THE ECONOMIC BENEFITS OF INTEGRATING LAND AND WATER PROTECTIONS

by

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ABSTRACT

The overall objective of this study is to evaluate the economic benefits of integrating land and water protection using a revealed preference approach. We used two hedonic specifications to look at the impact of land and water on residential property values. The sample included 323,088 single family home sale transactions within Montana. The data was refined by accommodating for transaction type, time, and attributes to define our empirical framework. The results show that land and water protection have a stronger statistical significant impact on the price of houses near both lakes and river. However, the stronger impact is on lakes than river housing prices. There is a statistically significant increase in residential property value with water and protected land integration for lakes larger than or equal to 4 ha (Model 4) and all lakes and rivers (Model 1). The findings show that integrating water and land protection has the most significant impact on residential property values when analyzing all lake sizes by increasing property values by 41.4% for properties with travel times greater than or equal to 60 minutes to urban areas with at least 20% nearby protected land.

1. INTRODUCTION

1.1 Background of the Study

Water quality has an essential role for all life on earth. Water is used for various purposes including agriculture, recreation, industry, drinking, and habitat. Water quality can vary based on time, location, weather, and pollution sources (Giri & Qiu, 2016). There are two primary sources of pollution that make maintaining water quality challenging, point and nonpoint source pollution. Point source pollution is easily definable and regulated by state and federal agencies (USEPA, 2009). Nonpoint source pollution tends to be difficult to identify due to the interaction of runoff and landscape (Chiwa et al, 2012). Urban runoff can carry animal waste from pets, human waste from sewage overflows or septic leaks. Agricultural runoff can carry livestock manure from industrial-scale feedlots and excess nutrients such as fertilizers and pesticides.

When these pollutants enter waterbodies, they can have adverse effects on human health and ecosystems. For example, microbial contaminates like E.coli and fecal coliform from human and animal waste can cause disease outbreaks (John & Rose, 2005). Excess phosphorus and nitrogen can lead to increased growth of algae and aquatic plants, reducing dissolved oxygen levels which will result in eutrophication. Eutrophication causes additional stress on aquatic life and decreases the aesthetics and recreational benefits of the water body (USEPA, 2020b). Heavy metals in the atmosphere like mercury are converted into methylmercury in waterbodies, where the toxic compound can accumulate in fish, shellfish, and animals that consume fish. There can be a negative effect on human health when humans consume the fish with high levels of mercury (USEPA, 2020b).

According to assessments made during the National Rivers and Streams Assessment 2013-2014, roughly 52.9% of 1,110,961 miles of rivers and streams were categorized as impaired. Out of 13,208,917 acres of lakes, reservoirs, and ponds, 70.9% were categorized as impaired and out of 56,141 square miles of bays and estuaries, 79.4% were categorized as impaired (USEPA, 2020a). Pollutants including fecal coliform or E.coli, sediment, nutrients, organic enrichment/oxygen depletion, temperature, metals other than mercury, Polychlorinated Biphenyls (PCBs), mercury, and habitat alterations were the top causes of impairment (USEPA, 2020b). The study also found that although most sources of impairment are unknown due to difficulty in tracking, agriculture, hydromodification, atmospheric deposition, habitat alterations, municipal discharge from sewage, natural wildlife, and urban-related runoff from stormwater were top probable sources of impairment (USEPA, 2020a).

The US Clean Water Act of 1972 required all states return their water sources to be 'fishable and swimmable'. EPA also required states to implement water quality assessments and establish "total maximum daily loads" (TMDL) for pollutants in "impaired" surface waters (Section 303d). Each state developed their own criteria for impaired waters which may include numeric or narrative criteria (Walsh and Milon, 2016). The USEPA has promoted numeric standards for nutrients in surface waters since 1998 to provide objective water quality indicators for development and administering TMDL programs (USEPA, 2000b), however, a majority of states do not use numeric nutrient criteria (Walsh and Milon, 2016). Despite the progress afforded by the Clean Water Act for states to restore their water sources, the nation still faces many challenges in protecting these resources and the variety of benefits and services they provide

(Papenfus, 2019).

1.2 Problem Statement

Urgently addressing the issue of water quality and quantity is critical for protecting the health and daily life of our society. We plan to examine this water issue at the interface of land and water. Due to urban sprawl and increased population density, the loss of forest and agricultural land to urban development has taken a toll on resources in various areas in the United States. The increase in impervious land cover like streets, roads, and homes have resulted in various environmental issues such as water quality degradation. Protected lands can intercept surface runoff, pollutants, sediments, and wastewater before they enter ground water recharging areas and surface waters (Welsch, 1991).

Undeveloped land with vegetation cover can reduce run-off by slowing down water flow compared to developed lands. Slower water flow reduces the chance of nutrient run-off and soil erosion which can also lead to increased infiltration and help replenish groundwater.

Studies have shown that polices that protect land and encourage sustainable land use can improve water quality and quantity (Halstead et al., 2014; Bowles et al., 2016; Chen et al., 2016; Shi., 2017). Positive interdependence of land and water protection can benefit local communities, by providing environmental amenities, healthy ecosystems, alleviating flood risks and more. There is a plethora of literature evaluating the amenity value from protected open space (Liu et al., 2013; Cho et al., 2008; Anderson & West, 2006; Irwin, 2002; Lutzenhiser & Netusil, 2001; and many others) and the economic benefits of using green space to alleviate flood risks to local communities (Johnson et al., 2020; Brody, 2017; Watson et al., 2016; Kousky & Walls, 2014; Kousky et al., 2013;

Arkema et al., 2013). There is also an increasing volume of studies evaluating the economic benefits of water quality (Peng et al., 2017; Van Houtven et al., 2014; Kwak et al., 2013; Artell, 2013). However, few have examined the economic benefit from integrating land and water protection.

