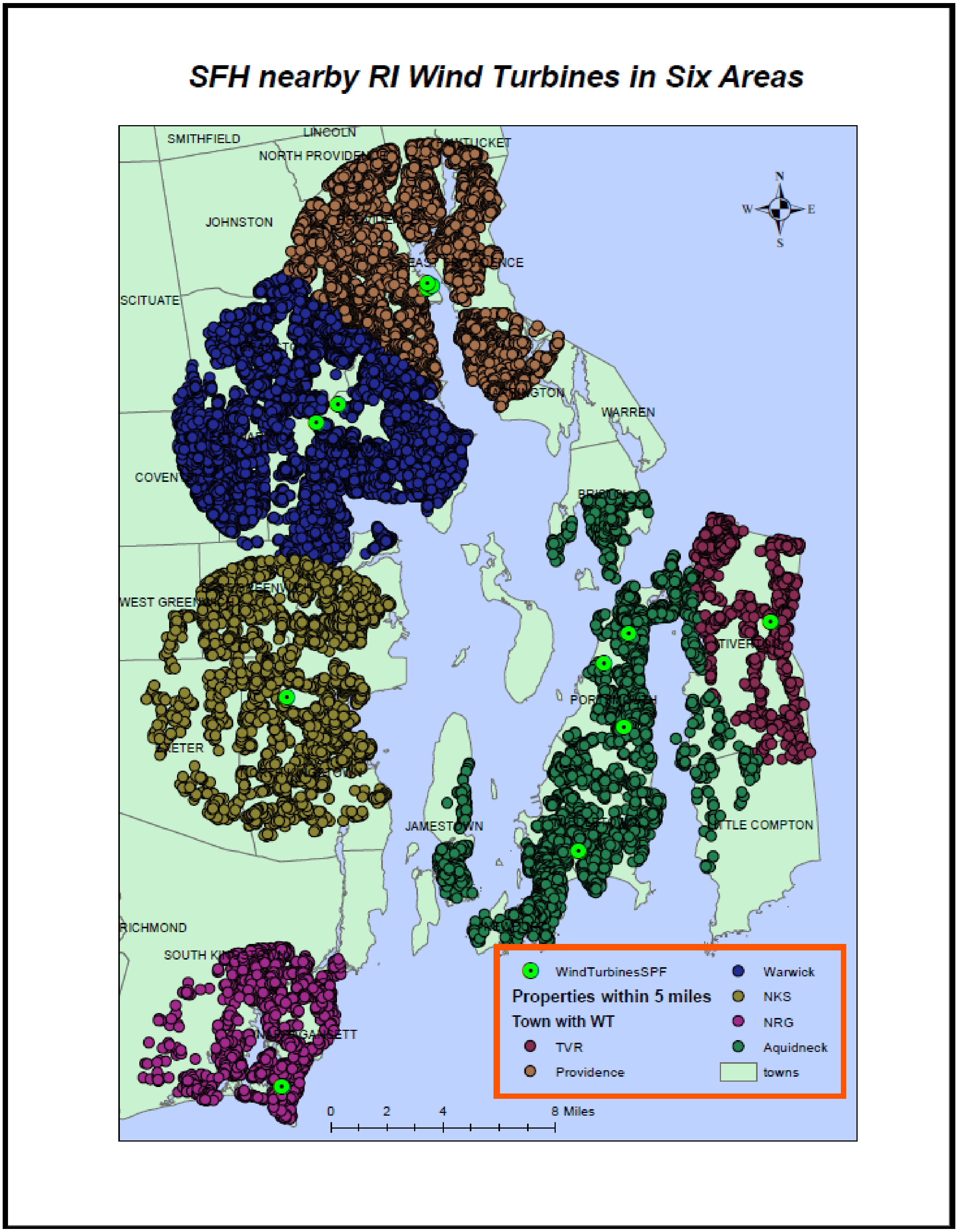


FIGURE 7A | *RI