A Comparative Analysis of Lakeshore Property Values in the Brainerd Lakes Area

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Abstract

This project takes an in-depth look at the environmental variables of freshwater lakes and how these variables affect the land value of lakeshore property. A GIS-based spatial and statistical analysis applied to lakeshore data from Crow Wing and Cass county Minnesota, provided the information necessary to establish general correlations applicable to Midwestern lakeshore property. The sample set includes: the Whitefish Chain, Pelican Lake, and Gull Lake. The environmental variables of these lakes can be divided into two groups; those that pertain to lakeshore parcels and those that pertain to the lakes. The parcel variables include: square footage, deeded acres, perimeter length, lakeshore frontage, accessible acres of water, and 2009 county-estimated land value. The variables of the lakes include: acreage, length of shoreline, littoral acreage, number of public accesses, water clarity, maximum depth, and median depth. The relationship between the environmental variables and the land value of lakeshore property is illustrated through correlations, multiple regression, and a Hedonic Value Analysis.

Introduction

There is much interest in recreational property within the Brainerd Lakes area of north-central Minnesota. The area is home to hundreds of resorts, camps and campgrounds, and is a popular summer vacation destination for fishing, boating, water sports, dining and golf. Much of the recreational lakeshore property ownership exists as second homes for many seasonal residents.

This project focuses on the measurable lake quality variables that are generally hypothesized to increase riparian property values. The focus is on single-family residential parcels – the most common type of lakeshore property for the lakes in this study. As an example, it is commonly accepted that an increase in shoreline footage alone can be directly correlated to the parcel's land value; this assumption was statistically correlated within this project with a simple random sample of residential parcels.

Other variables thought to directly relate to property values include: water clarity, accessible acres of water (as on a chain of lakes), number of public lake accesses, maximum depth of the lake, and the parcel's shoreline footage. These variables and several others were statistically studied through correlation analysis within this project.

The lakes included in this project are some of the largest and most desirable in the Brainerd Lakes area. The "Big Three" lakes include: Gull Lake, Pelican Lake, and the Whitefish Chain of lakes.

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Gull Lake is situated just north and west of the Brainerd/Baxter cluster and is nearest to the city of Nisswa. It is also surrounded by the East Gull Lake and Lake Shore townships.

Pelican Lake is further north with the city of Breezy Point to its immediate west and the city of Pequot Lakes nearby.

The Whitefish Chain is surrounded by the city of Crosslake, the city of Manhattan Beach, the city of Fifty Lakes, and also within the Ideal and Timothy townships. This Chain of lakes is made up of Arrowhead Lake, Bertha Lake, Big Trout Lake, Clamshell Lake, Cross Lake, Daggett Lake, Island and Loon Lakes, Little Pine Lake, Lower Hay Lake, Pig Lake, Rush Lake, and Whitefish Lake. These lakes vary in size from a mere 191 acres to over 7,300 acres. The Whitefish Chain is primarily fed by the Pine River and controlled by the Pine River Dam (on the east side of Cross Lake). Pine River then flows into the Mississippi.

These "Big Three" lakes span more than 32,000 acres of water and have approximately 5,600 residentially-classified lakeshore parcels. Figure 1 illustrates the "Big Three" lakes within the Brainerd Lakes Area.

Purpose

The purpose of this project was to utilize a GIS to perform a spatial and statistical analysis of environmental variables perceived to influence residential lakeshore property values. Variables of interest included those pertaining to the parcel and those that pertained to the lakes. The variables pertaining to the parcel included: square footage, perimeter, feet of shoreline, deeded acres, and property value. The variables pertaining to the lakes included: acres, littoral acres, number of public accesses, accessible acreage (as on a chain of lakes), water clarity, maximum depth, median depth of lake (where available), and feet of shoreline. With this data, a comparative analysis was performed utilizing a Hedonic Value model. Utilizing these analyses allows for future predictive analysis upon the influence of environmental variables on property value.

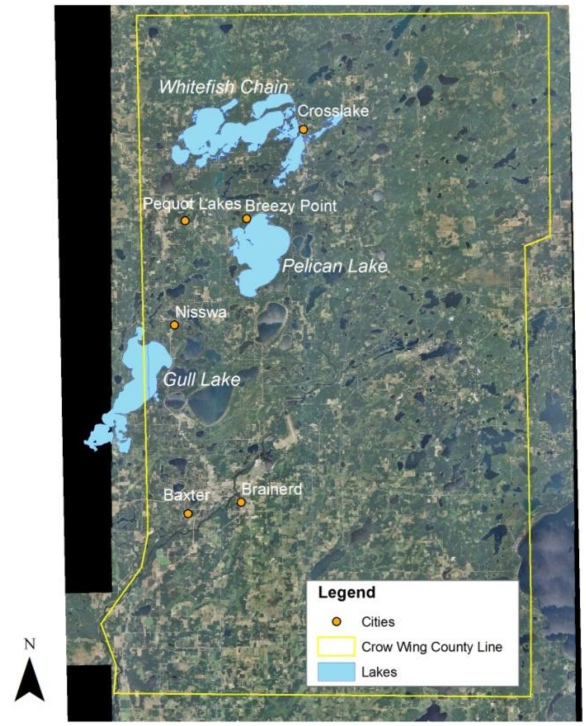


Figure 1. The Brainerd lakes area of Cass and Crow Wing counties.

Background

Recreational property value analysis began in the 1960's by David (1969) who obtained values from over 9,000 parcels of Wisconsin land from the years of 1952, 1957 and 1962. David noticed (among other trends) the growing desire of private ownership of lakeshore property and began predicting that this type of property would continue to increase in value over time. David's methodologies of sampling privately owned lakeshore spearheaded lakeshore land evaluation. The factors David alleged to have the most influence on lakeshore property value were two-fold: (1) aesthetics and human affinity toward lakes, and (2) environmental variables.

Water Quality as a Predictor of Value

By far, the most studied environmental variable influencing lakeshore property value is water quality. Krysel, Boyer, Parson and Welle (2003) utilized Secchi disc readings (an objective measure of water clarity) to define water quality standards in lakes of the Mississippi Headwaters Region. They also looked at property values along associated areas of the Mississippi River (turbidity was used as the water quality standard for properties along the river). Hedonic models suggest greater water quality yields higher property values and conversely, lower water quality values yield comparably lower property values.

In addition, Steinnes (1992) studied the effect of water quality on land values (not taking into account structural or locational values). Steinnes discovered greater water clarity ratings from Secchi disc readings correlated with higher property values.

Hedonic Value Analysis

Hedonic Value Theory, as discussed by Lansford and Jones (1995), is the method by which the value of a "composite good" is established by taking into account the value of each attribute that comprises the composite good. For example, Lansford and Jones cite air quality, which is dependent on many factors – oxygen content, carbon dioxide content, etc. – the values of which sum to provide the air quality value.

According to Michael, Boyle, and Bouchard (1996), "Lake-front properties can be viewed as heterogeneous goods; they have a number of different characteristics and are differentiated from each other by the quantity and quality of these characteristics." Research conducted by Michael et al. hypothesized water quality affected property values in Maine through use of a Hedonic value model. The price of a home was divided by the number of feet of lake frontage and was used as a dependant variable (FTPRICE). This variable is a function of the structural characteristics (S), locational characteristics (L), and the natural log of water clarity (W). The model presented by Michael et al. can be viewed mathematically as:

$$\text{FTPRICE} = f\,(\text{S, L, ln[W]})$$

Krysel et al. (2003) utilized a similar mathematical model to that of Michael et al. (1996). The model expresses purchase price (PP) as a function of property characteristics (P), characteristics of structures (S), locational characteristics (L) and the natural log of water clarity (WATERC) multiplied by lake size (SA). Their model can be viewed mathematically as:

$$\text{PP} = f\,(\text{P, S, L, lnWATERC * SA})$$

Two functions for assessing factors of (1) the purchase price of the land (PP), (2) the change in property value across an entire lake – the assessed value of land (AVL), and (3) the assessed value of land and structures (AVS) were given in their statistical methods. These functions are:

$$\text{PPLand} = f\,(\text{S, L, lnWQ * LA})$$
$$\text{PPLand (derivation)} = (\text{AVL / AVL + AVS}) * \text{PP}$$

Where WQ is water quality and LA is the size of the lake (Krysel et al., 2003).

A Hedonic Value analysis was performed by utilizing the attribute values for each lake to be comparable to the others. Structural values and locational values were not taken into account, simplifying the relationship of the land to the environmental factors of the lakes. The aforementioned studies typically involved the comparison of one variable of interest to both structural and locational values. By taking into account only the land's assessed value, no comprehensive predictive model of total value of real estate for the residential parcels utilized exists within this study.

