Predicting Opportunities for Greening and Patterns of Vegetation on Private Urban Lands

Shortened Title: Predicting Opportunities for Greening on Private Lands

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ABSTRACT

This paper examines predictors of vegetative cover on private lands in Baltimore, MD. Using high-resolution spatial data we generated two measures. “Possible stewardship” refers to the proportion of private land that does not have built structures on it, and hence has the possibility of supporting vegetation. “Realized stewardship” refers to the proportion of possible stewardship land upon which vegetation is growing. These measures were generated at the parcel level and averaged by US Census block group. Realized stewardship was further defined by proportion of woody vegetation and grass. Data about expenditures on yard supplies and services by block group were used to help better understand where current vegetation conditions appear to be the result of current activity, past legacies, or abandonment. PRIZM™ market segmentation data were first tested as predictors of possible and realized stewardship and yard expenditures at the Block Group level. PRIZM™ segmentations are hierarchically clustered into 5, 15, and 62 categories, which correspond to population density, social stratification (income and education), and lifestyle clusters, respectively. We found that PRIZM 15 best predicted variation in possible stewardship and PRIZM 62 best predicted variation in realized stewardship. These results were further analyzed by regressing each dependent variable against a set of continuous variables reflective of each of the three PRIZM groupings. Housing age, vacancy, and crime were found to be critical determinants of both stewardship metrics. In addition, the percentage of African Americans was positively related to realized stewardship but negatively related to yard expenditures.

Keywords: urban ecology, private land, neighborhood segmentation, urban forestry, Baltimore LTER, urban greening.

INTRODUCTION

Urban green space provides a variety of important benefits (Lohr and others 2004; Grove and others 2005). Examples include aesthetic amenities (Acharya and Bennett 2001; Morancho 2003; Tajima 2003; Lohr and others 2004; Grove and others 2005), reduction of energy usage for cooling (Shashua-Bar and Hoffman 2000; Akbari 2002), carbon sequestration (Jo and Mcpherson 1995; Nowak and Crane 2002), filtering and attenuating of stormwater runoff (Whitford and others 2001), and promotion of neighborhood social capital (Sullivan and others 2004; Vemuri 2004). Green space plays a particularly significant role in lower income central city areas (Sullivan and others 2004). For instance, inner city residents tend to gravitate disproportionately towards vegetated areas for activities occurring in outdoor common spaces, suggesting that urban greening could be an important tool for fostering increased social interaction among neighbors and ultimately increasing the vitality of the neighborhood (Levine Coley and others 1997; Kuo and others 1998). Many of the benefits mentioned here are recognized and appreciated by urban residents who, according to nationwide surveys, see trees as generally yielding far more benefits than costs (Lohr and others 2004).

Significant variation exists in the average amount of canopy cover of American cities, from 0.4% in Lancaster, CA, to 55% in Baton Rouge, LA (Nowak and others 1996). The reasons for such variation relates to a number of factors. Although surrounding natural vegetation, which reflects local environmental conditions, may be a critical factor, it explains only part of the variation (Nowak and others 1996). Soils have a significant effect on the spatial distribution of urban trees (Moffat 1991). The built environment of cities also imposes a clear constraint in that cities with high building densities, such as many in Europe, have less room in which to plant (Attwell 2000).

While variation in average vegetation cover at the scale of the metropolitan area has been fairly well addressed, less understood is the heterogeneity in vegetation cover within cities. With a 34% increase in the amount of urbanized land in the US between 1982 and 1997 (USDA1999) and the percentage of developed land in the nation projected to increase from 5.2% to 9.2% by 2025 (Alig and others 2004), indicators for measuring and predicting intra-urban vegetation patterns will become increasingly important. In this paper we present two such indicators. The first, "possible stewardship," is a measure of plantable area, defined as the proportion of privately owned property parcels not occupied by buildings (equivalent to the inverse of building lot coverage). Having room to plant does not mean that planting will occur, however. Where such space exists, action must be taken by individuals, institutions, or government agencies to plant or maintain existing vegetation. Our second indicator is "realized stewardship" or the proportion of a parcel's possible stewardship land (i.e. plantable land) on which vegetation is growing (see Figure 1 for a visualization of possible and realized stewardship).

These indicators are helpful for both understanding causes of the differences in the distribution of vegetation and in predicting opportunities for urban greening (Grove and others 2005; Galvin and others 2006; Grove and others 2006). However, the quantity of vegetation does not necessarily reflect the level of activity of current residents. Today's vegetation may be the result of current planting activity, historical legacies (e.g. past tree plantings or turf establishment) or unplanted volunteer vegetation in vacant lots.

The determinants of possible stewardship have unintentionally been well studied because plantable area is essentially the inverse of lot coverage (building footprint area divided by lot size), which is strongly correlated with population and building density. Understanding the causes and dynamics of density occupies much of the planning and urban economics literature (e.g. Alonso 1964; Muth 1969; Mills 1970; Harr 1975; Kau and Lee 1976; Craig and Haskey 1978; Mills 1979; Alperovich 1982; Cho 2001). Among the causes examined by this literature are "pull" factors such as employment and retail clustering, infrastructural investments, amenities, cheap land and services, and "push" factors, such as crime, fiscal problems, taxes, expensive land, and pollution. Existing building densities are a result of these processes operating over multiple time scales. What we see today is a result of a patchwork of drivers from many different points in time. For example, much of the built environment in the center of many Eastern U.S. cities is a result of the clustering of industries that occurred in the late 19th and early 20th centuries and the rail and water-based transportation infrastructure that accompanied that industrialization. Because of this, much of the dense housing we see in post-industrial cities is a latent indicator of past demand that often no longer exists. Construction has increasingly shifted towards the suburbs as automobiles, trucks, air traffic, and interstates have brought down transportation costs while communication systems such as telephones, faxes, and the Internet and have released businesses from their dependency on city centers and allowed them to decentralize towards the suburbs. These factors have amplified the preexisting pull of residents towards suburban amenities, services, and low land prices and the push of residents away from central city problems (Mieszkowski and Mills 1993). Because of the lowered cost of transportation, a greater land area could be utilized for urban uses, lowering the per unit land price paid by residents and allowing them to live at lower densities, on larger lots, with lower lot coverage.

