TARGETING AUDIENCES FOR IMPROVED LAWN MANAGEMENT: CAN GROUPING HOUSEHOLDS ASSIST WITH NONPOINT WATER POLLUTION REDUCTION

A THESIS
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

Sarah Nicole Panzer Wein

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

Dr. Kristen Nelson

January, 2011

Acknowledgements

Support and funding for the TCHEP was provided by the National Science Foundation, Dynamics of Coupled Human and Natural Systems program (award numbers BCS-0709581, BCS-0908549, and BCS-0908998), and by the Cedar Creek Long Term Ecological Research program. I would like to acknowledge the support of the University of Minnesota and the Water Resources Science graduate program for providing financial support for the development of this paper. Special thanks to the homeowners who took the time to reflect and respond to the survey and the student team members who have helped with vegetation sampling, data entry and everything that keeps the project running. Thanks also to the watershed district and watershed management organization administrators and other staff members who took the time for interviews and continuing conversations and guidance. Finally, many thanks to the Twin Cities Household Project researchers, past and present, including Dr. Kristen Nelson, Dr. Larry Baker, Dr. Sarah Hobbie, Dr. Cinzia Fissore, Ina Jakobsdottir, Daniel Nidzgorski, Stephanie Grayzeck-Souter, and Derek Burk for their support and help with initial and continuing ideas for this paper.

Dedication

This thesis is dedicated in part to the researchers of the Twin Cities Household Ecosystem Project (TCHEP). Their guidance and support was invaluable in the development of this research, and their dedication to their respective fields set a wonderful example for the drive it takes to succeed in balancing a career while leading a rich, fulfilling life.

I would also like to dedicate this to my family, who I know will always support me in all that I choose to strive for in life. My parents have consistently been the stable source of support guiding me in everything I have done and most likely will do. My accomplishments are as much an accomplishment of theirs and I am more grateful to them than they will know.

Finally, my husband is my strongest source of encouragement in all that I do, and this could not have been completed without his support. I dedicate this work to him not only for what we have achieved together, but for all of the amazing adventures we have to come.

Abstract

In urban ecosystems, households are important decision-making units that are resource consumers and contributors to urban water pollution. At the landscape level, individual household choices regarding lawn management vary greatly, contributing to the detriment or protection of water resources. To better target household behavior change, we need to understand the social influences that determine how and why households manage their lawns differently, and what characteristics of the household could be driving these differences. We suggest that a better understanding of households could inform targeted policies and programs for effective change strategies. By spatially examining income, house age and proximity to a lake, we analyzed whether household groupings reflect households that think and act in similar ways with respect to lawn management. We obtained data for this research through a 2008 mail survey completed by the Twin Cities Household Ecosystem Project in Ramsey and Anoka Counties, Minnesota. Responses to questions pertaining to fertilization, leaf and lawn clipping management, vegetation choice, and lawn management attitudes were analyzed. When households were grouped spatially across the landscape with respect to proximity to a lake, few significant differences were found between household groups within 200 meters vs. farther than 200 meters. While income did influence particular lawn management attitudes and behaviors, it did not group spatially at a county scale, or at the finer scale of Saint Paul, the major city in our study area. House age showed significant relationships with almost every attitude and behavior examined, and was the only factor to demonstrate important spatial grouping. The correlation of house age with lawn attitudes/behaviors, however, is partially an artifact of housing density and number of trees on a householdôs property. This study demonstrates that it may be possible to target households based on particular factors in order to tailor educational programming and policy to influence lawn management behavior, reduce pollutants leaving household lawns, and therefore improve water quality.

Table of Contents

List of Tables v
List of Figures vi
Introduction 1
Why are household landscapes an important target for improved management? 2
Explaining household environmental attitudes and behavior 4
Targeting and tailoring information towards households 6
Importance of targeting and tailoring for water resource managers 8
Research question and importance 10
Methods 10
    Mailed survey 10
    Data analysis 12
Results 13
    Grouping of total household income and house age 14
    Influence of lawn management attitudes and behaviors 14
Discussion 16
Conclusion 19
References 21

List of Tables

Table 1: Concept Measurement, 2010. 26

Table 2: Proximity to the nearest lake vs. lawn management behaviors, Ramsey and Anoka Counties, Minnesota, 2008.. 27

Table 3: Total household income vs. lawn management behaviors, Ramsey and Anoka Counties, Minnesota, 2008.. 28

Table 4: House age vs. lawn management behaviors, Ramsey and Anoka Counties, Minnesota, 2008.. 29

Table 5: Proximity to the nearest lake vs. averages of respondentsô answers to advantages and disadvantages of fertilization and level of environmental concern, 5pt Likert Scale, Ramsey and Anoka Counties, Minnesota, 2008. 30

Table 6: Total household income vs. averages of respondentsô answers to advantages and disadvantages of fertilization and level of environmental concern, 5pt Likert Scale, Ramsey and Anoka Counties, Minnesota, 2008. 31

Table 7: House age vs. averages of respondentsô answers to advantages and disadvantages of fertilization and level of environmental concern, 5pt Likert Scale, Ramsey and Anoka Counties, Minnesota, 2008. 32

List of Figures

Figure 1: Spatial distribution of respondent total household income, Ramsey and Anoka Counties, Minnesota, 2008.. 33

Figure 2: Spatial distribution of respondent total household income, Saint Paul, Minnesota, 2008.. 34

Figure 3: Spatial distribution of house age, Ramsey and Anoka Counties, Minnesota, 2008.. 34

Figure 4: Spatial distribution of housing density, Ramsey and Anoka Counties, Minnesota, 2008.. 35

Figure 5: Total household income vs. property value of respondent households, Ramsey and Anoka Counties, Minnesota, 2008. 35

1. Introduction

Studies examining pro-environmental household attitudes and behaviors typically focus on sociodemographic and psychological constructs as factors that are homogeneously, or randomly, distributed across a landscape. Many spatial variations in these factors, however, could affect where certain household attitudes and behaviors are occurring. Recent studies demonstrate that peopleôs beliefs are often similar around natural resource areas (Brody et al. 2004 & 2005) and landscape choices are similar in areas of similar housing densities (Luck et al. 2009) and therefore occur heterogeneously across a landscape. Further research examining factors that potentially group households spatially could help us understand the landscape arrangement of these factors and the associated household attitudes and behaviors.

A spatial understanding of household attributes will be important to consider when tailoring policy and programming towards changing household behaviors, specifically behaviors on household landscapes, as landscaping decisions are affected by a number of social constructs. Household landscapes are a substantial source of nutrients entering water bodies through leaching and stormwater runoff, and are an important contributor to poor water quality in urban areas (Barten 1997; Washbusch et al. 1999). Developing targeted, effective messages could improve the cost-effectiveness of education programs intended to reduce urban landscape pollution. In particular, findings from this study could be utilized by the ñpublic education and outreachò component of EPAôs municipal separate storm sewer systems (MS4) program, one of six required elements.

This paper examines three factors that if spatially grouped may influence household landscaping behaviors: proximity of a household to the nearest lake, total household income, and house age. First, we examined if total household income and house age grouped spatially on a landscape, then we analyzed if proximity to the nearest lake, income and household age were related to household landscaping attitudes and behaviors.