Limitations to Hedonic Value Analysis

The Hedonic Value Theory, although effective, is subjective. This model is being used to integrate factors of perceived value instead of those that can be measured, according to Steinnes (1992). Steinnes used a Hedonic pricing model to evaluate water quality in relation to property value. Steinnes cited in some areas acid rain causes water clarity to be greater than that of lakes in which tannins are produced by the plant life and often is correlated to an increase in suspended organic matter. Higher land value was more prevalent in the sterile, acidic lakes than that of the healthy, tannin-rich lakes (Steinnes).

Correlation Analysis

In statistics, correlation values are calculated to determine if there is a relationship between two variables. Although correlation does not always imply causation or influence, it is often used as a measure of how one variable relates to another. The variables in this study were chosen due to their assumed influence on property values.

Statistical Significance

Statistical significance is a means to determine if two sets of variable data relate or influence one another or if the data can be said to have happened by chance. Statistical significance is measured by a *p-value* which gives the probability of the null hypothesis being true (Zar, 1999). The null hypothesis, H_0, suggests the data is random and that no causation or influence exists between the environmental variable and property values. The alternate hypothesis, H_A, states there is a connection between the data causing relationships between the environmental factors and the estimated property values. In this study, the $\alpha = 0.05$ and $\alpha = 0.01$ levels of significance were used as the benchmark for statistical significance.

Multiple Regression Analysis

Multiple regression analysis is the step-wise process by which multiple independent variables are used to explain as much of the variability of the data as possible. The coefficient of determination (henceforth, R^2) is the statistic that exemplifies the percentage of variability that is explained by the independent variables. Variables that do not add additional explanation are excluded by the analysis.

Property Value Appraisal

The Crow Wing County assessor's office identified the factors that define property appraisal. They include: limited market value, estimated market value, use classification, new improvements, taxable market value, real property, real estate, land, fixtures, and personal property.

Within the land values used for this project, the use classification is residential, the market value and estimate are directly contained in the parcel land values, but none of the structural components will be included in the parcel land values. It is hypothesized that by standardizing the dataset the results will be more conclusive and the comparisons between the lakes will be more valid.

Methods

The land data and parcel shapefiles were obtained from Crow Wing and Cass counties. Lake data was obtained from published MNDNR Lake Information Reports. The following steps were taken after the data was acquired.

“Trimming” the Data

Data “trimming” was the process of standardizing the data by means of singling out only the residential parcels for comparison. Then the interquartile range (IQR) of parcel square footage for each lake trimmed the data further and identified the parcels of interest. This procedure is important because the lakeshore parcels amassed a wide range of use classifications and sizes. The data was standardized as to make more accurate and valid conclusions from the statistical analysis. See Figure 2 for the process of selecting and ‘trimming’ the parcel data.

- The lakes in the study were selected and shapefiles were created of the lake polygons.
- The parcels immediately surrounding the lakes (lakeshore properties) were selected and new layers were created from these selected parcels.
- The unnecessary classifications (state lands, federal lands, commercial properties, camps and campgrounds, resorts, agricultural and timber lands) were removed so that only residentially-classified parcels remained (labeled as either residential unit, seasonal recreational residential, or previously surrendered residential).
- Only residentially-classified parcels remained (classified). Boxplots were

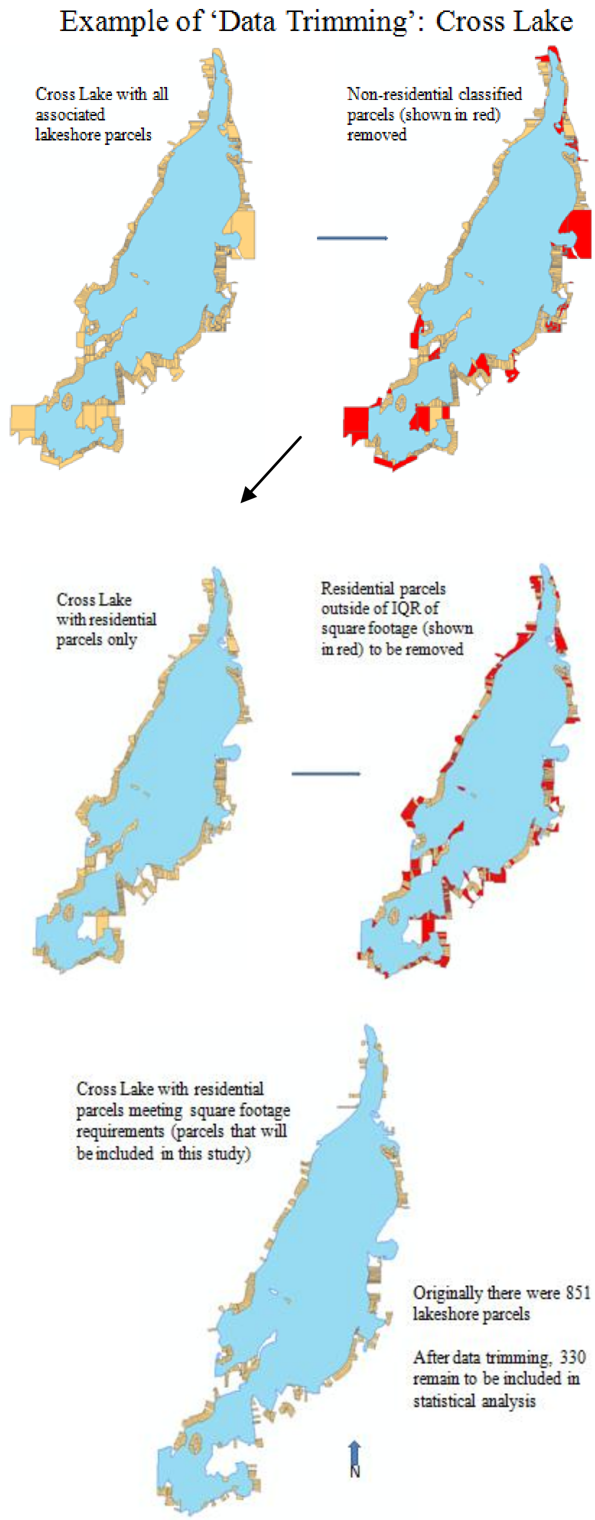


Figure 2. Data trimming in order to standardize the parcels of interest.

created (using Minitab statistical software) showing the interquartile range (IQR) of square footage for residential parcels on a given lake.
- The IQR was used to perform a correlation analysis between property value and the environmental variables (the 50% of the data immediately surrounding the median).

These parcels were used to eliminate outliers, and properties that were either too small (not buildable) or too large, enabling standardization of the data set.

The number of parcels that remained within the IQR range was reduced to approximately 45-50% of the original number of lakeshore parcels by data trimming. Of the remaining parcels in the IQR range, most lakes were randomly sampled at 50% to provide for the ‘feet of shoreline’ parcel variable because it provided a large yet feasible sample size. Approximately 20-25% of the total residential parcels were therefore sampled to obtain ‘parcel feet of shoreline.’

Obtaining “Parcel Feet of Shoreline” Variable Data

The only variable data not provided by the county’s database was ‘parcel feet of shoreline.’ To obtain a representative dataset, a sample of the lakeshore parcels was measured using the Measure tool in ArcMap following these steps:

- Download “Random Selection” script from *ESRI Support: Downloads* page.
- Utilize 50/50 principle: for lakes less than 50 parcels within the IQR, all parcels were sampled; otherwise, a 50% random sampling of the parcels within the lake’s IQR was taken.
- Manually measure feet of shoreline for sample parcels and add to attribute table.

Correlation Analysis Methods

- Attribute tables of all residentially-classified parcels of each lake within the Whitefish Chain were imported into SPSS statistical software, then compiled into a single table.
- Calculate correlations between each variable and the other variables.
- The attribute tables of the IQR parcels for each lake of the Chain were imported into SPSS statistical software.
- Calculate correlations between each variable and the other variables for just the parcels trimmed by the IQR of parcel area calculation.
- Import only the parcel attributes of the parcels randomly sampled for ‘parcel feet of shoreline’ variable.
- Correlate all attributes again including the measured ‘parcel feet of shoreline’ with property value.
- Repeat the six steps prior to obtain the same three sets of correlations between the “Big Three” lakes. In this analysis, the ‘acres accessible by water’ variable was removed and ‘median depth’ was added.

From correlation tables, the greatest correlation values for each lake and sample size were noted and examples of some of the plots were created. In all, six data sets were used to provide correlation data tables. These data sets can be seen in Table 1. As the data set gets smaller, the more standardized the data becomes. This occurs as a result of trimming the total number of parcels down by classification and size.

Table 1. Data sets used in correlation and multiple regression analyses.

