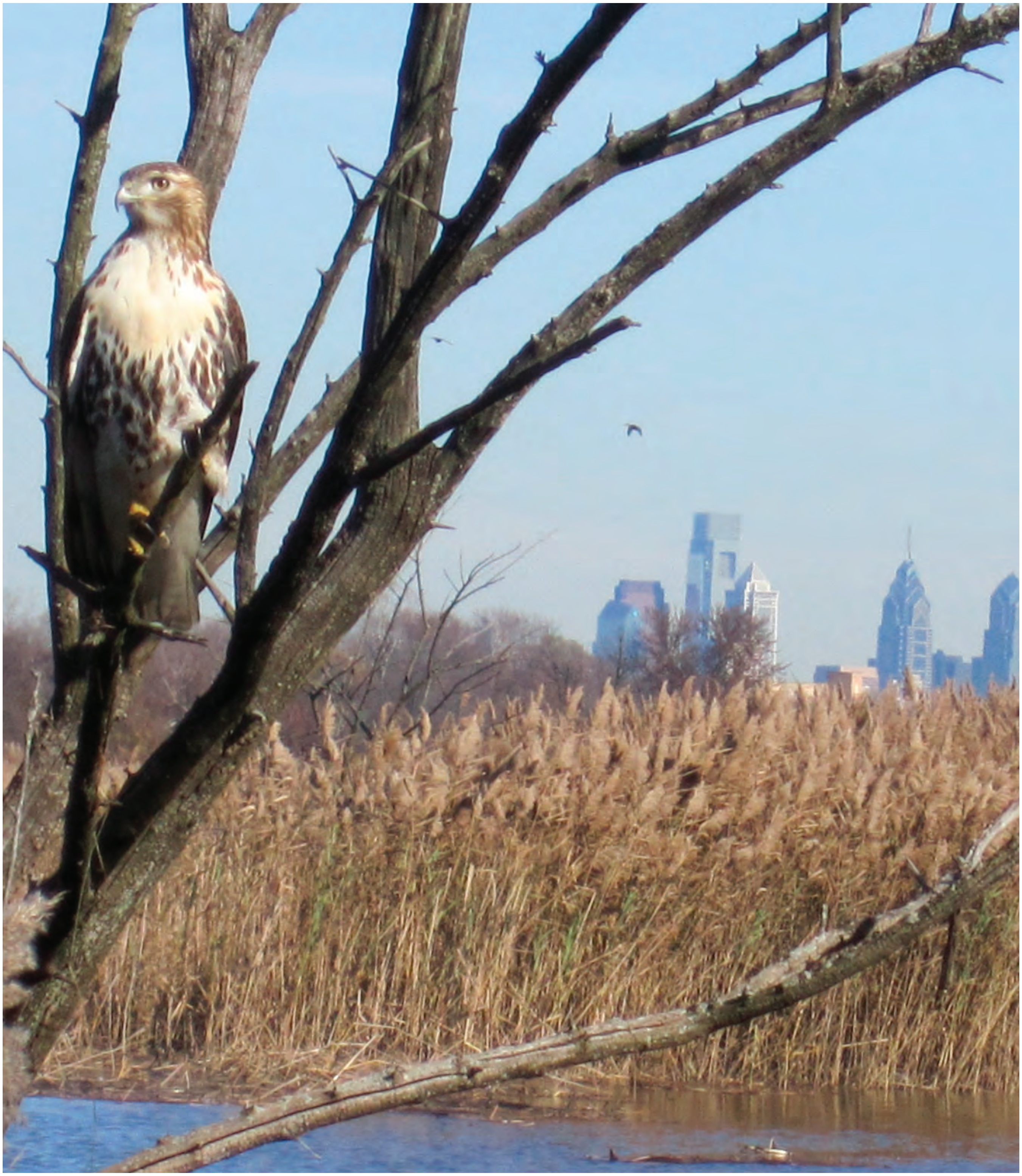
Amenity Values of Proximity to National Wildlife Refuges



By Laura O. Taylor, Xiangping Liu and Timothy Hamilton
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North Carolina State University, April 2012

John Heinz National Wildlife Refuge
Photo by Derik Pinsonneault/USFWS

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Final Report to:[1]

Jim Caudill and Kevin Kilcullen
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EXECUTIVE SUMMARY

This report summarizes the results of a national-scale analysis to determine the effect National Wildlife Refuges (NWR) have on nearby homeowners' property values. Given the evidence that being located near permanently protected open space increases property values, we expect that NWRs will also have similar positive property value effects. The unique national analysis is conducted using confidential micro-level U.S. Census Bureau data available through the Triangle Census Research Data Center. The data include detailed information on housing characteristics and owner-assessed values for a one-in-six sample of households across the entire U.S. Importantly, the confidential data identify the location of each house at a very fine geographic resolution, allowing us to carefully identify how close a home is to the boundary of an NWR. Regression analysis is conducted to determine how a home's value is impacted by its proximity to an NWR.

An important feature of the analysis is that we recognize that it is more likely that NWRs will have an impact if they are located near housing markets where open space is relatively scarce, e.g., in urbanized areas or at the urban fringe. Given this hypothesis, we focus our attention on the 93 NWRs in the lower-48 States whose boundary is within two miles of the boundary of an urbanized area with population greater than 50,000 as of the 2000 Decennial Census. The regression analysis is conducted on homes that lie within three miles of each of these 93 NWRs. Furthermore, we restrict the sample of homes to be within eight miles of the centroid of the urban area. We impose this restriction because NWRs can be rather large with some portions of an NWR lying in close proximity to an urbanized area, while other portions of the same NWR may be quite distant from urbanized areas. Sensitivity of our results to these restrictions is tested and reported herein.

Our analysis is conducted by U.S. Fish and Wildlife Service region and we find positive impacts for NWRs located in the Northeast and Southeast regions as well as in the California/Nevada region. Data limitations due to a paucity of NWRs near urban areas in the central mountains and south-central portions of the country resulted in these regions being excluded from the final analysis. In other regions, important confounding factors such as the NWRs being located on the Mexico/U.S. border or in a river flood plain result in an inability to disentangle the influence of these confounding factors with the value of the open space amenities provided by the NWRs themselves.

Results indicate that, on average, being in close proximity to an NWR increases the value of homes in urbanized areas, all else equal. Specifically, we find that homes located within 0.5 miles of an NWR and within 8 miles of an urban center are valued:

- 4% - 5% higher in the Northeast region;
- 7% - 9% higher in the Southeast region; and
- 3% - 6% higher in California/Nevada region.

These effects are consistent across a number of regression specifications and sample variations.

The percentage impacts described above are converted to a "capitalized value" that represents the total property value impact for homes surrounding an NWR. To compute the

capitalized value, the average impact estimated for each region is applied to homes that surround each NWR in the sample. For example, we attribute 4%-5% of the value of single-family homes in the Northeast that are within 0.5 miles of an NWR and within 8 miles of an urban center to their proximity to an NWR. The point estimates of the total capitalized value attributable to the NWRs in our final sample are (in 2000 dollars):

- $95 million for 11 NWRs in the Northeast region;
- $122 million for 14 NWRs in the Southeast region; and
- $83 million for 11 NWRs in the California/Nevada region.

Depending on the region and the NWR, the point estimates of the capitalized value that specific NWRs provide can be as little as $1 million to over $40 million. On average across the NWRs in our sample, we find the capitalized value of the open-space amenities that NWRs provide to be:

- $8.7 million per NWR in the Northeast region;
- $8.7 million per NWR in the Southeast region; and
- $7.6 million per NWR in the California/Nevada region.

It is important to note that "capitalized value" does not equal the value of creating a new NWR, expanding an existing NWR, or what is lost if an NWR were dismantled and developed. It does however provide an estimate of the increased property tax base that local communities enjoy as a result of the NWRs and their provision of open-space amenities to nearby homeowners. This is important to understand as one component of the overall benefit NWRs provide to local communities.

While this study's approach and results provide useful programmatic information on average property value impacts of NWRs, results from this study should be combined with more detailed analyses of local property markets if managers wish to precisely understand the impact of a specific NWR on residential properties in its community. The data needed to conduct a case study complementary to our work are increasingly available from local municipalities. Specifically, housing sales prices, housing characteristics, and geo-referenced parcel maps are typically available in most metropolitan areas. With this specific data in hand, the analyst may replicate the methods contained herein to more precisely gauge the property value impacts of a specific NWR on its neighbors.

Lastly, we attempt to include in our analysis characteristics of the NWRs to determine if different management features of an NWR lead to differential impacts on neighboring residential properties. Unfortunately, the data collected by the Service either have too little variability in the estimating sample or the level of precision of the recorded data (e.g., visitation rates) do not lend itself to being included in our analysis in a meaningful way.

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1. Introduction

Natural open spaces can provide multiple forms of benefits to local communities and the U.S. Fish and Wildlife Service (hereafter referred to as just "the Service") National Wildlife Refuge (NWR) System is unique in this respect. The economic impacts of recreational uses associated with NWRs have been well documented. Carver and Caudill (2007) summarize the on-site recreational uses of NWRs (e.g., hunting, fishing, bird watching, and hiking) as well as the beneficial economic impacts to the surrounding communities from the expenditures associated with the recreational activities. While the direct recreational impacts of NWRs are significant, they constitute only one aspect of how areas adjacent to NWRs may be affected by their proximity to an NWR.

Proximity to natural areas (open space) has been shown to have positive impacts on residential property values. McConnell and Walls (2005) conduct an extensive literature review of hedonic pricing models for open space, examining 40 papers published between 1967 and 2003. The review groups studies by the type of open space upon which they focus. There are five types of open space considered: general open space, parks, and natural areas; greenbelts; wetlands; urban/suburban forest preserves; and agricultural lands. McConnell and Walls report that across the five categories, the average increase in home price varies from slightly negative to 2.8% for being located 200 meters closer to some form of open space.[2] However, McConnell and Walls report that past studies suggest a higher premium for larger natural areas, parks with less recreational use, and forested lands – up to a 16% price premium for homes located within one-quarter mile of these types of open space (Lutzenhiser and Netusil, 2001).

As with other types of open space, we expect that NWRs could have a substantial positive effect on nearby property values due to the protections they provide against future development and the preservation of the many natural amenity benefits associated with open spaces (e.g., scenic vistas). Quantifying these potential economic impacts will provide important information to the Service that can be used for future NWR management and planning decisions. The goal of this study is to quantify the impacts NWRs have on

[2] More recently, Sander and Polasky (2009) find a price increase of approximately 1% for a home 200 meters closer to a public park.

neighboring property values for as large a set of NWRs as possible across the continental U.S.

Our study is similar to Boyle, Paterson and Poor (2002, henceforth referred to as BPP) who focus specifically on NWRs as a type of open space and estimate their impacts on local housing prices. Their analysis centers on four NWRs in the northeast – the Great Meadows, Montezuma, Iroquois, and Erie NWRs.[3] Housing sales data are collected surrounding each of these NWRs and a property value analysis is conducted to determine the impact proximity to one of these NWRs has on housing values. Their selection of NWRs to analyze are limited by the availability of housing sales data, both in terms of being able to collect the information from local municipalities as well as requiring there to be a large enough sample of housing sales to support the statistical analysis. Even considering these criteria, three of the four NWRs studied have a small number of transactions available for analysis (between 48 and 610 sales) and, more importantly, sales are often located a very great distance from the NWR (up to 32 miles away). Unobserved spatially-varying characteristics of the area could bias the estimated impacts of proximity to NWRs in these models, and perhaps explain the instability of their results across model specifications and samples.

The analysis conducted for this project takes a more programmatic approach than BPP to identify the potential property value impacts of NWRs on their surrounding neighbors. Rather than focus on a few NWRs for which transactions data are feasible to obtain, we attempt to identify the average impact for as many NWRs in the continental U.S. as possible by taking advantage of access to confidential micro-level census data available through the Triangle Census Research Data Center. These data include detailed information on housing characteristics and owner-assessed values and are available for one-in-six households across the entire U.S. Importantly, the confidential data identify the location of each house at a very fine geographic resolution, allowing us to carefully identify how close a home is to the boundary of an NWR. Given the spatially-resolute data nature of the data, and its wide coverage across the U.S., we are able to analyze a broader set of

[3] Neumann, Boyle and Bell (2009) later published a more detailed analysis of the relationship between property values and proximity to the Great Meadows NWR as well as other types of open space in the area.

NWRs and provide a more comprehensive analysis of the amenity benefits that NWRs provide to local communities.

The approach in BPP narrowly focuses on a detailed examination of the impacts of a specific NWR on a specific local market. Our approach identifies an average impact across a set of NWRs, providing a broader average programmatic impact of NWRs on their neighbors. Of course, because we estimate an average impact across many NWRs, the impact of any specific NWR may be greater, less, or equal to the average impact. The drawback of our approach, as compared to BPP is that we rely on owner assessments of housing value rather than actual transactions data.[4] While transactions data would be ideal, it is simply not feasible to obtain in a manner other than a case-by-case basis.

The remainder of this report is as follows. In the next section, we describe the data collected and developed for the analysis. Section III provides an overview of the methods used, the statistical models employed, and describes the regression results. Section IV uses the results in Section III to compute the estimated property value impacts of proximity to NWRs. Section IV concludes.

[4] To the extent there are systematic biases in the owner's perceived value of housing that is directly related to proximity of their house to an NWR, our results may be biased. Kiel and Zabel (1999) compared hedonic price estimates for housing based on owner responses to the American Housing Survey (a Census gathered survey, similar in format to the Census long-form that we analyze) to transactions prices. While Kiel and Zabel find that home owners overestimate the value of their home by an average of about 5%, they could not find a relationship between the degree of overestimation and housing or neighborhood characteristics, suggesting that owner-reported values may result in unbiased estimates of the value of these characteristics.

2. Data

Introduction

In this section we describe the collection and derivation of the final data used to estimate the amenity values of National Wildlife Refuges (NWRs) on property values. Our approach is based on observing effects in local housing markets. We must therefore control for factors other than NWRs, such as attributes of a house and its location, that may influence housing prices. There are five types of information that must be developed in order to correctly isolate the impact of NWRs on residential property values. These are described briefly below, and then in more detail in the following sections.

i. *Geospatial data for NWRs.* Geo-coded boundaries for each NWR are needed to develop relationships between residential properties and the boundary of the NWR. Boundary data also allow us to calculate the size of each NWR.

ii. *Characteristic information for each NWR.* The characteristics of each NWR, such as the type of recreational opportunities afforded at each site, are needed to allow for heterogeneity in the impacts of an NWR based on the types of services it provides to local communities.

iii. *Neighborhood and locational characteristics of housing*. Many factors contribute to the value of a residential property and must be included in the analysis. Information on neighborhood characteristics such as the racial and housing composition of the neighborhood are collected from public Census data. Locational characteristics such as proximity to an open body of water (ocean or large lake), proximity to urban centers, and proximity to highways are created using public geodatabases.

iv. *Housing information.* Data on the value, characteristics and spatial location of residential properties are needed, and form the basis on the analysis. Because of the broad geographic scope of the project (the entire U.S.), we will take advantage of confidential U.S. Census data available to researchers through special agreement with the U.S. Census Bureau.

v. *Non-NWR open space.* NWRs are one type of open space, other open space may be present in local communities and must be included in the analysis so that the value of these other open spaces is not incorrectly attributed to the presence of the NWR.

Each of the above data categories are described in turn below. Additional details on the data construction, the original data source files, intermediate data files, and final data files are available in the "read_me.doc" file that accompanies this report.

Geospatial and Characteristic Data for NWRs

The project goal is to estimate the amenity value of National Wildlife Refuges (NWRs) as capitalized into adjacent land values. To be candidates for inclusion in the analysis, NWRs should be in close proximity to areas with sufficiently dense housing to expect that the provision of open space through an NWR would be capitalized into nearby residential land values. It is not reasonable to expect NWRs to be capitalized into housing values in areas where open space is abundant (not scarce). This conjecture is supported by BPP who are not able to robustly identify impacts of NWRs that are located in more rural areas. As a result, our selected sample is comprised of the wildlife NWRs whose boundaries are within 2 miles of an urban area boundary. Two miles is a distance sufficient to capture the capitalized impact of NWRs on residential properties within or surrounding urban areas.

To differentiate between urban and rural areas, the analysis relies on the 2000 U.S. Census definitions for urbanized areas. According to Census, an urban area consists of contiguous, densely settled census block groups and census blocks that meet minimum population density requirements,[5] along with adjacent densely settled census blocks that together encompass a population of at least 50,000 people. We select the NWRs who have a boundary that lies within two miles of an urban area boundary and link them to their corresponding urban area using "spatial join", a Geoprocessing tool in ArcMap. The NWR boundaries come from GIS data provided by the Service. The dataset covers the 48 contiguous States plus the District of Columbia. Our urban area boundary data are from the

[5] Population density requirements are 1,000 people per square mile for BGs and 500 people per square mile for blocks.

U.S. Census Bureau Geography Division at the U.S. Department of Commerce and is obtained through the North Carolina State University library.

Before conducting the spatial join, we dissolve the boundaries of multiple tracts of land within the same NWRs that are contiguous. We then overlay the urban areas boundary file and join it to the dissolved NWR boundaries based on their spatial locations.[6] This process returns a list of records of NWRs that are within 2 miles to any urban area, their corresponding urban area, and the state in which they are located. If an NWR falls in the 2-mile buffers of more than one urban area, multiple records are created for that NWR. If an NWR is located on the border of two states, two records are created for the same NWR (for the technique details and the directories of the original, intermediate, and final data, see read_me).

In the lower 48 states, there are a total of 502 NWRs that were candidates for inclusion in our study. Of these 502 NWRs, there are 93 within two miles of an urban area that has population of greater than 50,000 residents. Table 1 reports the number of NWRs in our initial sample by state, as well as the total number of acres covered by those NWRs.

In addition to the NWR boundary data, other characteristics of the NWRs are incorporated into the data. In particular, the Service provided information on the seasonal openings, educational use, and recreational opportunities available at each NWR. We also obtained information on the date that each NWR was established and the NWR size (acres). We link these data to the NWR GIS boundary data using NWR names.