1.3 Objectives

The overall objective of this study is to evaluate the economic benefits of integrating land and water protection using a revealed preference approach. Three specific objectives are proposed as follows:

1. Estimate the impact of water body on nearby property values
2. Disentangle the impact of potential water quality improvement through land protection
3. To test whether there exists a gap between perception of water quality measured land protection and actual water quality measure in a hedonic framework

2. REVIEW OF THE LITERATURE

2.1 Valuing Water Quality and Protection

Measuring and modeling how water resources benefit humans can be inherently difficult (Papenfus, 2019). There have been two primary approaches to measuring these benefits. One of which is the traditional approach of using stated and revealed preference models. These models evaluate the impact of direct biophysical measurements of water quality, such as, nutrient levels, water clarity, or a combination of water quality indicators. The other l approach uses ecological production function (EPF) models and biophysical models to link human valued ecological endpoints, that can be driven by relevant policy changes. The challenge associated with the second approach, is developing a credible estimate of ecological services through an ecological production function (EPF) that can be valued using economic valuation methods (Papenfus, 2019). Most studies use benefits transfer methods to link ecological production function (EPF) estimates. This study will use the revealed preference approach to evaluate the economic benefits of integrating land and water protection.

Homes are heterogenous goods sold in a single market at an implicit price. This is referencing that homes are sold as a bundle of goods, but can not be characterized by a single price. These types of goods have a range of prices that depend upon the characteristics or quality of the good. Although there may not be a single price for the aggregate bundle, hedonic approach uses the consistency of individual attributes to solve for individual benefits (Sheppard, 1998). Environmental quality in the neighborhood where the house is located is among one of these individual attributes.

Hedonic approach allows users to identify the structure of component attribute prices and estimate a hedonic price function. Hedonic price method breaks down property sale price to structural, neighborhood, and environmental characteristics. With the assumption that the housing supply is fixed and prices are determined by demand, hedonic price models use property values to infer willingness to pay for non-traded attributes, like environmental quality.

The hedonic approach has been widely used to estimate the effect of environmental amenities materialized into housing prices (Paterson and Boyle, 2002). These amenities include open space (Anderson & West, 2006; Cho et al., 2008; Sander & Polasky, 2009), air quality (Anselin & LeGallo, 2006; Kim et al., 2010), wetlands (Paterson & Boyle, 2002; Mei et al., 2018), and water quality (Leggett and Bockstael, 2000; Poor et al., 2007; Moore, 2020; Liu et al., 2017).

2.2 Economic Benefits of Open Space

Various hedonic studies have found that nearby protected open space can increase residential property value by 0.57%-26.2%. The following are a few examples. Irwin (2002) evaluated the benefit from different types of open space in central Maryland. They found that houses adjacent to protected forests or farmland are valued significantly higher than houses next to developable forest or farmland. In particular,10-acres of farm land preserved under agricultural conservation easement, can result in a 2.6% or $4,523 higher mean value in the neighboring residential property. The effect from public land through fee is 1.17% or $2,038, from preserved pastureland is 1.87% or $3,307, and 0.57% or $994 from publicly owned land.

Qiu et al (2006) used a hedonic model and contingent valuation (CV) study to evaluate the economic value of open space and riparian buffers in the Dardenne Creek watershed in the St. Louis metropolitan area. They found that homes closer to streams had a higher property value except for properties within the flood zone whose values were reduced by 4.7 to 5.6 percent. The CV study estimated a willingness-to-pay (WTP) of $1,400 to $1,625 per property for open access to buffers along the creek. The WTP for properties adjacent to openly accessible and community owned buffers along the creek was $6,100 to $6,858.

Black (2018) conducted an additional study measuring the premium buyers paid for an adjacent parcel with preserved status, using boundary changes of guaranteed open space created by the Pennsylvania Game Commission. They found that homes adjacent to the open space of game lands increased adjacent home values between 20.4%-26.2% which could translate to a premium of $24,326 to $31,178 per home with a mean value of $119,000. They also found that the premium was driven by the preserved view and complement to lot size.

2.3 Hedonic Study on Water Quality

2.3.1 Water quality and property value

There have been an increasing number of studies on this topic ranging from coastal water quality (Leggett & Bockstael, 2000; Artell, 2014; Liu et al., 2017) to freshwater lakes (Tuttle & Heintzelman, 2015; Moore, 2020), and watersheds (Poor et al, 2007; Netusil et al, 2014). Most hedonic models investigating water quality focus on water clarity measured through various biophysical means. Based on pollutant types, most studies fall into three categories of biophysical measurements. The three categories are: clarity, nutrient levels, or a combination of clarity, nutrient, and pH values.

Combination measure of water quality

This type of study uses a combination approach to investigate the impact of water clarity, nutrient levels, and pH on property values using cross-sectional data. Poor et al. (2007) investigated the value of ambient water quality throughout the St. Mary's River watershed in Maryland. They found that marginal implicit price of a one mg/L change in dissolved inorganic nitrogen and total suspended solids are $-1,086 and -$17,642. Bin and Czajkoski (2013) compared technical measures to non-technical measures, location grade, of water quality in Martin County, Florida. Their findings show that a 1% change in water clarity yields a $36,070 change in mean waterfront property. They also find WTP values for water quality ranging from $7,531 for marginal change in pH to $43,158 for marginal change in location grade. Moore et al. (2020) studied water clarity in 113 U.S inland lakes in 32 states using total phosphorus concentration, lake surface temperature, and total nitrogen concentration to establish water clarity. The study found that a one-tenth of a meter change in clarity would yield a 1% change in housing price. They also found that one unit change in water clarity causes a 9.9% change in prices, one-foot change in SECCHI translates to estimated $12,104 price change.

Another group of studies evaluated water clarities effect on property value over time. Tuttle & Heintzelman (2015) used both a scientific and ecological endpoints to measure water quality of lakes in Adirondack Park over a nine-year period. The indicator species, common loon, had a significant positive impact by increasing the mean property value by $21,803 or 11%. They also found evidence that the presence of invasive plant, Eurasian water milfoil, reduces property value by $10,459 or 6% and acidity reduced property values by $30,144 or 18%. Bin et al. (2017) studied the change in implicit price of water quality over time in a fluctuating housing market in Martin County, Florida. They find an implicit price of $2,614 change in mean waterfront property value for a 1% change in a water quality index. They also find that water quality improvement is continuously associated with higher property values regardless of tough economic times. Liu et al. (2019) used hedonic analysis and soil and water assessment tool (SWAT) to measure water quality changes in the Upper Big Walnut Creek watershed using housing transaction data from 1990 to 2013. The results showed that with one-foot increase of Secchi-disk depth leads to 7.72% increase in mean property value within 0.3 miles of the Hoover Reservoir.