(W1) All residentially-classified parcels for the 12 lakes of the Whitefish Chain (3318 parcels in sample)	(W2) Residential parcels within the IQR of parcel square footage for the 12 lakes of the Whitefish Chain (1660 parcels in sample)	(W3) Sample of residential parcels within IQR of parcel square footage and measured for 'parcel feet of lakeshore' for the 12 lakes of the Whitefish Chain (861 parcels in sample)
(B1) All residentially-classified parcels for the "Big Three" lakes (5236 parcels in sample)	(B2) Residential parcels within the IQR of parcel square footage for the "Big Three" lakes (2791 parcels in sample)	(B3) Sample of residential parcels within IQR of parcel square footage and measured for 'parcel feet of lakeshore' for the "Big Three" lakes (1391 parcels in sample)

Multiple Regression Analysis Methods

Each of the data sets in Table 1 were used to compute multiple regression statistics. The R^2 values can be used to determine which variable(s) explain the dependent variable behavior. The data tables were imported into SPSS statistical software and analyzed using the linear regression function. 2009 estimated land value was used as the dependent or 'Y' variable and the rest of the lake and parcel variables were input as the independent or 'X' variables.

Hedonic Value Analysis Methods

The model created to provide a Hedonic value for analysis followed templates from Michael et al. (1996) and Krysel et al. (2003). The correlation calculations, along with the variables identified by previous studies, indicated the variables of greatest influence to be used within the Hedonic Value Analysis. The Hedonic model focused on these variables of interest using the dataset containing only the parcels falling within the IQR of property square footage.

The Hedonic Value function utilizes the area (in acres) of the lake (LA), the mean square footage of the parcel (SQ) for each lake, and the natural log of water clarity (WC) for each lake. These are the variables included in the function to create the model for predictive price (PP) of land. The function can be viewed mathematically as:

$$PP = f\,(SQ, \ln[WC] * LA)$$

To provide comparisons between the Hedonic Values from each lake, the mean assessed value of the land (AVL) was also included. Graphical representations of the different Hedonic variables of interest were created with the use of SPSS statistical software. These graphs allow the viewer to compare the variables of interest between the lakes. They can be viewed in Appendix B.

Results

Variable Correlations

The first set of correlations for the twelve lakes of the Whitefish Chain cited the 'deeded acres' variable correlating highest with land values. The correlation value was 0.361. Other notable correlations with land values included the variables of 'square feet of parcel' (0.352), 'parcel perimeter' (0.306), and 'water clarity' (-0.036). All of the correlations fell within the range of -0.036 and 0.361. When correlated with the '2009 estimated land value,' 9 of the 10 attributes were statistically significant at the $\alpha = 0.05$ level and 8 of the 10 attributes were significant at the $\alpha = 0.01$ level. Due to the 'accessible acres of water' attribute being constant, it was not correlated. Figure 3 illustrates the relationship between parcel square footage and land value (correlation

0.361) (reference Appendix A, Sample Set #1).

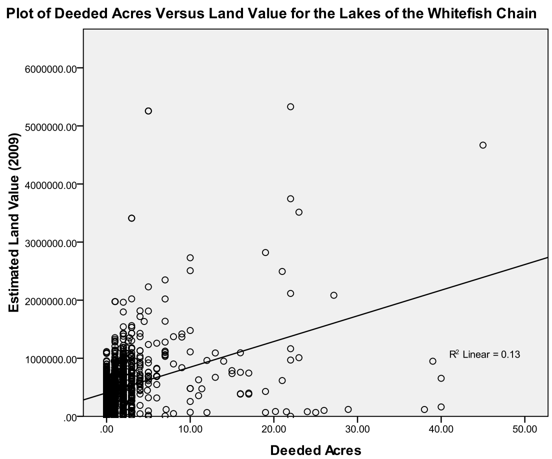


Figure 3. Greatest correlation to land value for the residentially-classified parcels of the twelve lakes of the Whitefish Chain (lake sizes ranging from 191 to 7,370 acres).

Similar correlations of residential parcels of the "Big Three" lakes were consistent with that of the Whitefish Chain. The highest correlation with land value was again with the 'deeded acres' variable at 0.360. Other notable correlations with land values included: 'square feet of parcel' (0.324), 'parcel perimeter' (0.318), and 'water clarity' (-0.112). Correlations with '2009 estimated land value' yielded 8 of the 10 attributes statistically significant at the $\alpha = 0.01$ level. Figure 4 displays the greatest correlation with land value from this data set (reference Appendix A, Sample Set #2).

After standardizing the data by utilizing only the IQR of the 'square feet of parcel' variable, the Whitefish Chain of lakes variables were again correlated with the '2009 estimated land value.' This time, the correlations were much lower. The highest was 'number of public accesses' (0.206), then 'square feet of parcel' (0.194), and 'littoral acres' (0.173). Still, 7 out of 10 attributes correlated at the $\alpha = 0.01$ level with '2009 estimated land value' (reference Appendix A, Sample Set #3).

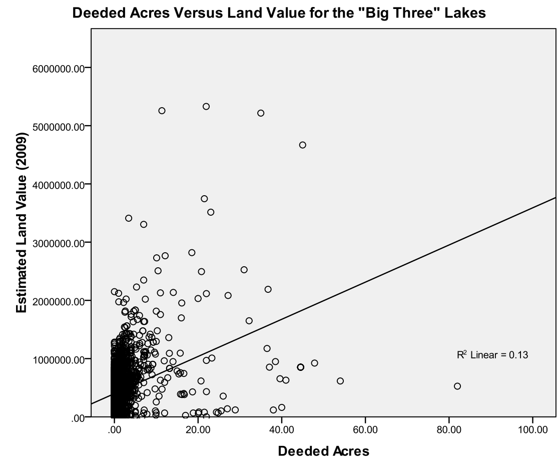


Figure 4. Greatest correlation to land value for the "Big Three" lakes (lake sizes ranging from 8,253 to 13,905 acres).

The IQR of parcel square feet was also used to standardize the data from the "Big Three" lakes. The following correlations were observed: 'shoreline of the lake' (0.287), 'median depth' (0.287), 'square feet of parcel' (0.239), and 'water clarity' (-0.249). With this correlation set, all 10 attributes were statistically significant at the $\alpha = 0.01$ level with '2009 estimated land value' (reference Appendix A, Sample Set #4).

The final set of correlation statistics for the Whitefish Chain was calculated using the sampled variable 'parcel feet of shoreline' against '2009 estimated land value.' 'Parcel feet of shoreline' had a correlation value of 0.089, being statistically significant at the $\alpha = 0.01$ level. The comparison between 'parcel feet of shoreline' and land value can be seen in Figure 5. The highest correlation within this dataset was with 'lake acres' (0.235), followed by 'shoreline of the lake' (0.234) and 'littoral acres' (0.233). 10 of the 11 attributes were statistically significant at the $\alpha = 0.05$ level, 9 of these being significant at the $\alpha = 0.01$ level (reference Appendix A, Sample Set #5).

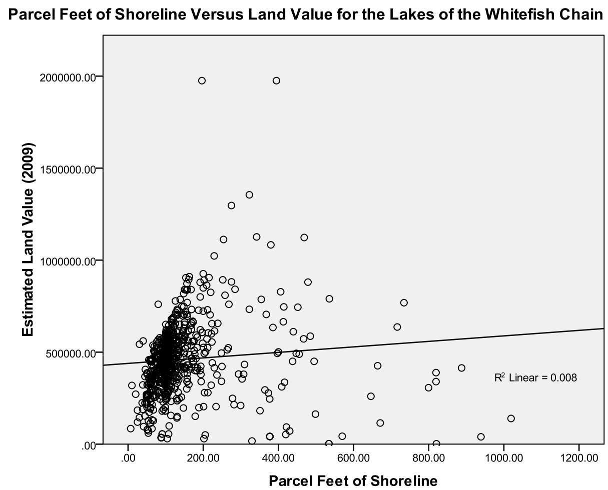


Figure 5. Parcel feet of shoreline as compared to land value.

The sample set including the 'parcel feet of shoreline' variable for the "Big Three" lakes yielded the following correlations: 'median depth' (0.282), 'shoreline of the lake' (0.282), 'square feet of parcel' (0.256), and 'water clarity' (-0.245). 'Parcel feet of shoreline' correlated with a value of 0.009 which is not statistically significant. 'Parcel feet of shoreline' is the only variable of the 11 not statistically significant at the $\alpha = 0.01$ level (reference Appendix A, Sample Set #6).

Multiple Regression Results

The data sets that contained only the residential parcels within the IQR range and measured for shoreline footage proved to have the greatest R^2 value for each of the two groups of lakes (reference Table 2 for R^2 values.) These two data sets are the smallest for each of the two groups of lakes. The highest R^2 values from these data sets were anticipated due to the similarities between parcel sizes and their associated classifications.

For the lakes of the Whitefish Chain, the greatest R^2 value is 0.260; 26% of the variability can be explained by the independent variables included in the regression. The independent variables included in the analysis were: parcel square footage, parcel perimeter, deeded acres, lake acreage, littoral acreage, accessible acreage, lake shoreline, maximum depth, number of accesses, and parcel lake frontage. Water clarity was excluded by the analysis as it did not warrant additional explanation for the variability.