The housing filtering model (Sweeney 1974a; Sweeney 1974b) suggests that as central city housing ages and depreciates, residents gain less utility from it and it “filters down” to lower income residents. Wealthier residents can pay to move to suburban locations where housing is newer, land is cheaper (but comes in bigger minimum units frequently resulting in higher priced housing), and public service levels are generally greater (Fischel 1985). Meanwhile, older urban housing “filters” to progressively poorer residents as the stock ages, until it is eventually abandoned. This implies consequently that income tends to be inversely correlated to housing age. While Muth (1969) found such a correlation, Bond and Coulson (1989) found that the correlation, although present, was not causal. Instead, they found that the true causal relationship is between housing size (which tends to be strongly correlated with housing age) and income, because demand for housing size rises with income. In other words, the extent to which housing filters down to lower income groups may be governed by the size of historic housing.

In contrast to the extensive planning and urban economics literature on urban form, far fewer studies have examined predictors of vegetative coverage on private urban lands. Among those that have, three social theories have been relied on: population density, social stratification, and lifestyle behavior. Population density is presumed to drive vegetative change directly through displacement by roads and buildings and indirectly by pollution as the by-product of human activities. Social stratification theory has been used to predict vegetative patterns based on relative power differences among neighborhoods that result in different levels of public and private investment in green infrastructure. Wealthy residential neighborhoods are more likely be characterized by 1) more homeowners and fewer renters and absentee landowners; 2) residents who are able to migrate to more desirable and healthy areas, effective at community organizing, and willing to become involved in local politics; and 3) elites who have differential access to government control over public investment, pollution control, and landuse decision making. In contrast, low income, denser minority areas are often 1) disproportionately in or next to polluted areas, 2) populated by residents who are unable to migrate to more desirable areas, and 3) have fewer human resources in terms of leadership, knowledge, political and legal skills, and communication networks to manipulate existing power structures (Logan and Molotch 1987).

Residents may also act to restore, maintain, or improve vegetation in their current location (Choldin, 1984; Logan and Molotch, 1987). This includes investing in trees, parks, lawns, community gardens, and clean streets. A number of studies have considered measures of income and education to examine the relationship between social stratification and vegetation cover (Whitney and Adams 1980; Palmer 1984; Grove 1996; Grove and Burch 1997; Dow 2000; Vogt and others 2002; Martin and others 2004). Hope and others (2003), Martin and others(2004) and Hope and others (2006) further proposed a luxury effect to explain the relationship between socioeconomic status and urban vegetation. This approach is limited by the underlying premise that there is a widespread and unified conception of luxury, independent of a household’s demography, ethnicity, culture or family structure. Examples of consumer market fragmentation (Solomon 1999; Weiss 2000; Holbrook 2001) suggest that this is not the case.

The so-called luxury effect is relevant to the third social theory: lifestyle behaviors. The term "ecology of prestige" refers to the phenomenon in which household patterns of consumption and expenditure on environmentally relevant goods and services are motivated by group identity and perceptions of social status associated with different lifestyles (Grove and others 2004; Law and others 2004; Grove and others In Press). This theory suggests that a household's land management decisions are influenced by its desire to uphold the prestige of its community and outwardly express its membership in a given lifestyle group.

This suggests that there are differences in preferences even within the same income group. Weiss (2000) notes this when he quotes F. Scott Fitzgerald's famous comment: "America's rich … aren't just different from you and me but different from each other" (p. 95). Analyzing Weiss' book, Holbrook (2001:76) notes that there is substantial variety even within lifestyle types in the "affluent market." Neighborhoods differ in terms of household lifestyle choices and these choices change over time. Lifestyle factors that may only be weakly correlated with socio-economic status, such as family size, life stage, and ethnicity, can play a critical role in determining where households choose to locate (Timms 1971; Knox 1994; Short 1996; Gottdiener and Hutchison 2000; Kaplan and others 2004), and potentially in how they manage their properties. Lifestyle behaviors also encompass less easily measurable factors, such as the desire to achieve prestige as a member of a neighborhood. A related concept of prestige exists in the literature. Product-related prestige is defined in the marketing literature as how well that product communicates superiority and relates to a fulfillment of a symbolic need, driven by a desire for self-enhancement, societal position, or group membership

(Park and others 1986; Brucks and others 2000). However, the meaning of and desire for prestige may vary systematically by neighborhood. For instance, in the case of lawns, Jenkins (1994) finds that desire for a certain type of lawn results less from innate preferences than from marketing efforts of lawn care companies, which, as with most other products, are targeted differentially based on demographics. She writes: "lawns were not a need expressed by consumers that was then met by producers. The need was fostered by producers, who continued to raise the standards of what constituted a good or acceptable front lawn" (p. 115). Private land trees have also been found to be influenced by lifestyle factors. For instance, Des Rosiers (2002) found that private trees have a positive impact on the price of surrounding homes and that this effect is greater in areas with a high proportion of retired people.

The empirical ability to examine the distribution of private land vegetation at the parcel level is relatively new. To date, most research assessing the condition of developed areas from remotely sensed imagery has focused on mapping impervious surfaces (e.g. Civco and others 2002). However, estimates of imperviousness are not particularly useful to mangers who are interested in identifying areas suitable for tree plantings or other greening initiatives (Galvin and others 2006) because not all impervious surfaces are equivalent with respect to urban greening opportunities. While some, such as parking lots, could conceivably be converted back to vegetation, it is far less likely to happen with buildings or roads (except in cases of neighborhoods with a high percentage of abandoned buildings).

Researchers in the Baltimore Ecosystem Study (BES) have taken advantage of these advances in data to study variations in vegetation cover. Among these are Grove and others (In Press) who studied how population density, socio-economic status, and lifestyle behavior theories predicted the distribution of vegetation cover in riparian zones, public rights of way and private land. To operationalize these three theories for analysis they used the PRIZM™ (Potential Rating Index for Zipcode Markets; hereafter referred to as "PRIZM") socio-demographic segmentation system from Claritas, Inc. This system, used for categorizing neighborhoods according to market type, has three levels of aggregation—5, 15, or 62 categories—which corresponds roughly with population density, social stratification, and lifestyle theories respectively (PRIZM is further described below under the Data section). This study found that variations in vegetation cover in riparian areas were not adequately explained by any of the three segmentations, while the lifestyle behavior segmentation best predicted differences in vegetation cover on private lands and on public rights of way. Vegetation cover on private lands was also found to relate quadratically to median housing age.