Summary statistics for the 93 NWRs are reported in Table 2. Among them, 76% acquired their first tract of land before 1990 and approximately 60% before 1980. The majority of NWRs are open to the public, more than 65% have trails and visitor facilities. Nearly half of the NWRs are open to hunting, and nearly 60% allow fishing. Seventy-percent of the NWRs offer educational programs.

Table 3 lists the NWRs included in each Service region that is included in our final sample of NWRs. A map of the U.S. Fish and Wildlife Service Regions is presented in Figure 3. The final sample excludes any NWR that was established after 2000 (the year in which the housing data was gathered). Note, Region 2 has very few NWRs that meet our inclusion

[6] Note that if part of a refuge is within 2 miles to a urban area, the entire refuge is included in our study area.

criteria, and the ones that do are all located in Texas. Similarly, Region 6 only has two NWRs that meet our inclusion criteria and these are located in Colorado. Not surprisingly, Region 5 (the northeast) and Region 4 (the southeast) have the richest possibilities as there are many NWRs in close proximity to urbanized areas. Figures 1 and 2 identify the NWRs used in our analysis, along with major urban areas. Figure 1 shows the NWRs for the lower-48 states, while Figure 2 concentrates on the eastern coast, where most of our sample lies. Note, in the figures, the outlines of the NWRs have been expanded greatly to show their relative position and thus do not reflect their true size. The same is true for the urbanized boundaries, although the weight on the boundaries for urban areas is smaller than for the NWRs.

Neighborhood and Locational Characteristics of Housing

The U.S. Census Bureau publicly releases summary statistics for variables it collects at three levels of geography: the block, block-group and tract level. Before describing what data we collect from this public data, we first describe the basic census geography units. The U.S. Census organizes data by three major spatial units: a census block, a census block group, and a census tract. Census blocks are the smallest spatial unit for which the Census releases data publicly. Blocks represent literally a physical "block" as defined by streets, roads, rivers, or other natural boundaries. Census blocks vary in geographic size and population as they are defined by physical infrastructure. Census aggregates blocks into block-groups, which are meant to represent populations of 600 to 3,000 individuals that have similar characteristics – i.e., a "neighborhood". Tracts are aggregations of block groups and generally represent a population of 1,500 to 8,000. They too are meant to represent a "neighborhood", albeit a larger definition than a block group. Census maintains geospatial data on the boundaries of each of these census geographic units. Each block, block-group, and tract has a unique identifier that may then be used to link the boundary files with census demographic and housing data.

The variables the Census Bureau chooses to release publicly vary by spatial scale to protect privacy. For instance, Census reports population counts at each level of geography. However, mean income is only reported publicly at the block-group and tract level. We utilize the publicly available data to summarize the neighborhood characteristics for each house that might affect property value, such as the racial composition of the neighborhood in which the house is located.

We isolate in a GIS database the blocks, block-groups and census tracts that lie within 20 miles of any of the NWRs identified as candidates for study. To these spatial units, we match information on average block, block-group or tract demographic and housing characteristics (as well as information on open space as described in the next section). The publicly available U.S. Census Summary File 1 reports census demographic and housing information at the block level and the variables collected at the block level are reported in Table 4. The publicly available U.S. Census Summary File 3 is used to collect demographics at the block-group level, including median family income, racial composition, housing information (e.g., the number of single family homes and total housing units). A summary of the data collected at the block group level is presented in Table 5. A key difference between the public data at block and block-group level is the lack of income and housing value measures at block level.

In addition to the Census variables describing a neighborhood's characteristics, we also characterize location attributes of a house's neighborhood. Variables are created that measure distance of blocks to several amenities, including metropolitan statistical areas (MSAs), transportation infrastructure, significant water bodies and the ocean, national parks and state parks. Urban areas and MSAs follow census definitions. The National Park Service sites include national parks, national monuments, national seashores. Transportation infrastructure consists of interstate highways, and significant water bodies include ocean and the Great Lakes coast lines.

The locational variables we create are listed in Table 6. To create these measures, we first compute the geographic center (centroid) of each Census block boundary. The centroids of MSAs and urban areas are similarly computed and the distance between each census block and the closest MSA or urban area centroid is computed. Water and transportation features are left as line or polygon attributes in the GIS database and the distance between each Census block centroid and the closest point on each transportation or water feature polygon is computed.

Housing Characteristics

Data on individual housing units are obtained through access to confidential census micro-data at the Triangle Census Research Data Center (TCRDC). The micro-data contain the individual responses of homeowners to the U.S. Census Long Form. The Long Form was distributed to one in six households in the 1990 and 2000 census. The form collects information on the household's dwelling including the owner's assessment of the dwelling's value, size and a number of features that are important for characterizing home value (e.g., age of the structure and lot size). Importantly, the micro-level survey responses are identified by their census block, and thus allow us to determine the proximity of the house to an NWR with reasonable accuracy.

Our final sample of housing units includes only those whose census block centroid is within 3 miles of an NWR. We expect that the impacts of proximity to an NWR to be highly localized, and thus limit our sample accordingly. This selection criteria results in a total of 243,931 individual housing units being available for analysis surrounding the 93 NWRs. By region, the number of housing units available for analysis varies between a maximum of 71,281 for the Midwest and a minimum of 754 housing units for one sample in the Southwest region. The counts of housing units for each region are presented in the next section with the estimation results.

Table 7 lists the variables available for analysis from the micro-data. The summary statistics reported are not computed with the confidential micro-data, but are rather based on publicly available Census data. As a result, our summary statistics are based on block-group geography. Specifically, the average of the variable as reported for a block-group is computed over all block-groups within 3 miles of any NWR in our sample. For instance, the mean house value per block-group (which is publicly reported) is averaged across all block-groups within three miles of an NWR in each region.

The summary statistics indicate, not surprisingly, that mean house values surrounding our sample of NWRs are greatest in California/Nevada, and smallest in the Southeast. Population density is also greatest in California/Nevada and least in the Southeast. This is also reflected in the land-use coverage data we compute using satellite data which indicates that 62% of the land area within three miles of our NWRs are developed as either medium or high-density residential properties in the California/Nevada region, and 33% of the land is in these same two categories for the Northeast. The Southeast, which is least densely populated only has 11% of its land area being classified as either medium or high-density residential. We also note the high percentage of properties in the Northeast and Southeast that are vacant at the time of the Census, which is between March 15 and April 1, because they are for seasonal use. This reflects a high number of vacation homes surrounding the coastal NWRs in these two regions. Lastly, properties in the northeast tend to be closer to the NWRs (mean distance 1.46 miles) and closer to other National or State parks than in the other two regions.

Non-NWR Open Space Measures

The NWRs constitute one type of open space, but there are others that may confound the estimated impact of NWRs on residential property values if not properly accounted for in the analysis. These open spaces include local parks, regional parks, national parks, golf courses, cemetery, and agricultural land (cropland, forest, and pasture). We collect information on these types of open space from the 2001 National Land Cover Database (NLCD). The NLCD data set is developed using satellite imagery, in which 30-meter pixels are categorized into the proper land cover category. The NLCD is maintained by the Land Cover Institute in the U.S. Geological Survey (USGS) and downloadable from the USGS website.[7]

The original NLCD data are available in raster format and are converted to shapefile format to be compatible with the other geographic data used for this analysis. Due to large size of the raster data, we only convert the land coverage that is relevant to our study areas. Specifically, we create a 10 mile buffer around each of the NWRs of interest for this study, and also create a 10 mile buffer around each urban area near each of the NWRs. We then overlay the boundary created by these buffers with the land cover data to select just the raster data within 10 miles of NWRs and urban areas of interest. We then calculate the acreage or percentage of open space for each census track, block group and block for 10 land cover categories.

The 2001 NLCD reports 29 land cover categories on spatial grid of 30x30 meters. The classification scheme is presented in the first panel of Table 8. The 2001 NLCD are aggregated to form broader land cover types for use in our analysis. The aggregation scheme we used is reported in the second panel of Table 8. ArcGIS is then used to calculate the amount of each land cover classification that is represented in a census block (block-group) as a percent of the total land area of the census block (block-group). Area

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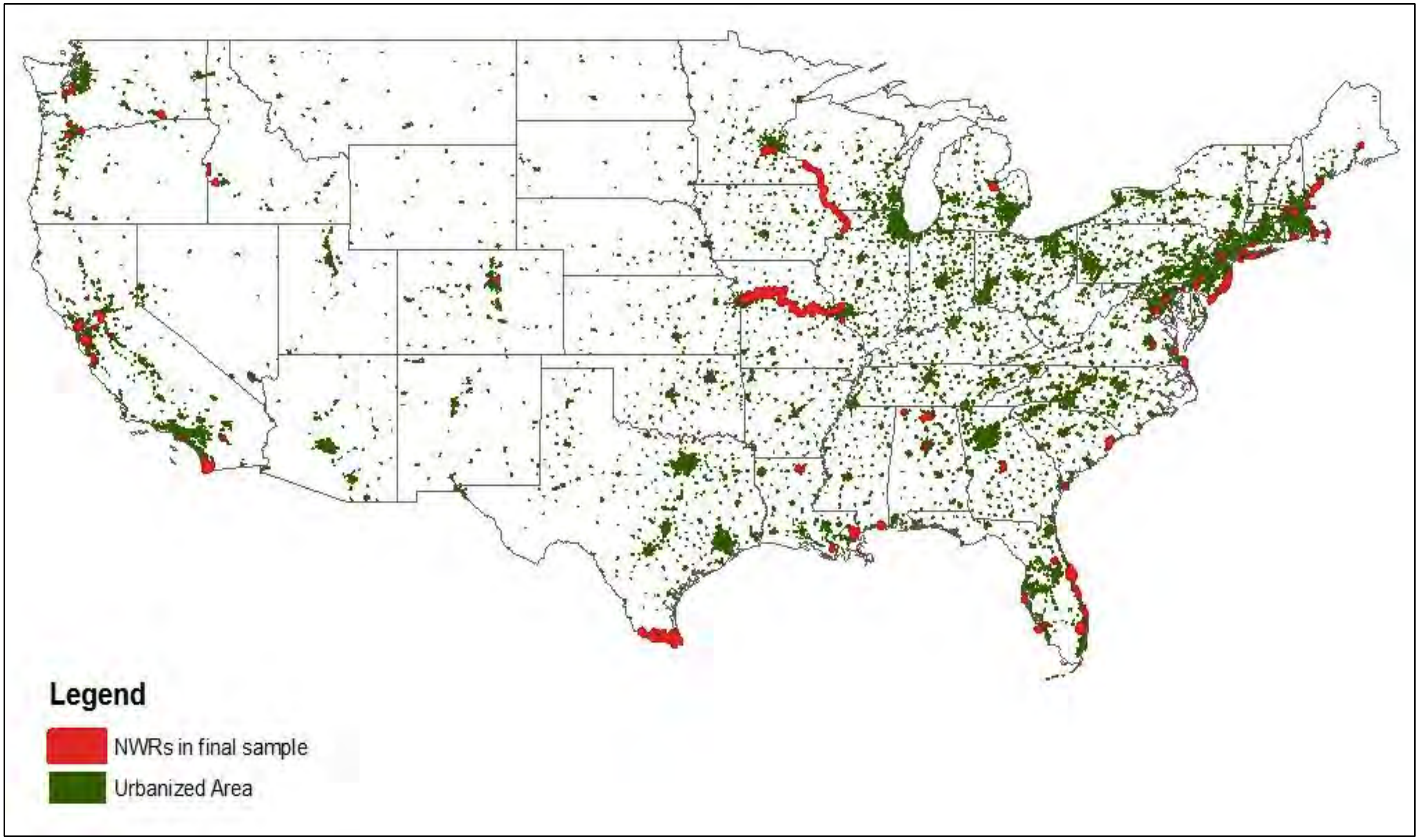
[7] http://www.mrlc.gov/index.php

calculations are carried out by measuring the geographic intersection of all blocks with each of the aggregated land cover classifications separately.[8] This produces ten new shapefiles that each include polygons of the respective land cover classification linked to a particular block. It is then straightforward to simply calculate the area of each of the new polygons. Finally, for blocks that include multiple noncontiguous polygons for a single land cover classifications, intersected polygons are linked by a unique block identifier and calculated areas are summed.

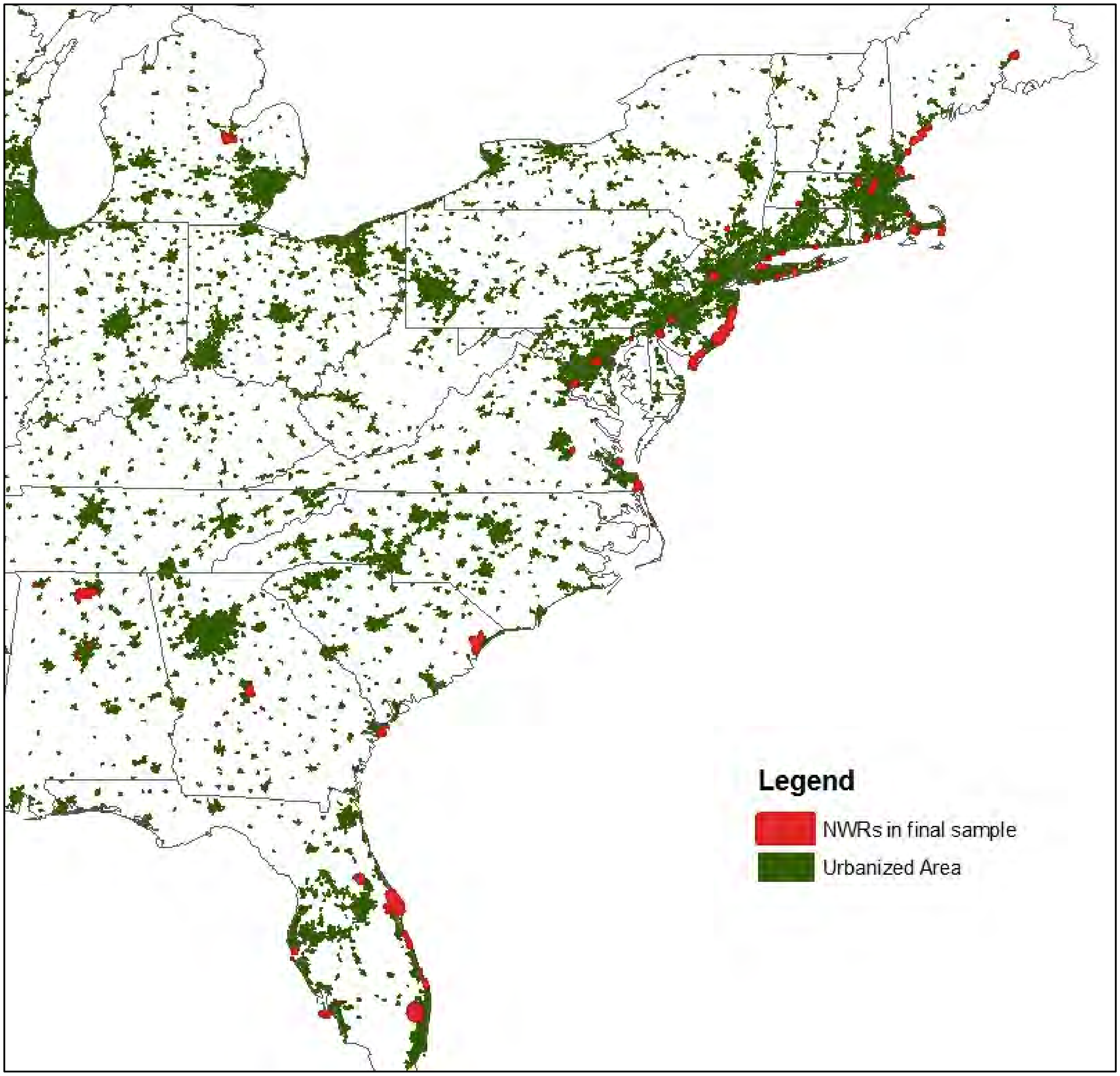
[8] GIS maps are projected using the Albers Equal Area Conic projection

Figure 1. Distribution of NWRs in Sample for the Lower-48 States.[a]



[a] NWR and Urbanized area boundaries are not to scale and are smaller than depicted on the maps.

Figure 2. Distribution of NWRs in Sample Along the East Coast.



[a] NWR and Urbanized area boundaries are not to scale and are smaller than depicted on the maps.

Figure 3. Map of Fish and Wildlife regions.

Source: U.S. Fish and Wildlife Service, http://www.fws.gov/where/, last accessed October 15, 2011.

Table 1: Summary of NWRs Used in Analysis by State[a]

State	Number	Acres	State	Number	Acres
Alabama	4	47,992	Minnesota	2	240,942
California	14	159,014	Mississippi	1	23,276
Colorado	2	15,942	Missouri	2	798,581
Connecticut	1	1,101	Nevada	1	9
Florida	12	331,527	New Jersey	4	100,190
Georgia	2	30,039	New Mexico	1	2
Idaho	1	11,318	New York	8	7,450
Illinois	2	230,508	Oregon	3	27,928
Iowa	1	225,889	Pennsylvania	1	1,136
Kansas	1	793,961	Rhode Island	2	1,189
Louisiana	6	91,783	South Carolina	2	52,949
Maine	2	18,876	Texas	3	251,230
Maryland	3	12,784	Virginia	6	22,751
Massachusetts	9	38,402	Washington	4	37,406
Michigan	2	94,783	Wisconsin	1	225,889

[a] Note, if an NWR crosses state boundaries it is included in the count for both states and thus the sum of NWRs in the table is more than 93.