As a foundation for this study, we present recent studies highlighting the importance of targeting households for improved lawn management, influences of environmental attitudes and behavior, recent research about the effectiveness of tailored information, and importance of this information for water resource managers. Our aim is to evaluate whether spatially grouping households is an effective way to examine whether or not similarities occur between households of similar characteristics in order to more effectively target households for behavior change.

2. Why are household landscapes an important target for improved management?

Household behavior change is an important target for improved management when focusing on the contributing factors to water pollution in urban areas. Many studies have shown that the decisions homeowners make to manage their landscapes are complex and influenced by a variety of social, psychological, and physical factors (Larson et al. 2009), which have the potential to influence household behavior. Robbins and Sharp (2003), for example, argue that homeowners value having lawns for social reasons, including associating with their communities, strengthening family ties, and connecting with the environment. These authors also argue that many influences external to communities, such as lawn care company marketing, can have a sometimes deceiving effect on the choices a homeowner makes on his/her landscape. Furthermore, in a study conducted in New England with area ñopinion leadersò in turf management, Peterson et al. (2009) discovered that many do-it-yourself homeowners are influenced by the amount of time, money and energy required for landscape management, as well as by social factors like the community standard of lawn care and norms surrounding what a ñhealthyò lawn should be. These examples demonstrate that landscape decisions are not being made based on one guiding principle, but through consideration of a multitude of different factors.

The outcomes from household decisions may also vary a great deal. Differences in lawn and landscape characteristics and lawn management decisions may result in disproportional amounts of pollution exiting household landscapes and entering area water bodies. Fissore et al. (2010) found that fertilizer application was the dominant input of nitrogen to a household landscape, and was also highly skewed; in an analysis of 360 households, 26% of households contributed 74% of the nitrogen input flux as fertilizer. This is an example of one common landscaping behavior where the potential for water pollution is often skewed by a minority of households. A focus on the disproportional contribution of households based on differences in biophysical and social attributes of household landscapes can result in more fair and effective lawn management programs that are targeted towards higher contributing households (Baker et al. 2008; Fissore et al. 2010).

Finally, the household is a socially and politically meaningful unit and therefore an important scale for management (Baker et al. 2007). Most homeowners have direct control over what happens on their land, and they can act as part of a larger group of residents within a community. Even though landscaping decisions may seem very individual, when aggregated within a community they have a large collective impact (Robbins et al. 2001), and can have an important influence on land and water systems.

Not only are households a good scale for targeted management, but they have also been shown to be a significant source of pollution to water resources. Many studies have attempted to model or quantify the contribution of household lawns to the pollution of water resources as a result of excess nitrogen and phosphorus runoff. These studies have shown that a significant amount of phosphorus found in lakes can be attributed to lawns (Barten 1997) and streets (Waschbusch et al. 1999), and that lawn runoff is a major contributor to urban water quality (Law et al. 2004). Too much fertilizer on a lawn that does not require additional nutrients will runoff or leach out, potentially contributing to the eutrophication of lakes and streams.

While studies have shown that overfertilization can cause increased nutrient runoff from urban lawns, underfertilization may not maintain a healthy lawn. Poorly managed lawns in need of fertilizer can have a high amount of excess nutrients in runoff because the soil is not healthy enough to maintain sufficient lawn cover, leading to eroded soils and additional runoff (SULIS 2010).

When evaluating fertilizing rates, however, many homeowners may not recognize the value of their lawn clippings as a nutrient source, which can actually replace the need to fertilize for certain types of lawns. Homeowners that leave their lawn clippings on and also apply recommended fertilization amounts could be overfertilizing. In Minnesota, studies show that annual lawn clippings left on a lawn are equal to approximately 1lb N/P, about 1/3 of the average fertilization rate (Rosen and Horgan 2009; SULIS 2010). Along with grass clippings, many factors affect the amount of N and P required for a lawn, such as soil and grass type (Rosen et al. 2006).

3. Explaining household environmental attitudes and behavior

There has been extensive research examining various predictors of household environmental attitudes and behavior, but fewer evaluating lawns and household vegetation (Zhou et al. 2009). Some of the common sociodemographic variables evaluated include income, age, ethnicity, and education. For example, household waste management, including waste reduction, reuse and recycling, has been extensively examined, and researchers have found, in general, that ñyoung, female, single-family dwelling, high-income earning, well-educated and politically liberalò individuals are most likely to participate in waste management activities (Barr 2007). Not surprisingly, household energy behavior studies have shown that larger and higher income households use more energy (Gatersleben et al. 2002; Poortinga et al. 2004). This research points to the significance of examining sociodemographics in relation to household environmental behavior.

Studies have examined household landscape attitudes and behavior with respect to many common sociodemographic variables. They have shown that income (one of the most common variables examined) is positively correlated with fertilization rate (Law et al. 2004; Osmond and Hardy 2004), lawn greenness and lawn-care expenditures (Zhou et al. 2009), and plant diversity (Hope et al. 2003) on household landscapes. Grove et al. (2006) also found that income has an effect on the percent cover of grass and trees.

In addition to sociodemographic factors, the location of a household can have an influence on the characteristics of a household and the attitudes of its members. Many studies focus on the relationship between the environment and home value such as Lutzenhiser and Netusil (2001), who found that proximity to different types of open space (i.e.: natural and urban parks, golf courses, etc) influence the value of houses. Mahan, Polasky, and Adams (2000) also demonstrated a relationship between home value and proximity to different types of water resources, where increasing the size of, and proximity to, a wetland increases home value. Sander and Polasky (2009) found an increase in home value with an increase in proximity to natural resources such as parks, lakes, streams and trails. But proximity can go beyond economic valuation, as several studies have found significant differences in views between people living within close proximity to a water body, as compared to further away from the water body (Brody et al. 2004 & 2005; Larson and Santelmann 2007). For example, people living within closer proximity to a creek in Texas exhibited a greater awareness of the creek, as well as a greater concern for the quality of the water for consumption by humans and livestock (Brody et al. 2004). Spatial factors, therefore, have been shown to be an important consideration for studies examining household perception of natural resources.

Along with spatial factors, several scholars argue that the influence of temporal factors, (i.e.: physical age of home and household landscape) is missing from the socio-demographic argument and should be included as it may affect household decisions (Luck et al. 2009; Zhou et al. 2009). Law et al (2004) found a positive linear relationship between the ñaverage application rate of nitrogen and the median year a house was builtò. Zhou et al. (2009) also found house age to be a predictor of both lawn greenness and lawn care expenditures. Grove et al. (2006) noted that house age was a strong predictor for household landscape vegetation cover (grass and trees). These studies demonstrate the importance of considering house age as an important predictor of homeowner landscape behavior.

4. Targeting and tailoring information towards households

Current urban ecosystem research has recognized the need for a better understanding about why and how homeowners do what they do on their landscape (Grove et al. 2006), with some practitioners acknowledging that in some areas most homeowners donôt even know what a watershed is or how their household might be negatively affecting water quality (Schueler 2000a). Recent reports have demonstrated the importance of considering a householdôs attitudes and behaviors surrounding their lawn management when you are designing educational programs. For example, one New England study found a significant lack of knowledge about the effect an individual household can have on water quality, but that homeowners were willing to accept more environmentally friendly lawn care practices (Peterson et al. 2009). Practitioners then used this information to design a better outreach program aimed at ñdo-it-yourselfò household lawn management.

