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Nudging Neighbors: Analyzing Peer Effects of the LakeSmart Program in the Belgrade Lakes

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Cover Page Footnote

I would like to thank Professor Nathan Chan for his invaluable assistance with the organization and insight on setting up and executing this project on such a limited time frame. Additionally I would like to thank professor Philip Nyhus and Sophia Sakar for their excellent survey data that allowed this project to move forward allowing us to control for many demographic characteristics of housing location. I would like to thank Professor Sahan Dissanayake for his involvement in starting the gears turning on this project. I would also like to thank professor Manny Gimond for his amazing assistance in the GIS analysis throughout this whole project. Lastly I would like to thank Colby College for this unique experience to conduct research that has been an involved process from start to finish, lending a unique perspective into the methods of research that are so uncommon as undergraduates.

1. Introduction:

Peer effects have recently become an important study area for the field of voluntary and information based approaches to achieving socially optimal outcomes. The idea was first identified during 1969 by Nel, Helmreich, & Aronson, and expanded in 1974 by Aronson, Chase, Helmreich, & Ruhnke. They refined earlier thoughts regarding cognitive dissonance and identified that people in order to be impacted need to feel a connection between their behavior and the environment. Cognitive dissonance refers to the effect of inconsistent thoughts and beliefs on behaviors. This is a cornerstone for peer effects because the impacts that neighbors/peers have on their counterparts create these inconsistencies in behavior.

This research seeks to connect the theory of cognitive dissonance, in addition with the extensive literature on peer effects with regard to information based approaches to an issue that is very salient here in Maine, water quality. Maine is a heavy hitter tourism state, with a large variety of outdoor recreation tourism throughout the year. Much of this activity occurs near Maine's lakes and rivers. As such, maintaining the quality of the water so that tourism is not negatively impacted is valuable. The study area that this research focuses on within the broader scope of Maine is the Belgrade Lakes. These lakes are located just north of Augusta. Several of the lakes have recently begun the transition from oligotrophic to eutrophic which represents the accumulation of organic matter in the lakes, leading to lower water quality.

In response to these threats to an important part of the local economy, a program was developed, one that evaluated owners of lakefront houses and graded them based on their impact to the lake's water quality. The reward for those houses that passed the standard were plaques that would go on the shorefront and the roadside to display that the house was working to reduce their negative impact on water quality. This is where the theory of cognitive dissonance is important. The LakeSmart program grades houses on their impact on the water quality of the lake, and if they score above an 80/100, they will be awarded two LakeSmart plaques which they put up on the shorefront and by their driveway. This publicly visible sign, is the incentive for action that we consider in this paper. The impact of having a neighbor who is certified should, through the cognitive dissonance theory, mean that their own interest in LakeSmart will increase.

2. Literature Review:

The existing literature on peer effects is extensive and spans a large range of topics. For the purpose of focusing this review and providing more specific context to the extent of the literature, I will focus on the state of the peer effect literature pertaining to environmentalism. The reason why this area is an important field of research is the idea that through community, a socially superior outcome can be achieved. Barclay in his 2004 paper discusses how under repeated interactions, individuals will exhibit prosocial behavior to maintain a reputation. This can occur despite individual incentives lining up against that behavior, suggesting that reputation has some value to the individual. Similarly, Andreoni in 1990 shows how altruism isn't really altruism because of a warm glow effect which provides benefit to the individual effectively offsetting any costs they incur through of the action. These works set the stage for the understanding of how people's behavior changes when their actions are visible to the community.

Much of the prior work in this area has focused on identifying whether such peer effects are present in various modes by examining different types of information which incentivizes individuals through cognitive dissonance. A common example of these fields is energy consumption, due to high frequency, household level data from utilities. Studies in those areas such as Allcott (2011) and Clark et al. 2003 show that peer effects exist and there are determinants of the magnitude of impact. However in addition to testing the existence of such effects in this study, I hope to demonstrate the value in using non pecuniary incentives.

Here the literature is divided. In Gachter et al. (2008), show that in longer horizon repeated games, the punishment incentive outperforms in achieving cooperation among players. This is a challenging point to overcome in a local program such as LakeSmart, due to the hurdle of implementing legislative power to punish those members of the lake community who do not conform to the proposed new social norm. However, Ferraro and Price (2013) provide a counterpoint to Gachter et al. In their study, the authors show that pro-social messaging can promote cooperative behavior, in their case it was with regard to water conservation. Unfortunately the effects of this messaging wane over time. Luckily, for this study the behavioral changes that impact whether a house passes are not repetitive actions. For instance, installing a rain garden help mitigate runoff from your house, and once that is installed there is no need for maintenance of it or further installations. Considering this, it seems reasonable to conclude that the use of pro-social messaging through social networks could have the cooperative outcome desired by the managers of LakeSmart.