Several studies not only included an average change in residential property value, but evaluated how distance from the waterbody affected property value. For example, Netusil et al. (2014) used hedonic price method to determine how five water quality parameters in two urbanized watersheds affected property sale prices. The results show that from a one mg/L increase in dissolved oxygen, percent change in property values increase as distance from Johnson Creek decreases during the dry season. They also found that an increase in E.coli during the dry season decreases property values seeing the greatest loss where properties are within ¼ mile to Johnson Creek. Burnt Bridge Creek followed the same trend as Johnson Creek.

Clarity measure of water

This type of study focuses on evaluated water clarity mostly through light attenuation. Walsh et al. (2011; 2017) studied multiple waterbodies to evaluate property value change due to clarity. Walsh et al. (2011) studied how enhanced water quality in 146 lakes would affect waterfront and non-waterfront properties in Orange County, Florida. They found an estimated $5,595 mean increase in lakefront properties for a one-foot change in SECCHI index and a statistically significantly impact on non-waterfront homes that extends up to 1,000m from a lake. Walsh et al. (2017) studied 14 counties in Maryland across spring and summer comparing a three-year average to a one-year average of water quality index. The indicator used was water clarity through light attenuation. They found that a 10% improvement in clarity would yield a 0.33% to 1.5% increase in value of waterfront homes.

Two studies found the significance of water quality change over time causing significant changes in property values. Wolf and Klaiber (2017) examined the impact of harmful algal blooms on housing prices using a hedonic analysis between 2009 and 2015 across 6 Ohio counties. . They found that housing values decreased by 11%-17% from algal booms. Homes adjacent to a lake with microcystin concentration levels surpassing the World Health Organization no-drinking threshold, decrease in value by 22% or $17,335. Klemick et al. (2018) evaluated the effect of water clarities using light attenuation on home values and whether such effect is heterogenous across counties and shore distance They found that the duration of water clarity had a positive impact economically and statistically. The estimated effect of three year average water clarity is a 1.1%, increase in value of waterfront properties, almost twice of the estimated of one year average, 0.6%. Which could suggest that residents are more concerned or aware of longer durations of water clarity.

Nutrient Levels of water

Leggett and Bockstael (2000) used hedonic models to estimate economic benefits of improving water quality around the Chesapeake Bay. The researchers found that a decrease from 103 fecal coliform count to 100 fecal coliform count per 100 mL in water would yield a 1.5% improvement in property prices, with the mean effect ranging from $5,114 to $9,824.

Liu et al. (2017) used hedonic price method to investigate the impact of chlorophyll concentration on housing prices in Narragansett Bay. They test the housing market's responds to extreme events or average water quality. They found that people have a higher concern with extreme environmental events, resulting in a decline in housing value by 0.10% within 100 m, 0.08% within 100-750m, 0.06% within 750-1,500m to the water bodies in the 99th percentile by a one-unit increase in chlorophyll concentration.

2.3.2 The mechanism through which water quality affects housing value

Perception of water quality

Many studies use water clarity as a measure of water quality due to its ease in perception for homebuyers and ease in measurement. The ability for buyers to easily observe and respond to such measures makes it a valid driver in actual homebuyer behavior (Bin and Czajkowski, 2013). Average home owners may not recognize or accurately interpret the measures of water quality commonly used by scientists, which causes them to make decisions based on their personal perceptions (Poor et al., 2001). This being stated, it is best to note that water clarity is not necessarily the most beneficial measure for ecology. Water clarity may be important for activities such as swimming, but not as important for activities such as aquatic life protection or fishing (Papenfus, 2019). Generally, water clarity is not an endpoint for establishing water quality standards (Papenfus, 2019). Indeed, Michael et al. (2000) found that water clarity came second to scenic beauty as the most important characteristic when purchasing a property, but water clarity was easier to measure with available data. They evaluated buyers' potential perceptions through the change in clarity during summer months and found that the buyers' perceptions of water clarity have a significant impact on implicit prices. Their survey found that out of those influenced by water clarity, 68% said it influenced their choice and price they paid to purchase their lake property (Michael et al., 2000). Liu et al. (2017) found that price is greatly impacted by extreme environmental events, rather than average water quality conditions. The extreme environmental events are often highly observable events, such as odors, algal blooms, and fish kills.

Technical versus non-technical measures

Several studies examined technical measures along with non-technical measures of water quality to evaluate which measures best predicted property values. Bin and Czajkowski (2013) found that the non-technical measure was weakly insignificant or significant depending upon the model. They find WTP values for water quality ranging from $7,531 for change in pH (technical) to $43,158 for location grade (non-technical), but ultimately found that technical measures provide better predictions of residential property values. Another study by Poor et al. (2001) directly compared hedonic models with subjective and objective measures of water clarity through eutrophication in comparable units. They found a trend of underestimating water clarity in subjective measures when compared to objective measures. They ultimately suggest that the objective measures are better predictors of property values.

Gibbs et al. (2002) used CV as well as a hedonic model to confirm lakefront property owners are concerned with water clarity. Mailed surveys on water clarity as a factor in home purchase showed, 76% made effort to inquire, 96.9% stated clean water is an important consideration, 98.5% stated clear water is very important, and water clarity influenced purchasing decisions of 45.5%. The model found that a one-meter decrease in water clarity can decrease property values by 0.9% to 6% on average. Marginal implicit prices for three Maine market areas ranged from $1,500 to $10,000 and New Hampshire $1,000 to $9,800.

3. METHODOLOGY

3.1 Study Area

Many states are currently facing a water crisis. In addition to the increase in demand, water quality is also rapidly deteriorating. For example, in Texas, between 2020 and 2070, the population is predicated to grow by more than 70%, leading to a 17% increase in demand on water (Texas Water Development Board, 2017). Meanwhile, ground and surface water supply is expected to decline by about 11%. Counties along the I-35 corridor are expected to experience the worst shortage where the population growth could reach 460% by 2050 (Texas Demographic Center, 2019). Some of these communities are already facing a water shortage and increased water bills (Phillips and Teng, 2020).