HVOTL in relevance to Wind Turbines*

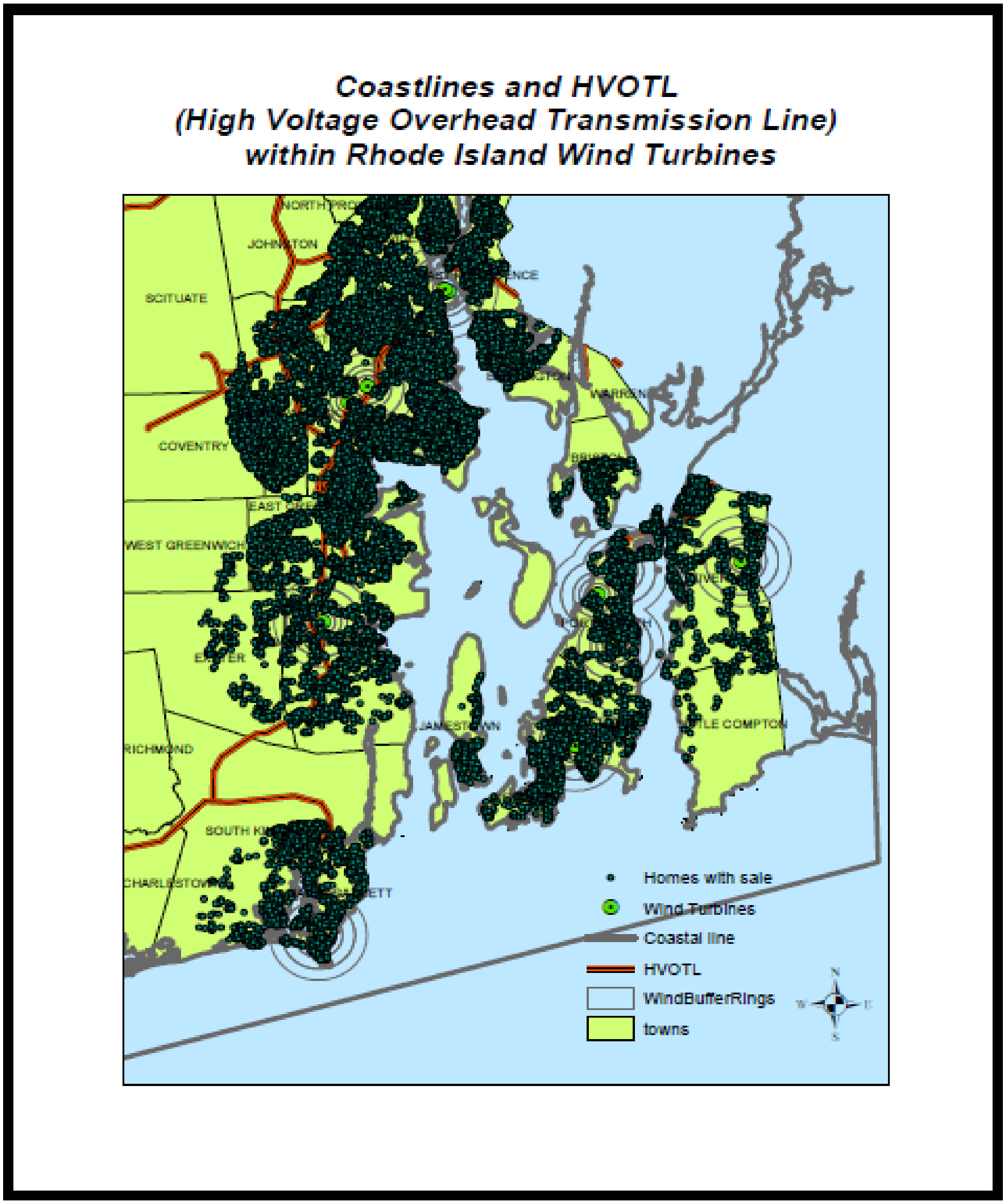