In addition to the pro social component of this program being supported by the literature, additional characteristics of this community predispose it to be a successful platform for LakeSmart. In Otto and Kaiser (2014), the age of a participant was correlated with environmental tendencies. This is later refined to recognize the intermediate step of cumulative education as the cause of older communities being more environmental. Due to the demographic composition of our sample, it is reasonable to assume that the population is more environmentally engaged that the national average due the older average age. Furthermore, Lacetera, Nicola, Macis and Mario (2010) show that the reputation effect of pro-social behavior must be providing utility to individuals because of how their community in question viewed the act of giving blood.

The last major component of the literature on peer effects is that of reputation. This is a cornerstone of the cognitive dissonance assumption that individuals need to be connected and feel the impact of their actions (i.e. there are no externalities in the market). In small communities, like the one this study focuses on, that salience is more readily satisfied. Videras et al. show in their 2012 paper that neighbors have a large impact in influencing positive social change because of the connection they have to each other. In small communities, individuals interact with a much higher proportion of the population than in cities, increasing the sense of community that forges the connections necessary for homeowners to feel the responsibility to maintain water quality in tandem with their neighbors. In Schelly 2012, the author points out typical characteristics of early adopters, and suggests that their value in the program comes more from promoting communities where information about various options is sought out.

This study seeks to expand the existing literature through a new lens. Prior work has looked at actions that have immediate effects. However, the LakeSmart program is a preventative measure, designed to protect the Belgrade Lakes from degrading. In this way homeowners can estimate the loss in home value from degraded water quality to put perspective to their actions. However, most will engage in the behavior because it is a social norm. I look at the impact of early adopters and whether the distribution of properties that are certified suggests clustering that promotes a changing social norm. Additionally this research provides a unique case study in how cognitive dissonance plays out on local scales where interactions and responsibility for actions are very traceable to an individual.

3. Methods:

3.1 Study Area:

The study area for this research is the Belgrade Lakes in Maine. Figure 1 shows the study area, focusing on the northern three Belgrade Lakes: North Pond, East Pond and Great Pond. This study will focus

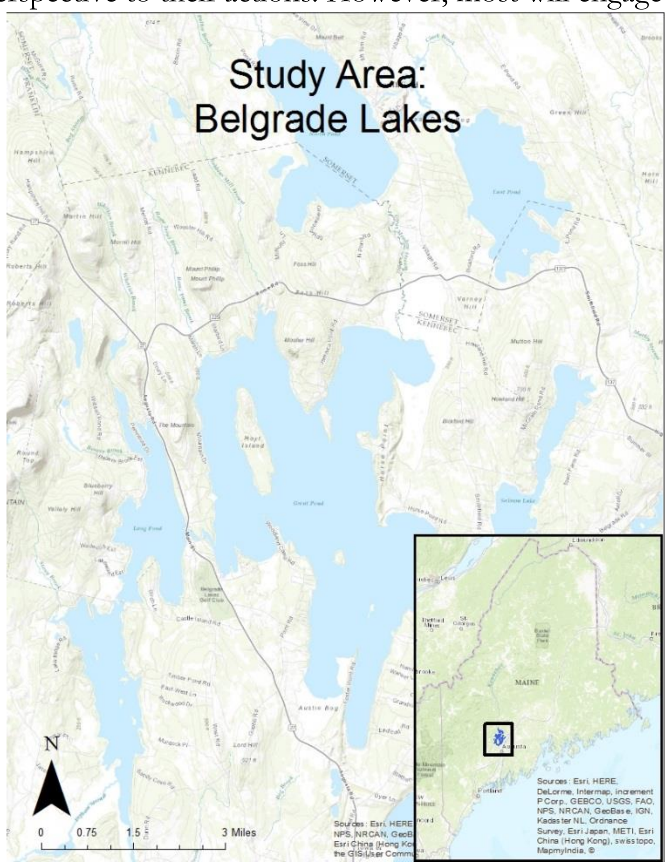
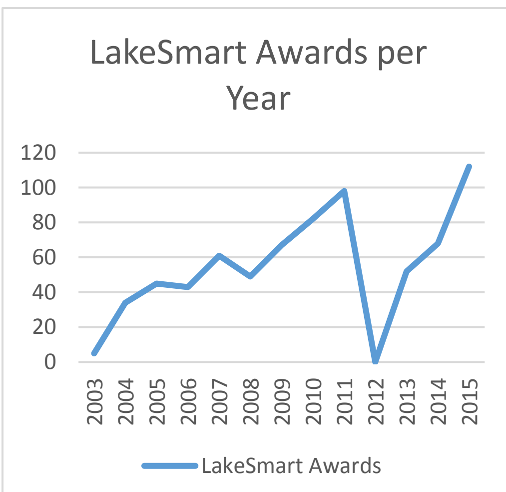