For this study, we will be focused on the state of Minnesota. In the state of Minnesota, there are 69,000 miles of rivers and streams and 11,800 lakes. In 2020 the state of Minnesota reported that approximately 6,000 bodies of water were considered impaired due to phosphorus and nitrates from agricultural activities and chloride from road salt and water softeners (MPCA, 2020). These chemicals could cause disease and harm to aquatic life after entering to lakes and reservoirs. There can be substantial costs to treating water that have been polluted by nutrients. For example, in Minnesota, the cost of drinking water increased from 5 to 10 cents per 1000 gallons to $4 per 1000 gallons (USEPA 2020b).

Water quality deterioration caused by nutrients, bacteria, stormwater, road salt use, and snow fences also affected the health and daily life of Minnesota residents. Minnesota Department of Health encourages residents with well water access to check for coliform bacteria every year and nitrate every other year. A study by the Minnesota department of Health in 2014 determined that 30% of drinking water wells may be contaminated with viruses that make people sick (LIDE, 2019).

Water quality deterioration caused by flood water and run-offs triggered by heavy rains have also affected the health and daily life of Texas residents. In September 2020, Texas Commission on Environmental Quality (TCEQ) warned Houston area residents to only use tap water for flushing toilets due to the possible contamination of a deadly brain-eating microbe. In 2018, Austin issued a city-wide boil water order due to heavy rains carrying dirt, silt, and debris into waterbodies that overwhelmed the city's water-infiltration systems. Several studies have found that drinking water in rural Texas contains radiation, lead, and arsenic concentrations above the national federal drinking water standard (Weissman, 2018). Researchers have also found that pollutants in Texas water bodies have contributed to birth defects (Agopian, 2013).

3.2 Data

Property sale data was obtained from the Zillow ZTRAX property transaction database. Property transaction data is combined with Loveland LLC property parcel boundary data. Data on protected land areas are from Protected Areas Database of the United States (PAD USA) from US Geological Survey. Finally, Neighborhood characteristics and water body boundary data are retrieved from National Land Cover Database (NLCD) from the US Geological Survey using ArcGIS software. Local demographics are also compiled from the US Census Bureau. The combined dataset was acquired from Christoph Nolte at Boston University.

Based on building code, we drop all transactions of properties that are not single family residential properties. We then narrowed our property sales occurrences to transactions between from 1990 to 2021. We then dropped non-arm's length transactions which do not reflect the true market value of a property. All sale prices are in 2021 dollar values using average annual Consumer Price Index available from the Federal Reserve database. In addition, we exclude from this analysis the properties with sales value less than or equal to \$20,000 or greater than or equal to \$1,000,000. Residential properties with more than 14 bedrooms or with building square footage smaller than 600 or larger than 30,000 are also excluded.

Descriptive Statistics

Models 1-3 are parallel with models 4-6. Meaning that equation 1-3 and 4-6 consist of the same variable except 4-6 replace percent protected land and interaction between land and housing prices with dummy variables. The all lakes and rivers models had 375,518 observations, lakes $\geq$ 4 ha (large lakes) only model had 364,652 observations, lakes $\leq$ 4 ha (small lakes) only had 10,866 observations, and 375,518 observations for the river only model.

Of the observations for homes located by all lakes and rivers, 323,088 had a travel time fitting the $\geq$ 0 minutes specification with a travel time to urban areas of 15.6 with a standard deviation of 21. 43,269 had a travel time of $\geq$ 30 minutes with a travel time to urban areas of 54.3 with a standard deviation 33.9, and 9,161 had a travel time of $\geq$ 60 minutes with a travel time to urban areas of 108.06 with a standard deviation of 39.18. The mean price of these homes are the greatest at $\geq$ 0 minutes at \$317,140.8 with a standard deviation of \$181,907.3. Travel time $\geq$30 minutes had the lowest mean price being \$191,676.7 with a standard deviation of \$123,663.8. Homes with travel time $\geq$30 minutes have the oldest age of 48.3 with a standard deviation of 34.9 and the lowest square footage of 1747.8 with a standard deviation of 1008.2. Homes with a travel time of ≥ 0 minutes had the youngest age of 30.8 with a standard deviation of 22.1, while travel time of ≥ 60 minutes had the age of 34.6 with a standard deviation of 24.7. The same pattern follows with the mean square footage of 1,974.9 with a standard deviation of 1,117.5 for travel time ≥ 0 minutes and 1779.8 with a standard deviation of 1135 for travel time ≥ 60 minutes.

Out of the observations for homes located by large lakes, 313,362 fit the specification of travel time ≥ 0 minutes with a travel time to urban areas of 15.7 with a standard deviation of 21.16 , 42,303 had a travel time of ≥ 30 minutes with a travel time to urban areas of 54.4 with a standard deviation of 34.1, and 8,987 had a travel time of ≥ 60 minutes with a mean travel time to urban areas of 108.16 of with a standard deviation of 39.2. The mean price of these homes are the greatest at ≥ 0 minutes at $315,106.2 with a standard deviation of $180,797 and the lowest mean price $169,120.6 with a standard deviation of $104,703 for travel time ≥ 30 minutes. Homes with travel time ≥ 30 minutes have the oldest age of 48.67 with a standard deviation of 34.9 and the lowest square footage of 1,737.65 with a standard deviation of 999.6. Homes with a travel time of ≥ 0 minutes had the youngest age of 30.9 with a standard deviation of 22.25, while travel time of ≥ 60 minutes had the age 34.73 with a standard deviation of 24.7. The same pattern follows with the mean square footage of 1,966.32 with a standard deviation of 1,112.5 for travel time ≥ 0 minutes and 1,777.8 with a standard deviation of 1,137.1 for travel time ≥ 60 minutes.