Table 2. R^2 values from multiple regression analysis.

Data Set (reference Table 1)	$\mathbf{R^2}$
W1	0.171
W2	0.180
W3	0.260*
B1	0.210
B2	0.394
B3	0.402**

* Greatest R^2 value for the data set including the lakes of the Whitefish Chain.
** Greatest R^2 value for the data set including the "Big Three" lakes.

The greatest R^2 value for the "Big Three" lakes was 0.402, much higher than the value for the lakes of the Whitefish Chain. For this data set, the independent variables of: parcel lake frontage, parcel square footage, parcel perimeter, littoral acreage, and deeded acres were included in the R^2 calculation. Lake acreage, lake shoreline, water clarity, median depth and maximum depth were excluded and deemed unimportant in this instance. The 'number of accesses' variable was removed because it was a constant.

Hedonic Value Results

The Hedonic Analysis method used four values to compare the mean land value for each lake. The first value was mean 'square feet of parcel' for each lake. The second value was the natural logarithm of water clarity. The third value was lake acreage. The last value was the product of natural log of water clarity and lake acreage (reference Table 3 for Hedonic Values).

Table 3. Hedonic values table.

Lake Name	LA	SQ	ln(WC)	ln(WC) * LA	AVL
Arrowhead	308	71327.74	2.2	677.6	322825
Bertha	334	31889.46	2.3	769.06	417092.6
Big Trout	1342	26077.26	2.83	3802.17	456282.6
Clamshell	189	34871.15	2.64	498.78	496688.7
Cross	1751	28886.9	2.64	4620.99	496383.9
Daggett	225	29362.84	2.01	453.35	420075.6
Island/Loon	232	39644.91	2.53	585.97	331005.9
Little Pine	387	23187.21	1.95	754.65	389769.1
Lower Hay	685	38226.05	2.56	1756.99	440405.5
Pig	191	35565.63	2.6	497.11	451681
Rush	891	26334.53	2.64	2351.4	415814.2
Whitefish	7370	32926.61	2.08	15325.48	501366.2
Whitefish Chain	13905	30187.81	2.45	34111.16	451211.7
Pelican	8253	31820.41	2.97	24514.83	328152.1
Gull	9947	33218.75	2.35	23389.2	425649.2

The mean 'square feet of parcel' value provides comparison between parcel size, mean assessed value of land (AVL), and lake of study. This value was chosen for comparison because of its consistently strong correlation with property values. The values range from 23,187.21 to 71,327.74 square feet.

The natural log of water clarity, *ln(WC)*, was used in this study because of its use in similar studies as an influential variable in comparing property values. It is expressed as the natural log to reflect the nonlinear relationship that exists between land value and water clarity. This allows for greater comparability between the lakes. The natural log of water clarity values fall within the range of 1.95 to 2.97 (actual values range from 7.0 to 19.5 feet).

The third value, lake acreage, was also found in previous studies to be influential in comparing property values from lake to lake. The values ranged from 189 acres to 13905 acres.

The fourth value, the product of the natural log of water clarity and lake acreage, created a new data set combining the influence of both variables. This computation was used in similar studies for comparison. The values from this calculation ranged from 453.35 for a very small lake with a very low water clarity rating to 34,111.16 for the largest lake in the study.

Discussion

Variable Correlation Analysis

It is interesting to note that in every correlation sample almost all of the environmental variables were statistically significant with land values. This can be interpreted in one of two ways: either (1) the environmental variables of interest do influence the assessed value of the land, or (2) the data gives false indication of influence on land values. A further analysis of the correlations identified which variables of interest do and do not influence the assessed value of the land.

There are several anomalies to consider when analyzing the results. The first was that no variable had the highest correlation value in more than two of the data sets. Five variables showed the highest correlation with land value in a set of six samples. Therefore, it may be suggested that no variable is an all-encompassing predictor of land value.

Second, when the correlation values were ranked between the six samples, the 'square footage of the parcel' proved to be most prevalent in the top three correlation values for each. The factor that ranked next was 'shoreline of the lake.'

Water Clarity

The most notable correlations existed between water clarity and land value. In every sample, water clarity correlated negatively with land value which is counterintuitive. In 5 out of the 6 samples, it was the greatest negative correlation, meaning property values increased with decreasing water clarity.

One reason this statistical relationship opposes what is expected is because the water clarity value for all properties on a given lake is the same. Big Trout Lake, for example, had 342 residential parcels that all had the same water clarity value of 17 feet whereas Little Pine Lake had 165 residential parcels that all had the same water clarity value of 7 feet. More weight is put on the water clarity values that pertain to the most parcels. Figures 6 and 7 display this relationship and help to illustrate why the correlation values between water clarity and land value appear inversely related, when it is possible they are not. To resolve this issue, it is suggested that more lakes be studied.

The relationship between water clarity and land value is better analyzed through the Hedonic Value analysis in which the natural logarithm of water clarity is used as a means for comparison.

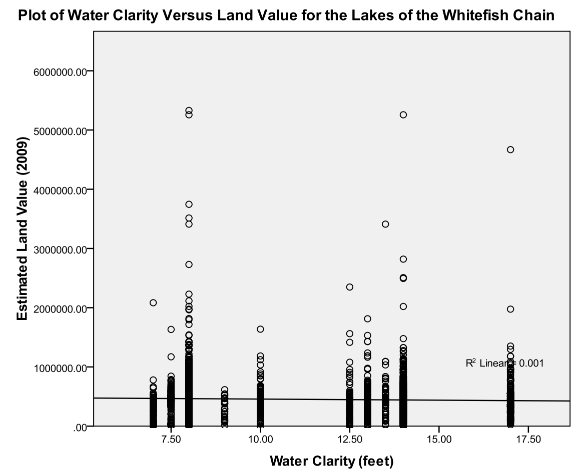


Figure 6. Water clarity as compared to land values for the lakes of the Whitefish Chain.

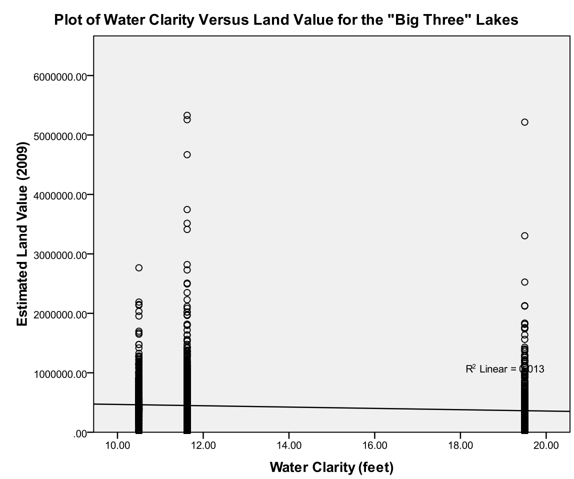


Figure 7. Water clarity as compared to land values for the "Big Three" lakes.

Shoreline Footage

There is a weak correlation between the parcel footage of shoreline and land value, which is noteworthy. Most people would assume there is a strong correlation between parcel footage of shoreline and land value. A comparison to land value that might show a stronger correlation is a variable taking into account parcel footage of shoreline and the condition of the land at the lake front (flat, sloping, swamp, forest, marsh, etc.).

Another comparison to land value that might show a strong correlation may be a variable taking into account the condition of the littoral zone (sandy, rocky, weedy, etc.). A parcel's footage of shoreline does not affect the property value as much as the square footage of the parcel itself, according to the correlations calculated with this data.

Other Correlations

Significant correlative relationships exist between variables not involving land values. For example, littoral acres always correlated highly with total acres of the lake and both of these variables also correlated highly with the lake's feet of shoreline, as expected. The number of public accesses highly correlated with the acreage of the lake. This suggests the number of access points may be set by lake acreage. The ratio of lake acres to public accesses is approximately 2,500:1, which was interpolated from the graph of these two variables. The variable 'maximum depth' of the lake held very little to no predictive weight. Water clarity ratings inversely correlate with most other variables.

Multiple Regression Analysis

The R^2 value for the data set that included the lakes of the Whitefish Chain explained 26% of the variability in the data. When compared to the R^2 for the "Big Three" lakes at 40.2%, it seems that there is less of an explanation for land values from the independent variables of the Whitefish Chain than there are for the "Big Three" lakes. It is also noteworthy that fewer variables were used to explain the amount of variability for the "Big Three" lakes than the lakes of the Whitefish Chain. This means that the variables used in the "Big Three" multiple regression analysis hold the most predictive weight for determining the land's value. The independent variables that hold the most predictive weight in this analysis of the "Big Three" lakes are: parcel lake frontage, parcel square footage, parcel perimeter, littoral acreage, and the parcel's deeded acres. Whereas shoreline frontage did not correlate well with land value, it did provide much in terms of its explanation of the variability in the data for this set. Not surprisingly, the parcel square footage and perimeter were also integral in explaining the variability.