A similar report from the Chesapeake Bay area investigated familiar household landscape behaviors that were directly linked to excess nutrient pollution and also had the highest potential for behavior change (Caraco et al. 1999). This study found residentsô preferred outreach approach was not the same as outreach used by education officials, indicating the importance of tailoring information to residentsô needs.

A better understanding of households can lead to an improved understanding of critical information for educational programs targeting homeowners, and a better understanding of how this targeted information should be tailored. Many studies have shown that targeting messaging for specific audiences is more effective than one general message. Tailored programs addressing waste reduction behaviors such as composting and recycling have been found to be cheaper and simpler than developing programs that address all types of households (Tobias et al. 2009). Grove et al. (2006) claimed that tailoring lawn care education and outreach, and ñsellingò certain greener neighborhoods to specific groups of households, is better than a generic campaign sent to all homeowners in an area. Abrahamse et al. (2001) also found that tailored information and feedback of household member energy use produced greater behavior change among household members than those who did not receive any tailored intervention. The Center for Watershed Protection stresses the importance of knowing an audienceôs awareness, behaviors and media preferences for effective education messages (Marc Aveni in Schueler 2000b), stating the need for ñé understanding the sociology of nonpoint source pollution when advocating watershed education practices. Credible outreach programs must be based on detailed knowledge of what homeowners actually do and why they do it.ò

Some research likens these modes of tailoring information to marketing firms who profile their consumer base to understanding where and how to market their products. In the environmental realm, McKenzie-Mohr and Smith (1999) profess the benefits of their strategy, community-based social marketing, as a way to promote environmentally friendly behavior. This marketing approach rests on the belief that behavior change should be addressed at the community level through engaging in direct contact with people. The strategy relies on knowing oneôs audience and understanding not only the behaviors they are performing, but also the influences, such as other households and other people, that could be affecting those behaviors. Grove et al. (2006) also suggest that profiling a consumer base may lead to more successful behavior change. They suggest a framework in which the consumer base is the neighborhood, and environmental planners promote vegetation strategies as ñproductsò in communities where preferences and motivations of residents are already known.

5. Importance of targeting and tailoring for water resource managers

In Minnesota, some of the most important groups that would benefit from an increased knowledge of household behavior are watershed districts/watershed management organizations (WD/WMOs). WDs are special units of government with taxing authority and an elected governing board appointed by a county board (MAWD 2010). Established in 1955 by the Minnesota Legislature under the Watershed Act, MSA103d, each is charged with managing and protecting the water resources in its respective watershed (MAWD 2010). Watershed management organizations are also regulated under the MSA103d, but do not have taxing authority, and governance boards are appointed by members of the management organization (Mississippi Watershed Management Organization 2010). Not only do these groups work to manage water flow, measure trends in water quality, and work to improve best management practices on various landscapes, but they also work to encourage homeowner behaviors that help improve water quality. WD/WMOs are therefore one set of organizations in Minnesota that could benefit from knowledge about what their households are doing on their landscape and why.

Baker et al. (2007) suggest that the largest differences in nitrogen leaving a household between two theoretical households, one low consumption and one high, are the result of different amounts of nitrogen (N) fertilizer. This argument suggests that conversion to a low-maintenance lawn requiring less N fertilizer (a relatively small lifestyle change) could therefore have large impacts on the amount of N being leeched from lawns and running off the lawn in stormwater. A more recent paper from this study in Ramsey and Anoka Counties, Minnesota, found that fertilizer application is the major source of N to a household landscape (Fissore et al. 2010). Household lawns could, therefore, be an important target for source reduction of nitrogen. Baker and Brezonik (2007), using models, proposed that most phosphorus (P) entering residential neighborhoods may enter via lawns. For watersheds dominated by single-family homes, therefore, export of N and P from lawns is most likely the major source of nutrients entering stormwater (Baker and Brezonik 2007). Therefore, if water managers were able to better understand household decisions and target lawns as a model for source reduction, changes could be cost and time effective.

So far we have presented a discussion of many variables that affect household decision-making. While many studies have found that sociodemographic variables are an important predictor of landscaping behavior, other variables may be affecting household decisions, such as spatial and temporal factors. Spatial grouping of influential factors could create ôhotspotsô of adverse effects for the ecosystem and opportunities for tailoring programming to specific groups. Adding to the body of literature examining household landscape attitudes and behaviors, this paper examines the effect of three spatial characteristics of a household on landscaping attitudes and behavior: proximity to the nearest lake, total household income, and house age. These factors were chosen because they have previously been shown to influence household landscape management and they can be spatially examined across a landscape.

6. Research question and importance

Our goal was to use information collected through the Twin Cities Household Ecosystem Project, an interdisciplinary study examining the fluxes of carbon, nitrogen and phosphorus through households on an urban to rural gradient in Ramsey and Anoka Counties, Minnesota. Our overarching question was: Can spatial grouping of households contribute to the more effective targeting and tailoring of educational programming to homeowners for improved household lawn management? To examine this question, we present two main propositions:

1) Certain spatial sociodemographic characteristics (total household income and house age) will be grouped on a landscape.
2) Household groups are significantly different from each other within each factor measured (proximity to the nearest lake, total household income, and house age) with respect to their landscaping attitude and behavior, and level of environmental concern.

7. Methods

Our research occurred within the Twin Cities Household Ecosystem Project (TCHEP), located in the Twin Cities Metropolitan area, Minnesota, with a sample of participants selected along a 55km urban to exurban gradient in Ramsey and Anoka Counties. Single-family, owner-occupied households (that had control over household landscape decisions) were selected in a stratified random sample based on housing density. (For further information on TCHEP methods, see Fissore et al. 2010).

7.1 Mailed survey

We obtained data on household characteristics and choices for the TCHEP through a 40 question survey distributed to randomly selected households between May and August of 2008. We selected households from census blocks that had at least 50% of land area that met three criteria: the land represented an ñuplandò hydrologic type, the block had greater than 0% impervious surface on the property, and where households were classified as ósingle-family detachedô homes. With the help of Survey Sampling International, we identified all homes in these census blocks that were owner-occupied and had telephones, and the final sample was 15,000 households, a stratified random sample from this grouping. More homes were selected in areas of higher populated census blocks such that our sample would have a geographic distribution proportional to the housing density of the target population.

As the survey was quite extensive, taking roughly 40 minutes to complete, we anticipated a low response rate. We therefore oversampled to obtain a representative sample and minimize error. Of the 15,000 surveys mailed, we received 3,100 returned surveys (resulting in a 21% response rate). These surveys were then coded, entered into a database, and consistency checked.

The survey contained questions pertaining to activities of households for the previous year which fell under several different categories. These categories included: household characteristics (e.g. number of household members), household member diet and level of physical activity, household energy consumption (e.g. type of heating), lawn care and landscaping behavior (e.g. fertilization, irrigation, grass clipping and leaf litter management), household waste behaviors (e.g. recycling), and socio-demographic variables about the household. In addition, survey questions inquired about household attitudes, norms and perceived control of specific behaviors, namely driving, diet, lawn fertilization, and home energy use in order to gain insight as to why the household performed certain behaviors.

This paper specifically focused on survey questions pertaining to lawn management behaviors, fertilization attitudes, and sociodemographic characteristics of the household.

