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INFLUENCES ON RESIDENTIAL YARD CARE AND WATER QUALITY: TUALATIN WATERSHED, OREGON[1]

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ABSTRACT: The Tualatin is the first watershed in Oregon to implement the Total Maximum Daily Load provisions of the Clean Water Act to deal with nonpoint source pollution. Local officials cite residential yard care practices as potential contributors to nonpoint source pollution in the basin. Qualitative and quantitative methods, including observation of yard maintenance styles, suggest behaviors potentially harmful to water quality and conservation. Yard maintenance is influenced by the importance of neighborhood appearance and concern for aesthetics. These concerns stimulate residents to water, fertilize, and apply weed control at more frequent intervals than yard care experts recommend. Better understanding of the effects that relations with neighbors and yard maintenance knowledge have on residential yard care practices can help improve water quality.
(KEY TERMS: residential yard care practices; urban water management; water quality; water conservation; environmental values; urban pollution.)

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INTRODUCTION

In July 2001, the U.S. Environmental Protection Agency (USEPA) set in motion the total maximum daily load (TMDL) provisions of the Clean Water Act (CWA) nationwide. Total maximum daily loads, seen by many as the next logical step in cleaning critically impaired water sources in the United States, focus on watershed based management techniques and target nonpoint source (NPS) pollution. Though part of the original CWA of 1972, TMDLs have been controversial and largely ignored for decades (Houck, 2002).

In residential areas, NPS management requires working with many small, private landowners. The research goal was to know the incentives that influenced behaviors related to residential yard care. Keeping green and homogeneous lawns is a tradition in many areas of the United States. An assumption is that maintenance of green and homogeneous lawns requires large amounts of water and fertilizer. A research objective is to determine the practices and factors that influence residential yard care.

The research looked at factors associated with yard care practices in the Tualatin watershed in the vicinity of Portland, Oregon. The watershed has a history of severe NPS pollution, and actions to reduce pollution were initiated well before USEPA proposed TMDLs (Wolf, 1992; Cass *et al.,* 1993; Shively, 1993; ODEQ, 2001; TRWC, 2002). Part of the Tualatin's water quality problem is attributed to residential yard care practices (Wolf, 1992; ODEQ, 2001). Farmers in the basin, asked to modify their practices, point to urban residents' overuse of water and fertilizer. Residential yard care practices have been the target of educational campaigns in the Tualatin watershed. In the summer of 2002, a sample of Tualatin Basin residents' yards were observed. Residents were then surveyed on their yard care practices.

Direct observations provided a picture of common "looks" of yards, while a survey asked residents to describe yard care practices, information sources, and values associated with yard care. To add further depth to understanding people's motivations for their yard care practices, a subsample of neighborhood residents was interviewed. Results of this research suggest persistence of behaviors that could inhibit water

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quality and retard conservation efforts, thus making the achievement of TMDL goals more challenging. Further, excessive lawn watering places demands on water supply.

In 1997, between 25 million and 30 million acres (10 and 12 million hectares) of lawn existed in the United States (Lawn Institute, 2002). If lawns were classified as an agricultural crop, they would rank as the United States' fifth largest on the basis of acres harvested (USDA, 1997). The acreage of lawns grew along with the tendency to settle in suburbs after World War II (Waytiuk, 1997). As the acreage of lawn increased, domestic fertilizer use in the United States also grew (Jenkins, 1994), amplifying the potential for excess nutrients to be added to water sources on a national scale.

Common residential practices of fertilizing and the application of herbicides to lawns and gardens negatively influence water quality by contributing pollutants to streams (Schueler and Holland, 2000). Excess nutrients cause a myriad of problems in local streams and lakes (Barth, 2000). A 2002 study conducted by the University of Minnesota at Duluth and partners measures the use of chemical fertilizers and phosphorous levels in neighboring lakes. Results from the Lake Access Study are preliminary, but real-time data available on the project website show a strong correlation between phosphorous levels and the use of chemical fertilizers (University of Minnesota *et al.,* 2002).

An estimated 136 million pounds (62 million kg) of pesticides are applied to urban lawns and gardens every year in the United States (USEPA, 1999). Some estimates suggest that 5 to 7 pounds (2 to 3 kg) of pesticide are applied annually to the average acre of a well maintained urban lawn (Schueler, 2000). Pesticide presence in urban storm water runoff not only impacts aquatic life but also can be a threat to humans, as toxic substances can contaminate fish and drinking water resources. Insecticides are of particular concern and can be harmful even at low levels. The U.S. Geological Survey (USGS) found that urban streams sometimes contain higher concentrations of household and garden insecticides than agricultural streams contain of farm pesticides (USGS, 1999).

RESEARCH AREA AND APPROACH

The Tualatin River watershed in northwestern Oregon is an area of 712 square miles (1,844 km^2) that is currently 15 percent urbanized, 35 percent farmland, and 50 percent forested (TRWC, 2002). Washington County, which roughly coincides with the borders of the Tualatin watershed, had 169,000 households in 2000. The number of households is expected to increase 46 percent by 2020 (Washington County Department of Land Use and Transportation, 2002). The projected growth means greater future demands on Tualatin River water supply and quality.