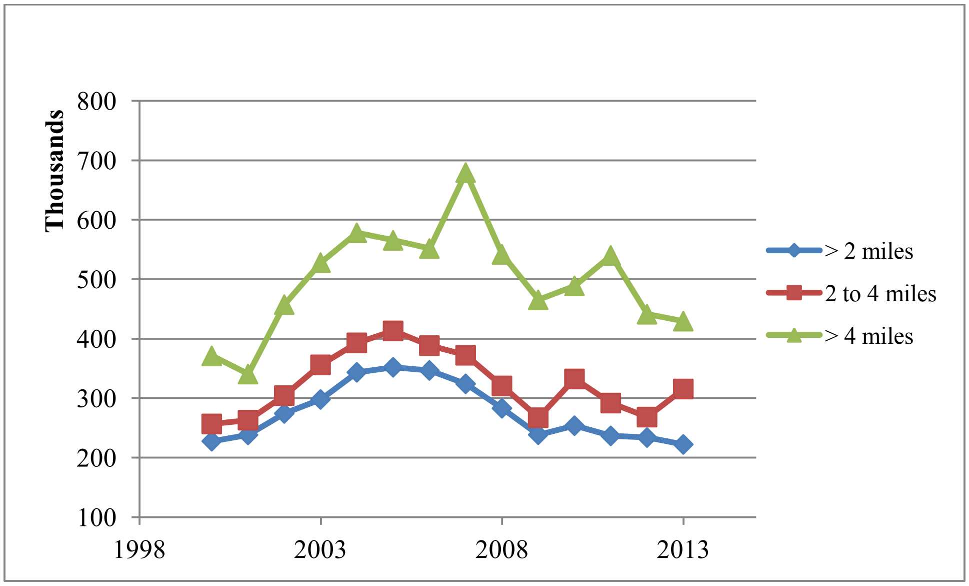