Figure 1.The study area for this research: East, Great, and North Pond of the Belgrade Lakes

on that specific area due to the larger number of properties and LakeSmart awards that are present along its shorefront, and the presence of survey data that was distributed primarily to homeowners on those lakes. On a larger scale the Belgrade lakes are comprised of several smaller lakes and have a vibrant seasonal and year round community. The large number of seasonal home owners was considered challenging to implement a program working on maintaining water quality through home alterations. However there was support through the lake associations which maintain regular relationships with the seasonal owners to implement the LakeSmart program which has grown significantly since its introduction in 2005. In Figure 2, we see the trends in yearly awards as well as the cumulative involvement with the program. The cumulative plot follows an exponential curve which is encouraging because it suggests that social norms are beginning to change and that homeowners along lakefronts are adopting the system as they recognize the need to address threats to their water quality. The data shown in Figure 2, are aggregated data for the LakeSmart program across all the lakes that they are involved at. As such the numbers are inflated compared to the Belgrade region but the same trend holds that there are more and more adoptions each subsequent year.



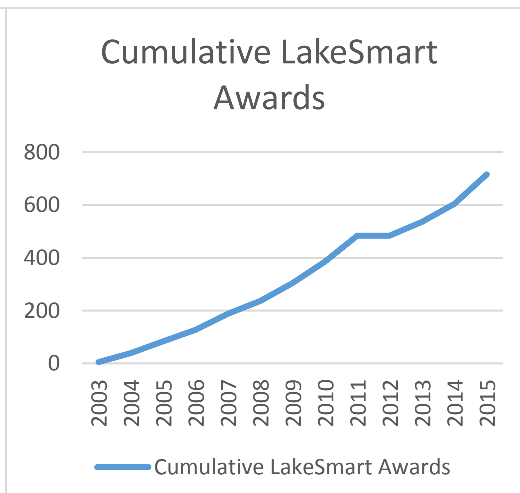


Figure 2. The rise in LakeSmart Award recipients since its creation in 2003

3.2 **Data:**

Our data combine several data sources: the first is a homeowner survey conducted by the Colby College Environmental Studies department in 2011 to determine the WTP for water quality efforts, the second is a list of LakeSmart certified houses from 2004 (start of the program) - 2016 (most recent published list of award winners) with the dates when these houses were certified and several variables regarding the score the house received, lastly we use a homeowner database for the entire lake population to connect these two using unique household identification tags that were gathered in the survey and the LakeSmart database.

The survey data importantly is composed of a combination of homeowners, some of whom have been certified, and some who have not. This is crucial for the study method we employ due to the importance of the counterfactuals, without which we would be unable to determine whether the presence of a neighbor who is certified actually has any impact on the decisions of a homeowner. The survey was designed and administered in 2011 for a WTP study and is being repurposing it to gain access to demographic characteristics. Because the survey is dated, it is important to incorporate LakeSmart award winners who have been certified since 2011. Those homeowners who are now certified but were not in 2011 would have skewed the results if they had been left as uncertified because their characteristics theoretically line up with other award winners. This is the reason why the LakeSmart data extend to 2016 rather than ending at 2011 when the survey was conducted. To accomplish this, more recent data on LakeSmart certified houses was aggregated with the existing data from 2011. The new LakeSmart data was available on the Maine Lakes Society website. This aggregation resulted in 135 observations of households with detailed demographic information and LakeSmart involvement.

Once the data had been cleaned and matched, we visualized it in ArcMap to view some of the differences and general trends in our distribution around the lakes in question. Figures 3 and 4 show the Euclidean distance and kernel density of the LakeSmart locations around the lakes. What is important to note is that while there is a relatively uniform distance to the nearest point using straight line geometry, the kernel density shows distinct areas of high density areas. This suggests that while our varying sites may be relatively spread across the study area, the density of awards are much more concentrated. This is promising as a preliminary visualization of data and suggests that there are clustering effects within LakeSmart certified houses. This may be a result of other factors than simply peer effects and it will take comprehensive fixed effects to control for other corollary factors that might muddy the analysis in determining.