The main TMDL substances that are affected by residential yard care practices in the watershed include dissolved oxygen, phosphorus, and bacteria. The Tualatin TMDL set for dissolved oxygen has identified two pollutants: ammonia and volatile solids. While ammonia sources are largely from water treatment plants, volatile (organic) solids arrive in streambeds from sediment, erosion, and runoff from various sources including residential areas, placing demands on oxygen levels, especially during critical times of the year (ODEQ, 2001). Phosphorus levels are affected by lawn and garden practices that employ the use of fertilizer, which contributes to nutrient loading (both phosphorus and nitrogen). Excess nutrients in turn lead to eutrophication and poor fish habitat. Improper management of animal waste, including pet waste, worsens the bacteria problems in the Tualatin River (ODEQ, 2001). Temperature and flow in waterways nationwide are also impacted by water demands during hot summer months. In the Tualatin watershed, domestic water use usually doubles during the long, dry summer, when water flows are lowest and water temperatures highest.

Ongoing relationships between human activities and environmental phenomena are embedded within human needs, social relationships, and community values (Bennett, 1996). Rational explanations for behavior choices assume that people make decisions according to their value preferences when presented with options (Heath, 1976). Values are of interest to social scientists as explanatory variables for people's actions (Heath, 1976; Kempton *et al.,* 1995; Culhane, 2001; Vaske *et al.,* 2001). What creates value preferences becomes complicated as people receive different action prompts or signals from such different sources as education and information, rules and regulations, economic incentives, and social pressures (Bennett, 1996). The research investigates the types of possible prompts and signals that dictate maintenance decisions in residential neighborhoods.

To study residential neighborhoods, a mix of qualitative and quantitative methods was used. Using direct observation of yard conditions, a mail survey, and short, semistructured interviews with residents, the research targeted specific practices, influences on maintenance styles, and values.

A judgment sample identified three separate neighborhoods in the Tualatin watershed. Judgment samples target a group of people based upon defining characteristics (Bernard, 2000). Each sample neighborhood consisted of approximately 60 residences for a total of 176 residences. Census data, geographic

criteria, and interview information from water quality and conservation managers were used as defining characteristics for neighborhood selection. Neighborhoods rather than more random sampling methods were chosen to facilitate the efficiency of observation and because lawn care practices are often influenced by real or assumed perspectives of neighbors.

Sample neighborhood locations were determined by the following procedures: several potential neighborhoods were identified using data from interviews with water quality managers and observation. Locations were then evaluated on the basis of overall neighborhood characteristics such as general state of repair or disrepair of homes, types of cars parked in the neighborhood, and presence of yards, in order that different neighborhoods and maintenance styles could be observed. Characteristics of homes in prospective neighborhoods such as property values and ages of homes were then researched using the Washington County Tax Assessor's office Surveynet system (Washington County Tax Assessor, 2002). Sample neighborhoods fit within one of the three most common property value categories listed in the 2000 Census data. In one neighborhood the majority property values were between $100,000 and $149,999, the second between $150,000 and $199,999, and the third between $200,000 and $299,999. Most (84.2 percent) homes in Washington County fall within these ranges (USBC, 2000). The median value of the sample neighborhood homes was $192,200.

Geographic considerations were also a factor in choosing neighborhoods in three municipalities of the watershed that were separated by a minimum distance of approximately 15 miles (25 km). All three neighborhoods were in similar suburban settings in the Tualatin watershed, near to but not adjacent to tributaries of the Tualatin River. The three study neighborhoods were within the Portland Standard Metropolitan Statistical Area. The neighborhoods were in areas considered suburbs of Portland. These three neighborhoods exhibit a variety of yard conditions and maintenance styles, were not situated on streams, and can be considered representative of residential neighborhoods in the United States.

Direct Observation and Mail Survey

Two direct unobtrusive observations (Bernard, 2000) were conducted on June 26 and August 20, 2002. These times were selected in order to observe the state of lawns and yards before and after a spell of hot, dry weather. The Willamette Valley of Oregon weather pattern includes an annual summer drought. June through August shows an increase in temperature and a decrease in precipitation (Online Highways, 2003). Lawn and yard conditions were observed for 176 homes. Observation targeted the overall state of the yard, presence and condition of flowers and shrubs, and color and composition of grass. Items observed were chosen due to their assumed link to water quality problems in the Tualatin watershed. Observation was followed by a 31-question survey. Survey questions focused on yard care practices, knowledge about water quality issues, factors influencing maintenance styles, environmental values, and demographic characteristics. The survey was administered in three waves using a direct mailing technique beginning in early September 2002 (Bernard, 2000).

Short Interviews

To check survey responses, 22 short, semistructured interviews were conducted in the three sample neighborhoods. Using a convenience sampling technique in which all those encountered were asked to participate (Bernard, 2000), these interviews focused on three central issues: residents' main priorities in yard care, types of issues that influence the way residents maintain their yards, and sources of knowledge about yard care practices. Neighborhood resident interviews were coded for common themes (Bernard, 2000). Data from these interviews reveal a range of goals and influences on the personal maintenance styles of residents that supplement survey data. Residents' values toward the environment were also examined through analysis of interview themes. Interview statements are referred to using code numbers to protect the identity of individual respondents.

RESULTS

Sample Population Background

Survey and observation data were analyzed using SPSS 12.0 (SPSS Inc., 2003). Variable relationships and distributions are reported using univariate, bivariate, and multivariate analysis. A total of 98 of 176 surveys were returned, a response rate of 56 percent (Table 1). Survey respondents were nearly evenly distributed between the sexes, with 48 percent female and 52 percent male. Respondents ranged from 25 to 86 years old, with 80 percent being between the ages of 35 and 75. The majority of respondents (59 percent) reported a college or graduate school education, which is higher than the county average of 42 percent. An

additional 36 percent attended some college or vocational school, a rate comparable to the 34 percent reported in county statistics. Median household income (23 percent of respondents) was between $50,000 and $75,000, and 72 percent of the households had an income between $35,000 and $150,000, which is above the 2000 U.S. Census data that list 64 percent of Washington County residents in the same range. Homeowners have higher levels of education and income in general than do renters. Management and professional occupations accounted for 41 percent of the respondents. The other major category was retired, which accounted for 30 percent. Homes in these neighborhoods were built between 1968 and 1990.