FIGURE 7B | *RI HVOTL impact trend on property values*



APPENDIX A: VIEW Levels

VIEW 1: Minor View


2013-03-09 13.28.51MinorView

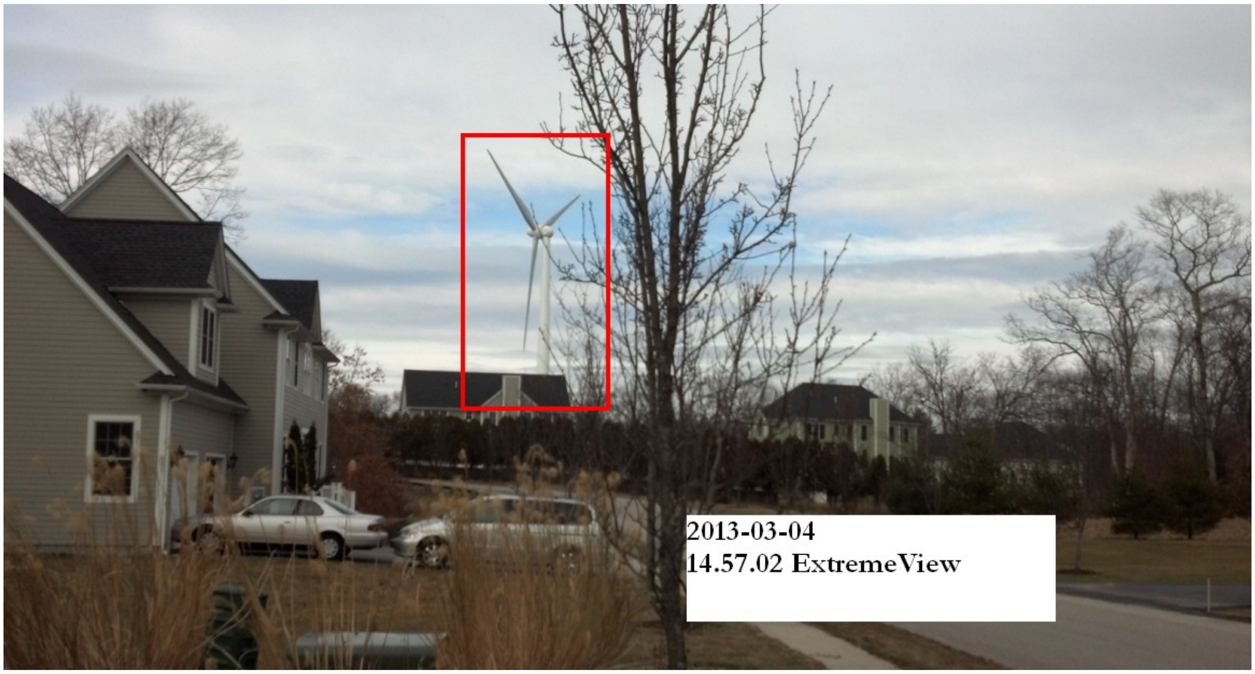

2013-03-09 14.41.32MinorView

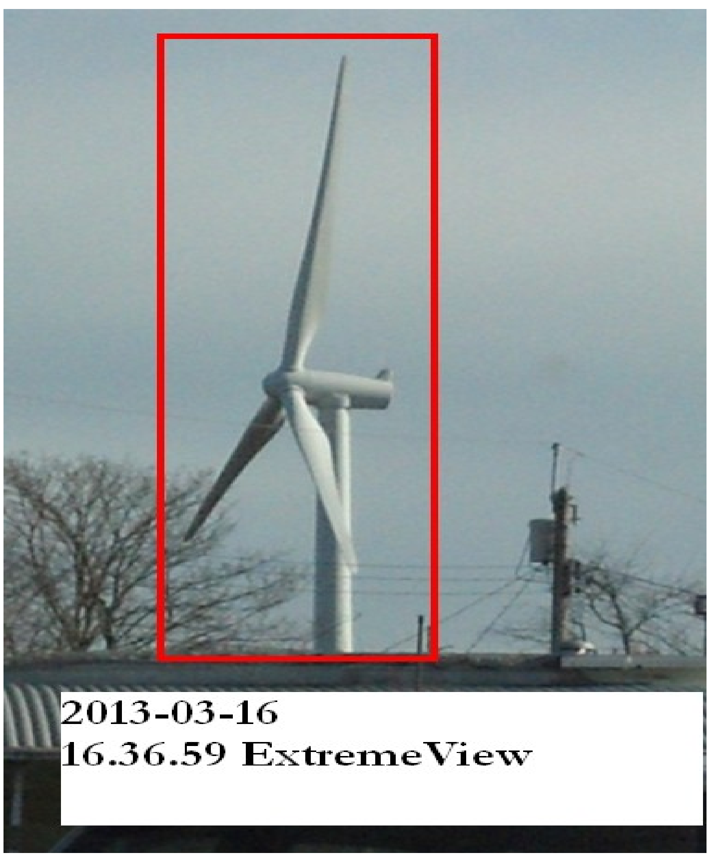
VIEW2: Moderate View

VIEW 3: Substantial (or High) View


2013-03-16
17.47.01HighView

VIEW4: Extreme view






2013-03-16
16.44.59ExtremeView

APPENDIX B: Vista Levels (% Residential)

Vista 1 (15% Residential)

Vista 2 (25 % Residential)

Vista 2.5 (40% Residential)

Vista 3 (55% Residential)

Vista 4 (70% Residential)

Vista 5 (90% Residential)