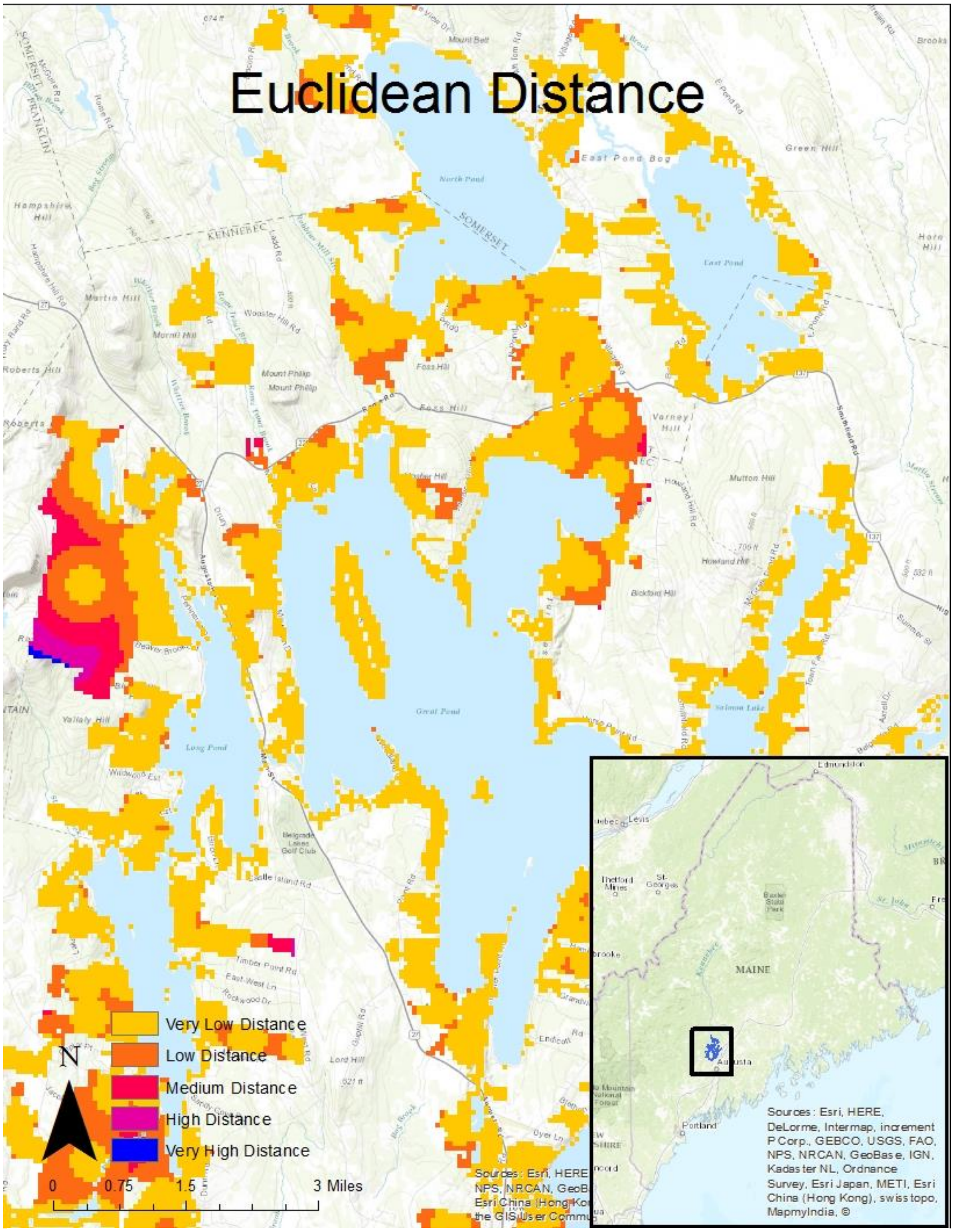


Figure 3. The Euclidean distance between LakeSmart properties on the Belgrade Lakes