TABLE 1. Background on Houses Observed and Survey Respondents.

Characteristic	Houses Observed	Surveys Returned
Number	176	98
Average Year Built	1975	1973
Average Lot Acreage	0.21	0.22
Average Value of Land and Improvements	190,490	196,420
Average Age of Survey Respondents		56
Average Length of Residence of Respondents		14.6
Average Household Size		2.57

Lawn and Yard Care: Direct Observations

Correlation analysis and interviews suggest that type of lawn is central to evaluation of residential yard care. Lawns within the three sample neighborhoods were classified into four categories based upon observation of their relative color and the homogeneity of vegetation. During direct observations in June and August 2002, the largest percentage of lawns in the three neighborhoods were classified as "green monoculture," meaning the lawns looked green and lacked an obvious presence of weeds. The next largest category of lawns in June 2002 was classified as "yellow monoculture," meaning the lawns had more of a yellow hue. The number of "yellow monoculture" lawns declined over the summer, while the category of "yellow mix," or a yellowish hue with evidence of a diverse mixture of plants growing in the lawn, increased from 13 to 30 percent. The "yellow monoculture" category declined from 27 to 18 percent. Green lawns that had the presence of weeds, or "green mix," began at roughly 15 percent in June and declined to 6 percent by August (Figure 1).

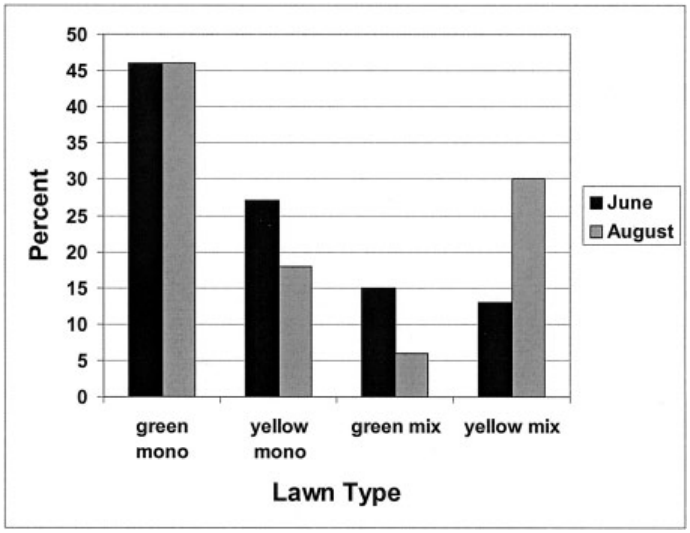

Figure 1. Percentage of Four Lawn Types Observed, June and August 2002.

Lawn Care Characteristics: Survey

The survey data enabled us to look at what people said they did for yard care. For example, 53 percent of survey respondents watered their lawns two to three times a week or more, 21 percent watered the recommended rate of once a week, and 26 percent did not water their lawns or did not have a lawn. Lawn fertilizer was applied three times a year by 26 percent of respondents, twice a year by 38 percent, once by 18 percent, and not at all by 17 percent. Weed control was applied to lawns three times a year by 18 percent, twice by 25 percent, once by 21 percent, and not at all by 36 percent. The majority of respondents who used fertilizers used weed-and-feed products on their lawns in the previous year (66 percent), and 44 percent used time-release fertilizers. A majority (60 percent) of survey respondents reported maintaining their yards on their own. Among those who used professional services, 18 percent used a professional service for fertilization, and 16 percent used professional services for pest control.

Correlations and pattern analysis between observation data and survey answers help explain yard care practices and reasons for them. Lawn categories were organized into green monocultural, green mixed, yellow monocultural, yellow mixed, and no lawn. Table 2

reports both percentages and chi-square values. The percentages compare the green monoculture lawns observed in August 2002 with the yellow mix lawns on frequency of watering, fertilizing, and using weed control. The table also shows the quality of flowers and those reporting neighborhood appearance as a factor influencing yard care practices.

TABLE 2. Percentages for Respondents in the Green Monocultural and Yellow Mix Lawn Categories on Lawn Inputs, Flowers, and Neighborhood Appearance.

Variable	Green Mono Lawns[a] (percent)	Yellow Mix Lawns[b] (percent)	Chi-Square Pattern[c]
Water 2x/week or more	33	9	58.5, df=16 p<0.001
Fertilize 2x/year or more	34	10	42.3, df=12 p<0.001
Weed control 2x/year or more	24	6	33.9, df=12 p=0.001
Flowers with no weeds and watershed	34	5	80.2, df=20 p<0.001
Neighborhood Appearance as an influence on maintenance style	35	10	8.6, df=4 p=0.072

[a]Forty percent of lawns in the analysis.
[b]Twenty-six percent of lawns in analysis.
[c]Chi-square patterns are for the variable against the sequence green monoculture, green mix, yellow monoculture, yellow mix, no lawn.

The table shows the association that watering, fertilizing, and weed control have with green monocultural lawns and the absence with yellow mixed lawns. Significant correlations were not found with demographic variables of age, income, education, occupation, length of residence, and house and land values. Templeton *et al.* (1999), looking at yard care in San Francisco, also did not find significant relations with age and income, suggesting that potential wealth gains were not important in yard care decisions.

The last column of Table 2 gives a measure of significance of pattern across the green monocultural, green mixed, yellow monocultural, yellow mixed, and no lawn categories. The chi-square values show that all these patterns, with the exception of neighborhood appearance, show significant differences at $p < 0.001$.