Survey variables regarding lawn management behaviors included percentage of lawn raked, management of leaves and grass clippings, and fertilization frequency (Table 1). Lawn management attitudes (measured on a Likert scale) included preferences for choice of vegetation and fertilization, which included homeowner attitudes about the advantages and disadvantages of fertilization, as well as a homeownerôs level of overall environmental concern (Table 1). We also examined variables regarding property value, housing density and number of trees on a householdôs property.

7.2 Data analysis

We analyzed our data using SPSS for statistical analysis, and GIS for spatial analysis of the distribution of households on the landscape with respect to three factors: proximity to the nearest lake, total household income, and house age (Table 1). We created the variable ñproximity to the nearest lakeò based on similar studies focusing on proximity and environmental perception (Brody et al. 2004; Larson and Santelmann 2007). In our study, we chose the division for proximity of 200m, where any household within 200m was determined to be ñwithin 200m of a lakeò and households outside of this cutoff were defined as ñfarther than 200m from a lakeò. There was a reasonable expectation that households within 200m of a lake likely know that a lake is in close proximity and have the possibility to frequently view this resource. This 200m cutoff also allowed for a robust statistical analysis (213 respondents were within a 200m radius and 2591 were outside of this radius). We obtained data for a householdôs proximity to a lake through the Metropolitan Council water resources metadata website (Metropolitan Council 2008).

Additionally, we created categories for income and house age. We determined income categories using modified survey data, where we grouped categories to reflect those seen in a similar survey, the 2008 MN Environmental Report Card (Murphy and Olson 2008): less than $30,000 (n = 248) , $30,000 ï $49,999 (n = 391), $50,000 ï 74,999 (n = 516),

$75,000 ï 99,999 (n = 539) , and greater than or equal to $100,000 (n = 843) (total n = 2795). To identify possible influence of house age, we created range extremes for house age, determined using divisions of the 2000 Metropolitan Council housing tract parcel data (Metropolitan Council 2003): households built before 1940 (n = 528), and households built after 1998 (n = 153). These extremes were chosen to see if a significant difference would occur, as we hypothesized that if a difference were occurring, it would most likely occur between the extremes of the house age range. Analysis of data consisted of Chi-Square, and t-tests and of proportions, using a significance level of $p<0.05$ to determine statistical significance.

Evaluation of spatial data was completed through visual interpretation of graphs of our data by GIS. We mapped both total household income and house age onto a separate GIS layer and assigned a specific color to each level of these two factors. The aforementioned divisions were then separated and examined by looking for dominant color patterns in order to determine if spatial grouping was occurring. If there were areas where one level of the factor was grouping in a visually distinct area than another level of that same factor, we concluded that the factor grouped spatially on the landscape.

8. Results:

For the household demographics in our study, the median income category was $75,000 ï $99,999, average house age was 49 years, and average household members was 2.53 (n = 2795). The average respondent age was 55.9, and our respondents consisted of 95% Caucasians and 59.5% males (n = 2795).

Overall, we found house age to group spatially and total household income to be homogenously distributed across our study area. Proximity was not a strong predictor of household attitude and behavior, while income predicted fertilization attitude and behavior. House age was our strongest predictor for the majority of attitudes and behaviors we examined.

8.1. Grouping of total household income and house age

We found mixed results regarding grouping on the landscape at a county scale. Household income appeared to be homogenously distributed across the study area at a county scale (Figure 1), and therefore it did not group into similar income pockets. Furthermore, no groupings emerged when analyzed at the finer spatial scale of a municipality, (i.e. municipality of Saint Paul) (Figure 2).

When examining the geographic distribution of house age, however, we observed that houses built before 1940 are mainly grouped in Ramsey County near city centers, while clusters of households built after 1998 are mainly found in Anoka County (Figure 3). This distribution is significantly related to housing density in this area, with more recently built homes found in areas of decreasing housing density ($p < 0.001$) and located farther from the city center ($p < 0.001$). Additionally, households located in less dense areas have significantly fewer trees than those in more dense areas ($p<0.001$).

8.2. Influence of lawn management attitudes and behaviors

In addition to examining variables to determine if households grouped on a landscape (income and house age), we also examined whether certain variables were predictors for household behaviors/attitudes: proximity to the nearest lake, total household income, and house age.

No significant differences in household lawn management attitudes and behaviors were found between households within 200m of a lake vs. farther than 200m from a lake (Tables 2 & 5). We found one difference with respect to attitudes, where homeowners within 200m of a lake were more likely to believe that an attractive lawn is good than those farther than 200m from a lake ($p<0.05$) (Table 5). There was no significant difference found between proximity and level of environmental concern (Table 5).

Income was shown to influence some lawn management attitudes and behaviors we examined (Tables 3 & 6). People in higher income households were more likely to say they normally fertilized their lawns, and have higher fertilizing rates among those who fertilized ($p<0.05$) (Table 6). Generally, as income increased, so did fertilization rates.

With respect to attitudes about the advantages of fertilization, people in higher income households were more likely to believe that fertilization results in a greener and more attractive lawn, and that an attractive lawn is good ($p<0.05$) (Table 6). But with respect to attitudes about the disadvantages, people in households of higher incomes were more likely to believe that fertilization results in water pollution and that this pollution is harmful ($p<0.05$) (Table 6).

A comparison of two categories of house age demonstrated differences in lawn management behaviors (Tables 4 & 7). With respect to vegetation choice, there were no significant differences between older and newer homes; both ñeasy to maintainò and ñcreates a beautiful yardò were the top two motivations for landscape management. People in older homes (those built before 1940) were more likely to not fertilize at all if they did normally fertilize ($p<0.05$), and less likely to fertilize at higher rates than those living in newer homes (built after 1998) ($p<0.001$) (Table 4). People in older homes were also more likely to leave their grass clippings on their property ($p<0.05$) and more likely to rake the leaves on their lawns ($p<0.05$) (Table 4). With respect to disposing of leaves, people in older homes were less likely to leave the leaves on their property (composting, adding to gardens, etc), but more likely to burn the leaves ($p<0.001$) (Table 4).

With respect to the advantages of fertilizing, people in older houses were less likely to believe that ñfertilization produces a greener lawnò, that a ñgreener lawn is beneficialò, that ñfertilizing results in an attractive lawn", and that ñan attractive lawn is goodò (all $p<0.05$) (Table 7). When examining attitudes towards the disadvantages of fertilizing, we found that people in older houses were more likely to believe that fertilizing their lawn will result in water pollution ($p<0.05$) and also more likely to believe that this water pollution is harmful ($p<0.05$) (Table 7).

House age was also the only factor to predict differences in a householdôs level of environmental concern. People in older houses were more likely to be very concerned that negative environmental effects have changed their quality of life than those in households built during or after 1999 ($p<0.001$) (Table 7).

9. Discussion

While we did not find strong evidence of spatial grouping of a household based on total household income, we did find that households grouped with respect to house age, and this factor was associated with differences in lawn management attitudes/behaviors. Total household income, however, was not as strong of a predictor as we had originally anticipated. Our results for proximity to the nearest lake did not support previous arguments in the literature, as we found no significant differences between groups for our study.

Our findings regarding house age support recommendations in the literature that incorporating a temporal component (such as house age) in studies examining household behavior can provide new insights (Luck et al. 2009; Zhou et al. 2009). Some of the effect of house age could be related to housing density (Figure 4), which has an effect on lot sizes and number of trees on a property, which may in turn have a significant effect on lawn management behaviors. Many of our findings related to house age, therefore, could be explained by differences in density and therefore the number of trees between houses built before 1940 and those built after 1998. These possibilities should be explored in later studies.