Currently, several gaps exist in the research we have summarized. First, no studies have examined the amount of vegetation relative to the amount of land available for planting, or what we have called possible stewardship (Acharya and Bennett 2001). Second, while PRIZM has been used as a categorical proxy for population density, social stratification, and lifestyle theories in predicting vegetation distribution (Martin and others 2004; Grove and others 2006; Grove and others In Press), no study has attempted to disaggregate the PRIZM segmentations into their component variables in order to understand how and why those theories relate to vegetation levels.

This research seeks to better understand the predictors of possible and realized stewardship and yard expenditures on private property in the urban landscape of

Baltimore, MD. At a minimum, quantifying these associations will help managers identify neighborhoods with significant opportunities or need for greening, using commonly available census and property data sets. These associations may also allow for some limited inference into the mechanism of how vegetation was established. While we lack the time series data needed to definitively assign causality, the combination of realized stewardship and yard expenditure data may at least offer indirect evidence on the question of mechanism. Such information could allow us to better model levels of effort and investments in private vegetation management, predict where such efforts are likely or unlikely, and identify areas that are likely to be vegetated but not well maintained.

We attempt to determine which of the three PRIZM segmentations best describes differences in these variables. Because the segmentations are cumulative, as described above, in answering this question we are really attempting to determine whether the increasing complexity of a higher level PRIZM segmentation is sufficiently made up for by increases in model fit.

While knowing which PRIZM segmentation best predicts differences in each dependent variable may help us understand which of the three theories is best, it does not tell us why or how that theory is predictive. For instance, if social stratification best explained realized stewardship, it could be because high income households live on highly vegetated lots or the opposite. To address these types of questions we “unpack” each segmentation theory into a number of continuous variables we expect to be reflective of the theories. We then regress these sets of variables against each dependent variable to help elucidate the predictive power of each theory’s constituent components. Because the theories are cumulative, variable sets for a given theory include variables from the “lower” or constituent theories as well (e.g. lifestyle regressions include lifestyle, social stratification, and population density variables).

In our continuous regressions we use three variables that we feel are important to the distribution of urban vegetation but are not considered as defining dimensions of PRIZM 5, 15 or 62 classes. The first, used in our social stratification regressions, is housing age. Researchers have found that age of housing stock is significantly associated with plant species composition (Whitney and Adams 1980), diversity (Hope and others 2003), and abundance (Martin and others 2004). Moreover, age of housing has also been found to correlate positively with lawn fertilizer application levels (Law and others 2004). Researchers have also found a temporal lag between changes in neighborhood socioeconomic status and vegetation cover (Grove 1996; Vogt and others 2002). Based on the housing filtering model, discussed above, we contend that housing age is strongly related to socio-economic status and hence include it as a social stratification variable in our regressions.

The next two are crime level and amount of protected open space, used in our regressions as lifestyle variables. We expect both to impact how residents perceive of and manage vegetation. Recent research has found that greener surroundings, especially when dominated by canopy trees, can serve to reduce crime (Kuo and others 1998), in part because such spaces are more heavily trafficked by a variety of age groups (Coley and others 1997; Kuo and others 1998; Sullivan and others 2004), and also because well maintained vegetation can sometimes be seen as a “territorial marker,” showing that the residents actively care about and are involved with their surroundings (Brown and Bentley 1993). It has also been found that the amount that homebuyers are willing to pay to live near public green spaces can vary based on lifestyle factors like retirement status (Des Rosiers and others 2002), suggesting that the amount of green space in a neighborhood may be an important component of lifestyle.

We hypothesize that the PRIZM 15(social stratification) segmentation most significantly predicts the distribution of possible stewardship on private lands because low possible stewardship is associated with small lot sizes and high lot coverage which, in Baltimore, is characteristic of lower socio-economic status neighborhoods. In contrast, we hypothesize that the lifestyle behavior segmentation most significantly predicts the distribution of realized stewardship on private lands because realized stewardship decisions are influenced by households' desire to uphold the prestige of their 'community' and express their membership in a given lifestyle group. In some cases, these different lifestyle preferences might cause two neighborhoods with similar income levels to have very different realized stewardship outcomes.

A limitation of realized stewardship is that it does not differentiate between vegetation that is actively, partially, or non-maintained. The latter category may include vegetation that was planted long ago and has survived without maintenance, or unplanted vegetation growing in abandoned lots. Lacking knowledge of residents' level of planting effort or of tree age we are unable to distinguish whether vegetation is the result of past or present efforts, or some combination. Although an imperfect substitute for such information, analyzing whether predictors of realized stewardship have a different relationship with yard expenditure provides evidence as to how vegetation was established. Where a discrepancy exists in these relationships, it is an indication that measured vegetation may be a result of past plantings or abandonment of lots.

METHODS

Site Description

Baltimore, Maryland (lower left: 39^{0}11′31″N, 76^{0}42′38″W, upper right: 39^{0}22′30″N, 76^{0}31′42″W), houses 614,000 people in 276 neighborhoods. In 2000, the City of Baltimore had 258,518 households and 300,477 household building units, with an average of 2.5 persons per household. The City has experienced extensive demographic and economic changes over the past 50 years, with its population declining from nearly 950,000 in the 1950s to its current level (Burch and Grove 1993).

Data

The PRIZM system, which was developed by demographers and sociologists for market research (Weiss 2000; Grove and others In Press), has two primary goals. First is to segment the population into socio-economically meaningful clusters. The second goal is to associate these clusters with consumer spending patterns and household tastes and attitudes using additional data such as market research surveys, public opinion polls, and point-of-purchase receipts. In addition to its utility for characterizing what people are likely to prefer, PRIZM is widely generalizable since this categorization system has been applied and evaluated on a national and global basis (Weiss 2000).

Segmentations come in three levels of aggregation: 5, 15 and 62 classes. The five group categorization is arrayed along an axis of urbanization. Disaggregating from 5 to 15 categories adds a second axis: socioeconomic status. The 62 class disaggregation further expands socioeconomic status with a lifestyle dimension whose components include household composition, mobility, ethnicity, and housing characteristics (Claritas

1999). In this way PRIZM aggregation levels are cumulative, each building on and inclusive of the previous one. Specific classes are described in Appendix 1.

PRIZM is useful for a number of reasons. In addition to having three levels of aggregation representative of our three theories, PRIZM is designed to predict variations in expenditures on different types of consumer goods and services, of which yard care products and services are an example. In this sense it should be well-suited for understanding variations in household land-management preferences and behavior. Additionally, PRIZM is useful at the neighborhood level because every U.S. Census block group is assigned a specific PRIZM category.