Table 2: Summary Statistics for the NWRs in Study Area

Characteristics of the NWRs	
Mean total acres	24,934
(standard deviation)	(87,512)
Established before 1980	61%
Established before 1990	76%
Established before 2000	95%
Facilities or Services Available	
Open to public	76%
Open in spring	72%
Open in summer	49%
Open in fall	75%
Open in winter	52%
Have visitor facilities	53%
Have education programs	70%
Wildlife viewing	76%
Have nature trails	66%
Have auto tour route	26%
Are historic sites	16%
Have motor boating	23%
Don't have motor boating	43%
Fishing	57%
Hunting	48%
2000 Census Demographics of Closest Urbanized Area	
	Mean (standard deviation)
Total area (sq. mile)	688 (945)
Total population	2,640,934 (4,795,384)
Population density (sq. mile)	2,633 (1,356)
Total housing units	1,037,295 (1,834,805)
Housing density (sq. mile)	977,336 (1,741,742)

Table 3. NWRs with Boundaries Within Two Miles of an Urban Area Boundary (with population > 50,000)[a]

Region 1 "Northwest"	Region 2 "Southwest"	Region 3 "Midwest"	Region 4 "Southeast"	Region 5 "Northeast"	Region 6 "Central Mountains"	Region 8 "California/Nevada"
			States in which the NWRs are Located			
Oregon	Texas	Illinois	Alabama	Connecticut	Colorado	California
Washington		Michigan	Arkansas	Massachusetts		Nevada
Idaho		Minnesota	Florida	Maryland		
		Missouri	Georgia	Maine		
		Wisconsin	Kentucky	New Jersey		
			Louisiana	New York		
			Mississippi	Pennsylvania		
			North Carolina	Rhode Island		
			South Carolina	Virginia		
			Tennessee			
			National Wildlife NWRs Within Two Miles of an Urban Area			
Deer Flat	Laguna Atascosa	Big Muddy	Archie Carr	Back Bay	Rocky Mtn. Arsenal	Antioch Dunes
McNary	Lower Rio Grande	Middle Mississippi	Arthur R. Marshall Loxahatchee	Cape May	Two Ponds	Coachella Valley
Nisqually	Santa Ana	Minnesota Valley	Bayou Sauvage	Conscience Point		Desert
Ridgefield		Shiawassee	Big Branch Marsh	Edwin B. Forsythe		Don Edwards San Francisco
Steigerwald Lake		Upper Mississippi	Black Bayou Lake	Elizabeth Alexandra Morton		Ellicott Slough
Tualatin River			Bond Swamp	Featherstone		Marin Islands
			Caloosahatchee	Great Meadows		North Central Valley
			D'arbonne	Great Swamp		Salinas River
			Hobe Sound	John H. Chafee		San Diego Bay
			J.N. 'Ding' Darling	John Heinz		San Diego
			Key Cave	Lido Beach Mgmt.		San Joaquin River
			Lake Woodruff	Mashpee		San Pablo Bay
			Mandalay	Mason Neck		Seal Beach

(continued, next page)

Region 1 "Northwest"	Region 2 "Southwest"	Region 3 "Midwest"	Region 4 "Southeast"	Region 5 "Northeast"	Region 6 "Central Mountains"	Region 8 "California/Nevada"
			Matlacha Pass	Massasoit		Stone Lakes
			Merritt Island	Monomoy		Tijuana Slough
			MS Sandhill Crane	Occoquan Bay		
			Passage Key	Oxbow		
			Pelican Island	Oyster Bay		
			Pinellas	Parker River		
			St. Johns	Patuxent Research		
			Tybee	Plum Tree Island		
			Waccamaw	Presquile		
			Wassaw	Rachel Carson		
			Watercress Darter	Sachuest Point		
			Wheeler	Seatuck		
				Shawangunk Grasslands		
				Silvio O. Conte		
				Stewart B. Mckinney		
				Sunkhaze Meadows		
				Supawna Meadows		
				Susquehanna		
				Target Rock		
				Thacher Island		
				Wertheim		

[a] This list also excludes NWRs created after 2000. The final regression samples include fewer NWRs than listed in this table. Often NWR boundaries extend away from urban centers, and thus homes located near one part of an NWR can be quite far from developed areas, while homes located near other parts of the same NWR may be near the urbanized core. Models that restrict the proximity of the homes to be within a certain distance of the urban center have fewer NWRs than reported here.

Table 4: Publicly Available Census Block Characteristics

Variable Name	Definition
Pop	Block population
Per_white	Percent of population reporting white race only
Per_black	Percent of population reporting black race only
Per_other	Percent of population reporting Asian, American Indian, other race, or multiracial
Per_hisp	Percent of population of Hispanic descent
Per_hsize#	Percent of families comprised of # individuals, where # = 1, 2 ,…, 7
Per_child	Percent of families with children under age 18
Units	Number of housing units
Per_ownocc	Percent of housing units occupied by owner
Per_vac	Percent of housing units unoccupied

* All variables are created from the 2000 U.S. Census Summary File 1

Table 5: Publicly Available Census Block Group Characteristics

Variable Name	Defintion
Pop	Block population
Per_white	Percent of population reporting white race only
Per_black	Percent of population reporting black race only
Per_other	Percent of population reporting Asian, American Indian, other race, or multiracial
Per_hisp	Percent of population of Hispanic descent
Per_hsize#	Percent of households comprised of # individuals, where # = 1, 2 ,..., 7
Units	Number of housing units
Per_ownocc	Percent of housing units occupied by owner
Per_vac	Percent of housing units unoccupied
HHolds	Number of households
Value_xx	Percent of households in unit with value interval 'xx', where intervals are 0- 9,999; 10,000-14,999; 15,000-19,999; 20,000-24,999; 25,000-29,999; 30,000- 34,999; 35,000-39,999; 40,000-49,999; 50,000-59,999; 60,000- 69,999; 70,000- 79,999; 80,000- 89,999; 90,000 – 99,999; 100,000- 124,999; 125,000- 149,999; 150,000- 174,999; 175,000- 199,999; 200,000- 249,999; 250,000- 299,999; 300,000-399,999; 400,000- 499,999; 500,000- 749,999; 750,000 - 999,999; 1,000,000+
Inc_xx	Percent of housholds in income interval 'xx', where intervals are 0- 19,999; 10,000-14, 999; 15,000-19,999; 20,000-24,999; 25,000-29,999; 30,000- 34,999; 35,000-39,999; 40,000-44,999; 45,000-49,999; 50,000-59,999; 60,000-74,999; 75,000-99,999; 100,000-124,999; 125,000-149,999; 150,000- 199,999; 200,000+
HHinc	Mean household income

* All variables are created from the 2000 U.S. Census Summary File 3

Table 6: Locational Characteristics of Census Blocks

Variable Name	Definition
Dist_NWR	Distance from block centroid to nearest NWR boundary
Dist_UA*	Distance from block centroid to nearest urban area centroid
Dist_MSA*	Distance from block centroid to nearest MSA centroid
Dist_water†	Distance from block centroid to nearest ocean or great lake coast
Dist_trans‡	Distance from block centroid to nearest interstate highway
Dist_parks‡	Distance from block centroid to nearest federal or state park boundary

* Data obtained from U.S. Census: http://www.census.gov/geo/www/cob/bdy_files.html
† Data created using NLCD classification and National Hydrography Dataset: http://www.horizon-systems.com/nhdplus/data.php
‡ Data obtained from Geolytics through North Carolina State University Library

Table 7. Census Long-Form Housing Data

Variable Name	Variable Definition	Northeast Mean	Northeast Std. Dev.	Southeast Mean	Southeast Std. Dev.	Southwest Mean	Southwest Std. Dev.
	Housing Characteristics						
House value	Owner occupied median value (in $1,000s)	195.2	148.8	114.6	101.0	258.9	190.9
Median rooms	Median number of rooms	6.00	1.17	5.44	0.83	5.02	1.21
Mean bedrooms	Mean number of bedrooms	2.81	0.50	2.64	0.41	2.49	0.66
Built 99-00	% built 1999-March 2000	0.01	0.03	0.03	0.05	0.02	0.08
Built 95-98	% built 1995-1998	0.04	0.06	0.09	0.11	0.05	0.11
Built 90-94	% built 1990-1994	0.05	0.07	0.09	0.09	0.07	0.12
Built 80-89	% built 1980-1989	0.13	0.13	0.23	0.16	0.16	0.17
Fuel Type: Gas	% with heating fuel as Gas	0.42	0.27	0.25	0.27	0.64	0.23
Fuel Type: Elec	% with heating fuel as Electricity	0.13	0.16	0.58	0.25	0.27	0.20
	Neighborhood Characteristics						
Pop. Density	Population density (1,000/sq mile)	5.03	6.84	1.91	2.03	7.79	7.08
Family Size	Average family size	4.81	19.26	3.66	0.67	4.35	3.64
Children	% population 18 year or under	0.26	0.08	0.25	0.09	0.27	0.09
Seniors	% population 65 year or above	0.15	0.11	0.17	0.14	0.12	0.11
Household income	Median household income ($1,000)	57.9	29.2	41.9	19.2	55.8	26.8
Owner occupied	% housing units that are owner occupied	0.63	0.24	0.65	0.20	0.57	0.26
Vacant, seasonal	% vacant for seasonal, recreational, or occasional use	0.35	0.39	0.27	0.32	0.16	0.28
Vacant, sale	% vacant for sale	0.17	0.27	0.22	0.28	0.25	0.35
Vacant, rent and other	% vacant for rent, migrant workers or other reasons	0.38	0.37	0.42	0.34	0.47	0.40
Single family detached	% housing units that are single family detached	0.63	0.34	0.68	0.26	0.59	0.32
Apartments	% housing units that are apartments	0.23	0.26	0.17	0.21	0.28	0.28

continued, next page

Variable Name	Variable Definition	Northeast Mean	Northeast Std. Dev.	Southeast Mean	Southeast Std. Dev.	Southwest Mean	Southwest Std. Dev.
	Land-use Characteristics						
Water	% land as open water	0.01	0.02	0.02	0.04	0.00	0.02
Open space	% land as developed open space	0.13	0.13	0.21	0.17	0.09	0.11
Medium density residential	% land as developed medium density residential	0.22	0.21	0.09	0.11	0.51	0.26
High density residential	% land as developed high density residential	0.11	0.18	0.02	0.04	0.11	0.14
Forest	% land as forest	0.18	0.21	0.11	0.16	0.01	0.04
Shrubs and grassland	% land as shrubs and grasslands	0.01	0.02	0.03	0.05	0.06	0.14
Pasture and cropland	% land as pasture and cropland	0.05	0.10	0.06	0.12	0.03	0.14
Wetlands	% land as wetlands	0.09	0.14	0.17	0.21	0.01	0.03
distmile_park[a]	Distance in miles of a block centroid to the nearest Federal or State park boundary	5.16	4.04	10.74	14.11	13.12	8.21
distmile_tran[a]	Distance in miles of a block centroid to the nearest transportation infrastructure	2.69	2.35	8.56	12.76	2.34	3.24
distmile_water[a]	Distance in miles of a block centroid to the boundary of the nearest ocean or Great Lake	9.91	14.54	4.61	6.83	8.14	14.24
distmile_nwr[a]	Distance in miles of a block centroid to the boundary of the nearest NWR	1.46	0.89	1.73	0.84	1.72	0.83
distmile_ua[a]	Distance in mile of a block centroid to the center of the nearest urban area	17.61	8.64	8.56	4.95	12.59	7.51

[a] Summary statistics measured at the block level.

Table 8: NLCD Land Cover Class Definitions and Aggregation

Panel A: NLCD 2001 Codes

Code	Class	Code	Class
11	Open Water	73	Lichens
12	Perennial Ice/Snow	74	Moss
21	Developed, Open Space	81	Pasture/Hay
22	Developed, Low Intensity	82	Cultivated Crops
23	Developed, Medium Intensity	90	Woody Wetlands
24	Developed, High Intensity	91	Palustrine Forested Wetland
31	Barren Land (Rock/Sand/Clay)	92	Palustrine Scrub/Shrub Wetland
32	Unconsolidated Shore	93	Estuarine Forested Wetland
41	Deciduous Forest	94	Estuarine Scrub/Shrub Wetland
42	Evergreen Forest	95	Emergent Herbaceous Wetlands
43	Mixed Forest	96	Palustrine Emergent Wetland
51	Dwarf Shrub	97	Estuarine Emergent Wetland
52	Shrub/Scrub	98	Palustrine Aquatic Bed
71	Grasslands/Herbaceous	99	Estuarine Aquatic Bed
72	Sedge/Herbaceous		

Panel B: NLCD Aggregated Categories

Aggregated Category Number	Aggregated Category Name	Codes From Original NLCD 2001 (Panel A)
10	Open Water	11
21	Developed, Open Space	21
22	Developed, Low Intensity	22
23	Developed, Medium Intensity	23
24	Developed, High Intensity	24
30	Rock, Sand and Perennial Ice	12, 31, 32
40	Forest	41, 42, 43
50	Shrubs and Grassland	51, 52, 71 – 74
60	Pasture and Cropland	81, 82,
70	Wetlands	90 – 99

3. Econometric Models and Results

Hedonic Model

We employ hedonic models to estimate the impact of proximity to an NWR on housing value. Hedonic modeling is a method for valuing component characteristics of a heterogeneous or differentiated good or product. Heterogeneous goods are those whose characteristics vary in such a way that there are distinct product varieties even though the commodity is sold in one market (e.g., cars, computers, houses). The variation in product variety gives rise to variations in product prices within each market. The hedonic method for non-market valuation relies on market transactions for these differentiated goods to determine the value of key underlying characteristics. For instance, by observing the price differential between two product varieties that vary only by one characteristic (e.g., two identical cars, but with one having more horsepower than the other), we indirectly observe the monetary trade-offs individuals are willing to make with respect to the changes in this characteristic. As such, the hedonic method is an "indirect" valuation method in which we do not observe the value consumers have for the characteristic directly, but infer it from observable market transactions.

Analyzing the choices households make over housing is particularly well suited to hedonic modeling. The choices of housing location, and therefore neighborhood amenities, are observable. In our case, location choice is directly linked to the open-space benefits that proximity to an NWR can confer to homeowners. As such, the choice of a house and its associated price implies an implicit choice over the environmental amenities linked to the house and their implicit prices.

As with any empirical investigation, the validity of the hedonic estimates of the value of an amenity relies on the quality of the data upon which the results are based. Perhaps the most important threat to the validity of the empirical results is the potential for there to be important omitted variables that are correlated with housing prices and the amenity of interest (proximity to open space in our case). In an attempt to mitigate the potential for spatially-varying unobservable characteristics, we include a rich set of variables that describe the land-use characteristics around a home and its proximity to other amenities/disamenities. In addition, following Kuminoff and Pope (2010), we employ census tract and NWR fixed-effects in a further attempt to capture potential spatially-varying unobservables. For a detailed review of the hedonic method please see Taylor (2002, 2008) and Palmquist (2003).

More formally, the hedonic model regresses housing price (or value) on the component characteristics of the housing, including neighborhood and location attributes. The base hedonic regression model we use is given in equation (1):

$$lnP \quad \alpha \quad i\beta_1 Distance \quad \beta_2 Distance^2 \quad NWR^{Ci}\eta \quad H\,\delta \quad Ni\gamma$$
$$G\;\theta i \quad C\,\text{Ü} \qquad {}_R \qquad \varepsilon\,, \tag{1}$$

where the natural log of housing price for the i^th house is regressed on the distance of the house to the boundary of the nearest NWR (*Distance*), a vector of NWR characteristics (NWR^C), a vector of housing characteristics describing the i^th house (H_i), a vector of neighborhood characteristics measured at the block-level (N_b), a vector of geographic descriptors of the census block in which the house is located (G_b), a vector of variables that describe the land-use cover of the block-group in which the house is located (C_{bg}), a vector of NWR fixed effects (φ_{NWR}), and a vector of census tract fixed effects (τ_{tr}). The coefficients α, β, η, δ, γ, θ, and μ are to be estimated, and ε_i is an error term.[9]

Each of the variables that are used in our final regression models are described in Table 9, and organized in a manner similar to equation (1). Although not presented in Table 9, we always allow the natural log of house value to vary non-linearly with continuous variables such distance to an NWR, the number of bedrooms, or proximity to a highway by including a squared-term of the continuous variable. We write this out explicitly for the distance to an NWR variable (*Distance*) in equation (1).

Given a specification for the hedonic model as in equation (1), we expect a negative coefficient estimate for β_1 because we expect housing value to decrease (or at least not increase), all else equal, the further a house is from an NWR. A positive estimate for β_2 is expected because we expect the effect of moving further away from an NWR to dissipate the further a house's baseline distance is to an NWR. For instance, we expect the effect of a house being located ½ mile further from an NWR to be larger for houses very close to NWRs as compared to houses that are already located 2 or more miles away from the NWR.

[9] All models use robust standard errors that allow for an unknown form of heteroskedasticity.

We consider other ways to model how house value varies with distance to an NWR. Rather than specifying the value/distance relationship through a quadratic distance term, we also estimate a model in which proximity to an NWR is measured in intervals. We develop six one-half mile intervals, and create a series of categorical variables that indicate the distance interval in which a house is located. These variables are listed in Table 9 as D0.5, D1.0, D1.5, D2.0, D2.5 and D3.0. The associated regression model is this case is:

$$lnP \quad \alpha \quad \beta_1 D0.5 \quad \beta_2 D1.0 \quad \beta_1 D1.5 \quad \beta_1 D2.0 \quad \beta_1 D2.5 \qquad (2)$$
$$H\delta \quad Ni\gamma \quad G\ \theta i \quad Ci \qquad {}_{Ri} \qquad i\varepsilon\ ,$$

where D0.5, D1.0, D1.5, D2.0, D2.5 are as defined in Table 9, and the rest is as defined for equation (1). As indicated in equation (2), D3.0 is the category left out of the model. Thus, for houses located within 0.5 of an NWR, β_1 represents the percentage increase in price given a house is within 0.5 as compared to being located between 2.5 and 3.0 miles from the NWR.

Equations (1) and (2) comprise our baseline models. We estimate these two specifications for each Fish and Wildlife Service region in the U.S..

Baseline Regression Results

In this section, we present and discuss results for Regions 4, 5, and 8, which we refer to as the “Southeast”, “Northeast”, and “California/Nevada”, respectively, for ease of exposition. Results for the other four regions are presented in Appendix A. In these other regions, we are unable to detect positive and statistically significant impacts of NWRs on local housing values. We discuss our hypotheses about why this may be the case for each region in Appendix A.

Tables 10 and 11 present the full results for the models in equation (1) and (2), respectively. Note, coefficients for categorical variables except those related to proximity to an NWR or characteristics of an NWR are suppressed for confidentiality reasons.[10] The models presented in Tables 10 and 11 include all homes within 3 miles of an NWR that are also within 8 miles of the centroid of an urban area. This latter restriction is imposed because some NWRs are quite large, and homes near one portion of the NWR can be near an urbanized area, while homes

[10] Coefficient estimates for categorical variables are possible to disclose, but require additional screening by the Census Bureau. As a result, we only requested release of results for key categorical variables.

surrounding other parts of the NWR can be in rural areas where we do not expect the open space amenity of the NWR to be capitalized into housing values. We examine the sensitivity of our models to this restriction after presenting the baseline results.