The differences between housing age categories in regard to level of environmental concern may be partially interpreted as a difference between an urbanized environment vs. a more suburban or peri-urban environment. More houses built before 1940 are located in urban settings, while more households built after 1998 are located on larger suburban lot sizes in less dense areas. Many studies have demonstrated links between highly urbanized areas and poor water quality (Mallin et al. 2009), habitat fragmentation (Wilcove et al. 1998), and degraded air quality (Cheng et al. 2000). One possibility is that these homeowners are within easier viewing of detrimental effects of increasing urbanization and feel more strongly that negative environmental effects threaten their quality of life.

In addition to the temporal component of house age, we also looked at total household income. Among our respondents, total household income was homogeneously distributed across the landscape. This could be due to a mixed housing stock and/or the scale at which we are looking for spatial variation. As residents of the area, we recognize neighborhoods in our cities with distinctly different socioeconomic status. In preparation for this study, we interviewed five WD/WMO administrators who mentioned areas of their respective districts where general socioeconomic status was known (Wein and Nelson 2009) and wondered if the income differences resulted in differences in land management.

While income did not group spatially, it was a considerable predictor of some of the attitudes and behaviors we examined, supporting the results of previous studies (Grove et al. 2006 and Law et al. 2004, among others). Surprisingly, we found that fertilization behavior was the only behavior that showed differences between lower and higher income households. We found no differences for leaf and lawn clipping behaviors. Interestingly, higher income households were dealing with some dissonance in their beliefs and behaviors. On one hand they were more likely to believe that fertilization will result in water pollution and that water pollution from fertilization is bad; on the other hand, they were more likely to fertilize in general and when they did fertilize, they fertilized at higher rates.

Robbins et al. (2001) found similar results in a study focusing on chemical use on household lawns, where homeowners that recognized the potential negative external effects of lawn chemical use were actually more likely to use chemicals than homeowners with less awareness. There could be different explanations for this behavior. Among many possibilities are that higher income households may have the knowledge that over-fertilization contributes negatively to water pollution, but they aren't necessarily making the connection between this knowledge and the fact that their own actions on their landscape contribute to this water pollution.

One of our main goals for this study was for WD/WMO administrators to apply our results to their education and outreach efforts. One setback to tailoring information based on income values, however, is that total household income is not readily available to public water resource managers without conducting a survey. Therefore, it is beneficial to look at another measure of socioeconomic status that can readily be measured: property value. For example, we found that total household income was positively correlated with property value ($p < 0.05$) (Figure 5). Since household property value can be obtained through public sources, this information could then be used to make similar conclusions from our results for total household income.

The final variable we examined was proximity to the nearest lake. Our initial proposal was that proximity would be a proxy for differences in awareness, ownership, and value of protecting a water body, which has been found in past studies (Brody et al. 2004 & 2005; Larson and Santelmann 2007). Our findings did not support this proposal, as we found few significant differences between lawn management attitudes and behaviors based on proximity. Minnesota, however, is considered the ñLand of 10,000 Lakesò, and homeowners are accustomed to seeing many bodies of water on a daily basis. Therefore, living within 200m of a lake may not be significantly unique enough to create an enhanced environmental awareness and sense of attachment to the lake. In Ramsey and Anoka Counties alone nearly 70% of surveyed households live within one mile of a lake. Therefore, it is possible that a homeownerõs proximity does not matter as much, as there are so many opportunities to view and interact with water in this region, and specifically in our study area. Similar studies focusing on proximity to water and environmental awareness/perceptions were located in areas such as San Antonio, Texas (Brody et al. 2004 & 2005), where water bodies are not as abundant as they are in Minnesota, and therefore proximity may play a more important role in peopleõs perceptions.

10. Conclusion

While this study demonstrates the possibility of spatial and temporal effects of household characteristics on groupings of landscaping attitudes and behaviors, it has limitations. Our findings demonstrate that it is possible to group households spatially on a landscape with respect to house age, which was a predictor of multiple landscape behaviors. Future work should add a statistical spatial analysis to give the spatial argument more validity. In addition, future studies could benefit by addressing additional questions regarding the motivations for diverse lawn and landscape practices, such as the influence of vegetation choice, lawn clipping behavior, watering, or leaf management.

Targeting groups and tailoring information to improve landscaping behaviors affecting water quality will continue to be a valuable way to become more effective. In the long run, similar studies will be an important way to inform effective management and focus time and financial resources strategically by incorporating household decision-making into planning and policy approaches for addressing non-point source water pollution problems.

References

Abrahamse, W., L. Steg, C. Vlek, & T. Rothemgatter. 2007. The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. Journal of Environmental Psychology 27: 265-276.

Baker, L. A. & P.L. Brezonik. 2007. Ecosystem approaches to reduce pollution in cities. In: Cities of the future: Towards integrated sustainable water and landscape management. Ed: Novotny, V. & P. Brown, IWA Publishing, London.

Baker, L.A., P.M. Hartzheim, S.E. Hobbie, J.Y. King & K.C. Nelson. 2007. Effect of consumption choices on fluxes of carbon, nitrogen and phosphorus through households. Urban Ecosystems 10: 97-117.

Baker, L. A., B. Wilson, D. Fulton, & B. Horgan. 2008. Disproportionality as a framework to target pollution reduction from urban landscapes. Cities and the Environment 1(2): article 7, http://escholarship.bc.edu/cate/vol1/iss2/7.

Barr, S. 2007. Factors influencing environmental attitudes and behaviors: A U.K. case study of household waste management. Environment and Behavior 39(4): 435-473.

Barten, J., & E. Jahnke. 1997. Suburban lawn runoff water quality in the Twin Cities metropolitan area, 1996 and 1997. Minnesota: Suburban Hennepin Regional Park District.

Brody, S. D., W. Highfield, & L. Alston. 2004. Does location matter? Measuring environmental perceptions of creeks in two San Antonio watersheds. Environment and Behavior 36(2): 229-250.

Brody, S. D., W. Highfield, & M.B. Peck. 2005. Exploring the mosaic of perceptions for water quality across watersheds in San Antonio, Texas. Landscape and Urban Planning 73: 200-214.

Caraco, D., P. Hinkle, R. Winer, & T. Schueler.1999. A survey of residential nutrient behavior in the chesapeake bay. Ellicott City, Maryland: Center for Watershed Protection.

Cheng, M. T., & Y.I. Tsai. 2000. Characterization of visibility and atmospheric aerosols in urban, suburban, and remote areas. The Science of the Total Environment 263: 101-114.

Fissore, C., L. A. Baker, S. E. Hobbie, J. Y. King, J. P. McFadden, K. N. Nelson, & I. Jakobsdottir. 2010. Carbon, nitrogen and phosphorus fluxes in household ecosystems in the Minneapolis-Saint Paul, Minnesota, urban region. Ecological Applications, In Press.

Gatersleben, B., L. Steg, & C. Vlek. 2002. Measurement and determinants of environmentally significant consumer behavior. Environment and Behavior 34(3): 335-362.