Of the observations for homes located by small lakes, 9,726 fit the specification of travel time ≥ 0 minutes with a travel time to urban areas of 12.6 with a standard deviation of 17.3. 966 had a travel time of ≥ 30 minutes with a travel time to urban areas of 50.5 with a standard deviation of 29.79. 174 had a travel time of ≥ 60 minutes with a mean travel time to urban areas of 102.8 with a standard deviation of 36.28. The further away from the urban areas the homes are located, mean price decreases starting at $382,693.7 with a standard deviation of $204,058.4 for homes ≥ 0 minutes and the lowest mean price at $183,802.5 with a standard deviation of $110,070.1 for homes ≥ 60 minutes. The building square footage and bedroom number also decrease as homes get further from urban areas. Contrary to the pattern seen in the previous criteria, homes with travel times ≥ 30 minutes have the oldest building age of 33.8 with a standard deviation of 30.15, while ≥ 60 minutes had the lowest age at 28.5 with a standard deviation of 19.37 and ≥ 0 had the age of 29.33488 with a standard deviation of 17.9. The mean square footage of 2,253.02 with a standard deviation of 1,236 for travel time ≥ 0 minutes and 1882.68 with a standard deviation of 1021.1 for travel time ≥ 60 minutes.

Table 1: Summary Statistics

		All Lakes and Rivers			**Large Lakes**			**Small Lakes**			**Rivers Only**	
Variables Travel Time ≥0	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std Dev.**
N	323,088			313,362			9,726			323,088		
Price		317140.8	181907.3		315106.2	180797		382693.7	204058.4		317140.8	181907.3
Travel Time to Urban Area		15.65246	21.0634		15.74464	21.16136		12.68259	17.35886		15.65246	21.0634
Building sqft		1974.954	1117.572		1966.323	1112.583		2253.025	1236.051		1974.954	1117.572
Number of bedrooms		3.878154	1.761875		3.871363	1.75889		4.096957	1.842251		3.878154	1.761875
Building Age		30.88047	22.14002		30.92844	22.25505		29.33488	17.97833		30.88047	22.14002
Variables Travel Time ≥30	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std Devi.**	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**
N	43,269			42,303			966			43,269		
Mean Price		191676.7	123663.8		190172.4	122175.4		257552.7	164028.4		191676.7	123663.8
Mean Travel Time to Urban Area		54.31641	33.92986		54.4033	34.01385		50.51143	29.79026		54.31641	33.92986
Building sqft		1747.838	1008.266		1737.655	999.6763		2193.768	1253.04		1747.838	1008.266

Number of bedrooms		3.232314	1.298273		3.229629	1.299027		3.349896	1.259877		3.232314	1.298273
Building Age		48.36476	34.93223		48.67248	34.97343		34.88923	30.15533		48.36476	34.93223
Variables Travel Time ≥60	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**
N	9,161			8,987			174			9,161		
Mean Price		169399.4	104820.3		169120.6	104703		183802.5	110070.1		169399.4	104820.3
Mean Travel Time to Urban Area		108.0619	39.18592		108.1636	39.23485		102.8056	36.28698		108.0619	39.18592
Building sqft		1779.805	1135.093		1777.814	1137.112		1882.684	1023.12		1779.805	1135.093
Number of bedrooms		3.357166	1.735116		3.363525	1.736586		3.028736	1.628603		3.357166	1.735116
Building Age		34.61554	24.71005		34.7335	24.78806		28.52299	19.37751		34.61554	24.71005

3.3 Methods

The hedonic price method determines the value of a good in the open market based on their characteristics. These models infer the price impact of individual characteristics on the overall price of the good by capitalizing on variation in home characteristics and prices across time (Tuttle and Heintzelman, 2015). Rosen (1974) was first to show how property prices carry consumers' marginal WTP for housing attributes and their quality using hedonic price method.

A bundle of individual home attributes can be used to write the hedonic property value equation. For this study, these attributes include structural characteristics for each home (X), water (W), and finally, price of the home when sold (P), protected land (L), and water as a function of land protection ($W(L)$). The hedonic price function is:

$$P=P(X,L,W(L))$$

Consistent to the hedonic function, our hedonic model includes several structural (parcel) and neighborhood attributes, lake and river front property indicators, variables indicating land protection within a radius of a property, social demographics, as well as year and season dummy variables controlling for seasonal fluctuations of housing prices and real estate market conditions. Housing attributes include eight structural variables including parcel square footage, age, number of beds, slope, etc. Neighborhood attributes include level of education and mean household income in Census Block Group, travel time to nearest urban area, and racial composition. Our lake and river indicators are dummies equal to 1 if a property is lake or river front and zero otherwise.

Given the effect of land protection can be heterogenous, we use two model specifications based on two alternative measures of land protection. The first is to use the percentage of land protection within 5,000-meter radius of a residential property. The second specification is to use four land protection dummies indicating if the percentage of land protection is with 0, 0-10%, 10-20%, or >20%. We run each of the model specification on four sub-samples of our data to account for heterogenous effects of water bodies. The four sub-samples are: 1) all lakes and rivers combined, 2) lakes larger than 4 hectares in size, 3), small lakes less than 4 hectare in size, and 4) river only.

Our study uses a standard log-linear specification to minimize error due to spatial correlation in price and model error. For example, the price of one home could affect the price of other homes in the neighborhood. These models can be written as:

$$ln(P_{house}) = \beta_0 + \alpha * L\text{prot} + \delta * Wfront + \tau * L\text{prot} * Wfront + \beta_1 X + \varepsilon \qquad (1)$$

X denotes housing attributes and neighborhood characteristic other than land and water, β is the impact of the homes structural characteristics. $L\text{prot}$ is the percentage protected land within 5000-meter radius of a residential property. α thereby captures the impact of protected land on nearby property values. *Wfront* is a dummy variable taking the value of 1 if a property is a waterfront residential property. δ thereby capture the impact of water front on property value. τ is the coefficient for the interaction of percent protected land and waterfront properties which captures the integrated impact of land and water protection on residential property value, and ε is normally distributed error.