Table 3 gives correlations between the greenness and homogeneity characteristics of lawns. The green monocultural, green mixed, yellow monocultural, yellow mixed, and no lawn categorizations include the dimensions of greenness and homogeneity. Thus, all the green lawns are in the column "greenness of appearance" and all the monocultural lawns were included as "homogeneity of appearance." The greenness and homogeneity variables were coded green/homogeneous, not green/homogeneous, and no lawn. This coding allowed determining if greenness and homogeneity distinguished between yard care practices. One might suspect that green lawns received more water and homogeneous ones more fertilizer and weed control.

TABLE 3. Correlations with Greenness and Homogeneity of Lawns in August 2003. Asterisks show significance level of Kendall's tau-b correlations.

Characteristic	Greenness of Appearance	Homogeneity of Appearance
Frequency of Lawn Watering	0.44***	0.37**
Quality of Flowers August 2002	0.35***	0.34***
Frequency of Fertilizer Application	0.31***	0.43***
Frequency of Weed Control in Last 12 Months	0.29***	0.34***
Use of Time Release Fertilizers	0.29**	0.36**
Frequency of Garden Watering	0.21*	
Higher Household Income		0.24*
Influenced by Neighborhood Appearance	0.22*	

*$p < 0.05$ to $p = 0.01$.
**$p < 0.01$ to $p = 0.005$.
***$p < 0.005$.

Correlations in Table 3 show greenness of the lawn correlated with the reported frequency of lawn watering (Kendall's tau-b $r = 0.44$, $p < 0.001$), and the homogeneity of the lawn correlated with frequency of fertilizer application (Kendall's tau-b $r = 0.43$, $p < 0.001$) and use of weed control (Kendall's tau-b 0.34, $p < 0.001$). Other significant correlations were with having flowers, use of time-release fertilizers, having a garden and frequency of garden watering, higher household income, and being influenced by neighborhood appearance.

Since greenness of lawn and the homogeneity, the monocultural nature of lawns, appear as key to

general yard care descriptions, multinomial logit regression was used to better understand these patterns. The research sought to distinguish between those with green, not green, and no lawn and monocultural, not monocultural, and no lawn. Multinomial logit regression was chosen in order to classify greenness and homogeneity of lawns as dependent variables. The tables for multinomial logit regression are quite complex; reported here are the results for green and not green and monocultural and not monocultural. When the presence or absence of a characteristic is being predicted, logistic regression can also be used. Logistic regression works on individual cases, while multinomial logit regression works on the specification of subpopulations (Norusis, 1999). The multinomial logit and logistic regression analyses reveal the variables that best describe characteristics of the study population related to the greenness and homogeneity of lawns.

Multinomial logit regression is suited to survey data because the variables collected through survey and observation are descriptive and placed into ranked and unranked categories. Other statistical procedures also suited to the categorical data of this research are binomial logistic regression, ordinal regression, and discriminant analysis.

For these analyses, results cover green and not green (Table 4) and monocultural and not monocultural (Table 5). For each of the two conditions, greenness and homogeneity, a number of regression models were tested to choose the best explanation for these conditions. From the regression models and interviews conducted in the neighborhoods, six variables were hypothesized to be important for explaining greenness and homogeneity – the amount of lawn watering and fertilizing, the presence of flowers and a garden, concern for neighborhood appearance, and attitudes toward the environment.

Tables 4 and 5 give the likelihood estimates for regressions for these six variables used in the multinomial logit regression to predict greenness and homogeneity. The research further hypothesized that use of water might be more associated with greenness and fertilizer use might be more associated with homogeneity. For greenness, the frequency of watering has the highest significance ($p < 0.024$). The only other significant variable is the care of flowers during the August observation ($p < 0.030$). Note that concern for neighborhood appearance, environmental and economic values, and frequency of fertilizing add little to the regression because they are not significant in predicting greenness. Presence of a garden and garden type show possible significance ($p < 0.098$). The parameter estimates for lawn watering follow an expected pattern with codes for more watering making a bigger contribution to parameter estimates. Flowers weeded and watered have the strongest positive parameter estimate (2.3). Note the very small parameter estimates for the frequency of fertilizing.

The classification table for greenness shows that the parameter estimates predict over 85 percent of the observed cases. The Cox and Snell R^2 is 0.48. The SPSS model calculates three R^2 statistics. The Cox and Snell, Nagelkerke, and McFadden R^2 statistics attempt to quantify the proportion of explained variation. The R statistic gives a sense of the contribution of independent variables to the model. These measures have the same intent as the traditional R^2 in linear regression models, but in logistic regression, the R^2 is defined differently. "The Cox and Snell R^2 is

$$R^2 = 1\text{-}[L(0)/L(B)]2/N$$

where L(0) is the likelihood for the model with only a constant, L(B) is the likelihood for the model under consideration, and N is the sample size" (Norusis, 1999, p. 46). The Cox and Snell R^2 cannot achieve a maximum value of 1. The Nagelkerke R^2 attempts to adjust for this. In all the regression models, the Nagelkerke R^2 is about one-third higher than the Cox and Snell R^2. The McFadden R^2 tracks very closely to the Cox and Snell R^2. The more conservative Cox and Snell R^2 is used to give a more modest estimate of the strength of the regression.

A multinomial logit regression model was evaluated for the three categories of green, not green, and no lawn. The regression had the same pattern of likelihood and parameter estimates as reported for the categories of green and not green. The final chi-square is 107.3, the degrees of freedom (df) = 42, $p < 0.001$. This regression model successfully predicted 83 percent of the cases.