A GIS data layer of census block groups coded by PRIZM category was created for Baltimore City by joining Geographic Data Technology's (GDT) Dynamap® Census data with a PRIZM classification for each block group from the Claritas 2003 database (http://www.claritas.com). Each of the 710 block groups in the city was assigned a unique PRIZM category. Because PRIZM is a nationwide classification system representing the full range of demographic variability, not all PRIZM classes are present in a given metropolitan area. In our data set, PRIZM 5, 15, and 62 classifications, have 4, 10, and 29 classes represented, respectively.

Median house age for each block group was obtained from Maryland Property View data at the individual property level.

Property parcel boundaries were obtained in digital format from the City of Baltimore. These parcel boundaries, converted to digital format from the City's cadastral maps, were current as of July 2001. Topological errors in the parcel data were corrected through manual editing using 1:3000 0.5m base imagery and scanned parcel maps as the reference data.

The vegetation data used in this study came from the Strategic Urban Forests Assessment (SUFA) for Baltimore City (Irani and Galvin 2003). Four land cover classes were derived from IKONOS satellite imagery (Space Imaging, LLC) acquired in October 2001: grass, forest, water, and other (developed). After fusing the 1m panchromatic imagery with the 4m imagery to create a pan-sharpened 1m multispectral image, Irani and Galvin (2003) applied a series of algorithms to extract land cover.

Building footprints were obtained in digital format from Baltimore City's planimetric database. The building footprint data consisted of all permanent structures greater than or equal to 100 ft^2 ($9.3m^2$). Buildings were originally mapped at a scale of 1:480 from imagery acquired during 2000-2001, then updated using 2001-2003 1:4080 scale imagery. Over 1,500 ha (~7% of Baltimore City) of building footprints were examined to check for errors in high, medium, and low density building areas using the IKONOS imagery as the reference data. In this 1,500ha area only eight errors of omission were found.

Total 2003 household yard care expenditure data by census block group was obtained from Claritas, Inc, including expenditures for lawn/garden services and supplies and yard machinery. Average household expenditure for each of these categories by census block group was derived by dividing the total amount spent per census block group by the number of households in that census block group. The "yard expenditures" variable used in our analysis refers to the sum of these three expenditure types.

Geoprocessing

Possible and realized stewardship were first calculated at the parcel level and then summarized at the census block group level. In the first step, the parcel boundary layer was combined with the building footprints layer using the union geoprocessing function, yielding a combined parcel-building layer in which each polygon was attributed with a Boolean code indicating whether or not a structure resides on that land. Roads were by default not part of this analysis due to their status as public rights-of-way. Next, the SUFA vegetation layer was unioned with the combined parcel-buildings layer. This resulted in a layer with polygons covering the entire study extent. Each polygon had a series of attributes associated with it indicating whether or not the polygon fell within a parcel, if it was a structure, and whether it was vegetated. Some polygons were attributed as both vegetation and building due to overhanging tree canopy. Identifying realized stewardship polygons involved selecting polygons that met the following criteria: (1) vegetation; (2) fell within a parcel; and (3) were not a structure. Similarly, possible stewardship was calculated from the union of the SUFA vegetation layer and the layer of building footprints subtracted from parcels. This was done by selecting out polygons that belonged to a parcel but were not buildings, vegetation, or water. Hence, possible stewardship land comprises those private lands that are not occupied by structures. Possible and realized stewardship areas were summarized at the parcel and census block group levels and then converted to percentages. Percent possible stewardship equals total possible stewardship are divided by block group area. Percent realized stewardship equals total realized stewardship area divided by total possible stewardship area. Percent realized stewardship was further broken down by grass and trees.

Statistical Analyses

Statistical analysis was broken down into two parts. First we used a multi-model comparison approach to determine which PRIZM segmentation most effectively and parsimoniously described differences in the following variables, all averaged by block group: 1) percent possible stewardship; 2) percent realized total stewardship; 3) percent realized stewardship accounted for by trees; 4) percent realized stewardship accounted for by grass; and 5) yard care expenditures. For each dependent variable, three models were compared (PRIZM 5, PRIZM 15 and PRIZM 62) yielding fifteen models (Table 1). For the second group of analyses we conducted regressions of each of the five dependent variables against continuous variables representing the three demographic theories.

For multi-model comparisons we used the information theoretic approach of Burnham and Anderson (2002) to compare whether Analysis of Variance models using PRIZM 5, 15 or 62 classifications best explained the variation in each of the response variables. Three models were compared for each dependent variable, yielding five three-way comparisons and five "best" models.

Burnham and Anderson's inferential modeling approach relies on the information theoretic method pioneered by Akaike (1973; 1978), which contends that minimization of the Akaike Information Criterion (AIC) can help select the "order" of likelihood of a set of nested or non-nested models. That is, for a given number of models of an underlying process, AIC scores help tell us which of those models approximate that underlying process the best. This is a superior approach to comparing R squared values which will always be higher with the addition of parameters. In other words, when using R-squared as a model heuristic, the more complex model will always appear superior (adjusted R-squared will adjust somewhat for the number of parameters, but the way in which it does this is far more arbitrary than AIC). However, complexity comes at the tradeoff of parsimony, and therefore it is commonly accepted that a better model is one that achieves a balance between fit and number of parameters (Myung and others 2000; Wagenmakers and Farrell 2004). AIC penalizes models that are less parsimonious. By accounting for the tradeoff between model fit and complexity, it can demonstrate which models best compromise between the two. The formula for AIC is given by:

$$AIC = -2\log L(M) + 2k \tag{1}$$

where k is the number of parameters plus one and log*L(M)* is the maximized log likelihood for the fitted model.

The AIC score for a model is a relative measure designed to be compared to the AIC scores for other models. The model with the lowest AIC score out of a set of models is considered to be most likely to be correct. However, while the order of AIC scores gives model rankings, this does not tell us how likely it is that a model with the lowest AIC score really is the best model. In some cases small differences in AIC scores can lead to a false sense of confidence that one model is superior to another (Wagenmakers and Farrell 2004). Akaike Weights (Burnham and Anderson 2002), show the probability of a given model being the correct one out of a set of potential models and are given by the equation:

$$w_i(AIC) = \frac{e^{-.5(\Delta_i(AIC))}}{\sum_{k=1}^{K} e^{-.5(\Delta_k AIC)}} \tag{2}$$

where k= the number of models.