Grove, J. M., A. R. Troy, J. P. M. O'Neil-Dunne, W.R. Burch Jr., M.L. Cadenasso, & S.T.A. Pickett. 2006. Characterization of households and its implications for the vegetation of urban ecosystems. Ecosystems 9: 578-597.

Hope D., C. Gries, W. Zhu, W. Fagan, C.L. Redman, N.B. Grimm, A.L. Nelson, C. Martin, & A. Kinzig. 2003. Socioeconomics drive urban plant diversity. Proceedings of the National Academy of Science 100(15):8788ï 8792.

Larson, K. L., & M. V. Santelmann. 2007. An analysis of the relationship between residents' proximity to water and attitudes about resource protection. The Professional Geographer 59(3): 316-333.

Law, N. L., L. E. Band, & J. M. Grove. 2004. Nitrogen input from residential lawn care practices in suburban watersheds in Baltimore County, Maryland. Journal of Environmental Planning and Management 47(5): 737-755.

Luck, G. W., L. T. Smallbone, & R. O'Brien. 2009. Socio-economics and vegetation change in urban ecosystems: Patterns in space and time. Ecosystems 12: 604-620.

Lutzenhiser, M., & Netusil, N. 2001. The effect of open spaces on a home's sale price. Contemporary Economic Policy 19(3): 291-298.

Mahan, B., Polasky, S., & Adams, R. 2000. Valuing urban wetlands: A property price approach. Land Economics 76(1): 100-113.

Mallin, M. A., V.L. Johnson, & S.H. Ensign. 2009. Comparative impacts of stormwater runoff on water quality of an urban, a suburban and a rural stream. Environmental Monitoring Assessment 159: 475-491.

Metropolitan Council. 2003. Profile of selected housing characteristics for census tracts: 2000. Retrieved December 9, 2009, from http://www.datafinder.org/metadata/demog_profile_4_housing_tract.htm

Metropolitan Council. 2008. Historic Lakes and Rivers 1990 ï Open Water Features. Retrieved April 24, 2008 from http://www.datafinder.org/metadata/lakes_and_rivers_1990.htm

McKenzie-Mohr, D., & Smith, W. 1999. Fostering sustainable behavior. Fostering sustainable behavior: An introduction to community-based social marketing. British Columbia, Canada: New Society Publishers, 1-18.

Minnesota Association of Watershed Districts. 2010. What is a watershed district? Retrieved 05/04, 2010, from http://www.mnwatershed.org/index.asp?Type=B_BASIC&SEC={1F1ACEE4-3C71-468E-8830-469FA9E1C8CE}

Mississippi Watershed Management Organization. 2010. Mississippi watershed management organization formation. Retrieved 05/04, 2010, from http://www.mwmo.org/MWMO%20Formation.html

Murphy, T. P., & A. M. Olson. 2008. The Third Minnesota Report Card on Environmental Literacy. MN: The College of Saint Catherine; Minnesota Pollution Control Agency.

Osmond, D. L., & D. H. Hardy. 2004. Characterization of turf practices in five North Carolina communities. Journal of Environmental Quality 33: 565-575.

Peterson, J., B. Eisenhauer, K. Filchak, M. Gold, K. Guillard, E. Melvin, et al. 2009. Changing homeowner's lawn care behavior to reduce nutrient losses in New England's urbanizing watersheds: Social Science Results Summary. New Hampshire: UNH Cooperative Extension.

Poortinga, W., L. Steg, & C. Vlek. 2004. Values, environmental concern, and environmental behavior: A study into household energy use. Environment and Behavior 36(1): 70-93.

Robbins, P., A. Polderman, & T. Birkenholtz. 2001. Lawns and toxins: An ecology of the city. Cities. 18(6) 369-380.

Robbins, P., & J. Sharp. 2003. Producing and consuming chemicals: The moral economy of the American lawn. Economic Geography 79(4): 425-451.

Rosen, C. J., Horgan, B. P., & R.J. Mugaas. 2006. Fertilizing lawns. FO-03338. Minnesota: University of Minnesota Extension Service.

Rosen, C. J., & B.P. Horgan. 2009. Preventing pollution problems from lawn and garden fertilizers. FO-02923. Minnesota: University of Minnesota Extension Service.

Sander, H., & S. Polasky. 2009. The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. Land use Policy 26: 837-845.

Schueler, T. R. 2000a. On watershed education. The practice of watershed protection. Maryland: Center for Watershed Protection, 629-635.

Schueler, T. R. 2000b. Homeowner survey reveals lawn management practices in Virginia. The practice of watershed protection. Maryland: Center for Watershed Protection, 666-667.

Sustainable Urban Landscape Information Series (SULIS). 2010. Fertilizer Practices. Retrieved from http://www.sustland.umn.edu/maint/fertiliz.htm. University of Minnesota.

Tobias, R., A. Brugger, & H. Mosler. 2009. Developing strategies for waste reduction by means of tailored interventions in Santiago de Cuba. Environment and Behavior 41(6): 836-865.

Waschbusch, R. J., W. R. Selbig, & R. T. Bannerman. 1999. Sources of phosphorus in stormwater and street dirt from two urban residential basins in Madison, Wisconsin, 1994-95 No. 99-4021. WI: U.S. Geological Survey.

Wein, S. P. & K. Nelson. Summer, 2009. Presentations to: Capitol Region Watershed District, Coon Creek Watershed District, Ramsey Washington Metro Watershed District, Rice Creek Watershed District and Vadnais Lake Area Watershed Management Organization, Twin cities household ecosystem project: Creating partnerships with watershed districts in Ramsey and Anoka Counties. Twin Cities, MN.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, & E. Losos. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48(8): 607-615.

Zhou, W., A. Troy, J. M. Grove, & J.C. Jenkins. 2009. Can money buy green? Demographic and socioeconomic predictors of lawn-care expenditures and lawn greenness in urban residential areas. Society and Natural Resources 22: 744-760.

Tables

Table 1: Concept Measurement, 2010.

Variable	Type	Measurement	Scale	Source
Proximity to the Nearest Lake	Independent	Household is within or outside of 200m	Dichotomous (Within/farther than 200m of a lake)	GIS
Total Household Income	Independent	Reported total annual household income	Ranges of household incomes	Survey
House Age	Independent	Year household was built	Dichotomous (Before 1940 and After 1998)	GIS
Lawn Management Behaviors	Dependent	Leaf/lawn clipping management, % lawn raked, fertilization	Multiple mutually exclusive choices	Survey
Lawn Management Attitudes	Dependent	Fertilization attitudes, vegetation choice	5 pt. Likert Scale (Continuous)	Survey
Level of Environmental Concern	Dependent	Level of Environmental concern	5 pt. Likert Scale (Continuous)	Survey

Table 2: Proximity to the nearest lake vs. lawn management behaviors, Ramsey and Anoka Counties, Minnesota, 2008.

[a-b] Different superscripts are significantly different at $p < 0.05$ based on z-tests adjusting for multiple comparisons through the Bonferroni method; *Significant at pÒ0.001
[1] Value computed on a 5pt Likert Scale, where 1 = raked 0% of lawn and 5 = raked 100% of lawn

	Proximity to the Nearest Lake	
Percentage	**Within 200m** *(n = 213)*	**Further than 200m** *(n = 2591)*
Households who Normally Fertilize	73.2	71.6
Households who Fertilized:		
0 Times	1.9	1.9
1-2 Times	62.3	62.4
3-4 Times	31.8	31.5
5+ Times	3.9	4.1
Lawn Clipping Disposal		
Off-site	17.9	19.2
Leave on lawn	63.2	64.2
Compost on property	18.9	16.6
Portion of Lawn Raked[1]	3.92	3.76
Leaf Disposal		
Mulch into lawn, compost on property or add to garden	49.1	43.7
Remove from property	40.6	42.4
Burn on-site	10.4	13.9

Table 3: Total household income vs. lawn management behaviors, Ramsey and Anoka Counties, Minnesota, 2008.