The validity of multinomial logit regression can become uncertain with small populations and many empty cells. Separation of data can be incomplete. Other multivariate analytical techniques have the same problem, when all the cells for the analysis are not filled. The objective in using multinomial logit regression is to test the priority of variables shown in the likelihood-ratio test. The multinomial logit regression is used to point out possible directions for future research. The regression patterns correspond with the patterns in bivariate correlations and interview data.

For homogeneity, well tended flowers ($p < 0.003$) and frequency of fertilizing ($p < 0.009$) were the significant explanatory variables. The presence of a garden, environmental and economic values, frequency of watering, and concern for neighborhood appearance explained little of the variance. Parameter estimates are in the direction and have patterns that suggest that taking better care of flowers and fertilizing more contribute to predicting homogeneity. Care of flowers

TABLE 4. Multinomial Logit Regression Likelihood-Ratio Tests for Greenness.

4a. Likelihood Ratio Tests.

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	63.2	0.0	0	
Frequency of Lawn Watering	74.4	11.2	4	0.024
Care of August Flowers	75.5	12.4	5	0.030
Presence of Garden	71.0	7.8	4	0.098
Concern for Neighborhood Appearance	63.7	0.5	3	0.465
Favoring Environment or Economy	65.4	2.2	1	0.698
Frequency of Fertilizing	64.6	1.4	2	0.702

N = 91, the final model has a chi-square of 58.8, df = 21, $p < 0.001$, Cox and Snell pseudo $R^2 = 0.48$.

4b. Parameter Estimates.

Variable	Code	B	Standard Error	Sig.
	Intercept	-4.2	2.1	0.048
Lawn	Water Lawn Daily	4.9	2.5	0.049
Watering	Water Lawn Two to Three Times Per Week	2.1	1.8	0.240
	Water Lawn Weekly	2.3	1.9	0.224
	Do Not Water Lawn	-1.6	1.7	0.343
	Have No Lawn	0*		
August	Flowers Weeded and Watered	2.3	0.9	0.012
Flowers	Flower Planters	0.9	1.5	0.547
	Flowers Weedy and Watered	0.5	1.8	0.771
	Flowers Weeded and Unwatered	-19.4	0.0	
	Flowers Weedy and Unwatered	-19.2	0.0	
	No Flowers	0*		
Garden	Have a Flower Garden	1.9	0.9	0.042
	Have Vegetable/Fruit Garden	1.7	1.4	0.233
	Have Container Garden	-0.7	1.5	0.617
	Have Flower and Vegetable/Fruit Garden	1.4	0.9	0.135
	No Garden	0*		
Environment	Environmental Conditions Have Highest Priority	0.7	0.9	0.466
vs	Environmental Conditions Are Important	0*		
Economic	Environmental and Economic Factors Weighted Equally	1.5	3.0	0.612
	Economic Considerations Are Important	-1.0	2.0	0.602
	Economic Considerations Given Highest Priority	0.2	1.7	0.916
Neighbor	Consider Neighborhood Appearance	-0.4	1.9	0.852
Concern	Neighborhood Appearance Not Mentioned	0*		
Lawn	Fertilize Lawn Three or More Times Per Year	-1.0	1.7	0.536
Fertilizing	Fertilize Lawn Twice a Year	0.1	1.5	0.955
	Fertilize Lawn Once a Year	0.0	1.7	1.000
	Do Not Fertilize Lawn	0*		

*This parameter is set to zero because it is redundant.

4c. Classification Table for Greenness.

Observed	Predicted		
	Lawn Green	Lawn Not Green	Percent Correct
Lawn Green	42	4	91.3
Lawn Not Green	9	36	80.0
Overall Percentage	56.0	44.0	85.7

TABLE 5. Multinomial Logit Regression Likelihood-Ratio Tests for Homogeneity.

5a. Likelihood Ratio Tests.

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	62.6	0.0	0	
Care of August Flowers	80.9	18.3	5	0.003
Frequency of Fertilizing	74.2	11.6	3	0.009
Presence of Garden	67.0	4.4	4	0.352
Favoring Environment or Economy	65.1	2.6	4	0.634
Frequency of Lawn Watering	64.8	2.2	4	0.703
Concern for Neighborhood Appearance	62.6	0.0	1	0.871

N = 91, the final model has a chi-square of 56.3, df = 21, $p < 0.001$, Cox and Snell pseudo $R^2 = 0.46$.

5b. Parameter Estimates.

Variable	Code	B	Standard Error	Sig.
	Intercept	-4.8	2.5	0.054
August	Flowers Weeded and Watered	2.9	1.0	0.004
Flowers	Flower Planters	2.4	1.3	0.066
	Flowers Weedy and Watered	-1.6	2.1	0.450
	Flowers Weeded and Unwatered	0.5	1.4	0.711
	Flowers Weedy and Unwatered	-18.4	0.0	
	No Flowers	0*		
Lawn	Fertilize Lawn Three or More Times Per Year	4.3	2.0	0.027
Fertilizing	Fertilize Lawn Twice a Year	2.9	1.2	0.019
	Fertilize Lawn Once a Year	1.0	1.3	0.473
	Do Not Fertilize Lawn	0*		
Garden	Have a Flower Garden	0.8	0.9	0.394
	Have Vegetable/Fruit Garden	0.3	1.7	0.864
	Have Container Garden	-2.1	1.4	0.143
	Have Flower and Vegetable/Fruit Garden	0.1	1.0	0.888
	No Garden	0*		
Environment	Environmental Conditions Have Highest Priority	2.1	2.7	0.434
vs	Environmental Conditions Are Important	0.9	2.3	0.707
Economic	Environmental and Economic Factors Weighted Equally	0.9	2.1	0.660
	Economic Considerations Are Important	-0.9	2.3	0.680
	Economic Considerations Given Highest Priority	0*		
Lawn	Water Lawn Daily	1.0	2.0	0.639
Watering	Water Lawn Two to Three Times Per Week	1.5	1.4	0.280
	Water Lawn Weekly	0.7	1.5	0.667
	Do Not Water Lawn	0.3	1.4	0.843
	Have No Lawn	0*		
Neighbor	Consider Neighborhood Appearance	-0.1	0.9	0.870
Concern	Neighborhood Appearance Not Mentioned	0*		

*This parameter is set to zero because it is redundant.