Continuous measures of land protection within a properties radius can introduce bias in estimation, as continuous distance measures can be correlated with other local characteristics. Furthermore, the effect of land protection on real estimate markets may only manifest when the percentage of land protection exceed certain threshold. As a result, we created a set of dummy variables on land protection as in the following model specification:

$$ln(P_{house}) = \beta_0 + \sum_{i=1}^{4}(\gamma_i * \mathrm{LD}_i) + \rho * Wfront + \sum_{i=1}^{4}\phi_i * (LD_i * Wfront_i) + \beta_1 X + \varepsilon \quad (2)$$

LD_i is a set of dummy variables measuring percentage protected land within the radius of a residential property to protected land. LD_i takes a value of 1 if a property is within a specific buffer zone of protected land and otherwise takes a value of zero. In particular, $LD_1 = 1$ if a residential property has 0-10% nearby protected land. $LD_2 = 1$ if a residential property has 10-20% nearby protected land. $LD_3 = 1$ if a residential property greater than 20% nearby protected land. γ_i (where i =1, 2, 3, 4) captures the effect of the set of dummy variables indicating percentage protected land within 5000-meter radius of a residential property. In this model, we leave the first dummy LD_1 out. ϕ_i (i =1, 2, 3, 4) is the coefficient for the intersection between the land dummy and water dummy, which capture the integrated impact of water and land protection on residential property values.

4. FINDINGS AND DISCUSSIONS

Our regression results using homes surrounding all lakes and rivers combined for both model specifications 1 and 2 are presented in Table 1. Table 2 presents the regression results for both model specifications using houses near lakes greater than or equal to 4 ha. The results for samples near lakes less than or equal to 4 ha are presented in Table 3, and in Table 4 are the results for rivers only. In all model specifications, we include the following structural and neighborhood attributes besides our variables on land protection and proximity to water. These attributes include eight structural variables and five neighborhood attributes. In all the model specifications, we include year dummies and quarter dummies to account for seasonal fluctuations of the housing market and the impact of the overall real-estate cycle on housing prices. To control potentially heterogenous impacts of different type and size of water bodies on residential property value, we run separate regressions, 1) lakes of all size combined and river, 2) all lakes only, 3) river only, 4) lakes larger than 4 ha only, and 5) lakes smaller than 4 ha only each with two protected land attributes and 27 dummy variables.

The results show that land and water protection have a stronger statistical significant impact on the prices of house near both lakes and river. However, the most significant impact is on lake than river housing prices.

We ran four models with six different specifications totaling to 24 regressions. The four models were based on the interested waterbody. Model 1 incorporated all lakes and rivers available in the dataset; Model 2 incorporated all lakes that were greater than or equal to 4 hectares (ha) only; Model 3 incorporated all lakes that were less than or equal to 4 ha only; and the final model incorporated all rivers only. The six specifications were based on the distance to nearest cities. Specification 1 is based on a distance greater than or equal to zero; specification 2 is based on a distance greater than or equal to 30 minutes; specification 3 is based on a distance greater than or equal to 60 minutes. Specification 4, 5, and 6 are mirrors of specification 1, 2, and 3, except with percent protected land dummy variables and their interactions with the waterfront dummy variables.

Table 2: Analysis of the interaction of water and protected land on all lakes and rivers

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice
lakefront dummy	0.206***	0.218***	0.295***	0.198***	0.220***	0.182**
	(0.00407)	(0.0125)	(0.0267)	(0.00371)	(0.0223)	(0.0761)
riverfront dummy	0.115***	0.0439	0.256***	0.209***	0.0990	0.165
	(0.0133)	(0.0356)	(0.0756)	(0.0121)	(0.0660)	(0.144)
Percent nearby protected land	-0.00159***	-0.00141***	-0.00381***			
	(0.000158)	(0.000323)	(0.000503)			
interaction of lakefront dummy and % nearby protected land	0.00331***	0.00495***	0.00611***			
	(0.000469)	(0.000783)	(0.00122)			
interaction of river front dummy and % nearby protected land	0.00133	0.00705***	0.00234			
	(0.00130)	(0.00191)	(0.00398)			
0-10% protected land				-0.0337***	0.0413***	-0.0943***
				(0.00167)	(0.00719)	(0.0231)
10-20% protected land				-0.0364***	-0.0237**	-0.172***
				(0.00482)	(0.0118)	(0.0266)
>20% protected land				-0.0875***	-0.0558***	-0.244***
				(0.00565)	(0.0135)	(0.0271)
interaction of lakefront dummy and 0-10% nearby protected land dummy				-0.000432	0.00912	0.151*
				(0.00708)	(0.0259)	(0.0802)
interaction of lakefront dummy and 10-20% nearby protected land dummy				0.00693	0.0491	0.125
				(0.0190)	(0.0405)	(0.0939)
interaction of lakefront dummy and >20% nearby protected land dummy				0.160***	0.242***	0.414***
				(0.0183)	(0.0392)	(0.0925)
interaction of river front dummy and 0-10% nearby protected land dummy				-0.169***	-0.0898	0.0799
				(0.0212)	(0.0776)	(0.166)
interaction of river front dummy and 10-20% nearby protected land dummy				-0.0370	0.150	0.235
				(0.0518)	(0.0951)	(0.186)
interaction of river front dummy and >20% nearby protected land dummy				0.00449	0.237***	0.190