For the second set of analyses we ran regressions of each dependent variable against sets of continuous variables that are reflective of each of the three social theories (see Table 5 for descriptions and summary statistics of variables). Since the 3 PRIZM segmentations sequentially build upon each other (i.e. social stratification includes population density, and lifestyle includes social stratification and population density), so do the regressions. Therefore population density models have only that one continuous predictor, while social stratification models include population density plus variables for income, race, education, crime level, vacancy level, and housing age. Lifestyle models contain all these plus variables for household size, owner occupancy rates, percent single family detached homes and townhomes, marriage rates, and amount of park or protected land in the block group. Since the continuous predictor variables are cumulative from theory to theory, and since space is limited, for a given dependent variable we include only the regression results from the lifestyle models where the ANOVA results indicate that PRIZM 62 is the best predictor and we include only results from the social stratification model where ANOVA indicates that PRIZM 15 is the best predictor. These models are listed in Table 6 below.

In cases where one or more variables from a given variable set were insignificant, they were dropped and the model was rerun. Models with the complete variable set including insignificant terms are noted with one star in Table 6 (and have the suffix “1” in the model name). Two stars indicate models where insignificant terms had been dropped (model names include the suffix “2”). Complete regression results are only given for models with insignificant terms dropped in the interests of space.

RESULTS

For the ANOVA of possible stewardship, PRIZM15 (social stratification) has the lowest AIC score, meaning it strikes the best balance of model fit and parsimony amongst the three candidate models. PRIZM62 (lifestyle) has the lowest AIC score for realized total stewardship (trees plus grass), realized tree stewardship and realized grass stewardship, as well as for yard care expenditures. Hence, we chose to run regressions of possible stewardship against continuous measures representing social stratification theory (which is inclusive of population density) and we chose to run regression of the other dependent variables against continuous predictors representing lifestyle theory(which is inclusive of population density and social stratification). ANOVA model descriptions and results are given in Table 1 and multi-model comparisons of ANOVAs using AIC scores are given in Table 2. Box and whisker plots comparing possible and realized stewardship by PRIZM class for each segmentation level are given in Figures 2a-c and 3a-c. Pairwise comparisons amongst the PRIZM groups (using the Tukey method) are given in Table 3 for possible stewardship and in Table 4 for realized total stewardship. Only pairs with significant differences are listed. Brief narrative descriptions of the PRIZM classes are given in Appendix 1

Next we present the results of the second part of analysis: regressions with continuous predictors (see Table 5 for variable descriptions and Table 6 for model descriptions). Possible stewardship regressed against all social stratification/population density variables (PSS1) revealed that a number of variables of expected importance, such as race and income, were insignificant. Removing insignificant terms resulted in PSS2, in which possible stewardship was found to relate negatively to population density, percent vacancy, and crime index, positively to median home value, and quadratically to housing age (see Table 8 for coefficients and test statistics). The shape of the relationship between possible stewardship and housing age, evaluated at the mean values for all other variables, is given in Figure 4. Both models had an R-squared value of near 0.6, but AIC scores were slightly lower for PSS2, yielding an Akaike weight of 72%, indicating that it was warranted to remove those terms (see Table 7 for all model fit and comparison statistics). Variables related to lifestyle were not regressed against possible stewardship based on the ANOVA results which found social stratification to be of superior explanatory power to lifestyle.

The model regressing realized total stewardship against all lifestyle/social stratification/population density variables (RLS1) also revealed several insignificant terms among the expected set, including income. Dropping these terms resulted in RLS 2, which had a slightly lower R-squared value than RLS1 (0.631 vs 0.627) but a lower AIC score (-710 versus -706), yielding an Akaike weight of 89% for RLS2 (Table 7). In RLS2, realized stewardship related positively to high school graduate rate, percent African American, household size, owner occupancy rate, percent single family detached homes, and percent protected open space and negatively to percent vacancy, crime index, and percent townhouses (Table 9). It related quadratically to housing age. The shape of this relationship, evaluated at the mean values for all other variables, is given in Figure 5.

Realized tree stewardship models indicated a somewhat different set of significant relationships than the models of realized total stewardship. TLS2 (tree stewardship as a function of lifestyle/social stratification/population density model with insignificant terms dropped) had an R-squared of 0.551 and a lower AIC score than TLS1, although TLS2's

Akaike weight was only 64% (Table 7). Realized tree stewardship was positively related to income, high school graduation rate, percent African American, percent single family detached homes, and percent protected open space (Table 10). It was related negatively to population density, crime index, and percent town houses. Again it was quadratically related to housing age. The shape of that relationship is similar to what is shown in Figure 5, except that whereas possible stewardship reaches a maximum at 30%, realized tree stewardship reaches a maximum at 20%.

Realized grass stewardship had a different set of significant predictors from realized total stewardship and from realized tree stewardship. GLS2 (grass stewardship as a function of lifestyle + social stratification + population density model with insignificant terms dropped) had a lower AIC score than GLS 1 (-1182 vs. -1173), yielding an Akaike weight of 99.2%. GLS2 had a lower model fit than RLS2, with an R-squared of 0.366. In GLS2 grass stewardship related positively with high school graduation rate, percent African American, percent owner occupied, percent single family detached homes, and percent protected open space (Table 11). It related negatively with income and population density and had a quadratic relationship with housing age. The shape of that relationship was similar to what is shown in Figure 5, except that whereas possible stewardship reaches a maximum at 30%, realized grass stewardship reaches a maximum at 40%.

YLS2 (yard expenditures as a function of lifestyle + social stratification + population density model with insignificant terms dropped) had a significantly higher model fit than any of the other regression models, with an R-squared.787. Its AIC score was lower than that of YLS2 (774 vs. 781), yielding an Akaike weight of 97.1% (Table 7). In YLS2, yard expenditures related positively to income, home value, median age, average household size, percent owner occupancy, and percent single family detached homes. It related negatively to percent African American (Table 12). Unlike with other dependent variables, population density and housing age were not significant.

All lifestyle models (e.g. RLS2, TLS2, etc.) were compared to simpler models using only social stratification variables and population density as predictors. In all cases, the simpler models had much higher AIC scores, Akaike weights of 0, and much lower R-squared values indicating the greater predictive power of the lifestyle models. In the interest of space these results are not listed here. Also in the interests of space, pairwise comparisons are only addressed in the Discussion section.