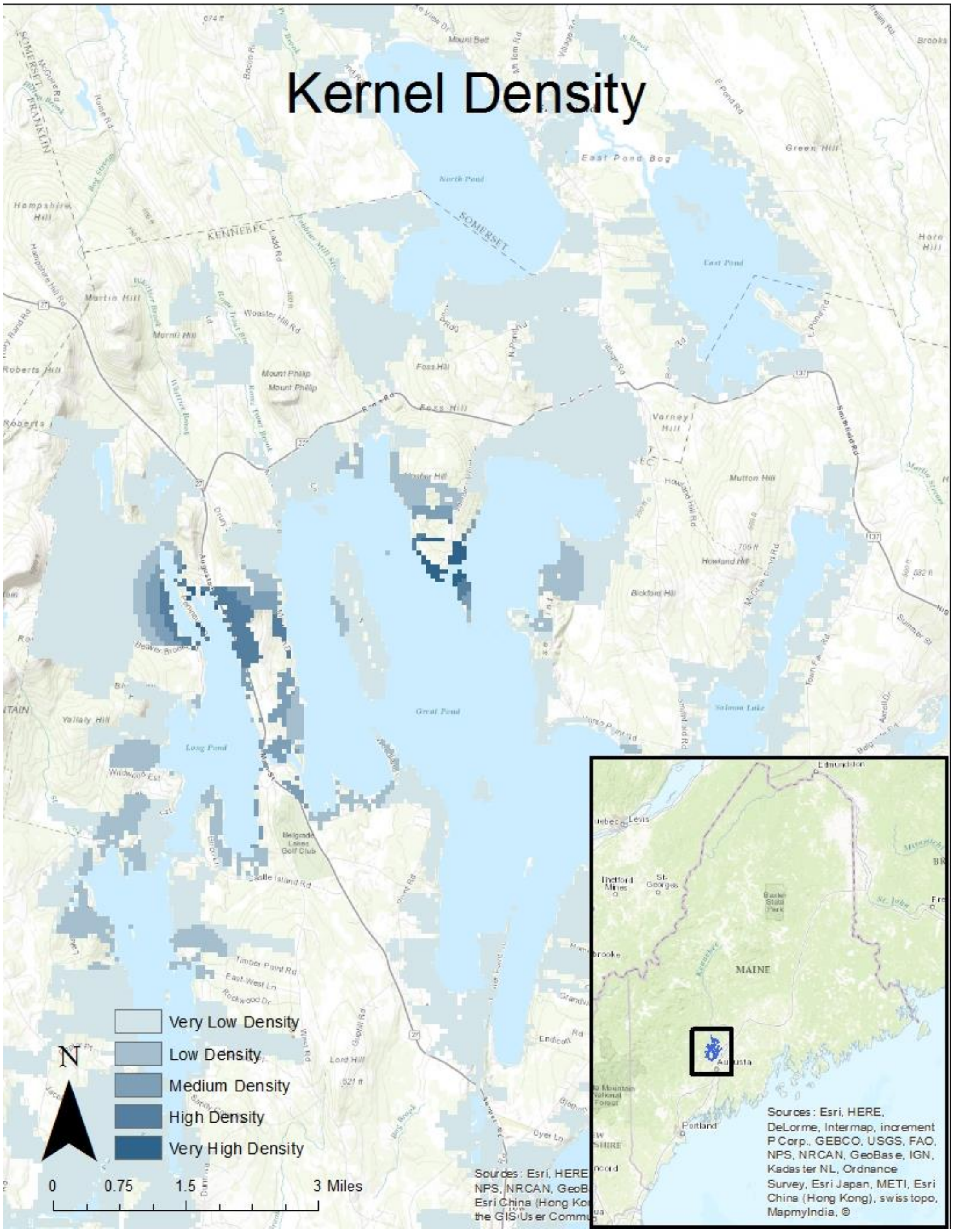


Figure 4. The Kernel density of LakeSmart Properties around the Belgrade Lakes

3.3 Empirical Methods:

To preliminarily identify if properties around the Lake were even clustered, it was important to perform spatial analyses to visualize their distribution. The preliminary ones, shown in Figures 3 and 4 paint a coarse picture of how the properties are laid out around the study area. The Euclidean distance metric is a simple measure of a straight line from any of the properties to the nearest LakeSmart certified property. From this visualized we see that there are no dead spots in our study area. This suggests that there is likely not a geographic component to the clustering if it should be present. The second preliminary method is the kernel density estimation method. Through this method we are able to estimate non-parametric probability density functions and compare the density of our own data to that distribution. This yields a cursory evaluation of whether the properties we are studying appear to be clustered.

To determine statistical significance of the clustering, we employed Moran's I spatial autocorrelation. Through this method we are able to statistically compare the distribution of LakeSmart properties, and the test will result in one of three outputs: clustered, dispersed, and random. It also gives us a p-value for that result which can be represented in the map. While this method is extremely efficient for determining general clustering patterns, it does not identify the cause of the clustering. To do that we must employ further statistical methods to derive causality from our inferences.