First, we discuss the overall model results. Generally, coefficients have the expected sign and are consistent across regions. Over the relevant range for housing size (2 or more rooms, 1 or more bedrooms), increases in house size increase value.[11] We find that increasing the population density of a census block in which a house is located decreases housing value, all else equal. Homes increase in value as the income of the neighborhood increases, and homes are higher valued in blocks in which there is a greater proportion of housing units that are vacant because they are for seasonal use. Given the large proportion of NWRs that are coastal, this is not surprising.

The geographic descriptor variables are not statistically significant in general. This is not surprising given all models include fixed-effects for the census tract in which a house is located, which controls for all time-invariant characteristics of the census tract (such as proximity to a national park). There are not consistent patterns in the impact of our measure of land-use cover across regions. For example, the models indicate that increasing the percentage of cropland or wetlands in a census block-group in the southeast increases housing values, while the opposite is true in the California/Nevada region.

Lastly, we find inconsistent results across regions (and models) for two variables that describe NWR characteristics: visitation rates and whether or not the NWR has an automobile touring route. There are several difficulties with these variables that likely lead to these results. First, we include in all models NWR fixed-effects which makes it difficult to identify the impacts of auto-tour routes separately since it is a categorical variable with little variation in the sample (very few NWRs have touring routes). Secondly, visitation rates for NWRs were provided to us by Fish and Wildlife Service based on best-available estimates. However, even casual inspection of this data indicates that these data are likely to suffer from significant measurement error. There are many NWRs with implausibly large values given their size, and some NWRs with implausibly low numbers given their size, proximity to urban areas, and that they are open to the public. As a result, unstable coefficient estimates are not surprising. Importantly, we estimate

[11] Results for the other housing characteristic variables – lot-size, fuel-type and age of the structure – have been suppressed for confidentiality reasons.

all models without these two variables to examine whether they have any influence on the magnitude or significance of the variables capturing proximity to an NWR. They have absolutely no impact on the coefficients describing distance to the NWRs, thus indicating no collinearity problems.

Turning to the key variable – proximity of a house to an NWR – we find results that are consistent across regions and consistent with our expectations. Table 10 indicates that houses further from an NWR decrease in value, although this effect diminishes over space as houses are further from the NWR (as indicated by the positive coefficient for Distance, squared). More specifically, results indicate that the proximity effects of being close to an NWR diminish to zero at approximately two miles from an NWR for the Northeast and Southeast and 2.5 miles for California/Nevada. Among the three regions, the impact of proximity to an NWR is strongest in the Southeast.

Table 11 reports the results from the model presented in equation (2). In this model, the effects of proximity to an NWR are allowed to vary in half-mile increments. These results highlight the nonlinearity of the effects of proximity to an NWR. For all regions, being within 0.5 miles of an NWR increases property value relative to the baseline (2.5-3 miles away), but this is the only location category for which proximity effects are apparent.

We now examine the robustness of the distance/value relationship to the sample of houses used in estimation. Tables 12 and 13 present key coefficient estimates for models that are identical to those presented in Tables 10 and 11, but which vary by the sample of houses used in the estimation. All houses in each sample still lie within 3 miles of the boundary of an NWR, but we vary how close a house can be to the center of the nearest urbanized area. In particular, we present models in which houses are within 5, 8, 10, or 15 miles of an urban area. We also present an unrestricted model in which houses may lie at any distance from an urban area, so long as the house is still within 3 miles of the border of one of our sample of NWRs.

As indicated in Tables 12 and 13, the proximity impacts of being near an NWR are strongest for models that rely on samples closer to urban centers. For samples up to 8 miles from the urban core, all regions show statistically significant impacts of proximity to an NWR in both the continuous and categorical distance models.[12] Models relying on continuous distance measures (Table 12) imply statistically significant proximity impacts up to 10 miles away, but as

[12] The exception is the Southeast region for which significant impacts are found in all models.

indicated in Table 12, the magnitude of the effect diminishes the broader the sample relative to the urban core. These results are consistent with our expectations that proximity to open space will be capitalized into areas where open space is relatively scarce in the first place.

<u>Alternative Specifications for the Value/Distance Relationship</u>

We now explore additional ways to model the relationship between the value of a house and its proximity to an NWR. For each region, we estimate the following three additional hedonic model specifications:

$$lnP \quad \alpha \quad \beta_1 lnDistance \quad NWR^{Ci}\eta \quad H\delta \quad Ni\gamma \quad G\ \theta i \quad C\,\text{Ü} \qquad {}_R \qquad \varepsilon\,, \qquad (3)$$

$$lnP \quad \alpha \quad \beta_1 Dist\_0.5 \quad NWR^{Ci}\eta \quad H\delta \quad Ni\gamma \quad G\ \theta i \quad C \qquad {}_R \qquad \varepsilon\,, \qquad (4)$$

$$lnP \quad \alpha \quad \beta_1 Dist\_1.0 \quad NWR^{Ci}\eta \quad H\delta \quad Ni\gamma \quad G\ \theta i \quad C\,\text{Ü} \qquad {}_{Ri} \qquad \varepsilon\,, \qquad (5)$$

where *lnDistance* is the natural log of distance to the NWR, *Dist_0.5* is a dummy variable equal to one if the house is within 0.5 miles of an NWR and equal to zero otherwise, and *Dist_1.0* is a dummy variable equal to one if a house is within one mile of an NWR and equal to zero otherwise. The model in equation (4) is identical to that in equation (2), except the comparison homes for those within 0.5 miles of an NWR are all other homes (i.e., those between 0.5 and three miles from an NWR). Similarly, in equation (5), all homes within one mile of an NWR are being compared to homes between one and three miles of an NWR.

Results for the models in equations (3) to (5) are presented in Table 14. We report models for three housing samples that vary according to whether the sample is within 5, 8, or 10 miles of the center of an urban area. As indicated in Table 14, the results are consistent with those reported earlier. Again, the estimated impact of proximity to an NWR is largest for 5 mile sample, and diminishes as we expand the sample to include homes further from the urban core. Also, the estimated impacts of proximity are smaller for models including *Dist_1.0* as compared to the models including *Dist_0.5*. This latter result is consistent with the results reported in Table 13 indicating that the category *D0.5* is positive and statistically significant, while *D1.0* is not significant.

Summary of Regression Results

Overall, we find the models to be reasonably consistent with expectations. Models that are based on housing samples lying closer to urban centers indicate larger impacts of proximity to an NWR on housing value. This result is consistent with our expectation that open space amenities would be capitalized into housing values in areas where open space, especially permanently protected open space, is scarce. The results also indicate the strongest impacts for NWRs on surrounding property values are in the Southeast. This sample is dominated by NWRs in Florida, and the open space premium associated with coastal NWRs appears to be significant.

The choice of continuous versus categorical specifications for describing the relationship between housing values and proximity does not affect the results qualitatively, although there is some sensitivity quantitatively as would be expected. The coefficients on the categorical variables do, however, indicate that proximity effects are highly localized and limited generally to less than a mile from an NWR.

Overall, our results suggest that properties within one-half mile of an NWR are valued between five to ten percent higher than homes further away. Our range is consistent with Boyle, Paterson and Poor (2002) and Neumann, Boyle and Bell (2009) who find that homes adjacent to the Great Meadows NWR sell for approximately 7% more than homes approximately a mile further from the NWR. Lutzenhiser and Netusil (2000) report a larger increase than what we find on average for homes located very close to natural areas. Specifically, they find a 16% increase in value for homes located within 1,500 feet (approximately one-quarter mile) of a natural area. Our closest analytical unit is one-half mile, perhaps giving rise to our somewhat smaller measures – although in some models for some regions (the Southeast), we find impacts approximating Lutzenhiser and Netusil. Conversely, Anderson and West (2003) find a value slightly below our range, suggesting a 4.64% price increase for homes located one-half mile closer to preservation-style parks.

Table 9. Variables Used in Hedonic Analysis

Variable Name	Variable Definition	Source
Proximity of a house to an NWR		
Distance	Distance, in miles, of the centroid of a census block in which the house is located to the boundary of an NWR	User created using ArcMap geospatial software.
D0.5	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is [0 0.5] miles; =0 otherwise.	User created.
D1.0	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is (0.5, 1] miles; =0 otherwise.	User created.
D1.5	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is (1, 1.5] miles; =0 otherwise.	User created.
D2.0	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is (1.5, 2] miles; =0 otherwise.	User created.
D2.5	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is (2, 2.5] miles; =0 otherwise.	User created.
D3.0	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is (2.5, 3] miles; =0 otherwise.	User created.
ln(Distance)	natural log of the distance, in miles, of the centroid of a census block in which the house is located to the boundary of an NWR	User created.
Dist_0.5	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is [0, 0.5] miles; =0 otherwise. This variable is used in models when the left-out category is all homes between 0.5 and 3 miles.	User created.
Dist_1.0	Categorical variable =1 if the distance between the centroid of the census block to an NWR boundary is [0, 1] miles; =0 otherwise. This variable is used in models when the left-out category is all homes between 1 and 3 miles.	User created.
NWR Characteristics		
ln(visitation rates)	Natural log of the reported visitation rates at each NWR for the year 2000	Fish and Wildlife Service, correspondence with Kevin Kilcullen
Auto-tour route	Categorical variable =1 if the NWR has an auto-tour route; =0 otherwise.	Fish and Wildlife Service, correspondence with Kevin Kilcullen
Housing Characteristics (H_i)		
Total rooms	Total number of rooms in housing unit.	2000 Dicennial Census,

		Confidential Microdata File
Total bedrooms	Total number of bedrooms in housing unit.	2000 Dicennial Census, Confidential Microdata File
One acre	Categorical variable =1 if the housing unit is on a lot less than 1 acre; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
One to ten acres	Categorical variable =1 if the housing unit is on a lot greater than one and less than ten acres; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Ten acres	Categorical variable =1 if the housing unit is on a lot greater than 10 acres; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Built 99-00	Categorical variable =1 if the housing unit was built between 1999 and 2000; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Built 95-98	Categorical variable =1 if the housing unit was built between 1995 and 1998; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Built 90-94	Categorical variable =1 if the housing unit was built between 1990 and 1994; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Built 80-89	Categorical variable =1 if the housing unit was built between 1980 and 1989; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Fuel type 1	Categorical variable =1 if the housing unit has heating fuel delivered via underground pipes serving the neighborhood; =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Fuel type 2	Categorical variable =1 if the housing unit has electricity as the main source of heating fuel =0 otherwise.	2000 Dicennial Census, Confidential Microdata File
Neighborhood Descriptions (N_b)		
Arealand	Area of the census block in which the housing unit is located (in square miles).	User created using ArcMap geospatial software.
Med. population density	Population density of the census block in which the housing unit is located (1,000 people/sq. mile).	2000 Dicennial Census, Confidential Microdata File
Med. family size	Median family size in the census block.	2000 Dicennial Census, Confidential Microdata File
Med. children	Median number of children 18 or under in the census block.	2000 Dicennial Census, Confidential Microdata File
Med. seniors	Median number of people 65 and over in the census block.	2000 Dicennial Census, Confidential Microdata File
Med. household income	Median household income in the census block ($1,000)	2000 Dicennial Census, Confidential Microdata File
Owner Occupied	Percent of housing units in the census block that are owner occupied.	2000 Dicennial Census, Confidential Microdata File
Vacant, Seasonal	Percent of housing units in the census block that are vacant for seasonal, recreational, or occasional use.	2000 Dicennial Census, Confidential Microdata File
Vacant, Sale	Percent of housing units in the census block that are vacant and for sale.	2000 Dicennial Census, Confidential Microdata File
Vacant, Rent and Other	Percent of housing units in the census block that are vacant and for rent, occupancy by migrant workers, or other reasons.	2000 Dicennial Census, Confidential Microdata File
Single-family Detached	Percent of housing units in the census block that are single-family detached housing units.	2000 Dicennial Census, Confidential Microdata File

Apartments	Percent of housing units in the census block that are apartment units.	2000 Dicennial Census, Confidential Microdata File
Geographic Descriptors (G_b)		
D_UA	Distance, in miles, of the centroid of a census block to the centroid of an Urbanized Area	User created using ArcMap geospatial software.
D_park	Distance, in miles of the centroid of a block to the nearest state or federal park	User created using ArcMap geospatial software.
D_highway	Distance, in miles, of the centroid of a block to nearest interstate highway.	User created using ArcMap geospatial software.
D_water	Distance, in miles, of the centroid of a block to nearest water body (ocean or Great Lake).	User created using ArcMap geospatial software.
Land-use Cover in Block-group (C_{bg})		
Open Water	Percent of block group that is open water.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.
Developed Open Space	Percent of block group that is developed open space.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.
Med. Density Residential	Percent of block group that is developed medium density residential.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.
High Density Residential	Percent of block group that is developed high density residential.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.
Forest Cover	Percent of block group that is forest.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.
Grassland	Percent of block group that is shrubs and grasslands.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.
Cropland	Percent of block group that is pasture and cropland.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.
Wetland	Percent of block group that is wetlands.	User created in ArcMap geospatial software using the 2001 NLCD, U.S. Geological Survey.

Table 10. Baseline Results Continuous Distance Specification.

Variable	Northeast	Southeast	California/Nevada
	coefficient (standard error)[b]		
Proximity of a house to an NWR			
Distance	-0.0744***	-0.186***	-0.0620**
	(0.0274)	(0.0287)	(0.0293)
Distance, squared	0.0209***	0.0518***	0.0126
	(0.00802)	(0.00793)	(0.00789)
NWR Characteristics			
ln(visitation rates)	-0.0698***	0.0441**	0.0868***
	(0.0162)	(0.0208)	(0.0135)
Auto-tour route	positive**	-0.439***	negative
	p<0.05	(0.166)	p>0.10
Housing Characteristics			
Total rooms	0.0114	-0.0146	-0.0228
	(0.0252)	(0.0231)	(0.0167)
Total rooms, squared	0.00576***	0.00836***	0.00685***
	(0.00186)	(0.00175)	(0.00128)
Total bedrooms	0.0206	-0.0461	0.0204
	(0.0343)	(0.0345)	(0.0201)
Total bedrooms, squared	0.00595	0.0195***	0.00333
	(0.00517)	(0.00526)	(0.00297)
Neighborhood Descriptions			
Arealand	0.00261	0.00396	0.0314**
	(0.0265)	(0.0101)	(0.0143)
Arealand, squared	-0.00897	-0.00109*	-0.00388**
	(0.0103)	(0.000609)	(0.00160)
Med. population density	-0.00880***	-0.00770***	-0.00586***
	(0.00148)	(0.00134)	(0.000808)
Med. population density, squared	8.12e-05***	2.14e-05***	4.05e-05***
	(1.36e-05)	(3.82e-06)	(5.29e-06)
Med. family size	-0.0211	0.0341**	-0.00897
	(0.0170)	(0.0165)	(0.0132)
Med. family size, squared	-0.00105	-0.00795***	0.00113
	(0.00274)	(0.00261)	(0.00209)
Med. children	0.00119	-0.0214**	-0.00944
	(0.00891)	(0.00848)	(0.00622)
Med. seniors	0.0298***	0.00425	0.0309***
	(0.00875)	(0.00824)	(0.00751)
Med. household income	0.00249***	0.00360***	0.00143***
	(0.000199)	(0.000236)	(0.000158)

Med. household income, squared	-2.25e-06***	-2.94e-06***	-5.65e-07**
	(2.55e-07)	(3.53e-07)	(2.81e-07)
Owner Occupied	-0.147	0.0501	0.00217
	(0.141)	(0.152)	(0.0940)
Owner Occupied, squared	0.106	0.0378	0.0663
	(0.0931)	(0.0983)	(0.0627)
Vacant, Seasonal	0.557***	0.782***	0.849***
	(0.114)	(0.199)	(0.146)
Vacant, Seasonal, squared	0.00252	-0.0217	-0.135
	(0.188)	(0.480)	(0.296)
Vacant, Sale	0.182	0.594***	0.0454
	(0.205)	(0.195)	(0.164)
Vacant, Sale, squared	-0.196	-1.030*	0.196
	(0.538)	(0.548)	(0.474)
Vacant, Rent and Other	0.278	0.582***	0.352***
	(0.188)	(0.160)	(0.126)
Vacant, Rent and Other, squared	-0.222	-0.930***	-0.106
	(0.537)	(0.350)	(0.340)
Single-family Detached	-0.00609	-0.151**	-0.0501
	(0.0333)	(0.0748)	(0.0346)
Apartments	-0.0285	-0.0319	0.0439
	(0.0498)	(0.0915)	(0.0462)
Geographic Descriptors			
D_UA	0.00766	0.0643***	-0.0817***
	(0.0191)	(0.0188)	(0.0209)
D_UA, squared	0.00273	-0.00408**	0.00505**
	(0.00186)	(0.00185)	(0.00246)
D_park	-0.00158	-0.00217	-0.000727
	(0.00236)	(0.00274)	(0.00384)
D_park, squared	3.89e-05*	2.90e-05	1.59e-05
	(2.21e-05)	(2.59e-05)	(0.000110)
D_highway	-0.00123	0.00388	0.00292
	(0.00219)	(0.00269)	(0.00205)
D_highway, squared	8.31e-06	-4.72e-05	-2.65e-05
	(2.42e-05)	(4.82e-05)	(3.02e-05)
D_water	-0.000711	0.00297	-0.000756
	(0.00127)	(0.00213)	(0.00109)
D_water, squared	-1.06e-05	-2.63e-05**	1.10e-05
	(9.91e-06)	(1.29e-05)	(6.80e-06)
Land-use Cover in Block-group			
Open Water	0.347	0.285	-0.376
	(0.378)	(0.241)	(0.970)

Developed Open Space	0.0510	0.150***	-0.215***
	(0.0851)	(0.0511)	(0.0697)
Med. Density Residential	-0.156*	0.0496	-0.240***
	(0.0947)	(0.126)	(0.0448)
High Density Residential	-0.146	0.0729	-0.287***
	(0.0964)	(0.182)	(0.0583)
Forest Cover	-0.208***	0.0599	-0.133*
	(0.0458)	(0.0504)	(0.0787)
Grassland	-0.201	-0.0706	-0.136*
	(0.192)	(0.147)	(0.0721)
Cropland	0.0239	0.183***	-0.242**
	(0.0786)	(0.0642)	(0.105)
Wetland	-0.0580	0.146***	-0.377*
	(0.0611)	(0.0475)	(0.212)
Constant	11.78***	11.07***	11.16***
	(0.138)	(0.226)	(0.118)
Observations	10755	13926	17614
R-squared	0.626	0.639	0.728

[a] All models include fixed-effects for NWR and census tract.
[b] All models include only households that are within 3 miles of an NWR and within 8 miles of the centroid of an urban area. Robust standard errors in parentheses. A***, **, and * indicate $p<0.01$, $p<0.05$, $p<0.1$, respectively. Coefficients for auto-tour route are suppressed for the Northeast and California/Nevada region for confidentiality reasons.