APPENDEX C

TABLE A | *Complete Regression Results for TABLE 1, All (1)*

Variables		Estimate	Std_Error	t_value	Pr(>|t|)	
	(Intercept)	93.59	14.79	6.329	2.49E-10	***
Housing Characteristics						
	totrooms	0.05683	0.001124	50.58	< 2e-16	***
	bathrooms	0.1058	0.002647	39.961	< 2e-16	***
numfirepl	*No. of fireplace*	0.08463	0.00334	25.335	< 2e-16	***
age	*age of the house*	-0.00182	0.00004872	-37.353	< 2e-16	***
Exterior Condition of House (relative to extcon 1:poor)						
extcon 2	*average*	0.1105	0.01181	9.355	< 2e-16	***
extcon 3	*above average*	0.4589	0.01707	26.889	< 2e-16	***
	longitude	0.269	0.1752	1.535	0.124682	
	latitude	-1.536	0.1747	-8.795	< 2e-16	***
Demographic and Neighborhood Characteristics						
p65plus2	*% population 65 & old*	0.05527	0.01705	3.241	0.001191	**
aveHH	*average household no.*	-0.007044	0.00512	-1.376	0.168871	
pFamHH2	*% family household*	0.05457	0.01457	3.746	0.00018	***
pOOHU2	*% owner occupied housing unit*	0.08768	0.009407	9.32	< 2e-16	***
Variables of Interest						
dist_mi	*distance to WT in miles*	0.03169	0.003278	9.666	< 2e-16	***
time period (relative to PA)						
	PAPC	-0.00282	0.01131	-0.249	0.803081	
	PC	0.01555	0.01389	1.12	0.262879	
Interaction Terms						
dist_mi	*PAPC*	-0.00722	0.002947	-2.45	0.014307	*
	PC	-0.01214	0.003518	-3.452	0.000557	***
view (relative to "no view")						
	minor	-0.3012	0.3483	-0.865	0.387078	
	moderate	-0.09379	0.3093	-0.303	0.761688	
	high	0.07638	0.1891	0.404	0.686308	
	extreme	0.008799	0.2894	0.03	0.975745	
Interaction Terms						
dist_mi	*minor*	0.3522	0.4335	0.812	0.416586	
	moderate	0.2942	0.3503	0.84	0.401063	
	high	-0.4058	0.3385	-1.199	0.230537	

	extreme	-0.1437	0.9113	-0.158	0.87468
minor view	*PAPC*	-0.537	0.8663	-0.62	0.535352
	PC	-0.01868	0.5016	-0.037	0.97029
moderate	*PAPC*	NA	NA	NA	NA
	PC	0.1835	0.3586	0.512	0.608811
high	*PAPC*	-0.7689	0.5233	-1.469	0.141761
	PC	-0.1727	0.2306	-0.749	0.454101
extreme	*PAPC*	-6.736	14.05	-0.479	0.631742
	PC	-0.1796	0.3181	-0.565	0.572385
Observations		*67,768*			
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*					
R-Squared		*0.6275*			

^Lot size is categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement.

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1

TABLE B | *Complete Regression Variables for TABLE 1, Big (2)*

	Variables	Estimate	Std_Error	t_value	Pr(>|t|)	
	(Intercept)	114.7	26.98	4.251	0.0000214	***
Housing Characteristics						
	totrooms	0.05727	0.001616	35.44	< 2e-16	***
	bathrooms	0.09394	0.003883	24.191	< 2e-16	***
numfirepl	*number of fireplace*	0.1042	0.005016	20.772	< 2e-16	***
age	*age of the house*	-0.001738	0.00007442	-23.359	< 2e-16	***
Exterior Condition of House (relative to extcon 1: poor)						
extcon 2	*average*	0.08549	0.01353	6.32	2.66E-10	***
extcon 3	*above average*	0.3275	0.0293	11.174	< 2e-16	***
	longitude	1.177	0.345	3.412	0.000646	***
	latitude	-0.4717	0.3182	-1.483	0.138178	
Demographic and Neighborhood Characteristics						
medhinc2	median household income	0.006228	0.002034	3.062	0.002202	**
popD	*population density*	-0.001229	0.0005416	-2.27	0.023233	*
pNHWhite2	*% Non-Hispanic White population*	0.2678	0.01967	13.609	< 2e-16	***
p65plus2	*% population 65 & old*	0.009692	0.02609	0.371	0.710317	
aveHH	*average household no.*	-0.01716	0.007409	-2.316	0.020552	*
pFamHH2	*% family household*	0.0946	0.02147	4.407	0.0000105	***
pOOHU2	*% owner occupied housing unit*	0.1071	0.01367	7.838	4.73E-15	***
Variables of Interest						
ocean_mi	*distance to coastline in mile*	5.36E-03	7.42E-03	0.723	0.469948	
hvotl_mi	*distance to nearest hvotl in mile*	9.94E-02	6.42E-03	15.482	< 2e-16	***
dist_mi	*distance to WT in miles*	2.12E-02	5.57E-03	3.808	0.00014	***
time period (relative to PA)						
	PAPC	-0.03596	0.01674	-2.148	0.031682	*
	PC	-0.002431	0.02653	-0.092	0.927001	
Interaction Terms						
dist_mi	*PAPC*	0.001643	0.003619	0.454	0.649751	
	PC	-0.02611	0.006559	-3.981	0.0000688	***
view (relative to "no view")						
	minor	-3.463	86.72	-0.04	0.968143	
	moderate					