The five variables that provided the most predictive weight for the Whitefish Chain were: parcel square footage, parcel perimeter, deeded acres, lake acreage, and littoral acreage. These findings are similar to the variables found to have an influence on the variability for the "Big Three" lakes. Recall, however, that nearly all of the independent or 'X' variables were utilized in the multiple regression, suggesting that they all play a part in explaining the 26% of the variability.

The R^2 values suggest the variability in the data can be explained primarily by parcel size, parcel perimeter, deeded acres, littoral acres, and shoreline frontage. These are the variables identified by one or both data sets to explain the majority of the variability in the data.

Hedonic Value Analysis

Hedonic Value comparisons were analyzed by reviewing the graphs that compare the variables of mean parcel size, lake acreage, and the natural log of water clarity to land value for each data set. It is difficult to make inferences from these graphs as there are very few data points to consider. However, notable trends are worth discussing in further detail (reference Appendix B).

The most surprising statistical comparison exists between mean parcel size and mean land value. The analysis of both data sets indicated an inverse relationship. In other words, as average parcel size increases, the average land value decreases. These results are highly counterintuitive. One possibility for these results for the lakes of the Whitefish Chain is the presence of outlying data points. The data was re-plotted after removing these points (Figure 8). The removal of outlying data points shows a much different relationship in which property values increase with increasing parcel size, which makes more sense.

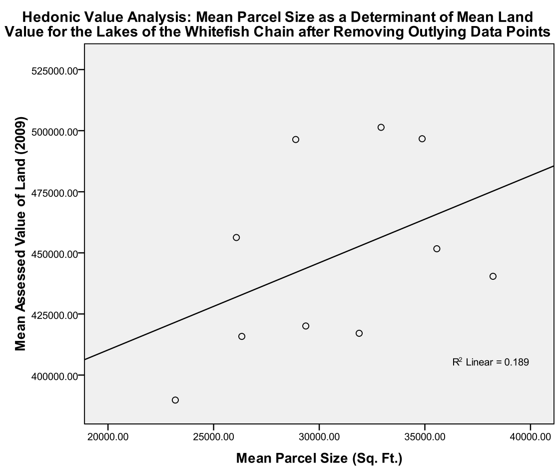


Figure 8. Re-plot comparing mean land value and mean parcel size after the removal of outlying data points.

The natural log of water clarity compared to land values produced different results than the correlation findings comparing water clarity and land value. For the lakes of the Whitefish Chain, the correlation showed a positive relationship between the natural log of water clarity and the mean land value. For the data set including the "Big Three" lakes, the correlation showed an inverse relationship between these two variables. When the natural log of water clarity was multiplied by the lake acreage, however, both relationships were directly related.

Future Predictive Analysis

It is nearly impossible to provide any sustainable model of estimating the land values from the variable data studied. Too many other variables affect the property value of a lakeshore parcel and assessment of land can be subjective. This study did identify variables that proved to be influential in land valuation – their statistical significance and influence in multiple regression analyses illustrate that. At the top of the list of influential variables for most of the statistical tests were parcel square footage, parcel perimeter and deeded acres. This suggests property price is probably best explained by a function that includes the parcel's shape and size.

It was hoped this data would be able to provide more models through the examination of the data and regression statistics. For example, a model that suggests an increase of 10 feet of lakeshore frontage results in an increase of *X* dollars in estimated land value. However, the factors prohibiting development of similar models are three-fold: (1) many other factors go into a property value appraisal (noted above, see Background: Property Value Appraisal section) than simply the ecological factors of the lakes, (2) too many other facets of the land (slope, condition, soil type, etc.) play a role in its value, and (3) personal affinity has an effect on the value in terms of how much a potential land owner would willing to pay for a certain type or location of property.

Conclusion

This GIS data is not conducive to providing an analytical model for predicting land value. The variable data of interest proved to be statistically significant in terms of their relationships with the assessed value of the land. Some variables showed more influence than others upon the land values. It is difficult for this analysis to prove that consistent trends exist between the variables and the property values because lots of other variables greatly affect the appraised land value. Location, quality of the land, and whether not the land is buildable are all important factors that also weigh heavily in land values.

From this data, however, the variables correlating greatest to land value were: the size of the parcel (sq. ft.) and the shoreline of the lake (ft.). The variables integral in explaining the variability in the data included: parcel size, parcel perimeter, deeded acres, littoral acres, and shoreline frontage. It can be concluded that many additional factors go into a lakeshore property value assessment that were not studied here. Of more importance within this study is how the lakes compared to one another, which can be viewed best through a Hedonic Value analysis. This analysis provided comparisons of the lakes within the two data sets and how the variables tend to affect property values.

Acknowledgements

I would like to thank Doug Hansen and Don Hoppe for their correspondence and for allowing me the use of the Crow Wing and Cass county GIS databases. I would also like to thank John Ebert, David McConville, and Patrick Thorsell of the Resource Analysis Department at Saint Mary's University for their support and guidance throughout this project.

References

David, E. J. 1969. The Exploding Demand for Recreational Property. *Land Economics*, 206-217. Retrieved on February 3, 2009 from http://www.jstor.org/pss/3145126.

Krysel, C., Boyer, E., Parson, C., and Welle, P. 2003. Lakeshore Property Values and Water Quality: Evidence from the Mississippi Headwaters Region. *Legislative Commission on Minnesota Resources*, 1-58. Retrieved on February 3, 2009 from http://archive.leg.state.mn.us/docs/2003/mandated/030502.pdf.

Lansford, N. H., and Jones, L. L. 1995. Recreational and Aesthetic Value of Water Using Hedonic Price Analysis. *Journal of Agricultural and Resource Economics*, 341-355. Retrieved on Febraury 3, 2009 from Google Scholar.

Michael, H. J., Boyle, K. J., and Bouchard, R. 1996. Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes. *Maine Agricultural and Forest Experiment Station Miscellaneous Report #398*, 1-18. Retrieved on February 3, 2009 from Google Scholar.

Steinnes, D. N. 1992. Measuring the Economic Value of Water Quality: The Case of Lakeshore Land. *The Annals of Regional Science*, 171-176. Retrieved on Febraury 3, 2009 from http://www.springerlink.com/content/b7643hm5x075pl05/.

Zar, J. H. 1999. Biostatistical Analysis. 4th Ed. New Jersey: Prentice Hall.

Appendix A. Table of Correlations.

Sample Set #1: Residentially classified parcels of the twelve lakes of the Whitefish Chain

Number of parcels in sample: 3318

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Square feet of parcel											
(2) Parcel perimeter (feet)	0.781**										
(3) Deeded acres	0.884**	0.68**									
(4) Lake acres	0.078**	0.092**	0.092**								
(5) Littoral acres	0.074**	0.09**	0.086**	0.994**							
(6) Accessible acres by water	NA	NA	NA	NA	NA						
(7) Lake shoreline (feet)	0.052**	0.053**	0.054**	0.95**	0.976**	NA					
(8) Water clarity (feet)	-0.067**	-0.05**	-0.086**	-0.509**	-0.504**	NA	-0.707**				
(9) Maximum depth (feet)	0.025	0.033	0.037*	0.73**	0.707**	NA	0.677**	0.118**			
(10) Number of public accesses	-0.001	0.058**	-0.017	0.269**	0.308**	NA	0.334**	0.338**	0.294**		
(11) 2009 estimated land value	0.352**	0.306**	0.361**	0.13**	0.125**	NA	0.098**	-0.036*	0.106**	0.055**	

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed) NA cannot be computed because one of the variables is constant

Sample Set #2: Residentially classified parcels of the "Big Three" lakes (Whitefish Chain, Pelican, Gull)

Number of parcels in sample: 5236

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Square feet of parcel											
(2) Parcel perimeter (feet)	0.739**										
(3) Deeded acres	0.816**	0.612**									
(4) Lake acres	-0.047**	-0.097**	-0.037**								
(5) Littoral acres	-0.042**	-0.053**	-0.04**	0.879**							
(6) Lake shoreline (feet)	-0.011	-0.13**	0.009	1**	-1**						
(7) Water clarity (feet)	0.031*	0.116**	0.014	-0.691**	-0.263**	-1**					
(8) Median depth (feet)	-0.011	-0.13**	0.009	1**	-1**	1**	-1**				
(9) Maximum depth (feet)	-0.041**	-0.049**	-0.04**	0.858**	0.999**	-1**	-0.222**	-1**			
(10) Number of public accesses	-0.046**	-0.08**	-0.04**	0.976**	0.962**	NA	-0.517**	NA	0.949**		
(11) 2009 estimated land value	0.324**	0.318**	0.36**	0.067**	0.015	0.171**	-0.112**	0.171**	0.01	0.045**	