Table 11. Baseline Results for Categorical Distance Specification.

Variable	Northeast	Southeast	California/Nevada
	coefficient (standard error)[b]		
Proximity of a house to an NWR			
D0.5	0.0365*	0.0686***	0.0571**
	(0.0214)	(0.0239)	(0.0273)
D1.0	-0.0203	-0.00862	0.0262
	(0.0183)	(0.0202)	(0.0216)
D1.5	-0.0151	-0.0420**	0.0194
	(0.0169)	(0.0168)	(0.0179)
D2.0	-0.00697	-0.0375***	0.0162
	(0.0150)	(0.0143)	(0.0142)
D2.5	-0.0180	-0.0191	0.00856
	(0.0125)	(0.0120)	(0.0101)
NWR Characteristics			
ln(visitation rates)	-0.0707***	0.0441**	0.0878***
	(0.0162)	(0.0209)	(0.0134)
Auto-tour route	positive**	-0.442***	negative
	p<0.05	(0.167)	p>0.10
Housing Characteristics			
Total rooms	0.0106	-0.0164	-0.0224
	(0.0252)	(0.0231)	(0.0167)
Total rooms, squared	0.00582***	0.00851***	0.00681***
	(0.00186)	(0.00175)	(0.00128)
Total bedrooms	0.0216	-0.0468	0.0200
	(0.0343)	(0.0345)	(0.0201)
Total bedrooms, squared	0.00578	0.0196***	0.00337
	(0.00517)	(0.00526)	(0.00297)
Neighborhood Descriptions			
Arealand	0.00808	0.00618	0.0328**
	(0.0265)	(0.0102)	(0.0143)
Arealand, squared	-0.00978	-0.00118*	-0.00405**
	(0.0103)	(0.000615)	(0.00158)
Med. population density	-0.00864***	-0.00777***	-0.00590***
	(0.00148)	(0.00135)	(0.000807)
Med. population density, squared	7.91e-05***	2.17e-05***	4.06e-05***
	(1.36e-05)	(3.84e-06)	(5.29e-06)
Med. family size	-0.0214	0.0337**	-0.00919
	(0.0170)	(0.0164)	(0.0132)
Med. family size, squared	-0.000947	-0.00787***	0.00115
	(0.00275)	(0.00260)	(0.00209)

Med. children	0.000754	-0.0212**	-0.00943
	(0.00891)	(0.00849)	(0.00623)
Med. seniors	0.0303***	0.00287	0.0317***
	(0.00874)	(0.00826)	(0.00752)
Med. household income	0.00247***	0.00359***	0.00143***
	(0.000199)	(0.000236)	(0.000157)
Med. household income, squared	-2.22e-06***	-2.93e-06***	-5.64e-07**
	(2.57e-07)	(3.52e-07)	(2.78e-07)
Owner Occupied	-0.137	0.0479	0.00105
	(0.141)	(0.152)	(0.0937)
Owner Occupied, squared	0.0990	0.0388	0.0668
	(0.0930)	(0.0986)	(0.0625)
Vacant, Seasonal	0.554***	0.786***	0.856***
	(0.114)	(0.200)	(0.147)
Vacant, Seasonal, squared	0.00819	-0.0243	-0.152
	(0.187)	(0.482)	(0.297)
Vacant, Sale	0.179	0.594***	0.0428
	(0.206)	(0.194)	(0.164)
Vacant, Sale, squared	-0.192	-1.025*	0.205
	(0.538)	(0.548)	(0.475)
Vacant, Rent and Other	0.266	0.589***	0.351***
	(0.189)	(0.160)	(0.126)
Vacant, Rent and Other, squared	-0.191	-0.935***	-0.0987
	(0.541)	(0.351)	(0.339)
Single-family Detached	-0.000211	-0.146*	-0.0510
	(0.0333)	(0.0750)	(0.0347)
Apartments	-0.0251	-0.0284	0.0421
	(0.0497)	(0.0918)	(0.0464)
Geographic Descriptors			
D_UA	0.00881	0.0685***	-0.0801***
	(0.0192)	(0.0188)	(0.0211)
D_UA, squared	0.00265	-0.00433**	0.00491**
	(0.00187)	(0.00186)	(0.00250)
D_park	-0.00189	-0.00192	-0.000704
	(0.00238)	(0.00274)	(0.00384)
D_park, squared	4.09e-05*	2.79e-05	1.65e-05
	(2.22e-05)	(2.59e-05)	(0.000110)
D_highway	-0.00135	0.00420	0.00279
	(0.00219)	(0.00268)	(0.00206)
D_highway, squared	9.67e-06	-5.73e-05	-2.43e-05
	(2.43e-05)	(4.81e-05)	(3.02e-05)
D_water	-0.000687	0.00297	-0.000787
	(0.00128)	(0.00213)	(0.00109)

D_water, squared	-9.84e-06	-2.74e-05**	1.13e-05*
	(9.94e-06)	(1.29e-05)	(6.82e-06)
Land-use Cover in Block-group			
Open Water	0.366	0.269	-0.350
	(0.378)	(0.241)	(0.971)
Developed Open Space	0.0637	0.141***	-0.211***
	(0.0861)	(0.0513)	(0.0697)
Med. Density Residential	-0.142	0.0460	-0.242***
	(0.0957)	(0.127)	(0.0449)
High Density Residential	-0.137	0.0840	-0.294***
	(0.0964)	(0.184)	(0.0586)
Forest Cover	-0.197***	0.0524	-0.141*
	(0.0462)	(0.0505)	(0.0785)
Grassland	-0.190	-0.0856	-0.134*
	(0.192)	(0.148)	(0.0721)
Cropland	0.0366	0.187***	-0.234**
	(0.0784)	(0.0646)	(0.105)
Wetland	-0.0560	0.137***	-0.403*
	(0.0613)	(0.0477)	(0.213)
Constant	11.72***	10.97***	11.07***
	(0.133)	(0.222)	(0.115)
Observations	10755	13926	17614
R-squared	0.627	0.639	0.727

[a] All models include fixed-effects for NWR and census tract.

[b] All models include only households that are within 3 miles of an NWR and within 8 miles of the centroid of an urban area. Robust standard errors are in parentheses. A***, **, and * indicate p<0.01, p<0.05, p<0.1, respectively. Coefficients for auto-tour route are suppressed for the Northeast and California/Nevada region for confidentiality reasons.

Table 12. Selected Results for Continuous Distance Model with Alternative Samples.

	Within 5 miles of an Urban Area	Within 8 miles of an Urban Area	Within 10 miles of an Urban Area	Within 15 miles of an Urban Area	No Restriction on Proximity to an Urban Area
Northeast					
Distance	-0.141***	-0.0744***	-0.0430*	-0.0141	-0.0162
	(0.0457)	(0.0274)	(0.0219)	(0.0154)	(0.0104)
Distance, squared	0.0360***	0.0209***	0.0132**	0.00450	0.000444
	(0.0132)	(0.00802)	(0.00639)	(0.00478)	(0.00318)
ln(visitation rates)	-0.0601***	-0.0698***	0.0417**	0.0699***	-0.0685
	(0.0207)	(0.0162)	(0.0180)	(0.0205)	(66.69)
Auto-tour route	--	--	-0.330	-0.647***	0.320
			(0.248)	(0.152)	(767.6)
Observations	4,660	10,755	14,551	23,320	58,825
R-squared	0.683	0.626	0.655	0.694	0.735
Southeast					
Distance	-0.221***	-0.186***	-0.171***	-0.113***	-0.122***
	(0.0449)	(0.0287)	(0.0248)	(0.0205)	(0.0197)
Distance, squared	0.0569***	0.0518***	0.0442***	0.0298***	0.0297***
	(0.0124)	(0.00793)	(0.00692)	(0.00585)	(0.00561)
ln(visitation rates)	-0.0134	0.0441**	0.110***	0.0109	0.117***
	(0.0149)	(0.0208)	(0.0289)	(0.0181)	(0.0283)
Auto-tour route	0.0223	-0.439***	-0.587	0.258	0.492
	(0.203)	(0.166)	(0.401)	(0.256)	(0.379)
Observations	6,970	13,926	18,134	25,543	28,743
R-squared	0.612	0.639	0.624	0.646	0.664
California/Nevada					
Distance	-0.0682*	-0.0620**	-0.0463*	-0.019	0.0145
	(0.041	(0.0293)	(0.0265)	(0.0217)	(0.0166)
Distance, squared	0.0106	0.0126	0.00852	0.00167	-0.00626
	(0.0109	(0.00789)	(0.00719)	(0.00588)	(0.0046)
ln(visitation rates)	-0.0206	0.0868***	0.0737***	-0.00193	0.0209
	(0.0137	(0.0135)	(0.011)	(0.0191)	
Auto-tour route	Negative	Negative	Positive	0.189	0.147
	p>0.10	p>0.10	p>0.10	-176.2	
Observations	8,105	17,614	22,999	40,979	58,823
R-squared	0.796	0.728	0.737	0.755	0.742

Table 13. Selected Results for Categorical Distance Model with Alternative Samples.

	Within 5 miles of an Urban Area	Within 8 miles of an Urban Area	Within 10 miles of an Urban Area	Within 15 miles of an Urban Area	No Restriction on Proximity to an Urban Area
			Northeast		
D0.5	0.0976***	0.0365*	0.0232	0.00671	0.0237***
	(0.0364)	(0.0214)	(0.0186)	(0.0133)	(0.00904)
D1.0	-0.00491	-0.0203	-0.0115	-0.00429	0.0254***
	(0.0294)	(0.0183)	(0.0159)	(0.0121)	(0.00812)
D1.5	-0.0110	-0.0151	-0.0185	0.00159	0.0267***
	(0.0285)	(0.0169)	(0.0144)	(0.0113)	(0.00746)
D2.0	0.00919	-0.00697	0.00430	-0.00274	0.00512
	(0.0242)	(0.0150)	(0.0128)	(0.0103)	(0.00662)
D2.5	-0.00562	-0.0180	-0.00986	-0.00472	-0.00589
	(0.0193)	(0.0125)	(0.0105)	(0.00841)	(0.00551)
ln(visitation rates)	-0.0564***	-0.0707***	0.0402**	0.0696***	-0.0691
	(0.0208)	(0.0162)	(0.0180)	(0.0206)	(71.02)
Auto-tour route	--	positive**	-0.308	-0.646***	0.328
		p<0.05	(0.248)	(0.152)	(826.1)
Observations	4,660	10,755	14,551	23,320	58,825
R-squared	0.683	0.627	0.655	0.694	0.735
			Southeast		
D0.5	0.101***	0.0686***	0.0874***	0.0633***	0.0918***
	(0.0350)	(0.0239)	(0.0206)	(0.0170)	(0.0162)
D1.0	0.0377	-0.00862	0.0171	-0.00386	0.0118
	(0.0294)	(0.0202)	(0.0171)	(0.0142)	(0.0135)
D1.5	-0.0352	-0.0420**	-0.00851	0.00349	0.0201*
	(0.0250)	(0.0168)	(0.0146)	(0.0124)	(0.0118)
D2.0	-0.0339	-0.0375***	-0.0193	-0.0108	0.00703
	(0.0210)	(0.0143)	(0.0123)	(0.0108)	(0.0103)
D2.5	-0.0231	-0.0191	-0.00501	-0.00338	0.000233
	(0.0181)	(0.0120)	(0.0103)	(0.00905)	(0.00863)
ln(visitation rates)	-0.0161	0.0441**	0.107***	0.0116	0.115***
	(0.0149)	(0.0209)	(0.0290)	(0.0180)	(0.0282)
Auto-tour route	0.0483	-0.442***	-1.709***	0.235	0.514
	(0.203)	(0.167)	(0.407)	(0.255)	(0.378)
Observations	6,970	13,926	18,134	25,543	28,743
R-squared	0.612	0.639	0.624	0.646	0.664

continued, next page

		Southwest			
D0.5	0.112***	0.0571**	0.0349	0.0198	0.00459
	(0.0353)	(0.0273)	(0.0239)	(0.0186)	(0.0144)
D1.0	0.0720***	0.0262	0.0283	0.0183	0.0114
	(0.0265)	(0.0216)	(0.0193)	(0.0145)	(0.0120)
D1.5	0.0547**	0.0194	0.0113	0.00758	0.00924
	(0.0224)	(0.0179)	(0.0158)	(0.0120)	(0.0101)
D2.0	0.0615***	0.0162	0.0218*	0.0182*	0.0220***
	(0.0183)	(0.0142)	(0.0127)	(0.0100)	(0.00825)
D2.5	0.0138	0.00856	0.00913	0.00935	0.00527
	(0.0131)	(0.0101)	(0.00898)	(0.00708)	(0.00579)
ln(visitation rates)	-0.0200	0.0878***	0.0760***	-0.00150	0.0213
	(0.0137)	(0.0134)	(0.0110)	(0.0191)	
Auto-tour route	Negative p>0.10	Negative p>0.10	Positive p>0.10	0.191 (35.33)	0.151
Observations	8,105	17,614	22,999	40,979	58,823
R-squared	0.796	0.727	0.737	0.755	0.742

Table 14. Selected Results for Alternative Specifications for the Price/Distance Gradient.

	Within 5 miles of an Urban Area	Within 5 miles of an Urban Area	Within 5 miles of an Urban Area	Within 8 miles of an Urban Area	Within 8 miles of an Urban Area	Within 8 miles of an Urban Area	Within 10 miles of an Urban Area	Within 10 miles of an Urban Area	Within 10 miles of an Urban Area
NORTHEAST REGION									
ln(Distance)	-0.0864**			-0.0377*			-0.0140		
	(0.0336)			(0.0202)			(0.0167)		
Dist_0.5		0.101***			0.0509***			0.0339**	
		(0.0309)			(0.0175)			(0.0140)	
Dist_1.0			0.0502**			0.0132			0.0100
			(0.0230)			(0.0130)			(0.0113)
Observations	4,660	4,660	4,660	10,755	10,755	10,755	14,551	14,551	14,551
R-squared	0.683	0.683	0.682	0.626	0.627	0.626	0.655	0.655	0.655
SOUTHEAST REGION									
ln(Distance)	-0.101***			-0.0582***			-0.0790***		
	(0.0337)			(0.0221)			(0.0188)		
Dist_0.5		0.0773***			0.0867***			0.0821***	
		(0.0230)			(0.0168)			(0.0152)	
Dist_1.0			0.0785***			0.0454***			0.0461***
			(0.0211)			(0.0143)			(0.0119)
Observations	6,970	6,970	6,970	13,926	13,926	13,926	18,134	18,134	18,134
R-squared	0.611	0.611	0.612	0.638	0.639	0.638	0.623	0.624	0.624
CALIFORNIA/NEVADA									
ln(Distance)	-0.0782**			-0.0529**			-0.0481**		
	(0.0334)			(0.0267)			(0.0241)		
Dist_0.5		0.0440*			0.0318**			0.00889	
		(0.0241)			(0.0161)			(0.0143)	
Dist_1.0			0.0238			0.0113			0.0166
			(0.0180)			(0.0132)			(0.0120)
Observations	8,105	8,105	8,105	17,614	17,614	17,614	22,999	22,999	22,999
R-squared	0.796	0.796	0.796	0.727	0.727	0.727	0.736	0.737	0.737

4. Economic Impacts

In this section, we use the results presented in Section III to compute the economic impacts of the open space amenity provided to local homeowners by NWRs. All monetary values are reported in 2000 dollars. These values can be converted to 2011 dollars, based on the U.S. Consumer Price Index by multiplying by a factor of 1.32. We present two types of measures: marginal values and total capitalized impacts. We describe each in turn below, and focus our discussion on the correct interpretation of these measures.

Marginal Values

The first economic impact we report is the estimated marginal value of proximity to an NWR. This measure represents the additional gain in property value attributable to being more proximate to an NWR as compared to being further away, all else equal. We compute the marginal value for the models in equations (1) and (4). The results based upon the models in equations (2) and (3) are reported in Appendix Table B.1.[13]

For the model presented in equation (1) the marginal value is computed as:

$$Marginal\ Value \quad {}^{\Delta HV_i}\!/_{\Delta Distance} \quad \left(\widehat{\beta_1} \quad 2\widehat{\beta_2} Distance\right) * HV_i \tag{6}$$

where the change in housing value (ΔHV) for a one unit (mile) change in distance to the NWR (ΔDistance) is a function of the estimated coefficients for distance ($\widehat{\beta_1}$) and distance-squared ($\widehat{\beta_2}$) in equation (1). To compute the marginal value, we must evaluate equation (6) at some level for distance and house value. Often the mean of the sample is chosen.

Equation (6) represents the incremental change in house value we expect to see if a housing unit were instead located incrementally further from an NWR as compared to its actual distance. For instance, say distance is measured in miles, we estimate that β_1 is -0.08 and β_2 is 0.02 in equation (6), and we choose to evaluate equation (6) for a hypothetical house located 0.25 miles from an NWR and valued at $250,000. In this case, equation (6) indicates that we would expect this house's value to be $17,500 less if it were instead located 1.25 miles from the NWR, all else equal.

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[13] We do not compute the marginal values based on the models including *Dist_1.0*, since the coefficient estimates are not significantly different than zero for this variable in two of the three regions.