high		-0.1095	0.3642	-0.301	0.763679
extreme		0.1232	0.3344	0.368	0.712559
Interaction Terms					
dist_mi	*minor*	3.044	75.87	0.04	0.967997
	moderate				
	high	-0.2582	0.4335	-0.595	0.551538
	extreme	-0.6023	1.001	-0.602	0.54734
minor view	*PAPC*	NA	NA	NA	NA
	PC	NA	NA	NA	NA
moderate	*PAPC*	-	-	-	-
	PC	-	-	-	-
high	*PAPC*	-13.33	47.69	-0.279	0.77993
	PC	0.6708	0.5218	1.286	0.198595
extreme	*PAPC*	13.24	24.9	0.531	0.595101
	PC	0.9971	1.068	0.934	0.350393
Observations		*34,058*			
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*					
R-Squared		*0.6536*			

^Lot size is categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement.

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1

TABLE C | *Complete Regresson Variables for TABLE 2 All (1)*

Variables		Estimate	Std_Error	t_value	Pr(>|t|)	
***Dependent Variable**: log of Property Sales Price adjusted to 2010 RIHPI, 3rd quarter*						
(Intercept)		83.970	14.830	5.661	0.000	***
Housing Characteristics						
totrooms		0.057	0.001	50.561	0.000	***
bathrooms		0.106	0.003	39.976	0.000	***
numfirepl	*number of fireplace*	0.084	0.003	25.254	0.000	***
age	*age of the house*	-0.002	0.000	-37.465	0.000	***
Exterior Condition of House (relative to extcon 1: poor)						
extcon 2	*average*	0.110	0.012	9.339	0.000	***
extcon 3	*above average*	0.458	0.017	26.801	0.000	***
longitude		0.150	0.176	0.853	0.394	
latitude		-1.507	0.175	-8.607	0.000	***
Demographic and Neighborhood Characteristics						
medhinc2	median household income	0.006	0.002	3.347	0.001	***
popD	*population density*	-0.002	0.000	-5.212	0.000	***
pNHWhite2	*% NonHispanic White population*	0.233	0.016	14.855	0.000	***
p65plus2	*% population 65 & old*	0.055	0.017	3.221	0.001	**
aveHH	*average household no.*	-0.007	0.005	-1.283	0.200	
pFamHH2	*% family household*	0.054	0.015	3.689	0.000	***
pOOHU2	*% owner occupied housing unit*	0.087	0.009	9.218	0.000	***
Variables of Interest						