[a-b] Different superscripts are significantly different at p <0.05 based on z-tests adjusting for multiple comparisons through the Bonferroni method; *Significant at pÒ0.001
[1] Value computed on a 5pt Likert Scale, where 1 = raked 0% of lawn and 5 = raked 100% of lawn

	Total Household Income				
Percentage	**<$30,000** *(n = 248)*	**$30-49,999** *(n = 391)*	**$50-74,999** *(n = 516)*	**$75-99,999** *(n = 539)*	**>$99,999** *(n = 843)*
Households who Normally Fertilize	61.1[a]	63.3	72.1[b]	74.8[b]	76.2[b]
Households who Fertilized:					
0 Times	32.2[a]	31.4[a]	23.1	21.2[b]	18.6[b]
1-2 Times	51.2	47.6	50.0	50.2	47.1
3-4 Times	13.7[a]	18.6	24.2[b]	25.5[b]	30.0[b]
5+ Times	2.8	2.4	2.6	3.1	4.3
Lawn Clipping Disposal					
Off-site	20.5	14.7	20.5	18.8	19.0
Leave on lawn	66.1	69.7[a]	63.5	63.6[b]	63.8
Compost on property	13.4	15.5	15.9	17.6	17.2
Portion of Lawn Raked[1]	3.73	3.71	3.82	3.77	3.76
Leaf Disposal					
Mulch into lawn, compost on property or add to garden	44.1	45.2	41.0	45.6	45.8
Remove from property	45.4	43.6	43.0	39.3	41.3
Burn on-site	10.5	11.2	15.9	15.1	12.8

Table 4: House age vs. lawn management behaviors, Ramsey and Anoka Counties, Minnesota, 2008.

[a-b] Different superscripts are significantly different at $p < 0.05$ based on z-tests adjusting for multiple comparisons through the Bonferroni method; *Significant at pÒ0.001
[1] Value computed on a 5pt Likert Scale, where 1 = raked 0% of lawn and 5 = raked 100% of lawn

	House age	
Percentage	**Before 1940** *(n = 528)*	**After 1998** *(n = 153)*
Households who Normally Fertilize	47.6	50.3
Households who Fertilized:		
0 Times	30.3[a,*]	1.4[b]
1-2 Times	54.0	45.2
3-4 Times	15.6[a,*]	46.6[b]
5+ Times	0.0	6.8
Lawn Clipping Disposal		
Off-site	18.8	19.3
Leave on lawn	66.7[a]	55.9[b]
Compost on property	14.5[a]	24.8[b]
Portion of Lawn Raked[1]	3.85[a]	2.99[b]
Leaf Disposal		
Mulch into lawn, compost on property or add to garden	40.4[a,*]	57.2[b]
Remove from property	42.7	37.2
Burn on-site	16.9[a,*]	5.5[b]

Table 5: Proximity to the nearest lake vs. averages of respondentsôanswers to advantages and disadvantages of fertilization and level of environmental concern, 5pt Likert Scale, Ramsey and Anoka Counties, Minnesota, 2008.

[a-b] Different superscripts are significantly different at $p < 0.05$ based on z-tests adjusting for multiple comparisons through the Bonferroni method.

	Proximity to the Nearest Lake	
Average Likert Scale Value	**Within 200m** *(n = 213)*	**Further than 200m** *(n = 2591)*
Advantages of Fertilization		
Fertilizing my lawn this year will result in an attractive lawn. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	1.76	1.89
An attractive lawn is extremely bad/good. *(Likert scale: 1 = extremely bad, 5 = extremely good)*	4.05^{a}	3.89^{b}
Fertilizing my lawn this year will produce a greener lawn. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	1.68	1.69
Creating a greener lawn by fertilizing is extremely harmful/beneficial. *(Likert scale: 1 = extremely harmful, 5 = extremely beneficial)*	3.23	3.17
Disadvantages of Fertilization		
Fertilizing my lawn this year will result in water pollution. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	2.89	2.89
Water pollution from fertilizing is extremely harmful/beneficial. *(Likert scale: 1 = extremely harmful, 5 = extremely beneficial)*	2.29	2.33
Level of Environmental Concern		
How concerned are you that negative environmental effects have changed your quality of life? *(Likert scale: 1 = unconcerned, 5 = very concerned)*	3.09	3.24

Table 6: Total household income vs. averages of respondentsô answers to advantages and disadvantages of fertilization and level of environmental concern, 5pt Likert Scale, Ramsey and Anoka Counties, Minnesota, 2008.

[a-b] Different superscripts are significantly different at p <0.05 based on z-tests adjusting for multiple comparisons through the Bonferroni method.

	Total Household Income				
Average Likert Scale Value	**<$30,000** *(n = 248)*	**$30-49,999** *(n = 391)*	**$50-74,999** *(n = 516)*	**$75-99,999** *(n = 539)*	**>$99,999** *(n = 843)*
Advantages of Fertilization					
Fertilizing my lawn this year will result in an attractive lawn. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	2.15[a]	2.10	1.87[b]	1.84[b]	1.77[b]
An attractive lawn is extremely bad/good. *(Likert scale: 1 = extremely bad, 5 = extremely good)*	3.90	3.79[a]	3.92	3.87	3.95[b]
Fertilizing my lawn this year will produce a greener lawn. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	1.98[a]	1.89	1.69[b]	1.64[b]	1.56[b]
Creating a greener lawn by fertilizing is extremely harmful/beneficial. *(Likert scale: 1 = extremely harmful, 5 = extremely beneficial)*	3.21	3.11	3.18	3.10	3.16
Disadvantages of Fertilization					
Fertilizing my lawn this year will result in water pollution. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	3.12[a]	2.92	2.85	2.82[b]	2.83[b]
Water pollution from fertilizing is extremely harmful/beneficial. *(Likert scale: 1 = extremely harmful, 5 = extremely beneficial)*	2.50[a]	2.30	2.33	2.26[b]	2.28[b]
Level of Environmental Concern					
How concerned are you that negative environmental effects have changed your quality of life? *(Likert scale: 1 = unconcerned, 5 = very concerned)*	3.37	3.23	3.25	3.21	3.20

Table 7: House age vs. averages of respondentsô answers to advantages and disadvantages of fertilization and level of environmental concern, 5pt Likert Scale, Ramsey and Anoka Counties, Minnesota, 2008.

[a-b] Different superscripts are significantly different at $p < 0.05$ based on z-tests adjusting for multiple comparisons through the Bonferroni method.