5c. Classification Table for Homogeneity.

Observed	Predicted		
	Lawn Homogeneity	Lawn Not Homogeneous	Percent Correct
Lawn Homogeneity	51	6	89.5
Lawn Not Homogeneous	6	28	82.4
Overall Percentage	62.6	37.4	86.8

by weeding and watering or having flowers in planters have positive parameter estimates. Higher levels of fertilizing get higher positive parameter estimates, suggesting that greater use of fertilizer predicts the homogeneity observed in lawns.

The multinomial logit regression model predicts almost 87 percent of the cases. The chi-square significance of the regression is 56.3, df = 21, $p < 0.001$. The Cox and Snell pseudo R^2 is 0.46. The prediction of greenness and homogeneity suggest that the amount of watering contributes most to greenness and that fertilizing is a significant contributor to homogeneity. Other practices associated with yard care, such as maintenance of flowers and possible presence of a garden, also may be associated with these variables.

Another regression model using the three characteristics – a homogeneous lawn, a nonhomogeneous lawn, and no lawn – had a chi-square significance of 102.3, df = 42, $p < 0.001$. The Cox and Snell pseudo R^2 is 0.68, and the model predicted 83 percent of the cases.

Logistic regression analysis was used for comparison. For the presence or absence of greenness, the same variables predicted 80 percent of the cases correctly. The Cox and Snell R^2 is 0.47. For the presence or absence of a monocultural lawn, 87 percent of the cases were predicted correctly and the Cox and Snell R^2 is 0.39. As a hypothesis for future work, the amount of lawn watering, fertilizing, care for flowers and gardens, and concern about neighbors' opinions are important variables for explaining residential lawn care.

Knowledge and Influence Characteristics: Survey

In addition to the statistical analysis, the survey also revealed knowledge gaps characteristic of the whole survey population and not related to lawn care practices but significant for communicating with residential households about maintaining water quality. When asked what happens to water that goes down the storm drain nearest their homes, the majority of respondents (57 percent) marked "I don't know," 15 percent correctly identified that water goes directly to the nearest stream, 19 percent believed the water went to a water treatment plant, 6 percent believed water goes into a nearby filtration system, and 3 percent believed it goes into the ground water table after entering a storm drain. Water quality managers were especially disappointed with these results, since considerable effort had been expended trying to educate the public that "fish live downstream" of their yards. One of Oregon's environmental concerns is removing certain species of salmon from threatened species status.

Few respondents understood that the recommended disposal method for pet waste was to flush it down the toilet. While 62 percent of respondents had pets, only 8 percent of pet owners reported flushing pet waste. The research did not gather information on the type of pet, and those with outdoor cats might find flushing impractical. The most common disposal method, 61 percent, was to put pet waste in the garbage. While the connection of streams and pet waste responses are not what water quality managers would prefer, the responses do make logical sense if people have not listened to and absorbed the details of water quality messages.

One of the hypotheses was whether people who were more environmentally conscious would have different yard care practices. Research by Templeton *et al.* (1999) found, "Proxies for wealth, potential gains in property values, and land costs are the most important determinants of the decision to have and keep a yard." An effort was made to look at people's views on the importance of environmental conditions and economic considerations through the question "Maintaining your home and yard often involves difficult trade-offs between environmental conditions and economic considerations. Where would you locate yourself on the following scale concerning these issues?" The scale went from highly favoring the environmental conditions to highly favoring economic considerations. An equal balance between environmental conditions and economic considerations, however, was the preference of 66 percent. Priority to economic considerations was preferred by 12 percent and to environmental conditions by 22 percent. A significant correlation (Kendall's Tau-b $r = 0.33$, $p < 0.001$) was also found between listing cost as an influence and choosing economic considerations as having a priority over environmental conditions. Income and house value showed no significant correlations with yard care practices.

A desire to balance environmental conditions and economic considerations is a common result in surveys using this question (Smith *et al.,* 1997). On average, just under half the people surveyed prefer the middle ground between economic and environmental priorities. Tualatin residents were at the upper limit of survey populations in preferring the middle ground. They most closely matched a survey done of southeast Georgia and northeast Florida residents, who had 68 percent in the balanced category (Brunson *et al.,* 2002). With so many wanting to balance environmental conditions and economic considerations and so few on the economic considerations side of the value ranking, the cell size was not sufficient to adequately test this hypothesis. Semistructured interviews, however, provided another line of inquiry.

Influences on Maintenance Styles: Interviews

The 22 short, semistructured interviews came from approaching people doing a variety of activities outside of their homes. such as coming home from shopping, leaving their homes, chatting with neighbors, working in the yard, working on cars, or strolling the neighborhood. After being asked a few general questions about their yards to introduce the topic, interviewees were asked about their priorities for taking care of their yards, influences on how they take care of their yards, and sources of knowledge about yard or home maintenance.