ocean_mi	*distance to coastline in mile*	-0.021	0.003	-7.920	0.000	***
hvotl_mi	*distance to nearest hvotl in mile*	0.032	0.003	10.184	0.000	***
Discrete Distance Increment (relative to 3-5 miles)						
2-3 miles		-0.023	0.006	-3.943	0.000	***
1-2 miles		-0.067	0.008	-8.307	0.000	***
0.67-1 miles		-0.096	0.011	-8.391	0.000	***
0.34-0.66 miles		-0.141	0.013	-10.516	0.000	***
0-0.33 miles		-0.160	0.024	-6.673	0.000	***
time period (relative to PA)						
PAPC		-0.034	0.009	-3.915	0.000	***
PC		-0.032	0.011	-2.824	0.005	**
Interaction Terms						
2-3 miles	*PAPC*	0.019	0.009	2.182	0.029	*
	PC	0.008	0.010	0.800	0.423	
1-2 miles	*PAPC*	0.014	0.010	1.389	0.165	
	PC	0.030	0.012	2.585	0.010	**
0.67-1 miles	*PAPC*	-0.010	0.018	-0.547	0.584	
	PC	0.081	0.020	4.018	0.000	***
0.34-0.66 miles	*PAPC*	0.083	0.023	3.650	0.000	***
	PC	0.067	0.028	2.377	0.017	*
0-0.33 miles	*PAPC*	0.062	0.049	1.255	0.210	
	PC	-0.036	0.084	-0.423	0.673	
view (relative to "no view")						
minor		-0.097	0.198	-0.490	0.624	
moderate		-0.086	0.397	-0.216	0.829	
high		0.087	0.174	0.498	0.619	
extreme		0.015	0.116	0.128	0.898	
Interaction Terms						
minor	*2-3 miles*	NA	NA	NA	NA	
	1-2 miles	0.157	0.313	0.501	0.617	
	0.67-1 miles	NA	NA	NA	NA	
	0.34-0.66 miles	NA	NA	NA	NA	

	0-0.33 miles	NA	NA	NA	NA
moderate	*2-3 miles*	NA	NA	NA	NA
	1-2 miles	0.439	0.466	0.944	0.345
	0.67-1 miles	0.153	0.524	0.292	0.771
	0.34-0.66 miles	0.204	0.366	0.557	0.578
	0-0.33 miles	NA	NA	NA	NA
high	*2-3 miles*	NA	NA	NA	NA
	1-2 miles	-0.492	0.384	-1.281	0.200
	0.67-1 miles	NA	NA	NA	NA
	0.34-0.66 miles	-0.224	0.263	-0.849	0.396
	0-0.33 miles	NA	NA	NA	NA
extreme	*2-3 miles*	NA	NA	NA	NA
	1-2 miles	NA	NA	NA	NA
	0.67-1 miles	0.071	0.361	0.198	0.843
	0.34-0.66 miles	-0.021	0.193	-0.109	0.913
	0-0.33 miles	NA	NA	NA	NA
Observations		*67,768*			
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*					
R-Squared		*0.6279*			

^Lot size is categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement.

Level of Significance codes: 0 ‘***’ 0.001’ 0.01 ‘*’0.05 ‘.’0.1 ‘ ’1; 0.000 denotes the number less than 10e-6.

TABLE D | *Complete Regresson Variables for TABLE 2 Big (2)*

Variables		Estimate	Std_Error	t_value	Pr(>|t|)	
***Dependent Variable**: log of Property Sales Price adjusted to 2010 RIHPI, 3rd quarter*						
(Intercept)		105.300	27.270	3.861	0.000	***
Housing Characteristics						
totrooms		0.057	0.002	35.471	0.000	***
bathrooms		0.094	0.004	24.110	0.000	***
numfirepl	*number of fireplace*	0.104	0.005	20.806	0.000	***
age	*age of the house*	-0.002	0.000	-23.467	0.000	***
Exterior Condition of House (relative to extcon 1: poor)						
extcon 2	*average*	0.085	0.014	6.260	0.000	***
extcon 3	*above average*	0.327	0.029	11.147	0.000	***
longitude		1.068	0.349	3.065	0.002	**
latitude		-0.431	0.320	-1.349	0.177	
Demographic and Neighborhood Characteristics						
medhinc 2	median household income	0.006	0.002	3.111	0.002	**
popD	*population density*	-0.001	0.001	-2.304	0.021	*
pNHWhite2	*% NonHispanic White population*	0.269	0.020	13.717	0.000	***
p65plus 2	*% population 65 & old*	0.012	0.026	0.441	0.660	
aveHH	*average household no.*	-0.018	0.007	-2.374	0.018	*
pFamHH2	*% family household*	0.097	0.021	4.495	0.000	***
pOOHU 2	*% owner occupied housing unit*	0.107	0.014	7.821	0.000	***
Variables of Interest						