DISCUSSION

Possible Stewardship

Multi-model comparisons of categorical predictors indicated that PRIZM 15 (social stratification), which because of the cumulative nature of the segmentations is inclusive of population density (PRIZM 5), best described differences in possible stewardship. This is notable because PRIZM 62 includes 29 categories as opposed to only 10 categories for PRIZM 15 for Baltimore City. One might expect that further parsing PRIZM 15 into nearly three times as many categories would make at least a small improvement in predicting possible stewardship. However AIC scores indicated that whatever small improvement may have been made in prediction was outweighed by the penalty from increased model complexity.

This result is consistent with our hypotheses. We expected possible stewardship to relate best to social stratification because it is essentially a measure of lot coverage and building density. We expected areas of high lot coverage and density (corresponding to low possible stewardship) to be located in older and more centrally located neighborhoods, which are characterized by higher population density and are frequently characterized by lower incomes and high proportions of minority households.

Disaggregating this result using regressions of continuous predictor variables further confirmed these expectations. Possible stewardship's positive relationship with median home value and negative relationship with percent vacancy and crime levels not only indicated that wealth and social class are clearly important factors, but show the directionality of that relationship. We had expected income to be an important predictor of social stratification and hence predictive of possible stewardship. The fact that race and income were not significant was due to their strong correlation with the crime and vacancy rate variables, which were both more significant predictors of possible stewardship. When vacancy and crime were dropped, percent African American and median income became significant with the expected sign (positive and negative respectively). Further, when the percent vacancy variable was replaced with its inverse, percent occupancy, median income became significant and of the expected sign (negative). However, these alternate models had much lower R-squared values and much higher AIC scores than the possible stewardship model with insignificant terms dropped (PSS2) and so they are not considered here.

The nonlinear relationship between possible stewardship and housing age was expected. Holding all else constant, a block group had a mean possible stewardship value of approximately 25% for new housing, increased to 50% at around 35 years of age and declined thereafter until reaching 0% at 77 years. In other words, lot coverage in the city was at its lowest for neighborhoods built in the early 1970s. New homes have on average slightly higher lot coverage than the maximum, but their coverage is still quite low compared to prewar housing. This suggests that many--but certainly not all--prewar neighborhoods are characterized by high lot coverage and small yards. Prewar neighborhoods are particularly likely to have very low possible stewardship when also characterized by low incomes and home values and high vacancy rates. This lends support to earlier findings that income is more strongly correlated with building density and lot size than with housing age (Bond and Coulson 1989), although it is related to both. In other words, while the trend is towards smaller amounts of plantable space for older houses, some old houses have large yards. Neighborhoods characterized by both old homes and low income tend to have the lowest amount of plantable area.

Pairwise comparisons from the ANOVA of possible stewardship provided further insight into these differences. In the interests of space only a few are discussed. For instance, Elite Suburbs had 28% more land available for possible stewardship than Urban Cores. Consistent with our hypotheses and results, Claritas (1999) describes significant differences in education and affluence among these two PRIZM 15 groups. Elite Suburbs are dominated by households with college and graduate education. The median household income is $81,900 per year, median home value is $225,000, and most of the housing is owner-occupied. In contrast, Urban Cores is dominated by households with, on average, less than an 8th grade or high school education. The median household income is $18,800, median home value is $56,700, and most of the housing is renter-occupied. Four other PRIZM15 categories, including Affluentials, 2nd City Blues, Inner

Suburbs and Urban Midscale, had significantly higher possible stewardship than the Urban Cores.

Realized Stewardship

Differences in realized total stewardship (grass and tree stewardship combined) were best predicted by PRIZM 62, or lifestyle clusters which, like social stratification, is cumulative and hence inclusive of population density and social stratification. In other words parsing the PRIZM 15 categories more finely did yield far better explanatory power, unlike with possible stewardship. Again, this result was hypothesized because we expected planting and maintenance behavior to vary based on many factors in addition to the socio-economic status of the neighborhood.

Disaggregating the PRIZM 62 segmentations into a series of continuous variables provided additional insight. The social stratification variables vacancy, crime and population density were all negatively associated with realized stewardship, just as they were with possible stewardship. However, for realized stewardship, percent African American and high school graduate were also significant and positive. The race result is discussed further below under the Yard Expenditures section. While the relationship between housing age and realized stewardship had the same functional form as with possible stewardship, the response was somewhat different. Realized stewardship started out at zero for new homes, increased to 58% at roughly 45 years of age and then declined again, reaching zero at about 85 years. This suggests that some vegetation present today is a function of past planting efforts and that the amount of vegetation present today is a function of the time since construction and preferences during the era of construction.

Lifestyle factors not present in social stratification index added further insight. Average household size, percent owner occupancy and percent single family detached homes were, as expected, positively related to realized total stewardship. All of these factors are more generally associated with suburban or lower density neighborhoods, where yards tend to be larger and better maintained. Similarly, the percent town house variable, which most of Baltimore's dense urban row houses are classified as, were negatively associated with realized stewardship. One of the most interesting results was that percent protected open space was positively related to realized total stewardship. In other words, homes in neighborhoods with considerable public green space were more likely to maintain private green space. Whether this is causal (i.e. seeing green space causes people to want to plant), associative (i.e. the underlying cause may be good planting conditions), or due to self-selection (i.e. homeowners with a taste for private greening move to neighborhoods with public green space), is a tantalizing question, but cannot be answered with our data.

When realized stewardship was broken down by trees and grass, the differences were telling. Percent protected open space, single family homes, high school graduates and African American population were positive and significant predictors of both grass and trees. The first two make intuitive sense. The third suggests that education level and planting are positively related. The last is discussed under the Yard Expenditures section. The fact that the percent owner occupied variable was significant for grass and not for trees suggests there may be a legacy effect from trees. Specifically, if we assume that home ownership is associated with better stewardship and that grass requires constant maintenance (except for volunteer vegetation in vacant lots) while trees require less maintenance, then it makes sense that home ownership rates for today are only associated with grass, since trees may have been planted long ago. The fact that crime was negatively related to tree stewardship but not at all to grass stewardship lends some further evidence to recent findings that urban trees, especially canopy trees, can serve to increase pedestrian traffic, reduce crime and make people feel safer (Coley and others 1997; Levine Coley and others 1997; Kuo and others 1998; Kuo and Sullivan 2001; Sullivan and others 2004). Another interesting discrepancy is that the sign on income was negative for grass and positive for trees. This may be an artifact of unmanaged volunteer vegetation being classified as grass. It may also be a result of the underprediction of grass where trees overhang grass. However, it may also be a valid finding. For instance, it might reflect the fact that higher income households often choose to move to neighborhoods with trees, whereas grass can be found in the yards of a variety of income groups. It may also reflect the fact that in older neighborhoods dominated by low income groups, many trees have long ago senesced and have not been replaced.