For the model presented in equation (4), the computation of marginal values is of the following general form:

$$Marginal\ Value = \Delta HV_i / \Delta Distance = \widehat{\beta_1} * HV_i \quad (8)$$

where $\widehat{\beta_1}$ is the coefficient estimate for the variable *Dist_0.5*. Again consider a hypothetical example in which $\widehat{\beta_1}$ is estimated to be 0.08 for the model including *Dist_0.5*. In this case, equation (8) indicates that the marginal value associated with being within 0.5 miles of an NWR, as compared to any distance further (up to 3 miles), is $20,000 for a house valued at $250,000, all else equal.

The marginal values as computed by equation (7) and (8) are presented in Table 15. We choose models based on the sample of homes that are up to 8 miles from an urban area. For this sample, models are consistent across regions, and sample sizes are more than double that for the 5 mile sample (and the number of NWRs included in the model are expanded as compared to the 5 mile sample).

For the Northeast, the continuous distance model (first row in the Northeast panel of Table 15) indicates that estimated marginal effects of a house being located 0.5 miles from an NWR as compared to 1.5 miles is $13,375 for a home valued at $250,000. The 95% confidence interval is also presented and does include zero. The categorical distance model indicates a similar value of approximately $12,725. The confidence interval for the categorical model in the Northeast does not include zero.

For the Southeast, the continuous distance model that includes distance and distance-squared results in an estimated marginal value of $33,550. The categorical model comparing houses within 0.5 miles to those further away (row 2 under the Southeast panel of Table 15) indicate a value of $21,675, somewhat smaller than for the continuous model. Lastly, for California/Nevada, the continuous distance model results in a marginal value estimate of $12,350, which is very similar to the northeast. On the other hand, the categorical model results in an estimate of $7,950. Neither of these point-estimates are particularly precise. The 95% confidence interval for the continuous distance model includes zero, and almost includes zero for the categorical model.

Total Capitalized Value

The second measure we present is the total capitalized value (TCV), which aggregates the marginal values over the houses whose prices are influenced by their proximity to an NWR. Before presenting the mechanics of how we compute the TCV, it is important to discuss exactly what this aggregated value represents and how it can be interpreted. The marginal values discussed in the previous section are a measure of the mean willingness-to-pay of a homeowner to have their home located incrementally closer to an NWR. These values are also referred to as implicit prices. The implicit price of proximity that is calculated in the previous section can be summed over houses impacted by their proximity to an NWR to calculate the market value of this feature of houses ("proximity") as they are currently distributed around the NWR. The TCV may be computed for any housing feature for which we estimate an implicit price. For instance, say we estimate that having a fireplace present adds $1,000 to the value of the house. This marginal value, or implicit price, can be used to compute the total value that fireplaces add to the capital stock. For instance, if ten homes in a census block have a fireplace, then the total capitalized value of fireplaces in that block is $10,000. This number represents the market value of this feature of houses as they are built.

The TCV is well suited to examining how property tax revenues are impacted by the presence of an NWR. Since tax revenues are linked directly to property values, one can measure the amount of current tax revenue that is generated by the presence of NWRs. However, the TCV cannot be interpreted as representing the value of adding a new NWR, or what would be lost if an NWR were removed and the land developed. Thus, while it is worthwhile to demonstrate the tax revenue impact of NWRs, one must be careful in discussing tax revenue changes due to the addition, removal, or expansion of an NWR. These latter questions require a different analytical approach.

The computation of the TCV proceeds in several steps. First, we compute the mean capitalized value by block for houses in our regression sample. The block-level mean impact is then multiplied by the number of owner occupied single-family detached houses in each block to compute an estimate of the TCV by block. We then sum over the blocks surrounding the NWR which lie within the impact zone to compute the total impact by NWR.

We present two estimates of the total capitalized value associated with NWRs that vary by the regression results upon which they are based. The first estimate is based on the model given in equation (4). This model is chosen because the categorical definition of distance allows a straightforward computation of total capitalized value and its standard error. In addition, as compared to the similar model presented in equation (2), the coefficient for the variable indicating whether or not a home is within 0.5 miles of an NWR is more precisely estimated in equation (4). However, Appendix B also presents TCV estimates that are based on the model in equation (2).

To compute the total capitalized value for an NWR, we first compute the total capitalized value in each census block *b*: TCV_b. With sufficient information, we would compute TCV_b simply by summing the estimated marginal value for each home in block *b*. However, Census only collects data on individual home values for one-in-six households. As such, we compute an average marginal value for homes in block *b* that appear in our data, and then multiply this value by the total number of owner-occupied single-family detached homes in a block to compute TCV_b. We then sum TCV_b over all blocks that are within 0.5 miles of an NWR and within eight miles of an urban area. More formally, we first compute <u>block-level</u> total capitalized value by:

$$TCV_i \quad \left(\sum_{i} {}_{1}\widehat{\beta_1} * HV_i \Big/ I\right) * N^{S\ D_i}, \qquad (9)$$

where $i\widehat{\beta_1}$ is the estimated value for the coefficient of the categorical variable Dist_0.5, I_b is the total number of individual households observed in our sample residing in single-family detached (SFD) owner-occupied homes in block *b*, and $N^{Si\ D}$ is the total number of SFD owner-occupied housing units in block *b*.[14] The term in parentheses in equation (9) is the average capitalized value for homes in block *b* that appear in our regression data.

Given an estimate for TCV_b from equation (9), we then compute the total capitalized value associated with proximity to an NWR by:

$$TCV^{DIST\_i.} \quad \sum^{B} \cdot \ TCV_i, \qquad (10)$$

[14] N^{SFD} is not directly reported by the Census (even within the confidential micro-data) and thus had to be estimated. First, we use the confidential Census micro-data to compute the proportion of owner-occupied, single-family detached houses among the total housing units contained in the Census one-in-six sample of households. We then multiply this proportion by the total number of housing units in a block, which is publicly available data, to arrive at our estimate of N^{SFD_i}. This computation assumes that the proportion of homes in the Census one-in-six sample of households that are owner-occupied, single-family detached is the same as for the entire population of households.

where $B_{0.5}$ is the set of all blocks that are within 0.5 miles of the NWR boundary and also within the regression sample (e.g., blocks also within eight miles of an urban area).[15]

We also compute total capitalized value using results from equation (1), which assumes that the natural log of housing value is a function of quadratic-distance to the NWR. This model tended to result in the highest estimates of the marginal value of proximity. The computation of total capitalized value is somewhat different when based on the model in equation (1). First, we compute total capitalized value by block as follows:

$$TCV^{UAD\_2i} \quad \left(\sum_{U} {}_{1}\left(\widehat{P_1} - \widehat{P}\right) i \Big/ Ii \right) * N^{S\ D}, \tag{11}$$

where $\widehat{P_1}$ is the predicted price of a home at its current location and $\widehat{P}\,i$ is the predicted price of the home at a baseline distance where the NWR proximity effects have dissipated. In general, our models indicate this to be at 2 miles or less, and thus we use a baseline distance of 2 miles. All else in equation (11) is as defined for equation (9).

The continuous distance model in equation (1) predicts that impact of proximity declines smoothly over space. When computing the total capitalized value, we must choose the set of blocks that are assumed impacted by their proximity to an NWR. We include all blocks within two miles of an NWR because this approximates the distance at which most models predict the impacts dissipate completely. Thus, we sum equation (11) over all blocks within 2 miles of an NWR or:

$$TCV^{UAD\_2.} \quad \sum^{B} TCV^{UAD\_2i}, \tag{12}$$

where $B_{2.0}$ is the set of all blocks that are within two miles of an NWR boundary. All blocks used in these calculations must also be within the regression sample and thus be within eight miles of an urban area.

Note, the TCV in equation (12) is computed over the larger set of homes within 2 miles of each NWR. For more comparability to $TCV^{DIST\_0.5}$, we also compute TCV modifying equation 12 to only sum over homes within 0.5 miles of an NWR or:

$$TCV^{UAD\_i.} \quad \sum^{B} TCV^{UAD\_2i}, \tag{13}$$

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[15] The TCV calculation presented in Appendix B for the model based on equation (2) is identical to equation (9) except that a different coefficient is used (the coefficient for D0.5 in equation (2) is used instead of the coefficient for DIST_0.5 in equation (4)).

where $B_{0.5}$ is the set of all blocks that are within 0.5 miles of an NWR boundary, and all else is as defined for equation (12). Results for $TCV^{QUAD\_0.5}$ are very similar to $TCV^{DIST\_0.5}$, and thus we present $TCV^{QUAD\_0.5}$ in Appendix B.

In sum, there are two measures of total capitalized value presented in the main text:

(*1*) *TCV* based on the regression model presented in equation (4) and computed by equations (9) and (10), referred to as $\mathbf{TCV^{DIST\_0.5}}$;

(*2*) *TCV* based on the regression model presented in equation (1) and computed by equations (11) and (12), referred to as $\mathbf{TCV^{QUAD\_2.0}}$;

and two measures are presented in Appendix B:

(*3*) *TCV* based on the regression model presented in equation (2), and computed by equations (9) and (10), referred to as $\mathbf{TCV^{D0.5}}$;

(4) *TCV* based on the regression model presented in equation (1) and computed by equations (11) and (13), referred to as $\mathbf{TCV^{QUAD\_0.5}}$.

The computation of the TCV in (*1*), (*3*), and (*4*) above is based on the same sample of houses, while the total impacts in (*2*) expand the houses under consideration to those up to two miles away. Overall, $TCV^{DIST\_0.5}$ tends to be a mid-range estimate of the capitalized value and thus our focus on this measure in the main text. $TCV^{D0.5}$ provids the smallest estimate in two of three regions, and $TCV^{QUAD\_2.0}$ is the largest across all regions. This latter result is not surprising given $TCV^{QUAD\_2.0}$ is summed over a larger number of homes. However, we note $TCV^{QUAD\_0.5}$ has nearly identical estimates to $TCV^{DIST\_0.5}$ presented in the main text, thus indicating that the larger results for $TCV^{QUAD\_2.0}$ are due to the summation over the larger number of homes and not an inherent difference in the estimated impact when considering only homes within 0.5 miles of an NWR. We choose to present $TCV^{QUAD\_2.0}$ in the main text as an upper-bound point estimate.

Total Capitalized Value Results

Table 16 presents our main results for $TCV^{DIST\_0.5}$ and $TCV^{QUAD\_2.0}$ for each NWR in the regression samples upon which $TCV^{DIST\_0.5}$ and $TCV^{QUAD\_2.0}$ are based.[16] Recall, we choose the regression samples that include homes that are within eight miles of the urban centroid because these models are found to provide a reasonable middle-ground among all the results presented in

[16] Appendix tables B.2 to B.4 repeat the results for $TCV^{DIST\_0.5}$ and $TCV^{QUAD\_2.0}$ and present them alongside the results for $TCV^{D0.5}$ and $TCV^{QUAD\_0.5}$ for comparison.

the previous section. Note also that the NWR-specific TCV is suppressed for some NWRs due to confidentiality concerns arising from small samples of homes being located within 0.5 miles of the NWR. The 95% confidence intervals for $TCV^{DIST\_0.5}$ are presented in Table 16 directly. Because the calculation of $TCV^{QUAD\_2.0}$ includes predictions of housing value from the regression model with a transformed dependent variable (and not just marginal implicit prices as is the case for $TCV^{DIST\_0.5}$), the confidence interval calculations are substantially more complicated and are not reported.

Before discussing the results, we remind the reader that the TCV calculations are based upon a mean implicit value of proximity in each region, and are not based on NWR-specific regression results. As such, the TCV calculations by NWR vary within a region only because the distribution of homes around each NWR varies, and not because we have estimated a different impact of proximity on houses around each NWR in a region. In other words, the regression models only estimate the average impact of proximity to an NWR within a region. We apply this average impact to each NWR's specific set of houses to arrive at an NWR-specific total capitalized value. If instead, we had conducted a 'case-study' approach that estimated the impact of proximity to each NWR separately, such as done by Boyle, Paterson and Poor (2002), it is likely that estimated impacts would be different for each NWR since the estimated coefficient for proximity would vary across NWRs as well.

Across all three regions, the point estimate for $TCV^{QUAD\_2.0}$ is consistently larger than the estimate based on $TCV^{DIST\_0.5}$, and usually lies outside the 95% confidence interval for $TCV^{DIST\_0.5}$. In addition, there is a considerable amount of variation in the NWR-specific TCV estimates within a particular region. For the Northeast, the capitalized values based on $TCV^{DIST\_0.5}$ vary from less than \$1 million to over \$45 million. The 95% confidence intervals do not include zero, but only include the point estimates of $TCV^{QUAD\_2.0}$ for the three NWRs with the largest TCV estimates (Cape May, John Heinz, and Rachel Carson). In the Southeast region, the results vary from less than \$1 million to nearly \$55 million. The 95% confidence intervals for the estimates based on $TCV^{DIST\_0.5}$ do not overlap with the point-estimates for $TCV^{QUAD\_2.0}$ for any of the NWRs.

Lastly, results for California/Nevada show the largest divergence between $TCV^{DIST\_0.5}$ and $TCV^{QUAD\_2.0}$ indicating that homes are spatially concentrated in the outer rings (from 0.5 miles to 2.0 miles from the NWR). Point estimates based on $TCV^{DIST\_0.5}$ are between about \$1 and \$30 million, while point estimates based on $TCV^{QUAD\_2.0}$ are between \$8.5 and \$202 million. It should be noted that for this region, $TCV^{DIST\_0.5}$ yielded the smallest point-estimates for TCV.

Lastly, we present regional results for the TCV. Here, we simply sum the NWR-specific impacts across all NWRs, including those NWRs whose results are suppressed due to confidentiality reasons. We focus on our preferred model and method for computing the TCV which is to compute $TCV^{DIST\_0.5}$ for all blocks within 0.5 of an NWR and within 8 miles of the center of an urban area (as was assumed for the NWR-specific estimates just presented). Regional results are presented in Table 17, along with their 95% confidence interval.[17] As indicated in Table 17, the point estimate of the regional total capitalized value varies from \$83 million in California/Nevada to \$121 million in the Southeast. We also include in Table 17 the number of NWRs over which the total capitalized value is computed and then implied average impact per NWR. In other words, we divide the regional TCV by the number of NWRs upon which the calculation was based to arrive at an average impact per NWR. We find average impacts to be nearly identical across regions. Specifically, the average TCV by NWR for the Northeast, Southeast, and California/Nevada regions is \$8.66, \$8.65, and \$7.58 million, respectively.[18]

[17] Additional results are presented in Appendix B in which we vary the sample by how proximate the homes are to the urban core. Specifically, we compute regional results for all homes that are within 0.5 miles of an NWR **and** within either 5, 8, or 10 miles of the centroid of the nearest urban area in Appendix Table B.8.

[18] Calculated as: \$8.66 = (\$95.23 million / 11 NWRs); \$8.65 = \$121.50 million / 14 NWRs), and \$7.58 = (\$83.41 million / 11 NWRs).

Table 15. Marginal Values[a]

Specification for Distance to an NWR	Computation Type	Marginal Value (95% confidence interval)
	Northeast	
Distance + (Distance)^2	House located 0.5 miles from an NWR as compared to 1.5 miles away	$13,375 (-194 – 26,944)
Dist_0.5	House located 0.5 miles from an NWR as compared to 0.5 to 3.0 miles away	$12,725 (4,150 - 21,300)
	Southeast	
Distance + (Distance)^2	House located 0.5 miles from an NWR as compared to 1.5 miles away	$33,550 (19,353 – 47,747)
Dist_0.5	House located 0.5 miles from an NWR as compared to 0.5 to 3.0 miles away	$21,675 (13,443 - 29,907)
	Northeast	
Distance + (Distance)^2	House located 0.5 miles from an NWR as compared to 1.5 miles away	$12,350 (-2,137 – 26,837)
Dist_0.5	House located 0.5 miles from an NWR as compared to 0.5 to 3.0 miles away	$7,950 (61 - 15,839)

[a] All values are computed based on the model sample that includes homes within 8 miles of an urban area and assume a baseline value of a house to be $250,000.

Table 16. Point Estimates of the Total Capitalized Value by NWR (in millions).[a]

	Computation Method[b]	
	$TCV^{DIST\_0.5}$	$TCV^{QUAD\_2.0}$
	Northeast Region	
Cape May	$15.98 (5.2 – 26.7)	$20.79
Conscience Point	$1.71 (.6 – 2.9)	$3.22
Elizabeth Alexandra Morton	$1.36 (.4 – 2.3)	$2.85
John H. Chafee	$4.54 (1.5 – 7.6)	$8.15
John Heinz	$28.88 (9.5 – 48.3)	$42.80
Mashpee	$1.23 (.4 – 2.1)	$3.92
Monomoy	$3.66 (1.2 – 6.1)	$6.30
Oxbow	$0.75 (.2 – 1.3)	$3.71
Rachel Carson	$33.22 (10.9 – 55.6)	$45.66
Shawangunk Grasslands	$0.26 (.1 - .4)	$0.68
Supawna Meadows	$3.62 (1.2 - 6.1)	$8.01
	Southeast Region	
Big Branch Marsh	$40.76 (25.3 – 56.2)	$82.66
Black Bayou Lake	$5.10 (3.2 – 7.0)	$16.79
Bond Swamp	$1.44 (.9 – 2)	$2.37
D'Arbonne	$0.60 (.4 - .8)	$6.00
Hobe Sound	n/a	$32.64
Lake Woodruff	$0.52 (.3 - .7)	$2.09

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	Computation Method[b]	
	$TCV^{DIST\_0.5}$	$TCV^{QUAD\_2.0}$
Southeast Region, continued		
Mandalay	$18.08 (11.2 – 24.9)	$50.25
Merritt Island	n/a	$1.67
Mississippi Sandhill Crane	$6.76 (4.2 – 9.3)	$12.42
Pelican Island	$4.56 (2.8 – 6.3)	$11.71
St. John's	$1.74 (1.1 – 2.4)	$7.73
Waccamaw	$6.66 (4.1 – 9.2)	$30.96
Watercress Darter	$3.13 (1.9 – 4.3)	$9.92
Wheeler	$29.87 (18.6 – 41.2)	$54.81
California/Nevada		
Antioch Dunes	$7.19 (.1 – 14.3)	$30.68
Coachella Valley	$5.87 (.1 – 11.7)	$43.84
Desert	$6.91 (.1 – 13.8)	$46.12
Don Edwards San Fran. Bay	$30.49 (.3 – 60.7)	$201.82
Ellicott Slough	$4.68 (.0 – 9.3)	$34.23
Marin Islands	$4.35 (.0 – 8.7)	$47.95
North Central Valley	n/a	$0.20
Salinas River	n/a	$0.26
San Diego	$19.82 (.2 – 39.5)	$118.47
San Joaquin River	$0.88 (.0 – 1.7)	$8.54
San Pablo Bay	$3.06 (.0 – 6.1)	$37.08

Table notes follow on the next page.