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed) NA cannot be computed because one of the variables is constant

Sample Set #3: Residentially classified parcels within the IQR of 'square feet of parcel' of the twelve lakes of the Whitefish Chain

Number of parcels in sample: 1660

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Square feet of parcel											
(2) Parcel perimeter (feet)	0.673**										
(3) Deeded acres	0.469**	0.362**									
(4) Lake acres	0.071**	0.065**	0.147**								
(5) Littoral acres	0.064**	0.052*	0.139**	0.994**							
(6) Accessible acres by water	NA	NA	NA	NA	NA						
(7) Lake shoreline (feet)	-0.03	-0.037	0.025	0.95**	0.976**	NA					
(8) Water clarity (feet)	-0.119**	-0.43	-0.135**	-0.510	-0.505**	NA	-0.706**				
(9) Maximum depth (feet)	-0.039	0.044	0.067**	0.729**	0.706**	NA	0.676**	0.119**			
(10) Number of public accesses	-0.019	0.035	-0.018	0.269**	0.309**	NA	0.336**	0.337**	0.294**		
(11) 2009 estimated land value	0.194**	-0.033	0.094**	0.167**	0.173**	NA	0.172**	-0.003	0.133**	0.206**	

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed) NA cannot be computed because one of the variables is constant

Sample Set #4: Residentially classified parcels within the IQR of 'square feet of parcel' for the "Big Three" lakes (Whitefish Chain, Pelican, Gull)

Number of parcels in sample: 2791

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Square feet of parcel											
(2) Parcel perimeter (feet)	0.540**										
(3) Deeded acres	0.557**	0.236**									
(4) Lake acres	-0.120**	-0.223**	-0.185**								
(5) Littoral acres	-0.145**	-0.107**	-0.258**	0.876**							
(6) Lake shoreline (feet)	0.081**	-0.32**	0.242**	1**	-1**						
(7) Water clarity (feet)	0	0.280**	-0.055**	0.611**	-0.144**	-1**					
(8) Median depth (feet)	0.081**	-0.320**	0.242**	1**	-1**	1**	-1**				
(9) Maximum depth (feet)	-0.146**	-0.096**	-0.261**	0.856**	0.999**	-1**	-0.103**	-1**			
(10) Number of public accesses	-0.135**	-0.175**	-0.226	0.974**	0.963**	NA	-0.410**	NA	0.951**		
(11) 2009 estimated land value	0.239**	-0.174**	0.215**	0.209**	0.115**	0.287**	-0.249**	0.287**	0.106**	0.171**	

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed) NA cannot be computed because one of the variables is constant

Sample Set #5: Residentially classified parcels within the IQR (parcel square footage) and within the 50% sample of 'parcel feet of shoreline' of the Whitefish Chain

Number of parcels in sample: 861

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Square feet of parcel												
(2) Parcel perimeter (feet)	0.702**											
(3) Deeded acres	0.508**	0.382**										
(4) Lake acres	0.053	0.008	0.105**									
(5) Littoral acres	0.048	0	0.102**	0.993**								
(6) Accessible acres by water	-0.015	-0.52	-0.062	0.179**	0.138**							
(7) Lake shoreline (feet)	-0.059	-0.101**	-0.031	0.952**	0.972**	0.279**						
(8) Water clarity (feet)	0.015	0.052	0.062	-0.180**	-0.138**	-1**	-0.280**					
(9) Maximum depth (feet)	-0.092**	-0.033	-0.003	0.201**	0.686**	0.426**	0.682**	-0.425**				
(10) Number of public accesses	0.011	0.052	0.061	-0.167**	-0.124**	-0.999**	-0.267**	0.999**	-0.412**			
(11) Parcel feet of shoreline	0.290**	0.146**	0.184**	0.061	0.072*	-0.003	0.04	0.003	-0.057	0.001		
(12) 2009 estimated land value	0.199**	-0.055	0.111**	0.235**	0.233**	0.088**	0.201**	-0.088**	0.201**	-0.077*	0.089**	

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed) NA cannot be computed because one of the variables is constant

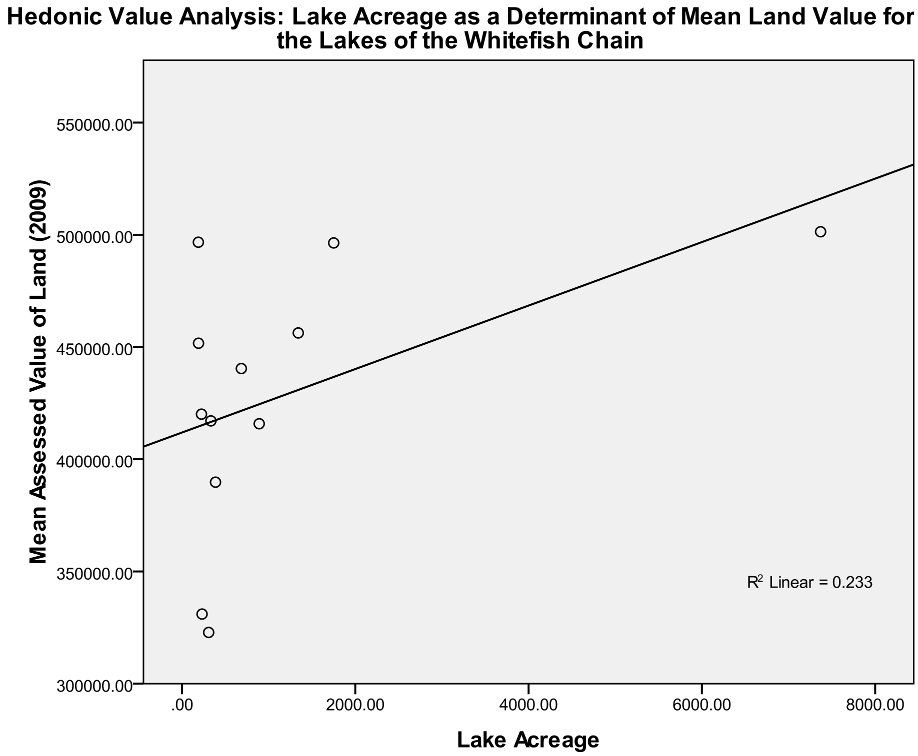
Sample Set #6: Residentially classified parcels within the IQR (parcel square footage) and within the 50% sample of 'parcel feet of shoreline' for the "Big Three" lakes

Number of parcels in sample: 1391

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Square feet of parcel												
(2) Parcel perimeter (feet)	0.550**											
(3) Deeded acres	0.437**	0.256**										
(4) Lake acres	-0.108**	-0.259**	0.011									
(5) Littoral acres	-0.128**	-0.119**	0.088**	0.876**								
(6) Lake shoreline (feet)	0.063	-0.366**	-0.219**	1**	-1**							
(7) Water clarity (feet)	0.012	0.335**	0.121**	-0.613**	-0.156**	-1**						
(8) Median depth (feet)	0.063	-0.366**	-0.219**	1**	-1**	1**	-1**					
(9) Maximum depth (feet)	-0.128**	-0.106**	0.093**	0.856**	0.999**	-1**	-0.117**	-1**				
(10) Number of public accesses	-0.121**	-0.201**	0.047	0.974**	0.963**	NA	-0.417**	NA	0.951**			
(11) Parcel feet of shoreline	0.115**	0.173**	0.025	-0.45	0.014	-0.193**	0.116**	-0.193**	0.019	-0.019		
(12) 2009 estimated land value	0.256**	-0.155**	0.180**	0.216**	0.120**	0.282**	-0.245**	0.282**	0.111**	0.178**	0.009	

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed) NA cannot be computed because one of the variables is constant

Appendix B. Hedonic Value Analysis.
I.