Using regression discontinuity based on the method outlined in Lee and Lemieux 2009, I compare the shorefront population of the Belgrade Lakes to identify whether the presence of a neighbor having been certified increases the likelihood of a homeowner being evaluated. Using a simple OLS regression we can evaluate the coefficient of interest by controlling for counterfactuals. Using demographic variable information from the WTP survey we are able to control factors of household characteristics that may have led to the location, rather than the naïve assumption that houses are randomly distributed along the shorefront.

$$(1) \quad LakeSmart_i = \beta_1 + \gamma * Neighbor_i + \beta_2 * v_i + \varepsilon_i$$

Equation 1 shows the preliminary regression where we check to see if the likelihood of being LakeSmart certified increases with the presence of a neighbor who is also LakeSmart certified. We control for possible double counting of peer effects by only considering those neighbors who are certified before $household_i$ seeks certification. v_i represents the counterfactuals that are controlled for by the demographic variables. It is a vector unique to each household and contains information on: income, schooling, political orientation, age, town of residence, and lake which property borders. β_2 represents the coefficient for each household which translates their specific household characteristics into a probability of being LakeSmart certified. ε_i represents the error term that is generated from each of the models. The error term has been visualized to ensure that there are no trends in it which would lead to biased estimates for the beta coefficients. Since this equation's dependent variable is binary, we are employing a technique known as a linear probability model, which is to say that the coefficients are measuring the percentage change in likelihood of the dependent variable event occurring given a unit change in the explanatory variable.

Using refinements of the first equation, we look at the robustness of the results by comparing varying levels of neighborhood sizes. Using arbitrary values of 100m - 1200m at 100m increments from the house, we aggregate total number of LakeSmart certified houses in each of those areas. This allows for a comparison of varying levels of impact, which could determine the strength of a peer effect. Is a homeowner paying attention to a neighbor's status if they live almost 1km away from their house, or is it really only your immediate neighbors who can shape your behavior. Comparing those zones allows for the answer of that question to be explored.

4. Results:

As figure 5 shows, there are a number of LakeSmart properties that are not only positively correlated in distance with their neighbors, but the Moran's I statistic reinforces this statement. Suggesting that the areas on the lake that show signs of significant clustering even if those regressions were not significant in their coefficients. This statistic suggests that there is clustering of LakeSmart properties. However, these results do not control for some of the counterfactuals that, if accounted for would lead to a causal conclusions.

This result is not reinforced through the regressions that were run. Table 1 shows the estimated coefficients of the peer effects. Each of the different model specifications in Table 1. shows the different ranges for the neighborhood value (ranging from 100m to 1200m). Some values of note is that none of the coefficients are statistically significant at reasonable levels, and that the R-Squared values for all of the specifications are relatively low. However, despite this low R-Squared we tested for omitted variable bias and found that none of the specifications suffer from omitted variables bias.

Expanding beyond the simple testing of significance for each specification, we analyze the trends across the neighborhood range. When we plot the coefficients plus and minus the standard errors across all neighborhood ranges, it yields figure 5. When we visualize this trend, we see that as the neighborhood range increases there is a downward trend in the coefficient.