The pairwise comparisons from the ANOVA of realized stewardship are generally consistent with the findings of the regressions. For instance, the Money and Brains category has 47% more realized stewardship than Bohemian Mix. Consistent with our hypotheses and results, Claritas (1999) describes similar levels of population density, and education and significant differences in income, family composition, and housing between these two classes. Both groups can be found in relatively dense settlements, and dominated by households with college and graduate education. The median household income for “Money and Brains” is $67,500 per year, which is more than the $38,500 per year for households in the “Bohemian Mix” lifestyle group. The other major differences are apparent in family composition and housing, however. Households associated with the “Money and Brains” lifestyle group are dominated by married couples who are 45 years or older, living in their own homes, and these homes are primarily detached single family houses. In contrast, households associated with the “Bohemian Mix” lifestyle group are dominated by singles (not married) who are between 25-44 years old, living in a rental unit, and these rental units are primarily multi-unit buildings.

Yard Expenditures

Realized stewardship simply tells us how much vegetation is present. It says nothing about the quality, type, or productivity of the vegetation, how much work went into its planting and landscaping, or if it was intentionally planted or simply germinated through lot abandonment. Looking at discrepancies between yard expenditures and realized stewardship allowed us to better understand the realized stewardship results. In particular it allowed us to better understand where realized stewardship may be the result of current planting and maintenance, past legacies, or only natural succession processes.

Among the categorical models, differences in yard expenditures were best explained by PRIZM 62. There was no surprise that yard expenditures varied positively with income, home value, median age of resident, average household size, percent owner occupancy or percent single family detached homes. If yard expenditure is considered a normal good then we expect it to go up with income, and with home value, which is an additional indicator of wealth. We also expect it to increase with household size since children are often the main users of yards, and with owner occupancy and single family homes, since both are traditionally associated with lower density neighborhoods where yards are commonly a critical component.

The most interesting discrepancy was that percent African American related positively to realized stewardship but negatively (and with a high magnitude) to yard expenditures. That is, residents of neighborhoods with high proportions of African Americans are less likely to spend money on planting and yard maintenance, but live in neighborhoods with higher than average private vegetation, after holding all else constant. This result may be due to a combination of three factors. First, this may reflect that African American neighborhoods are disproportionately characterized by vegetation that is predominantly the result of historical legacies (e.g. past tree plantings). Second it may reflect that residents in such neighborhoods plant using resources other than those measured by spending surveys; for instance they may benefit more from municipal or nonprofit community greening efforts whose expenditures are not reflected in these surveys, or they may substitute their labor for these purchased inputs. Third, this result may be partially due to the large number of vacant lots found in predominantly African American neighborhoods. According to the Parks and People Foundation, many such lots in Baltimore are characterized by unmanaged vegetation (Parks and People Foundation 2002) and thus would appear to have high realized stewardship levels. This suggests that in some neighborhoods (e.g. wealthier, predominantly white), realized stewardship is better at measuring intentional, current yard greening activities, while in predominantly African American neighborhoods, it may be measuring a combination of intentional current greening, past planting, and unmanaged vegetation in abandoned lots. The relative importance of each component has yet to be understood.

Yet another discrepancy between yard expenditure and other models is that housing age was not significant. This suggests that housing age's association with stewardship is largely due to its legacy effect and probably not due to any change in behavior associated with older housing.

Management Implications

Our results suggest that built form alone does not predetermine the distribution of urban vegetation. This has significant implications for urban natural resource policy makers, planners, managers, and modelers. For example, urban tree canopy (UTC) goals are being developed for urban areas in the Chesapeake Bay Watershed. Private lands are a critical component to achieving these goals. In Baltimore, total canopy cover is 20%, with 2% in public-rights-of-way (PROW) and 18% on private lands. Total possible land for increasing canopy cover is approximately 53%, with 8% in PROW and 46% on private lands. With the City considering a goal of increasing canopy cover to 46.3% over the next 30 years, it is clear that increasing canopy cover on private lands is essential to this goal (Galvin and others 2006).

The results from this research can be used to begin to develop strategies for increasing canopy cover on private lands. These results make evident that household lifestyle behaviors are associated significantly with the distribution of realized stewardship in urban areas. This suggests the potential for novel management and policy approaches that could employ environmental marketing strategies where planners and managers "sell" greener neighborhoods to different neighborhood-based consumer markets, building upon different groups' sense of social status and group identity.

Indeed, Robbins and Sharp(2003:427) describe recent trends in how and to whom the lawncare-chemical industry markets its products by associating "community, family, and environmental health with intensive turf-grass aesthetics" and household consumer demand for "authentic experiences of community, family, and connection to the nonhuman biological world through meaningful work." In the case of urban foresters and environmental planners, an environmental marketing strategy could be done systematically using tools of geodemography and cluster-based market segmentation, measuring different lifestyle groups' preferences and motivations for various environmental behaviors and developing communication strategies to address those preferences and motivations in a spatially explicit context. In essence, such an approach would enable natural resource professionals to answer three basic questions about potential clients: 1) What is their housing type and value, family composition, and age? 2) Where do they live and shop? and 3) How can they be reached using different marketing approaches and media?

Marketing firms already use geodemography and cluster-based market segmentation tools to sell commercial products and brands. Increasingly, political parties, non-profit organizations, and government agencies are using consumer profiles of lifestyle groups to design target-marketing strategies of all varieties including public health (Heitgard 2000), urban revitalization (Lang and others 1997), adoption services (Claritas 2005), and the arts (Holbrook 1995). As Holbrook (2001) notes, a tool such as lifestyle profiling, like any tool, can be used for good or ill. The point is "to recognize patterns in our lives" as the key towards "a new way to understand the behavior of huge segments of the populace" (Weiss 2000).

The results from this research also indicate that realized stewardship does not vary in constant proportion to possible stewardship. For instance, modelers cannot assume that vegetation will always be 20% of plantable space on a parcel. Modelers will need to know the household socio-demographic characteristics of areas they would like to model. Our research suggests that realized vegetation, as a percentage of possible stewardship, can be predicted based upon lifestyle behavior characteristics.