[a] Results for some NWRs are suppressed for confidentiality reasons (noted with n/a in the table).
[b] $\mathbf{TCV}^{\mathbf{DIST\_0.5}}$ is computed by equations (9) and (10) and based on the regression model presented in equation (4); $\mathbf{TCV}^{\mathbf{QUAD\_2.0}}$ is computed by equations (11) and (12) and based on the regression model presented in equation (1).

Table 17. Total Capitalized Value (TCV) by Region (in millions).[a]

	TCV (95% Confidence Interval)	**# NWRs in Sample**	**Average TCV per NWR**
Northeast Region	\$95.23 (31.2 - 159.3)	11	\$8.66
Southeast Region	\$121.50 (75.5 - 167.5)	14	\$8.65
California/Nevada	\$83.41 (0.7 - 166.1)	11	\$7.58

[a] Estimates are based on the model using $\mathbf{TCV^{DIST\_0.5}}$. The regression samples are limited to blocks within eight miles of an urban area.

5. Conclusions and Summary

In this report, we summarize the results of a national-scale analysis to determine the impact that National Wildlife Refuges may have on nearby homeowner's property values. Given the evidence that being located near permanently protected open space increases property values, we expect that National Wildlife Refuges will also have positive property value impacts on neighboring residential properties. However, we recognize that it is more likely that NWRs will have an impact if they are located near housing markets where open space is relatively scarce, e.g., in urbanized areas or at the urban fringe. Given this hypothesis, we focus our attention on NWRs that are in close proximity to an urbanized area with population greater than 50,000.

To conduct a national analysis, we utilize confidential micro-level census data available through the Triangle Census Research Data Center. This data includes detailed information on housing characteristics and owner-assessed values and is available for one-in-six households across the entire U.S. Importantly, the confidential data identify the location of each house at a very fine geographic resolution, allowing us to carefully identify how close a home is to the boundary of an NWR. Boundary files for all NWRs in the U.S. are then linked to Census and other geospatial data to determine the proximity of NWRs to urban areas.

After identifying all NWRs that are within two miles of an urbanized area boundary, we conduct regression analyses to determine how a home's value is impacted by its proximity to an NWR boundary. We conduct our analysis by Fish and Wildlife region, and find positive impacts for NWRs located in the Northeast and Southeast regions as well as in the California/Nevada region. Data limitations due to a paucity of NWRs near urban areas in the central mountains and south-central portions of the country resulted these regions being excluded from the final analysis. And although there was sufficient data, we could not identify consistent impacts in the Pacific Northwest or Midwest.

Results for the Northeast, Southeast, and California/Nevada area indicate that on average across our entire sample, NWRs result in increased property values for homes located in very close proximity (within 0.5 miles of the NWR). These effects are consistent across a number of regression specifications and sample variations. In general, we find that homes located within 0.5 miles of an NWR and within 8 miles of an urban center are valued between three and eight percent higher as compared to homes located further away from the NWR (but still within 8 miles of the urban center). These percentage impacts can be converted to a "capitalized value" that represents the total property value impact for homes surrounding an NWR. Depending on region and NWR, our point estimates of the capitalized value that NWRs provide to local homeowners can be as little as $1 million to over $40 million. Theoretically, these values are not equal to the value of creating a new NWR, or what is lost if an NWR were dismantled and developed. However, they do provide an estimate of the increased property tax base that local communities receive as a result of the NWRs.

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Appendix A: Results for Other Regions

Four regions are not included in the main report. These regions indicate negative or not significant estimates for proximity to an NWR. We provide results for these regions in this appendix, along with a discussion of the results.

For two of these four regions – the Southwest and Central Mountains – the sample restriction resulted in very few NWRs available for analysis. In the Southwest, the NWRs with boundaries within 2 miles of an urban area are all located in Texas. Furthermore, the analysis sample for the Southwest (Texas) is dominated by an NWR whose geographic boundaries follow a segment of the Rio Grande river forming the border between the US and Mexico. As such, for a large part of the sample, proximity to the NWR is equivalent to proximity to the US/Mexico border. Examination of the area (via satellite images and web-based searches for information about the urban areas), we are not surprised that a negative correlation between property prices and proximity to the border is found as a result.

In the Central Mountain region, there are two NWRs in the sample, and as indicated in Table A1 and A2, the homes are relatively more distant from urban areas as compared to other regions. Specifically, there are no homes within 5 miles of the center of an urban area, and very few within 8 miles of an urban area. Models for all our regions in the main report tend to indicate little to no impacts beyond 8-10 miles from the center of an urban area. As such, it is not surprising we could not identify an impact for these two NWRs.

In the Midwest, Table A2 indicates a strong, negative influence of proximity to an NWR if within 0.5 miles, and none otherwise. In this region, the sample is dominated by NWRs that follow major rivers (e.g., the Mississippi) and thus proximity to the NWRs may reflect flood-plain hazards more than proximity to open space. Previous work has suggests substantial negative and significant on property prices of being located in a flood plain (e.g., Bin and Polasky, 2004; Bin, Kruse and Landry 2008, Speyrer and Ragas, 1991). Given the nature of our sample, it is impossible for us to test this conjecture by separately isolating whether or not properties were in a river flood plain.

Lastly, in the Northwest, we are less able to identify a potential confounding variable that could impact our results accordingly. We are, however, able to identify a particular NWR with a large sample size but which appeared to have a negative influence on surrounding property values. Examination of online descriptions of the NWR did not immediately suggest a strong reason why it might influence surrounding properties in a negative fashion. Regardless, when the model is estimated without this NWR, results remain statistically insignificant.

Table A.1. Select Results for Four Regions, Continuous Distance Models.

	Within 5 miles of UA	Within 8 miles of UA	Within 10 miles of UA	Within 15 miles of UA	No Restriction
			Central Mountains		
Distance		-0.0932	0.0367	0.0357	0.0357
	There is	(0.249)	(0.0532)	(0.0403)	(0.0403)
Distance, squared	*no housing*	0.0278	-0.0190	-0.0190	-0.0190
	within this	(0.0499)	(0.0151)	(0.0117)	(0.0117)
Auto Tour Route	*geographic*	*not included due to a lack of variation*			
	location in				
ln(visitation rate)	*this region.*	*not included due to a lack of variation*			
Observations		754	4544	6014	6014
R-squared		0.665	0.541	0.552	0.552
			Midwest		
Distance	0.0547***	0.0564***	0.0479***	0.00673	-0.000265
	(0.0207)	(0.0165)	(0.0145)	(0.0119)	(0.0117)
Distance, squared	-0.0201***	-0.0144***	-0.0125***	-0.000853	0.00146
	(0.00658)	(0.00508)	(0.00448)	(0.00364)	(0.00359)
Auto Tour Route	-0.0801***	-0.0739	-0.0680***	-0.0663***	-0.115
	(0.0259)	(2,117)	(0.0176)	(0.0161)	
ln(visitation rate)		*not included due to a lack of variation*			
Observations	23554	36393	45595	66607	71281
R-squared	0.665	0.673	0.667	0.684	0.678
			Northwest		
Distance	0.0523	0.0440	0.0493	0.0513*	
	(0.0619)	(0.0343)	(0.0314)	(0.0268)	
Distance, squared	-0.0140	-0.0124	-0.0135	-0.0152*	
	(0.0177)	(0.0107)	(0.00974)	(0.00784)	*Sample is*
Auto Tour Route	-0.00498	-0.0582*	0.0436*	-0.0386*	*identical*
	(0.0408)	(0.0333)	(0.0229)	(0.0210)	*to the 15*
ln(visitation rate)	0.724***	0.592***	0.720***	0.742*	*mile sample*
	(0.252)	(0.126)	(0.113)	(0.400)	
Observations	3243	5689	6762	8985	
R-squared	0.530	0.618	0.640	0.678	

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			Southwest		
Distance	0.122**	0.122**	0.0653	0.0631	0.0289
	(0.0584)	(0.0491)	(0.0452)	(0.0400)	(0.0396)
Distance, squared	-0.0330*	-0.0215	-0.00224	-0.00507	0.00342
	(0.0180)	(0.0148)	(0.0138)	(0.0122)	(0.0121)
ln(visitation rate)	-0.0315	0.0172	-0.00530	-0.00656	-0.00828
	(0.0836)	(0.0463)	(0.0465)	(0.0465)	(0.0460)
Observations	6637	8272	9275	10948	11260
R-squared	0.532	0.532	0.517	0.497	0.496

Table A.2. Select Results for Four Regions, Categorical Distance Models.

	Within 5 miles of an Urban Area	Within 8 miles of an Urban Area	Within 10 miles of an Urban Area	Within 15 miles of an Urban Area	No Restriction on Proximity to Urban Area
Central Mountains					
D0.5	*There is no housing within this geographic restriction*	positive not significant	0.0157	0.0279	0.0279
			(0.0475)	(0.0382)	(0.0382)
D1.0		0.0402	0.0726*	0.0675**	0.0675**
		(0.314)	(0.0423)	(0.0339)	(0.0339)
D1.5		0.0973	0.0515	0.0530**	0.0530**
		(0.305)	(0.0318)	(0.0260)	(0.0260)
D2.0		-0.221*	0.00956	0.0326	0.0326
		(0.125)	(0.0290)	(0.0238)	(0.0238)
D2.5		-0.0854	0.0101	0.00433	0.00433
		(0.0708)	(0.0217)	(0.0164)	(0.0164)
Observations		754	4544	6014	6014
R-squared		0.673	0.543	0.553	0.553
Midwest					
D0.5	0.00383	-0.0383***	-0.0324***	-0.0195*	-0.0223**
	(0.0187)	(0.0140)	(0.0123)	(0.0102)	(0.00999)
D1.0	0.0208	-0.0133	-0.00728	-0.00405	-0.00316
	(0.0172)	(0.0127)	(0.0112)	(0.00923)	(0.00903)
D1.5	0.0363**	-0.00628	-0.00471	-0.00816	-0.0123
	(0.0161)	(0.0121)	(0.0105)	(0.00847)	(0.00828)
D2.0	0.0322**	-0.000992	-0.00113	-0.0187**	-0.0222***
	(0.0143)	(0.0107)	(0.00950)	(0.00766)	(0.00745)
D2.5	0.00166	-0.00775	-0.00765	-0.0172***	-0.0205***
	(0.0127)	(0.00914)	(0.00803)	(0.00650)	(0.00632)
Auto Tour Route	-0.0811***	-0.0720	-0.0683***	-0.0651***	-0.114
	(0.0258)	(1,736)	(0.0176)	(0.0161)	
ln(visitation rate)	*not included in the model due to no variation*				
Observations	23554	36393	45595	66607	71281
R-squared	0.665	0.673	0.667	0.684	0.678

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Northwest					
D0.5	-0.0261	-0.00307	-0.0136	-0.00799	
	(0.0495)	(0.0292)	(0.0267)	(0.0228)	
D1.0	0.0189	0.0155	0.0107	0.0133	
	(0.0418)	(0.0260)	(0.0240)	(0.0201)	
D1.5	-0.000200	0.0216	0.0104	0.0200	*Sample is*
	(0.0371)	(0.0234)	(0.0215)	(0.0170)	*identical*
D2.0	-0.00651	0.00191	-0.00124	0.00708	*to the 15*
	(0.0348)	(0.0238)	(0.0218)	(0.0157)	*mile sample*
D2.5	0.0387*	0.0342*	0.0301*	0.0231*	
	(0.0234)	(0.0189)	(0.0161)	(0.0125)	
Auto Tour Route	-0.00580	-0.0550*	0.0454**	-0.0380*	
	(0.0412)	(0.0334)	(0.0230)	(0.0211)	
ln(visitation rate)	0.759***	0.593***	0.741***	0.754*	
	(0.254)	(0.126)	(0.113)	(0.401)	
Observations	3243	5689	6762	8985	
R-squared	0.531	0.618	0.640	0.678	
Southwest					
D0.5	-0.0344	-0.123***	-0.144***	-0.124***	-0.106***
	(0.0539)	(0.0429)	(0.0383)	(0.0342)	(0.0337)
D1.0	0.0431	-0.0498	-0.0707**	-0.0491	-0.0393
	(0.0490)	(0.0399)	(0.0357)	(0.0313)	(0.0306)
D1.5	0.0354	-0.0321	-0.0810**	-0.0804***	-0.0749***
	(0.0429)	(0.0347)	(0.0318)	(0.0278)	(0.0272)
D2.0	0.0404	-0.0366	-0.0659**	-0.0625**	-0.0672***
	(0.0357)	(0.0293)	(0.0278)	(0.0245)	(0.0242)
D2.5	0.0360	0.0262	0.00402	0.0183	0.0121
	(0.0261)	(0.0219)	(0.0214)	(0.0194)	(0.0191)
Auto Tour Route	*not included due to a lack of variation*				
ln(visitation rate)	-0.0412	0.0146	-0.00490	-0.00436	-0.00562
	(0.0834)	(0.0463)	(0.0465)	(0.0464)	(0.0459)
Observations	6637	8272	9275	10948	11260
R-squared	0.532	0.532	0.518	0.498	0.497

Appendix B: Additional Estimates of Economic Impacts

In this section we provide additional results for the Northeast, Southeast and California/Nevada that are based on additional models. Table B.1 repeats Table 15 in the main text but provides marginal value estimates based on two additional models: the model using the natural log of distance to an NWR (*lnDistance*) and the model using five categorical variables to describe distance to an NWR where the value results focus on the coefficient estimate for the variable *D0.5*.

Tables B.2 through B.4 provide point-estimates for the total capitalized value for the Northeast, Southeast and California/Nevada, respectively. Columns 3 and 4 in Tables B.2 through B.4 repeat the results presented in Table 16. Column 1 presents results based on models using the alternative categorical distance model (*D0.5*). As indicated in Tables B.2 through B.4, the estimated total capitalized values are somewhat smaller based on TCVD0.5 as compared to TCVDIST_0.5 for the Northeast and Southeast, but somewhat larger for California/Nevada.

Column 2 in Tables B.2 to B.4 presents estimates of the total capitalized value that are identical to the computation in the last column (and in the last column of Table 16 in the main text), but instead of summing up the impacts over all homes within 2 miles of an NWR as done for Table 16, the capitalized values are summed over only homes within 0.5 miles of an NWR. As one would expect, the total capitalized value estimates are smaller when estimated in this manner because fewer homes are included in the calculation. The value point estimates are 26% to 30% smaller when summed over 0.5 miles as compared to 2.0 miles in the Northeast and Southeast, respectively. However, the difference is much larger in the California/Nevada region (64%), indicating that a much larger concentration of housing is located between 0.5 and 2.0 miles of the NWRs in this region.

Tables B.5 through B.7 repeat the point estimates for the total capitalized values in Table 16, but include 95% confidence intervals when available. The first panel in each table presents the same point estimate of the TCV for each NWR as presented in Table 16, but also includes the 95% confidence interval. The second panel in Tables B.5 to B.7 present the TCV based on the alternative categorical distance model (*D0.5*) and its 95% confidence interval.

Lastly, Table B.8 presents the regional estimates of TCV that varies by model upon which the computations are based and the sample upon which the original regression is estimates (i.e., homes with 5, 8 or 10 miles to an Urban Area). As indicated in the table, in the Northeast, the TCV impacts for the whole region are relatively insensitive to the sample used in the original models (homes within 5, 8 or 10 miles to an urban area). This is because as the underlying sample included more homes further from the urban center, the estimated impact declined. Thus, even though we sum over more homes, the total impacts stay relatively constant. In the Southeast, however, the estimated impact stayed relatively constant no matter how large the geographic sample underlying the models and so the TCV point-estimates for the region increase substantially as the geographic sample is increased. This is also the case with California/Nevada, although not to the same extent as for the Southeast.

Table B.1. Marginal Values[a]

Specification for Distance to an NWR	Computation Type	Marginal Value (95% confidence interval)
	Northeast	
Distance + (Distance)^2	House located 0.5 miles from an NWR as compared to 1.5 miles away	$13,375 (-194 – 26,944)
lnDistance	House located 0.5 miles from an NWR as compared to 1.5 miles away	$8,425 (-1,473 - 18,323)
D0.5	House located 0.5 miles from an NWR as compared to 2.5 to 3.0 miles away	$9,125 (-1,361 - 19,611)
Dist_0.5	House located 0.5 miles from an NWR as compared to 0.5 to 3.0 miles away	$12,725 (4,150 - 21,300)
	Southeast	
Distance + (Distance)^2	House located 0.5 miles from an NWR as compared to 1.5 miles away	$33,550 (19,353 – 47,747)
lnDistance	House located 0.5 miles from an NWR as compared to 1.5 miles away	$14,550 (3,721 - 25,379)
D0.5	House located 0.5 miles from an NWR as compared to 2.5 to 3.0 miles away	$17,150 (5,439 - 28,861)
Dist_0.5	House located 0.5 miles from an NWR as compared to 0.5 to 3.0 miles away	$21,675 (13,443 - 29,907)
	California/Nevada	
Distance + (Distance)^2	House located 0.5 miles from an NWR as compared to 1.5 miles away	$12,350 (-2,137 – 26,837)
lnDistance	House located 0.5 miles from an NWR as compared to 1.5 miles away	$13,225 (142 - 26,308)
D0.5	House located 0.5 miles from an NWR as compared to 2.5 to 3.0 miles away	$14,275 (898 - 27,652)
Dist_0.5	House located 0.5 miles from an NWR as compared to 0.5 to 3.0 miles away	$7,950 (61 - 15,839)

[a] All values are computed based on the model sample that includes homes within 8 miles of an urban area and assume a baseline value of a house to be $250,000.