Interviewees overwhelmingly expressed their number one priority as being the "look" of their yard. Residents commonly used words such as: "neat," "clean," "green," and "nice" to describe priorities. A concern for the look of one's yard was coupled with statements about responsibility to neighbors, personal enjoyment of yard aesthetics, or statements that expressed a fear of neighbor disapproval if yards were not kept up: "I like to keep my yard looking nice. The rest of the neighborhood would hate you if you didn't!"

As for influences on the way residents take care of their homes and yards, a variety of considerations were mentioned. Neighborhood appearance was mentioned by 40 percent of interviewees, a personal desire to do yard or maintenance work for aesthetic reasons by 36 percent, upkeep as a matter of habit by 10 percent, needs for low maintenance styles because of time by 10 percent, and a concern for environmental impact by 5 percent. The importance of neighborhood appearance was expressed in a variety of ways: "Around here it is a competition! I think it is important for everyone to keep their yards nice;" and "I think we have a responsibility to our neighbors to keep our yard looking nice." Another resident's comment made a connection between the outward appearance and personal and yard maintenance: "Would you want your yard looking scraggly? Why do you take a bath? It's the same reason." This comment is especially interesting because it makes yard care an extension of the self or a reflection of the type of people who live inside the home. Knowledge about home and yard care came from a variety of sources. "Just knowing" what to do was expressed by 40 percent of interviewees, learning from friends or family by 40 percent, talking to home and garden store employees by 10 percent, from professional companies by 5 percent, from labels and by reading in newspapers or on the Internet by 5 percent each.

Throughout the interviews the theme of watchful, judgmental neighbors was present. Comments exemplify the types of judgments about neighbors' yards, such as: "Most of my neighbors do an extremely poor job. That guy over there only comes out twice a year!" and "People have been getting better, but most of them have a long way to go."

These results show that yard care and yard appearance are cultural phenomena and are guided by perceived feelings of neighbors. Responses suggest the tendency to value the human benefits gained from keeping a nice yard. Only 1 of the 22 interviewed mentioned environmental impact as an influence on their particular maintenance style.

A survey question asked respondents to check influences on their yard care decisions. Responses to this question showed that neighborhood appearance was most often mentioned as affecting yard care decisions – 65 percent of survey respondents chose this response. The next most common influences were cost (52 percent), aesthetics (46 percent), and property values (44 percent). Environmental impact (32 percent), safety (21 percent), past experience (18 percent), and following good examples (13 percent) were less commonly cited as influences on maintenance styles.

Aesthetic Factors Relating to Neighborhood Appearance

Neighborhood appearance shows up in structured interviews and survey data as one of the potentially significant influences on people's yard care practices. To understand reasons for the importance of neighborhood appearance as influencing their actions, multinomial logit regression analysis was used. Issues like valuing the environment, being concerned about economics, and demographic factors do not show up as strongly in correlations with yard care styles.

The general theme of the variables in Table 6 shows that being a good neighbor is mainly about aesthetics. Flowers, a green monocultural lawn, a garden, and responding to aesthetic influences are the variables that most strongly explain neighborhood appearance. While the multinomial logit regression model is less strong than the ones explaining greenness and homogeneity (Cox and Snell pseudo R^2 = 0.28), it still classifies 84 percent of the cases correctly.

The parameter estimates show positive values for having flowers watered and weeded, maintaining a green and homogeneous lawn, and mentioning aesthetics as an issue affecting yard care practices. The garden parameter estimates are more difficult to interpret. One hypothesis for the negative score on the vegetable and fruit garden is that this makes a residence look more like a farm and does not meet the aesthetic expected of suburban neighborhoods. The

TABLE 6. Multinomial Logit Regression Likelihood-Ratio Tests for Neighborhood Appearance.

6a. Likelihood Ratio Tests.

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	60.7	0.0	0	
Flowers Well Cared For to None	73.6	12.9	5	.025
Aesthetics Mentioned and Not Mentioned	65.3	4.5	1	.033
Greenness of Lawn	66.9	6.2	5	.046
Garden Present to No Garden	69.5	8.7	4	.068
Homogeneity of Lawn	65.6	4.8	2	.089

N = 95, the final model has a chi-square of 31.7, df = 14, $p < 0.004$, Cox and Snell pseudo $R^2 = 0.28$.

6b. Parameter Estimates.

Variable	Code	B	Standard Error	Sig.
	Intercept	0.0	0.9	0.972
August	Flowers Weeded and Watered	1.7	0.8	0.028
Flowers	Flower Planters	-1.8	1.3	0.160
	Flowers Weedy and Watered	-0.6	1.3	0.631
	Flowers Weeded and Unwatered	-0.2	1.2	0.859
	Flowers Weedy and Unwatered	-15.5	0.0	
	No Flowers	0*		
Greenness	Lawn Green	20.1	1.2	0.000
	Lawn Not Green	19.8	0.9	0.000
	No Lawn	0*		
Homogeneity	Lawn Homogeneous	-19.5	0.8	0.000
	Lawn Not Homogeneous	-19.9	0.0	
	No Lawn	0*		
Garden	Have a Flower Garden	-1.1	0.7	0.142
	Have Vegetable/Fruit Garden	-3.0	1.1	0.007
	Have Container Garden	-0.0	1.3	0.971
	Have Flower and Vegetable/Fruit Garden	-1.4	0.9	0.129
	No Garden	0*		
Aesthetics	Aesthetics Mentioned	1.2	0.6	0.042
	Aesthetics Not Mentioned	0*		

*This parameter is set to zero because it is redundant.

6c. Classification Table for Neighborhood Appearance.