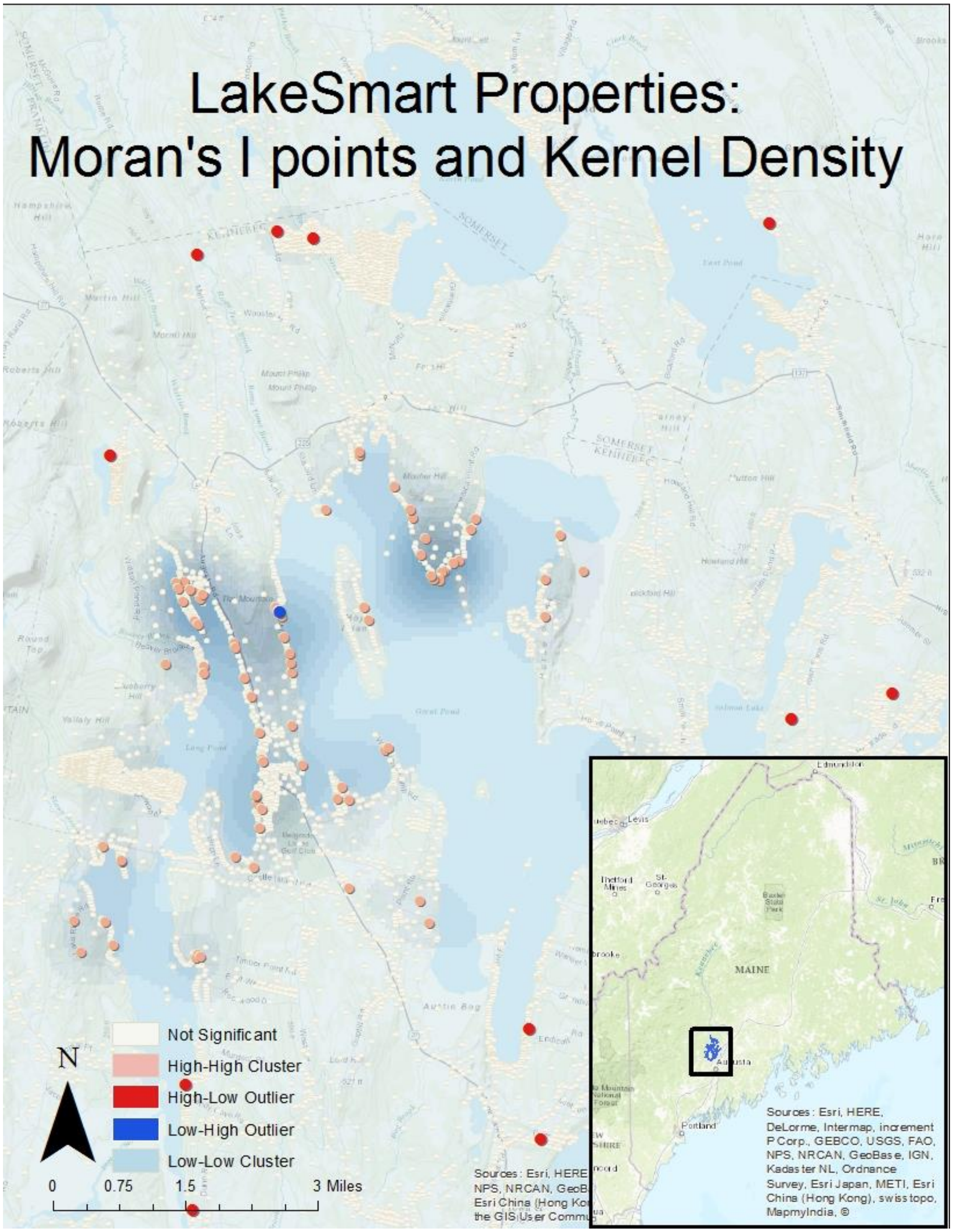


Figure 5. The Moran's I outliers and statistically clustered points overlaid on the Kernel Density raster for the study region

Table 1. Model Estimates for each of the 12 neighbor range models

	Model Estimations											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Peer Effect Coefficient	.2626	.2214	.1164	.0395	.0142	.0121	.0097	.0125	-.0049	.0078	.0320	.0629
Standard Error	.1856	.1662	.1419	.0985	.0866	.0806	.0643	.0618	.0603	.0566	.0563	.0518
Observations	92	92	92	92	92	92	92	92	92	92	92	92
Constant	.382	.3546	.3692	.3692	.3728	.3748	.3737	.3739	.3845	.3768	.3597	.3560
R-Squared	.1666	.1643	.1532	.1479	.1465	.1465	.1465	.1466	.1463	.1464	.1496	.1613

Notes: *, **, and *** indicate significance at the .1 , .05 , and .01 levels, respectively.

Despite not being able to say statistically that the coefficients of interest are different from zero, their signs are consistent with priors, aside from the 900m estimate. With positive coefficient estimates we are seeing that while effects might be week, the models seem to attribute some change in behavior to the presence of neighbors who are also certified. We also see that the peer effect is decreasing with distance, an inverse relationship that is predicted intuitively.

For all the specifications, heteroscedasticity, specification error and multicollinearity tests were conducted to ensure that no assumptions that our model is based off of were violated. None of the results from those tests led me to believe that any of the models had serious flaws in them that would exclude them from the final analysis.