ocean_mi	*distance to coastline in mile*	0.003	0.007	0.432	0.666	
hvotl_mi	*distance to nearest hvotl in mile*	0.100	0.006	15.467	0.000	***
Discrete Distance Increment (relative to 3-5 miles)						
2-3 miles		-0.020	0.009	-2.153	0.031	*
1-2 miles		-0.044	0.014	-3.154	0.002	**
0.67-1 miles		-0.067	0.020	-3.425	0.001	***
0.34-0.66 miles		-0.103	0.026	-4.012	0.000	***
0-0.33 miles		-0.059	0.046	-1.290	0.197	
time period (relative to PA)						
PAPC		-0.034	0.015	-2.314	0.021	*
PC		-0.108	0.025	-4.308	0.000	***
Interaction Terms						
2-3 miles	*PAPC*	0.023	0.011	2.188	0.029	*
	PC	0.078	0.019	4.175	0.000	***
1-2 miles	*PAPC*	-0.006	0.013	-0.488	0.625	
	PC	0.038	0.023	1.664	0.096	.
0.67-1 miles	*PAPC*	-0.078	0.025	-3.085	0.002	**
	PC	0.068	0.039	1.730	0.084	.
0.34-0.66 miles	*PAPC*	0.048	0.031	1.533	0.125	
	PC	0.104	0.048	2.161	0.031	*
0-0.33 miles	*PAPC*	0.006	0.067	0.086	0.932	
	PC	-0.075	0.109	-0.682	0.495	
view (relative to "no view")						
minor		0.004	0.244	0.018	0.986	
moderate		-	-	-	-	
high		0.086	0.369	0.234	0.815	
extreme		-0.023	0.160	-0.146	0.884	
Interaction Terms						
minor	*2-3 miles*	NA	NA	NA	NA	
	1-2 miles	NA	NA	NA	NA	
	0.67-1 miles	NA	NA	NA	NA	
	0.34-0.66 miles	NA	NA	NA	NA	
	0-0.33 miles	NA	NA	NA	NA	
moderate	*2-3 miles*	-	-	-	-	

	1-2 miles	-	-	-	-
	0.67-1 miles	-	-	-	-
	0.34-0.66 miles	-	-	-	-
	0-0.33 miles	-	-	-	-
high	*2-3 miles*	NA	NA	NA	NA
	1-2 miles	-0.480	0.504	-0.953	0.341
	0.67-1 miles	NA	NA	NA	NA
	0.34-0.66 miles	-0.592	0.505	-1.172	0.241
	0-0.33 miles	NA	NA	NA	NA
extreme	*2-3 miles*	NA	NA	NA	NA
	1-2 miles	NA	NA	NA	NA
	0.67-1 miles	0.165	0.374	0.440	0.660
	0.34-0.66 miles	-0.109	0.235	-0.464	0.642
	0-0.33 miles	NA	NA	NA	NA
Observations		*34,058*			
*Fixed Effects: Year-Quarter, Census Tract, Region and Lot size^*					
R-Squared		*0.654*			

^Lot size is categorical variable to control house characteristics. PAPC stands for post announcement and pre construction; PC for post construction; the base category for time period is PA, pre announcement.

Level of Significance codes: 0 '***' 0.001' 0.01 '*'0.05 '.'0.1 ' '1; 0.000 denotes the number less than 10e-6.