				(0.0463)	(0.0902)	(0.181)
Travel time to major cities (2018) (min) (Weiss et al (2018))	-0.00418***	-0.00232***	-0.00159***	-0.00390***	-0.00232***	-0.00163***
	(5.66e-05)	(0.000107)	(0.000204)	(4.77e-05)	(0.000107)	(0.000211)
Square footage, total living area (sqft) (ZTRAX (ZAsmt))	8.80e-05***	5.91e-05***	6.08e-05***	0.000101***	5.88e-05***	5.75e-05***
	(1.19e-06)	(3.43e-06)	(7.63e-06)	(9.45e-07)	(3.43e-06)	(7.63e-06)
age of the property after update	-0.00288***	-0.00342***	-0.00544***	-0.00231***	-0.00346***	-0.00559***
	(4.39e-05)	(9.62e-05)	(0.000292)	(3.25e-05)	(9.63e-05)	(0.000292)
Number of bedrooms (ZTRAX (ZAsmt))	0.0209***	0.0485***	0.0388***	0.0191***	0.0496***	0.0397***
	(0.000727)	(0.00261)	(0.00523)	(0.000552)	(0.00262)	(0.00522)
Median household incomeat BG from 2012-2016 ($) (NHGIS)	9.83e-07***	2.87e-06***	1.78e-06***	1.52e-06***	3.15e-06***	1.93e-06***
	(4.75e-08)	(2.22e-07)	(6.64e-07)	(3.22e-08)	(2.24e-07)	(6.64e-07)
Population density at BG from 2012-2016 (NHGIS)	5.23e-05***	-2.01e-05***	-7.64e-06	2.27e-05***	-2.02e-05***	-9.41e-06
	(2.35e-06)	(6.18e-06)	(1.61e-05)	(1.20e-06)	(6.19e-06)	(1.61e-05)
% with higher education	1.029***	1.302***	1.201***	0.916***	1.248***	1.173***
	(0.00831)	(0.0331)	(0.0682)	(0.00546)	(0.0338)	(0.0688)
Average slope (deg) (USGS National Elevation Dataset)	0.0110***	0.0137***	0.0215***	0.0103***	0.0132***	0.0248***
	(0.000391)	(0.00103)	(0.00356)	(0.000294)	(0.00103)	(0.00360)
Average elevation (m) (USGS National Elevation Dataset)	-0.00209***	-0.00102***	0.000660***	-0.00247***	-0.000980***	0.000867***
	(3.39e-05)	(5.78e-05)	(0.000134)	(2.73e-05)	(5.88e-05)	(0.000147)
Parcel area (ha) (Parcel map)	0.00962***	0.00736***	0.00607***	0.0101***	0.00739***	0.00616***
	(0.000343)	(0.000514)	(0.00102)	(0.000304)	(0.000514)	(0.00102)
% building footprint area in vicinity of 500 meter (%) (NHGIS)	-0.0174***	-0.0177***	-0.0139***	-0.0117***	-0.0172***	-0.0141***
	(0.000323)	(0.00100)	(0.00230)	(0.000222)	(0.00101)	(0.00229)
sold in quarter 2	0.0407***	0.0723***	0.0657***	0.0443***	0.0714***	0.0667***
	(0.00271)	(0.00845)	(0.0187)	(0.00193)	(0.00844)	(0.0187)
sold in quarter 3	0.0571***	0.0869***	0.0693***	0.0599***	0.0863***	0.0693***
	(0.00271)	(0.00846)	(0.0187)	(0.00194)	(0.00845)	(0.0186)
sold in quarter 4	0.0233***	0.0516***	0.0424**	0.0292***	0.0512***	0.0435**
	(0.00286)	(0.00895)	(0.0199)	(0.00205)	(0.00894)	(0.0199)
Constant	11.88***	11.35***	9.751***	11.99***	11.33***	9.747***
	(0.0756)	(0.207)	(0.420)	(0.0528)	(0.207)	(0.419)
Observations	323,088	43,269	9,161	509,786	43,269	9,161
R-squared	0.398	0.270	0.216	0.419	0.272	0.220
Standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

Table 3: Analysis of the interaction of water and protected land on all lakes greater than or equal to 4 ha

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice
lakefront dummy	0.347***	0.286***	0.365***	0.352***	0.312***	0.281***
	(0.00574)	(0.0145)	(0.0298)	(0.00557)	(0.0275)	(0.0924)
0-10% protected land				-0.0336***	0.0427***	-0.0918***
				(0.00167)	(0.00714)	(0.0229)
10-20% protected land				-0.0344***	-0.0174	-0.166***
				(0.00479)	(0.0117)	(0.0263)
>20% protected land				-0.0839***	-0.0434***	-0.238***
				(0.00559)	(0.0133)	(0.0268)
interaction of lakefront dummy and 0-10% nearby protected land dummy				-0.0492***	-0.0303	0.113
				(0.00988)	(0.0314)	(0.0963)
interaction of lakefront dummy and 10-20% nearby protected land dummy				-0.0568**	0.0642	0.137
				(0.0247)	(0.0484)	(0.111)
interaction of lakefront dummy and >20% nearby protected land dummy				0.0622***	0.200***	0.399***
				(0.0224)	(0.0451)	(0.109)
Percent nearby protected land	-0.00144***	-0.00112***	-0.00377***			
	(0.000156)	(0.000317)	(0.000498)			
interaction of lakefront dummy and % nearby protected land	0.00120**	0.00462***	0.00669***			
	(0.000595)	(0.000875)	(0.00135)			
Constant	11.89***	11.21***	9.738***	12.00***	11.18***	9.738***
	(0.0769)	(0.220)	(0.418)	(0.0540)	(0.220)	(0.418)
Observations	313,362	42,303	8,987	497,019	42,303	8,987
R-squared	0.402	0.273	0.221	0.421	0.274	0.224
Standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

Table 4: Analysis of the interaction of water and protected land on all lakes less than or equal to 4 ha

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice
lakefront dummy	0.0580	0.371		0.0446	0.318	
	(0.0451)	(0.315)		(0.0377)	(0.318)	
0-10% protected land				0.0359	0.0733	0.0944
				(0.0868)	(0.0516)	(0.159)
10-20% protected land				-0.373	-0.00875	-0.154
				(0.299)	(0.0822)	(0.208)

>20% protected land				-0.120	0.146	0.133
				(0.260)	(0.0913)	(0.213)
protected land combination	-0.00743	0.00223	0.00103			
	(0.0100)	(0.00183)	(0.00313)			
interaction of lakefront dummy and 0-10% nearby protected land dummy				-0.0582		
				(0.0876)		
interaction of lakefront dummy and 10-20% nearby protected land dummy				0.368		
				(0.301)		
interaction of lakefront dummy and >20% nearby protected land dummy				0.226		
				(0.262)		
interaction of lakefront dummy and % nearby protected land	0.00971					
	(0.0100)					
Constant	11.62***	12.09***	12.26***	11.71***	12.14***	12.15***
	(0.400)	(0.773)	(0.571)	(0.272)	(0.774)	(0.597)
Observations	9,726	966	174	12,767	966	174
R-squared	0.306	0.213	0.264	0.340	0.215	0.280
Standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