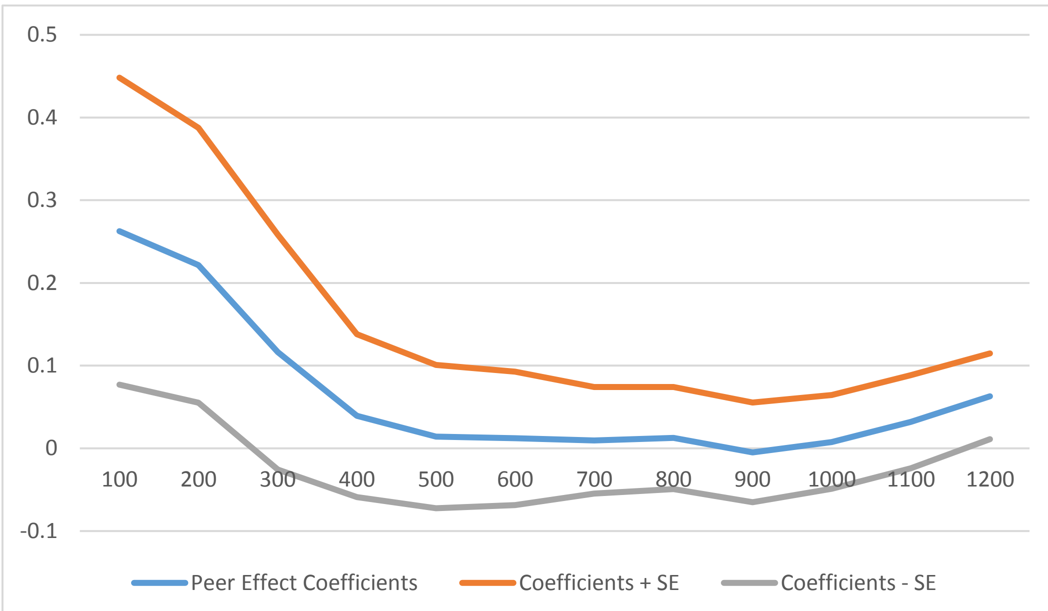


Figure 6. A visualization of how the coefficient of the peer effects term changes as the distance threshold for being a neighbor increases. The two bounding lines show the coefficients plus or minus the standard errors.

5. Discussion:

As shown in figure 5, clustering of LakeSmart houses suggests that there is a factor that is leading to this pattern. However, to draw causal relationships we need to control for counterfactuals. For instance, if we were to find that all LakeSmart certified homeowners were left leaning politically, we might hypothesize that there is a clustering of the properties more for political reasons than their proximity to other LakeSmart properties. While it is unfortunate that none of the specifications resulted in significant coefficients for our neighbor variable, the significance of this study does provide some value to the literature in that frequently these methods simply run regression discontinuities without visualizing the spatial component of the research.

One result of note is the low R-Squared for all the specifications. When generating the specification by determining what counterfactuals to include, the challenge became maintaining enough degrees of freedom while trying to increase the R-Squared. One challenge with this specification is that there was so much information on variables that are not highly correlated with being LakeSmart, and as a result the adjusted R-Squared remained close to .18 even when the R-Squared was closer to .95. I decided to aim for a small difference between the adjusted R-Squared and R-Squared by evaluating if variables that are highly collinear with other variables should be included. In the original specification there were large variance inflation factors, which is the reason for the low adjusted R-Squared. As a result many of the counterfactuals were dropped from the regression and the R-Squared decreased until it was much more similar to the adjusted R-Squared.

6. Conclusion:

Given the results in this study, it is inconclusive whether there are significant peer effects at work within the LakeSmart program. However, there is still statistically significant clustering of LakeSmart properties, which suggests that either a variable was omitted from the specification, which is unlikely due since I checked for omitted variables when running the various specifications. This suggests that further research is necessary in this area to generate conclusive evidence. Perhaps a more targeted survey to ensure a higher proportion of LakeSmart properties since the low number of those properties who also conducted the survey was a limiting factor in our analyses.

Several other limitations with this study were that the sample of homeowners are not comparable to that of the greater United States population. However, that degree of generalization is beyond the scope of what this research set out to examine. Additionally, the data used within the study were not designed specifically for research of this type which led to low degrees of freedom once the datasets were matched.

Some of the policy implications from this research are present even though there were no significant results from our regressions. The first is that the clustering of LakeSmart properties is significant. This means that left alone to their own devices, the clusters will develop around small threshold numbers of properties. This suggests that organizers should try to identify those areas where the natural clusters will occur and supplement the rest of their surroundings. The second policy recommendation could be the result of another WTP survey to evaluate what people's revealed preferences are for cleaning up their lakes, which could be used by local or state governments to take care of themselves. Taken together, there is evidence that some metric should be a proxy for LakeSmart adoption, and identifying that metric would allow program coordinators to manage scarce marketing resources efficiently to target their audience.

This research has established a number of possible future work possibilities. The first is identifying the difference in treatment effect between seasonal and year round residents. This would if addressed increase the specificity about how program directors should target funds given the distribution of homeowners that they face in their given region, this could range from a difference between treatment effects to determining if one group had decreasing treatment effects as neighborhood distance increased. Both of these issues would be very novel behavioral studies looking at how the different types view the natural resource and perhaps how their own social image is linked to that natural resource. A second avenue for future work on this subject would be to establish how sensitive various constituents are to water quality changes. Here we had three different water qualities between North, East and Great Pond. However, if a study were able to obtain more and quantify the water quality in all of them using a consistent metric, they could establish a social interest in LakeSmart programs given a certain water quality.

In conclusion, while this study was unable to determine whether there was a peer effect for the LakeSmart program in the Belgrade Lakes, it did identify that the properties are clustered. This research pushed the peer effects literature by more directly incorporating spatial statistics and analytics into the analysis. Despite significant data challenges, this study suggests that a similar survey targeted at the specific audience desired would yield data that could be used in the same process outlined here, with a higher chance of showing some trend due to a more representative sample.

Acknowledgements:

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