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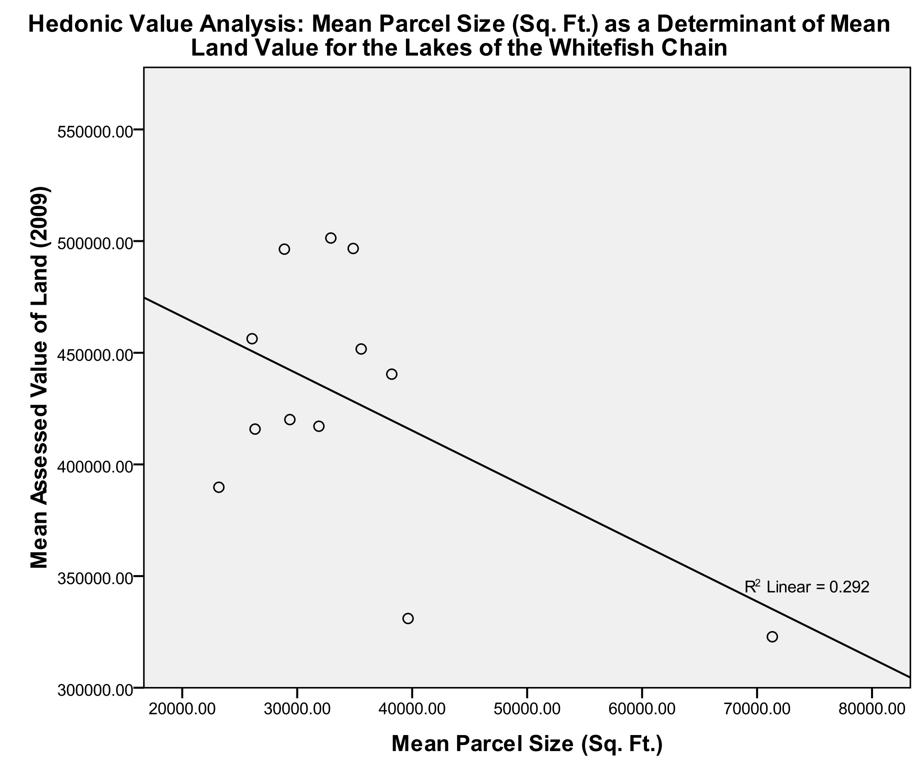
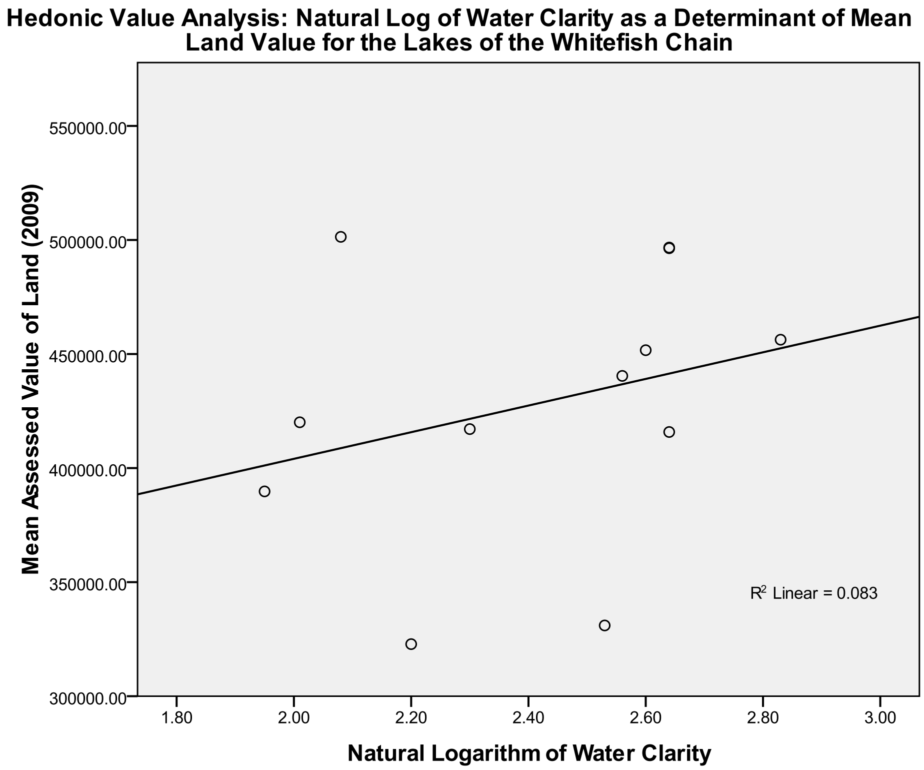
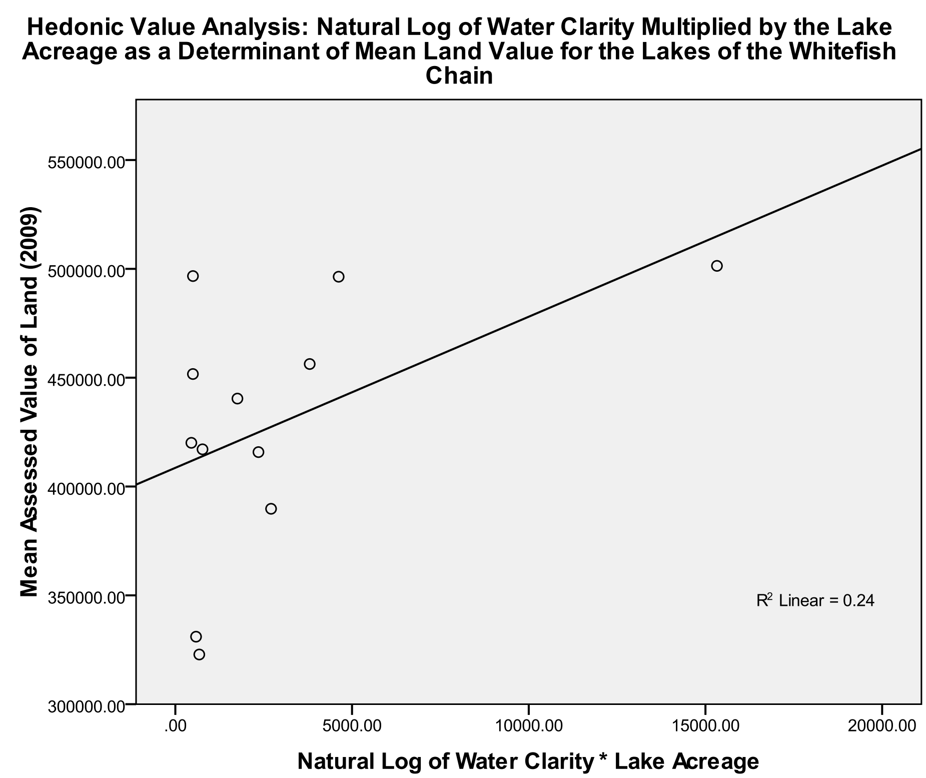


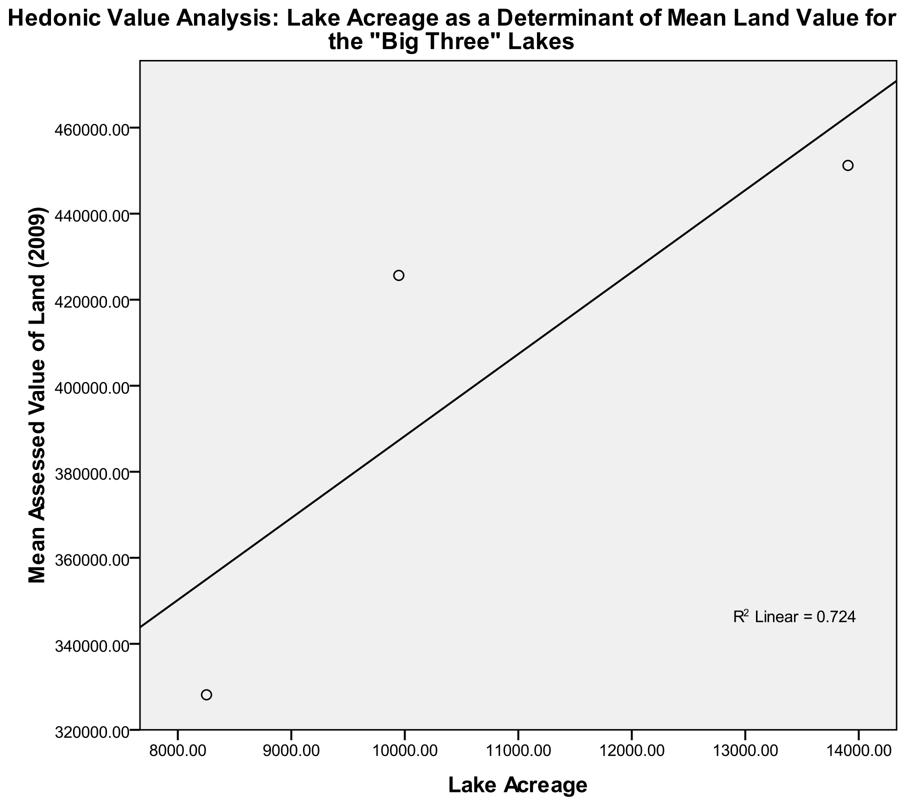
III.