Table B.2. Point Estimates of the Total Capitalized Value for Northeastern NWRs.[a]

	Computation Method[b]			
			(presented in main text)	
	$TCV^{D0.5}$	**$TCV^{QUAD\_0.5}$**	**$TCV^{DIST\_0.5}$**	**$TCV^{QUAD\_2.0}$**
Cape May	$11.46	$15.38	$15.98	$20.79
Conscience Point	$1.23	$1.23	$1.71	$3.22
Elizabeth Alexandra Morton	$0.98	$1.11	$1.36	$2.85
John H. Chafee	$3.26	$4.07	$4.54	$8.15
John Heinz	$20.71	$25.75	$28.88	$42.80
Mashpee	$0.88	$1.05	$1.23	$3.92
Monomoy	$2.63	$3.54	$3.66	$6.30
Oxbow	$0.54	$0.58	$0.75	$3.71
Rachel Carson	$23.83	$29.16	$33.22	$45.66
Shawangunk Grasslands	$0.19	$0.25	$0.26	$0.68
Supawna Meadows	$2.60	$3.13	$3.62	$8.01

[a] Results for some NWRs are suppressed for confidentiality reasons (noted with n/a in the table). 95% confidence intervals, when available are presented in Appendix Table B.5.
[b] **$TCV^{D0.5}$** is computed by equations (9) and (10) and based on the regression model presented in equation (2); **$TCV^{QUAD\_0.5}$** is computed by equations (11) and (13) and based on the regression model presented in equation (1); **$TCV^{DIST\_0.5}$** is computed by equations (9) and (10) and based on the regression model presented in equation (4); **$TCV^{QUAD\_2.0}$** is computed by equations (11) and (12) and based on the regression model presented in equation (1).

Table B.3. Point Estimates of the Total Capitalized Value for Southeastern NWRs.[a]

	Computation Method[b]			
			(presented in main text)	
	$TCV^{D0.5}$	$TCV^{QUAD\_0.5}$	$TCV^{DIST\_0.5}$	$TCV^{QUAD\_2.0}$
Big Branch Marsh	$32.26	$52.80	$40.76	$82.66
Black Bayou Lake	$4.03	$6.42	$5.10	$16.79
Bond Swamp	$1.14	$1.69	$1.44	$2.37
D'Arbonne	$0.47	$1.14	$0.60	$6.00
Hobe Sound	n/a	n/a	n/a	$32.64
Lake Woodruff	$0.41	$0.53	$0.52	$2.09
Mandalay	$14.31	$25.17	$18.08	$50.25
Merritt Island	n/a	n/a	n/a	$1.67
Mississippi Sandhill Crane	$5.35	$10.27	$6.76	$12.42
Pelican Island	$3.61	$5.01	$4.56	$11.71
St. John's	$1.38	$2.01	$1.74	$7.73
Waccamaw	$5.27	$8.69	$6.66	$30.96
Watercress Darter	$2.48	$3.65	$3.13	$9.92
Wheeler	$23.64	$34.39	$29.87	$54.81

[a] Results for some NWRs are suppressed for confidentiality reasons (noted with n/a in the table). 95% confidence intervals, when available are presented in Appendix Table B.6.
[b] $TCV^{D0.5}$ is computed by equations (9) and (10) and based on the regression model presented in equation (2); $TCV^{QUAD\_0.5}$ is computed by equations (11) and (13) and based on the regression model presented in equation (1); $TCV^{DIST\_0.5}$ is computed by equations (9) and (10) and based on the regression model presented in equation (4); $TCV^{QUAD\_2.0}$ is computed by equations (11) and (12) and based on the regression model presented in equation (1).

Table B.4. Point Estimates of the Total Capitalized Value for California/Nevada NWRs.[a]

	Computation Method[b]			
				(presented in main text)
	$TCV^{D0.5}$	**$TCV^{QUAD\_0.5}$**	**$TCV^{DIST\_0.5}$**	**$TCV^{QUAD\_2.0}$**
Antioch Dunes	$12.92	$11.05	$7.19	$30.68
Coachella Valley	$10.56	$11.80	$5.87	$43.84
Desert	$12.42	$11.71	$6.91	$46.12
Don Edwards San Fran. Bay	$54.82	$54.19	$30.49	$201.82
Ellicott Slough	$8.41	$9.25	$4.68	$34.23
Marin Islands	$7.82	$7.65	$4.35	$47.95
North Central Valley	n/a	n/a	n/a	$0.20
Salinas River	n/a	n/a	n/a	$0.26
San Diego	$35.65	$34.64	$19.82	$118.47
San Joaquin River	$1.58	$1.25	$0.88	$8.54
San Pablo Bay	$5.50	$4.19	$3.06	$37.08

[a] Results for some NWRs are suppressed for confidentiality reasons (noted with n/a in the table). 95% confidence intervals, when available are presented in Appendix Table B.7.
[b] **$TCV^{D0.5}$** is computed by equations (9) and (10) and based on the regression model presented in equation (2); **$TCV^{QUAD\_0.5}$** is computed by equations (11) and (13) and based on the regression model presented in equation (1); **$TCV^{DIST\_0.5}$** is computed by equations (9) and (10) and based on the regression model presented in equation (4); **$TCV^{QUAD\_2.0}$** is computed by equations (11) and (12) and based on the regression model presented in equation (1).

Table B.5. Total Capitalized Value, with 95% confidence intervals, for Northeastern NWRs.[a]

National Wildlife Refuge	Computation Method[b]	Total Impact	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Cape May	$TCV^{DIST\_0.5}$	$15.983	$5.237	$26.728
Conscience Point	$TCV^{DIST\_0.5}$	$1.713	$0.561	$2.864
Elizabeth Alexandra Morton	$TCV^{DIST\_0.5}$	$1.364	$0.447	$2.282
John H. Chafee	$TCV^{DIST\_0.5}$	$4.543	$1.488	$7.597
John Heinz	$TCV^{DIST\_0.5}$	$28.880	$9.462	$48.298
Mashpee	$TCV^{DIST\_0.5}$	$1.233	$0.404	$2.062
Monomoy	$TCV^{DIST\_0.5}$	$3.660	$1.199	$6.121
Oxbow	$TCV^{DIST\_0.5}$	$0.751	$0.246	$1.255
Rachel Carson	$TCV^{DIST\_0.5}$	$33.218	$10.884	$55.553
Shawangunk Grasslands	$TCV^{DIST\_0.5}$	$0.262	$0.086	$0.438
Supawna Meadows	$TCV^{DIST\_0.5}$	$3.620	$1.186	$6.053
Cape May	$TCV^{D0.5}$	$11.463	-$1.730	$24.657
Conscience Point	$TCV^{D0.5}$	$1.228	-$0.185	$2.642
Elizabeth Alexandra Morton	$TCV^{D0.5}$	$0.979	-$0.148	$2.105
John H. Chafee	$TCV^{D0.5}$	$3.258	-$0.492	$7.008
John Heinz	$TCV^{D0.5}$	$20.714	-$3.126	$44.554
Mashpee	$TCV^{D0.5}$	$0.884	-$0.133	$1.902
Monomoy	$TCV^{D0.5}$	$2.625	-$0.396	$5.646
Oxbow	$TCV^{D0.5}$	$0.538	-$0.081	$1.158
Rachel Carson	$TCV^{D0.5}$	$23.826	-$3.596	$51.247
Shawangunk Grasslands	$TCV^{D0.5}$	$0.188	-$0.028	$0.404
Supawna Meadows	$TCV^{D0.5}$	$2.596	-$0.392	$5.584

[a] Confidence intervals are not computed for the quadratic models and thus we do not repeat $TCV^{QUAD\_0.5}$ or $TCV^{QUAD\_2.0}$ results in this table (all available information is directly reported in Table B.2).

[b] $\mathbf{TCV^{DIST\_0.5}}$ is computed by equations (9) and (10) and based on the regression model presented in equation (4); $\mathbf{TCV^{D0.5}}$ is computed by equations (9) and (10) and based on the regression model presented in equation (2).

Table B.6. Total Capitalized Value, with 95% confidence intervals, for Southeastern NWRs.[a]

National Wildlife Refuge	Computation Method[b]	Total Impact	95% Confidence Interval	
			Lower Bound	Upper Bound
Big Branch Marsh	$TCV^{DIST\_0.5}$	\$40.761	\$25.325	\$56.198
Black Bayou Lake	$TCV^{DIST\_0.5}$	\$5.096	\$3.166	\$7.025
Bond Swamp	$TCV^{DIST\_0.5}$	\$1.435	\$0.892	\$1.979
D'Arbonne	$TCV^{DIST\_0.5}$	\$0.597	\$0.371	\$0.823
Hobe Sound	$TCV^{DIST\_0.5}$	n/a	n/a	n/a
Lake Woodruff	$TCV^{DIST\_0.5}$	\$0.519	\$0.322	\$0.715
Mandalay	$TCV^{DIST\_0.5}$	\$18.081	\$11.233	\$24.928
Merritt Island	$TCV^{DIST\_0.5}$	n/a	n/a	n/a
Mississippi Sandhill Crane	$TCV^{DIST\_0.5}$	\$6.763	\$4.202	\$9.325
Pelican Island	$TCV^{DIST\_0.5}$	\$4.565	\$2.836	\$6.294
St. John's	$TCV^{DIST\_0.5}$	\$1.741	\$1.082	\$2.401
Waccamaw	$TCV^{DIST\_0.5}$	\$6.657	\$4.136	\$9.178
Watercress Darter	$TCV^{DIST\_0.5}$	\$3.128	\$1.943	\$4.312
Wheeler	$TCV^{DIST\_0.5}$	\$29.865	\$18.555	\$41.175
Big Branch Marsh	$TCV^{D0.5}$	\$32.260	\$10.250	\$54.270
Black Bayou Lake	$TCV^{D0.5}$	\$4.033	\$1.281	\$6.784
Bond Swamp	$TCV^{D0.5}$	\$1.136	\$0.361	\$1.911
D'Arbonne	$TCV^{D0.5}$	\$0.472	\$0.150	\$0.794
Hobe Sound	$TCV^{D0.5}$	n/a[c]	n/a	n/a
Lake Woodruff	$TCV^{D0.5}$	\$0.411	\$0.130	\$0.691
Mandalay	$TCV^{D0.5}$	\$14.310	\$4.547	\$24.073
Merritt Island	$TCV^{D0.5}$	n/a	n/a	n/a
Mississippi Sandhill Crane	$TCV^{D0.5}$	\$5.353	\$1.701	\$9.005
Pelican Island	$TCV^{D0.5}$	\$3.613	\$1.148	\$6.078
St. John's	$TCV^{D0.5}$	\$1.378	\$0.438	\$2.318
Waccamaw	$TCV^{D0.5}$	\$5.269	\$1.674	\$8.863
Watercress Darter	$TCV^{D0.5}$	\$2.475	\$0.787	\$4.164
Wheeler	$TCV^{D0.5}$	\$23.636	\$7.510	\$39.763

[a] Confidence intervals are not computed for the quadratic models and thus we do not repeat $TCV^{QUAD\_0.5}$ or $TCV^{QUAD\_2.0}$ results in this table (all available information is directly reported in Table B.3).

[b] $TCV^{DIST\_0.5}$ is computed by equations (9) and (10) and based on the regression model presented in equation (4); $TCV^{D0.5}$ is computed by equations (9) and (10) and based on the regression model presented in equation (2).

Table B.7. Total Capitalized Value, with 95% confidence intervals, for California/Nevada NWRs.[a]

National Wildlife Refuge	Computation Method[b]	Total Impact	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Antioch Dunes	$\mathbf{TCV^{DIST\_0.5}}$	$7.186	$0.059	$14.312
Coachella Valley	$\mathbf{TCV^{DIST\_0.5}}$	$5.874	$0.049	$11.700
Desert	$\mathbf{TCV^{DIST\_0.5}}$	$6.905	$0.057	$13.753
Don Edwards San Francisco Bay	$\mathbf{TCV^{DIST\_0.5}}$	$30.486	$0.252	$60.719
Ellicott Slough	$\mathbf{TCV^{DIST\_0.5}}$	$4.678	$0.039	$9.318
Marin Islands	$\mathbf{TCV^{DIST\_0.5}}$	$4.349	$0.036	$8.662
North Central Valley	$\mathbf{TCV^{DIST\_0.5}}$	n/a	n/a	n/a
Salinas River	$\mathbf{TCV^{DIST\_0.5}}$	n/a	n/a	n/a
San Diego	$\mathbf{TCV^{DIST\_0.5}}$	$19.823	$0.164	$39.481
San Joaquin River	$\mathbf{TCV^{DIST\_0.5}}$	$0.878	$0.007	$1.749
San Pablo Bay	$\mathbf{TCV^{DIST\_0.5}}$	$3.057	$0.025	$6.089
Antioch Dunes	$\mathbf{TCV^{D0.5}}$	$12.922	$0.835	$25.009
Coachella Valley	$\mathbf{TCV^{D0.5}}$	$10.563	$0.683	$20.444
Desert	$\mathbf{TCV^{D0.5}}$	$12.418	$0.803	$24.033
Don Edwards San Francisco Bay	$\mathbf{TCV^{D0.5}}$	$54.823	$3.544	$106.103
Ellicott Slough	$\mathbf{TCV^{D0.5}}$	$8.413	$0.544	$16.282
Marin Islands	$\mathbf{TCV^{D0.5}}$	$7.821	$0.506	$15.136
North Central Valley	$\mathbf{TCV^{D0.5}}$	n/a[c]	n/a	n/a
Salinas River	$\mathbf{TCV^{D0.5}}$	n/a	n/a	n/a
San Diego	$\mathbf{TCV^{D0.5}}$	$35.647	$2.304	$68.991
San Joaquin River	$\mathbf{TCV^{D0.5}}$	$1.579	$0.102	$3.056
San Pablo Bay	$\mathbf{TCV^{D0.5}}$	$5.497	$0.355	$10.639

[a] Confidence intervals are not computed for the quadratic models and thus we do not repeat $TCV^{QUAD\_0.5}$ or $TCV^{QUAD\_2.0}$ results in this table (all available information is directly reported in Table B.4).
[b] $\mathbf{TCV^{DIST\_0.5}}$ is computed by equations (9) and (10) and based on the regression model presented in equation (4); $\mathbf{TCV^{D0.5}}$ is computed by equations (9) and (10) and based on the regression model presented in equation (2).

Table B.8. Total Capitalized Value by Region (95% confidence intervals in parentheses).

	Computation Method[a]		
	$TCV^{D0.5}$	**$TCV^{DIST\_0.5}$**	**$TCV^{QUAD\_0.5}$**
Northeast Region			
5 miles to UA	$63.38	$65.30	$60.54
	(17.1 - 109.7)	(25.9 - 104.7)	n/a[b]
8 miles to UA	$68.30	$95.23	$82.25
	(-10.3 - 146.9)	(31.2 - 159.3)	n/a
10 miles to UA	$63.18	$92.42	$62.40
	(-36.3 - 162.7)	(17.4 - 167.5)	n/a
Southeast Region			
5 miles to UA	$95.40	$73.29	$140.14
	(30.3 - 160.5)	(30.6 - 116.0)	n/a
8 miles to UA	$96.16	$121.50	$156.61
	(30.6 - 161.8)	(75.5 - 167.5)	n/a
10 miles to UA	$177.04	$166.32	$221.73
	(95.1 - 259.0)	(106.1 - 226.6)	n/a
California/Nevada			
5 miles to UA	$137.00	$53.70	$90.91
	(52.6 - 221.4)	(-4.0 - 111.4)	n/a
8 miles to UA	$150.00	$83.41	$146.08
	(9.7 - 290.3)	(.7 - 166.1)	n/a
10 miles to UA	$194.67	$49.56	$247.39
	(-66.1 - 455.5)	(-106.0 - 205.4)	n/a

[a] **$TCV^{D0.5}$** is computed by equations (9) and (10) and based on the regression model presented in equation (2); **$TCV^{DIST\_0.5}$** is computed by equations (9) and (10) and based on the regression model presented in equation (4); **$TCV^{QUAD\_0.5}$** is computed by equations (11) and (13) and based on the regression model presented in equation (1); **$TCV^{QUAD\_2.0}$** is computed by equations (11) and (12) and based on the regression model presented in equation (1).
[b] Confidence intervals are not available for calculations based on this model.

Appendix C: Glossary

Census Block[a] - defined by the U.S. Census Bureau as "A geographic area bounded by visible and/or invisible features shown on a map prepared by the U.S. Census Bureau. A block is the smallest geographic entity for which the Census Bureau tabulates decennial census data." Census blocks are often a literal "block" outlined by streets, as one typically envisions in an urban area.

Centroid - a point that denotes the geographic center of a spatial entity (Census Block, Urban Area, MSA).

Hedonic Pricing Model - a decomposition of the price of an asset into the values of its constituent components, used to obtain market prices for the individual components. For example, the price of a parcel of land may be decomposed into the value of the land separately from its improvements. Further, the hedonic pricing model recovers the value of the each characteristic of the land (e.g., proximity to an amenity) and the value of each building characteristic (e.g., bedrooms, baths or presence of a fireplace). The model is typically a linear regression in which the price of an asset is regressed on its component characteristics. The resulting coefficient estimates for each characteristic return, or can be used to recover, the marginal value for each characteristic in the regression.

Marginal Value - the additional value of an asset resulting from an incremental increase in one of its component characteristics.

Metropolitan Statistical Area (MSA)[a] - defined by the U.S. Census Bureau as "A geographic entity designated by the federal Office of Management and Budget for use by federal statistical agencies. A metropolitan statistical area (MSA) is a metropolitan area (MA) that is not closely associated with another MA. An MSA consists of one or more counties, except in New England, where MSAs are defined in terms of county subdivisions (primarily cities and towns)."

Total Capitalized Value - the total contribution of a component characteristic of an asset to its market price.

Urban Area - Throughout this report, we refer to "Urbanized Areas" as Urban Areas for ease of exposition. See definition of an Urbanized Area below.

Urbanized Area[a] - defined by the U.S. Census Bureau as "A densely settled area that has a census population of at least 50,000. A UA generally consists of a geographic core of block groups or blocks that have a population density of at least 1,000 people per square mile, and adjacent block groups and blocks with at least 500 people per square mile. A UA consists of all or part of one or more incorporated places and/or census designated places, and may include additional territory outside of any place."

[a] see definition at http://www.census.gov/geo/www/tiger/glossary.html

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