Table 5: Analysis of the interaction of water and protected land on all rivers

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice	log price of realprice
riverfront dummy	0.105***	0.0447	0.226***	0.196***	0.0818	0.120
	(0.0134)	(0.0358)	(0.0768)	(0.0121)	(0.0664)	(0.146)
0-10% protected land				-0.0364***	0.0421***	-0.0944***
				(0.00165)	(0.00698)	(0.0226)
10-20% protected land				-0.0418***	-0.0304***	-0.183***
				(0.00471)	(0.0115)	(0.0261)
>20% protected land				-0.0751***	-0.0248*	-0.216***
				(0.00544)	(0.0129)	(0.0264)
interaction of river front dummy and 0-10% nearby protected land dummy				-0.161***	-0.0696	0.0679
				(0.0213)	(0.0781)	(0.168)
interaction of river front dummy and 10-20% nearby protected land dummy				-0.0275	0.162*	0.214
				(0.0520)	(0.0957)	(0.189)
interaction of river front dummy and >20% nearby protected land dummy				-0.00307	0.215**	0.161
				(0.0464)	(0.0908)	(0.184)
Percent nearby protected land	-0.00135***	-0.000641**	-0.00237***			
	(0.000151)	(0.000300)	(0.000467)			
interaction of river front dummy and % nearby protected land	0.00119	0.00609***	0.00179			

	(0.00131)	(0.00193)	(0.00406)			
Constant	11.90***	11.32***	9.630***	12.02***	11.30***	9.783***
	(0.0760)	(0.209)	(0.427)	(0.0531)	(0.208)	(0.425)
Observations	323,088	43,269	9,161	509,786	43,269	9,161
R-squared	0.392	0.260	0.186	0.414	0.262	0.196
Standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

4.1 Effect of Structural and Neighborhood Variables on Sale Price

The effect of structural characteristics, land parcel attributes, and neighborhood characteristics on residential housing prices are relatively consistent across all four model specifications. The regression criteria with small lakes only (Table 3) presents more results with a lower level of significance. Increasing building square footage and number of bedrooms have a positive effect on a property's sale price with number of beds being the highest between the two. Building age consistently had a negative impact on sale price while elevation had a negative impact until the greater than or equal to 60 minutes specifications.

Land parcel area hectare and slope have a positive effect on property sale price. The education level in the Census Block Group where a residential property is located had the most significant impact on property sale value. Travel time to major cities and percent building footprint in a 500m radius had the most negative impact on sale price for neighborhood attributes.

For Model 1 (Table 2), the protected land variable has a negative impact in the first three regressions starting at .159%, then decreasing to .00141% for regression two, then finally -.381% for regression 3. While running multiple regressions for this study we realized that protected land and travel time are positively correlated which is potentially why we have a negative sign for protected lands effect on price. As percent protected land increases, the distance from the city or urban area is likely increasing, causing the value of the land to decrease overall. This is potentially why we have this outcome for each model. This finding could also potentially be attributed to the exogeneity of open space where the land has a lower development potential lowering the price. The interactions between the lakefront dummy and percent nearby protected land had a statistically significant positive impact of .331% for travel time > 0 minutes, .495% for travel time >30 minutes, and .611% for travel time > 60 minutes with 99% confidence. The interactions between the riverfront dummy and percent nearby protected land had a statistically significant positive impact of .705%, for travel time >30 minutes with 99% confidence, while travel time > 0 and > 60 were statistically insignificant.

4.2 Effect of the Interaction of Water and Protected Land on Sale Price

For Model 1 (Table 2) regressions 4-6, the percent protected land dummies were included in the regressions. These regressions are looking at the interaction of waterfront properties and percent nearby protected land dummies of 0-10%, 10-20%, and >20%. The dummies for protected land showed that for percent nearby protected land to have a positive effect on price, percent nearby protected land needs to be at least 20% for a statistically significant positive result of 16% for > 0 minutes, 24.2% for > 30 minutes, and 41.4% for > 60 minutes with 99% confidence. The interaction between riverfront dummies and percent protected land only presented significant results for the > 0 minutes specification with a negative impact of 16.9% for 0-10% and a significant positive impact of 23.7% for > 20% for > 60 minutes.

In Table 3, percent nearby protected land variable had a negative relationship with price as expected from the note before. For regressions 1-3, the interactions between the lakefront dummy and percent nearby protected land had a statistically significant positive impact of .12% for travel time > 0 minutes, .462% for travel time > 30 minutes, and .669% for travel time > 60 minutes with 99% confidence. In regressions 4-6 the percent protected land dummies were included in the regressions. Like the previous model, percent nearby protected land needs to be at least 20% for a statistically significant positive result. For the regressions representing > 20 % protected land yielded positive result of 6.22% for ≥ 0 minutes, 20% for > 30 minutes, and 39.9% for > 60 minutes with 99% confidence. The interaction between lakefront dummies and percent protected land only presented significant results for the > 0 minutes to urban area specification, with 0-10% and 10-20% showing a negative relationship between waterfront residential property and percent nearby protected land.

For table 4 the only interaction results presented with these specifications were either insignificant or there was not enough observations for stata include in the regression.

In Table 5 for regression 1-3 the percent nearby protected land variable had a negative relationship with price as expected from the note before. The interaction between the riverfront property and percent nearby protected land was only significant for the >30 minutes travel time specification at .609% at 99% confidence.

For regressions 4-6 there was either a negative or insignificant relationship between riverfront dummies and percent nearby protected land for the 0-10% nearby protected land dummy and 10-20% protected land dummy variable except for the 10-20% dummy with a 16.2% positive impact for > 30 minutes travel time.

5. CONCLUSION

There is a statistically significant increase in residential property value with water and protected land integration for lakes greater than or equal to 4 ha (Model 4) and all lakes and rivers (Model 1). The findings show that integrating water and land protection has the most significant impact on residential property values when analyzing all lake sizes by increasing property values by 41.4% for properties with travel times > 60 minutes to urban areas with at least 20% nearby protected land.

There should be further investigation into the relationship of travel time to nearest city and percent nearby protected land. Investigating potential control for urban, suburban, and rural areas to fully understand the negative impact seen in the relationship of protected land and lakefronts.

Lastly, the integration of the effect on improved water quality data to investigate how protected land can improve water quality and in return increase the value of nearby residential property.

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