Observed	Predicted: Neighborhood Appearance Mentioned	Predicted: Neighborhood Appearance Not Mentioned	Percent Correct
Neighborhood Appearance Mentioned	60	3	95.2
Neighborhood Appearance Not Mentioned	12	20	62.5
Overall Percentage	75.8	24.2	84.2

interview and survey data suggest that aesthetics and their neighbors' aesthetic judgments are an important concern. The variables identified by multinomial logit regression need further exploration. The overall hypothesis suggests that the social pressure on neighbors for aesthetic qualities in yard care lead to frequency of watering and fertilizing beyond recommended levels. The costs in time and money

and the potential problems to the environment do not show up as important concerns.

DISCUSSION

As an exploratory study, this research uncovered common "look" of yards, common practices, and influences on those practices. Survey respondents' self-reports documented use of water, fertilizers, and chemical weed control for yard maintenance at frequencies that are higher than those commonly recommended by water quality specialists. Data show a strong relationship between the look of the observed lawn and reported inputs of water, fertilizer, and herbicides.

Although survey results do not show the exact amount of water being applied per week, 53 percent of residents watered more than the recommended one time per week. Due to high rates of use during the summertime, it can be assumed that residents are most likely watering more than necessary or not watering efficiently.

Exact amounts of fertilizer applied are not known, but the frequency of use suggests residents are fertilizing more than necessary. Further, recommended amounts on packaging are highly variable (Dindorf, 1992; Aveni, 1994; Gene Kroupa and Associates, Madison, Wisconsin, 1995, unpublished report; Smith, 1996; Barth, 2000). Short interviews conducted with residents during the course of this study suggested that "just knowing" what to do in the yard or learning from friends and family (80 percent) are much more prevalent than learning from packaging labels or experts (20 percent).

Urban residents experience a complex set of prompts and signals on their actions. The survey, interview, and observational data show that survey respondents in the Tualatin watershed are, for the most part, unaware or unconcerned with the environmental cost of their individual yard care decisions. They are more concerned with how their neighbors will view them. Further, many residents have missed some of the details that water quality managers have tried to promote. The majority water more frequently than the recommended, "Once per week, until a tuna can is filled." The fact that storm drains are connected to streams is not known by 85 percent of the survey population.

Resident actions are prompted by social pressure to keep one's yard "clean," "green," and "nice." The aesthetic pressures faced by residents in the Tualatin watershed are best summarized in one resident's comment: "The rest of the neighborhood would hate you if you didn't keep up your yard." The short interviews and survey results, which listed neighborhood appearance as the most common influence on maintenance style, suggest that people feel pressure from neighbors to maintain well kept yards. This social pressure in turn leads to actions such as more frequent watering, fertilizing, and use of herbicides that can harm water quality. Neighborhood appearance was the most common influence on maintenance styles, listed by 66 percent of survey respondents and 76 percent of short interview respondents.

Social pressure based on neighborhood appearance and aesthetic values are strong influences on yard care patterns. The values associated with yard care are anthropocentric rather than ecocentric. Neighborhood appearance and aesthetics, as important influences on maintenance styles, can be seen as anthropocentric, or human centered priorities that are about aesthetic and utilitarian aspects of nature (Kempton *et al.,* 1995).

Research results were reported to local policy makers. A partnership, nicknamed the Clean Water Action Group (CWAG), was created to address the amount of fertilizer and herbicide use. This partnership, made up of Metro Regional Services, the Oregon Department of Environmental Quality, Clean Water Services, and the cities of Tualatin, Tigard, and Eugene, developed a test program that targets a reduction in weed and feed use in the Tualatin and Upper Willamette watersheds (Cole, 2004). The CWAG did a baseline telephone survey in December 2003 and plans a variety of marketing techniques or "treatments" such as direct mail, discount coupons, and a gardening hotline and workshops to determine the most effective and cost efficient methods to change the amount of fertilizers and herbicides applied.

Unpublished research results from CWAG support the results of this research. For example, the December 2003 survey showed that the majority of residents in the Tualatin watershed sample (62 percent) use weed-and-feed products, comparable to the 66 percent percent found in this research. Eighty-one percent of those who use this type of product apply it between one and three times per year. Results of the CWAG survey also yielded important insights into incentives and influences on yard maintenance style in the region. The survey showed that the majority (71 percent) of residents who desire a green, weed free lawn use chemicals to achieve these results.

In addition, the neighborhood observation protocol used in this research has been expanded and refined. This new observation protocol was used on the test areas before the incentive programs that target behavioral change began and will be repeated after

the programs have ended, in hopes of seeing physical, observable change in behavior based on the state of lawns in the target neighborhoods.

CONCLUSION

The combination of observation, survey, and interview results suggest that residential home and yard care practices do not follow water quality improvement recommendations. These results, however, do not offer detail on the specifics of practices such as the amount or type of fertilizer applied or whether residents are watering the recommended 1 inch (2.5 cm) per week. To calculate exact impacts on TMDL issues, further research on detailed practices of residential home and yard care is needed. Specific amounts of water, fertilizer, pesticides, and herbicides applied would provide clearer connections to water quality and conservation efforts. Further, the research did not get into issues of turf height, plant varieties, and low flow irrigation techniques.

To target behavioral and value change, knowledge of the effectiveness of different educational efforts in residential neighborhoods would also be helpful. Further research on notions of aesthetic beauty in residential neighborhoods is needed along with better understanding of cultural pressures to achieve aesthetic standards. The acceptability of different types of low input designs by populations who are more concerned with looks than environmental impact would be helpful in the promotion of low input yard care. Since aesthetic issues associated with neighborhood appearance are important as an influence on yard care practices, the social pressures neighbors put on one another for neighborhood appearance need to be changed in order to promote more environmentally friendly practices.

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