	House age	
Average Likert Scale Value	**Before 1940** *(n = 528)*	**After 1998** *(n = 153)*
Advantages of Fertilization		
Fertilizing my lawn this year will result in an attractive lawn. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	2.24[a]	1.46[b]
An attractive lawn is extremely bad/good. *(Likert scale: 1 = extremely bad, 5 = extremely good)*	3.67[a]	4.13[b]
Fertilizing my lawn this year will produce a greener lawn. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	1.94[a]	1.36[b]
Creating a greener lawn by fertilizing is extremely harmful/beneficial. *(Likert scale: 1 = extremely harmful, 5 = extremely beneficial)*	2.76[a]	3.51[b]
Disadvantages of Fertilization		
Fertilizing my lawn this year will result in water pollution. *(Likert scale: 1 = extremely likely, 5 = extremely unlikely)*	2.54[a]	3.06[b]
Water pollution from fertilizing is extremely harmful/beneficial. *(Likert scale: 1 = extremely harmful, 5 = extremely beneficial)*	2.02[a]	2.42[b]
Level of Environmental Concern		
How concerned are you that negative environmental effects have changed your quality of life? *(Likert scale: 1 = unconcerned, 5 = very concerned)*	3.48[a]	3.06[b]

Figures

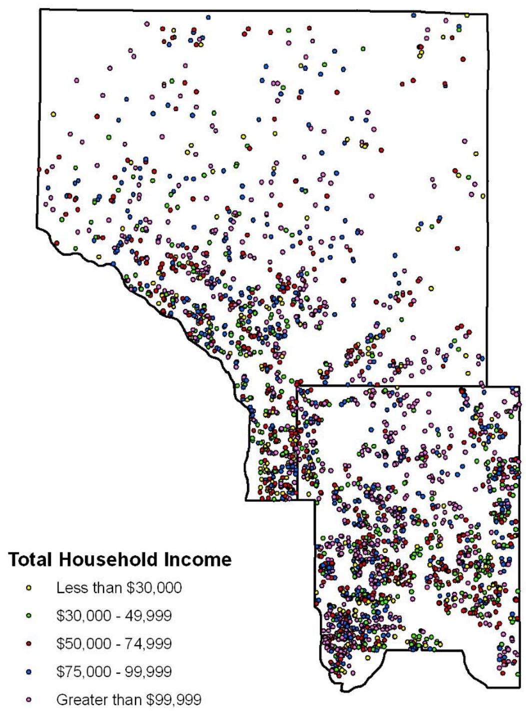

Figure 1: Spatial distribution of respondent total household income, Ramsey and Anoka Counties, Minnesota, 2008.

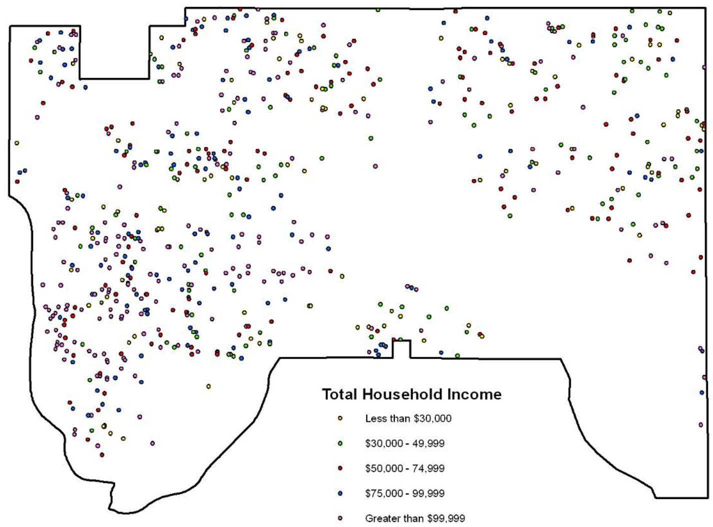

Figure 2: Spatial distribution of respondent total household income, Saint Paul, Minnesota, 2008.

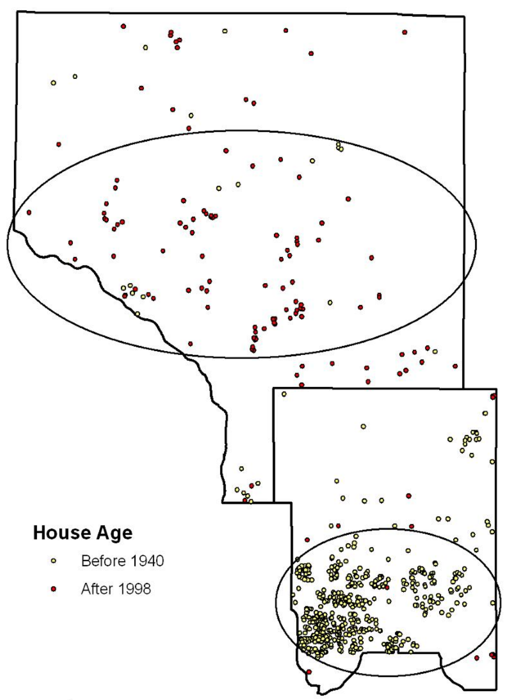

Figure 3: Spatial distribution of house age, Ramsey and Anoka Counties, Minnesota, 2008.

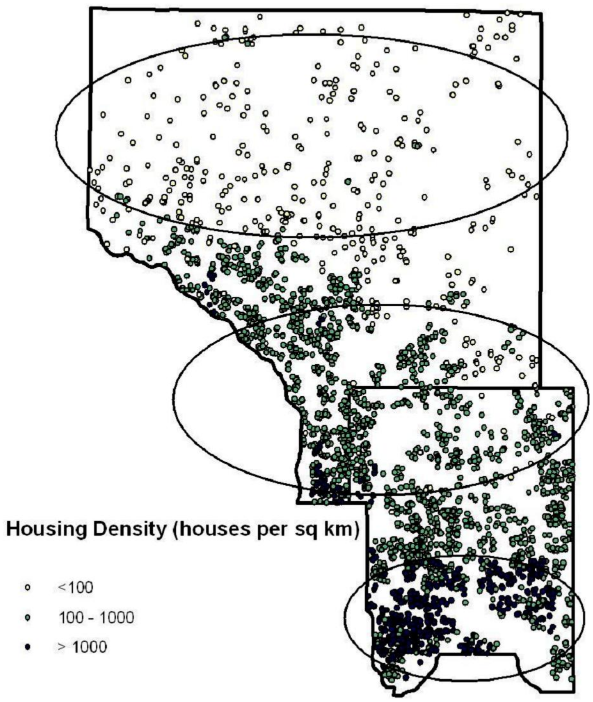

Figure 4: Spatial distribution of housing density, Ramsey and Anoka Counties, Minnesota, 2008.

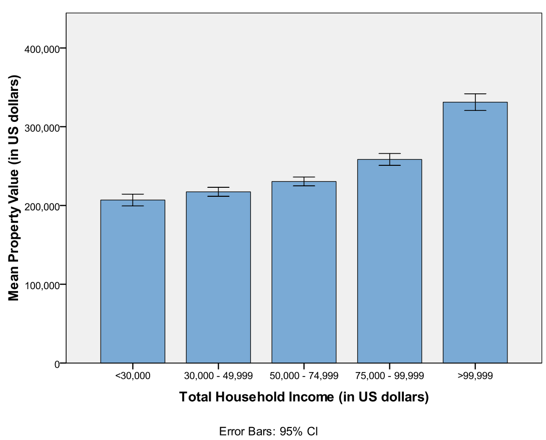

Figure 5: Total household income vs. property value of respondent households, Ramsey and Anoka Counties, Minnesota, 2008.