Hedonic Value Analysis: Natural Log of Water Clarity as a Determinant of Mean Land Value for the Lakes of the Whitefish Chain
Mean Assessed Value of Land (2009)
550000.00
500000.00
450000.00
400000.00
350000.00
300000.00
1.80
2.00
2.20
2.40
2.60
2.80
3.00
Natural Logarithm of Water Clarity
R² Linear = 0.083

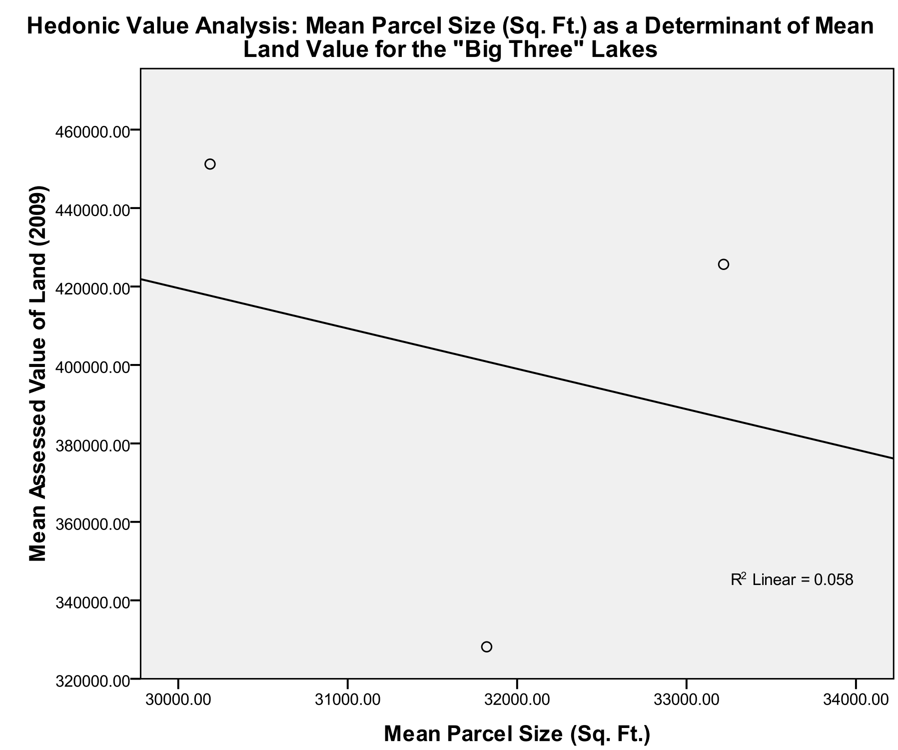
IV.


Hedonic Value Analysis: Natural Log of Water Clarity Multiplied by the Lake Acreage as a Determinant of Mean Land Value for the Lakes of the Whitefish Chain
Mean Assessed Value of Land (2009)
550000.00
500000.00
450000.00
400000.00
350000.00
300000.00
.00
5000.00
10000.00
15000.00
20000.00
Natural Log of Water Clarity * Lake Acreage
R² Linear = 0.24

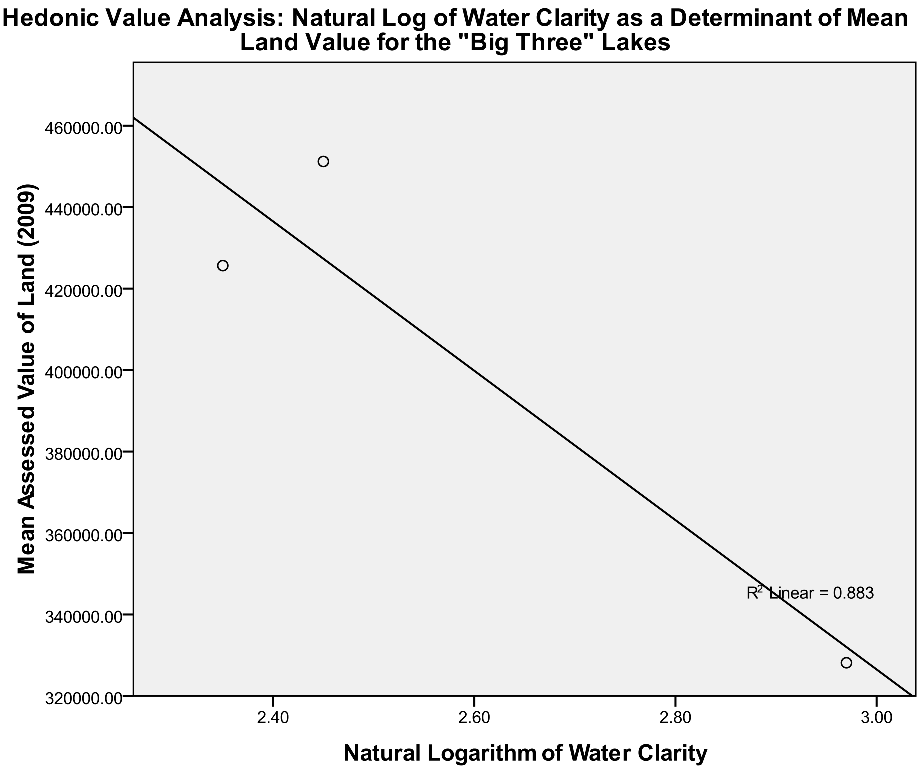
V.


Hedonic Value Analysis: Lake Acreage as a Determinant of Mean Land Value for the "Big Three" Lakes
Mean Assessed Value of Land (2009)
460000.00
440000.00
420000.00
400000.00
380000.00
360000.00
340000.00
320000.00
8000.00
9000.00
10000.00
11000.00
12000.00
13000.00
14000.00
Lake Acreage
R2 Linear = 0.724

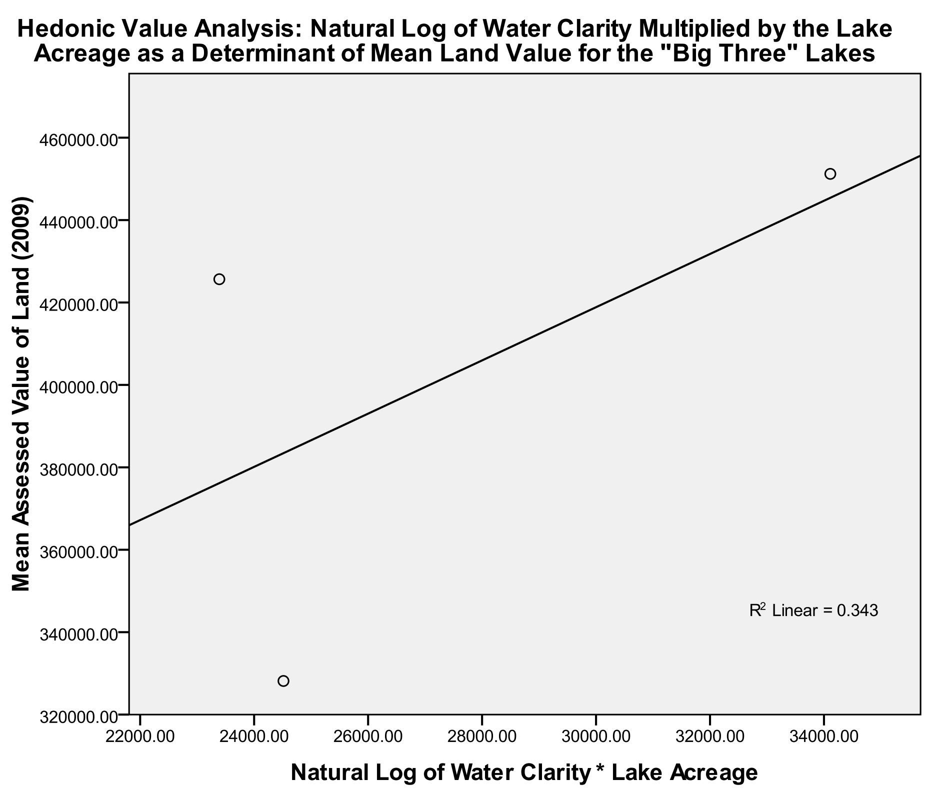
VI.


Hedonic Value Analysis: Mean Parcel Size (Sq. Ft.) as a Determinant of Mean Land Value for the "Big Three" Lakes
Mean Assessed Value of Land (2009)
460000.00
440000.00
420000.00
400000.00
380000.00
360000.00
340000.00
320000.00
30000.00
31000.00
32000.00
33000.00
34000.00
Mean Parcel Size (Sq. Ft.)
R2 Linear = 0.058

VII.


Hedonic Value Analysis: Natural Log of Water Clarity as a Determinant of Mean Land Value for the "Big Three" Lakes
Mean Assessed Value of Land (2009)
460000.00
440000.00
420000.00
400000.00
380000.00
360000.00
340000.00
320000.00
2.40
2.60
2.80
3.00
Natural Logarithm of Water Clarity
R^2 Linear = 0.883

VIII.


Hedonic Value Analysis: Natural Log of Water Clarity Multiplied by the Lake Acreage as a Determinant of Mean Land Value for the "Big Three" Lakes
Mean Assessed Value of Land (2009)
460000.00
440000.00
420000.00
400000.00
380000.00
360000.00
340000.00
320000.00
22000.00
24000.00
26000.00
28000.00
30000.00
32000.00
34000.00
Natural Log of Water Clarity * Lake Acreage
R^2 Linear = 0.343