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Tables

Table 1: ANOVA model descriptions and results

Model name	Response variables	Explanatory variables	F stat (P val)
P1	Possible Stewardship	PRIZM5	20.58(P<0.0001)
P2	""	PRIZM15	11.99(P<0.0001)
P3	""	PRIZM62	4.98(P<0.0001)
R1	Total Reazlied Stewardship	PRIZM5	15.65(P<0.0001)
R2	""	PRIZM15	10.94(P<0.0001)
R3	""	PRIZM62	6.95(P<0.0001)
T1	Realized Stewardship:Trees only	PRIZM5	12.95(P<0.0001)
T2	""	PRIZM15	11.37(P<0.0001)
T3	""	PRIZM62	6.72(P<0.0001)
G1	Realized Stewardship:Grass only	PRIZM5	7.58(P<0.0001)
G2	""	PRIZM15	6.93(P<0.0001)
G3	""	PRIZM62	4.72(P<0.0001)
Y1	Yard expenditures	PRIZM5	18.23(P<0.0001)
Y2	""	PRIZM15	68.20(P<0.0001)
Y3	""	PRIZM62	35.96(P<0.0001)

Table 2.
Categorical model comparisons

Model	residual df	K	AIC	rank	Akaike weight
P1	706	5	-443.688	3	0%
P2	700	11	-473.919	1	98%
P3	681	30	-466.371	2	2%
R1	706	5	-73.0235	3	0.0%
R2	700	11	-108.764	2	0.0%
R3	681	30	-155.753	1	100.0%
Y1	706	5	8813	3	0.0%
Y2	700	11	8431	2	0.0%
Y3	681	30	8271	1	100.0%
T1	706	5	-622.337	3	0.0%
T2	700	11	-669.184	5	0.0%
T3	681	30	-707.458	1	100.0%
G1	706	5	-893.69	3	0.0%
G2	700	11	-919.79	2	0.0%
G3	681	30	-947.1	1	100.0%

Residual df= residual degrees of freedom
K= number of parameters

Table 3. Significant pairwise comparisons from ANOVAs for possible stewardship

			Diff. between means	Simultaneous 95% confidence limits	
Possible Stewardship by PRIZM 5					
Suburban	-	Urban	0.191774	0.122451	0.261097
2nd City	-	Urban	0.11309	0.026879	0.1993
Possible Stewardship by PRIZM 15					
Elite Suburbs	-	Urban Core	0.27672	0.05194	0.50149
Inner Suburbs	-	Urban Midscale	0.14939	0.04062	0.25816
Inner Suburbs	-	Urban Uptown	0.16513	0.04291	0.28735
Inner Suburbs	-	Urban Core	0.23519	0.12767	0.34272
Affluentials	-	Urban Core	0.20537	0.04496	0.36577
2nd City Blues	-	Urban Core	0.1902	0.06137	0.31902
Urban Midscale	-	Urban Core	0.08581	0.03954	0.13207
Realized Total Stewardship by PRIZM 5					
Suburban	-	2nd City	0.19141	0.05166	0.33116
Suburban	-	Urban	0.23033	0.14033	0.32033
Suburban	-	Town	0.62487	0.0291	1.22064
Realized Stewardship by PRIZM 15					
Elite Suburbs	-	Urban Midscale	0.29799	0.00652	0.58946
Elite Suburbs	-	Urban Uptown	0.33339	0.03314	0.63364
Elite Suburbs	-	Urban Core	0.41988	0.12919	0.71058
Elite Suburbs	-	2nd City Center	0.43448	0.04202	0.82694
Affluentials	-	Urban Uptown	0.22298	0.00234	0.44362
Affluentials	-	Urban Core	0.30947	0.10202	0.51692
Inner Suburbs	-	Urban Uptown	0.16278	0.00471	0.32084
Inner Suburbs	-	Urban Core	0.24927	0.11021	0.38833
Urban Midscale	-	Urban Core	0.12189	0.06206	0.18172

Table 4. Significant pairwise comparisons from ANOVAs for realized total stewardship

Realized Stewardship by PRIZM 62			**Diff. between means**	**Simultaneous 95% confidence limits**	
Blue Blood Estates	-	Single City Blues	0.48853	0.01618	0.96089
Blue Blood Estates	-	Bohemian Mix	0.50206	0.02035	0.98377
Money & Brains	-	Young Literati	0.33869	0.02493	0.65245
Money & Brains	-	Inner Cities	0.37565	0.1194	0.6319
Money & Brains	-	Towns & Gowns	0.40342	0.01138	0.79545
Money & Brains	-	Old Yankee Rows	0.44409	0.1496	0.73858
Money & Brains	-	Single City Blues	0.4562	0.18151	0.73089
Money & Brains	-	Bohemian Mix	0.46972	0.17924	0.7602
Mobility Blues	-	Old Yankee Rows	0.38941	0.0021	0.77672
Mobility Blues	-	Single City Blues	0.40152	0.02904	0.774
Mobility Blues	-	Bohemian Mix	0.41505	0.03077	0.79932
American Dreams	-	Inner Cities	0.30674	0.05049	0.56299
American Dreams	-	Towns & Gowns	0.33451	-0.05753	0.72654
American Dreams	-	Old Yankee Rows	0.37518	0.08069	0.66967
American Dreams	-	Single City Blues	0.38729	0.1126	0.66198
American Dreams	-	Bohemian Mix	0.40081	0.11033	0.69129
Gray Collars	-	Old Yankee Rows	0.26997	0.00142	0.53852
Gray Collars	-	Single City Blues	0.28208	0.0354	0.52876
Gray Collars	-	Bohemian Mix	0.2956	0.03145	0.55976
Mid-City Mix	-	Inner Cities	0.13206	0.05463	0.20949
Mid-City Mix	-	Towns & Gowns	0.15983	-0.1468	0.46646
Mid-City Mix	-	Old Yankee Rows	0.2005	0.03602	0.36499
Mid-City Mix	-	Single City Blues	0.21261	0.08696	0.33825
Mid-City Mix	-	Bohemian Mix	0.22613	0.06893	0.38333
Urban Achievers	-	Single City Blues	0.19318	0.02703	0.35933
Urban Achievers	-	Bohemian Mix	0.2067	0.01557	0.39783
Note: brief descriptions of PRIZM classes are given in Appendix 1					

Table 5: Description of predictor variables

Variable	Description	Mean	StDev	Median
POPD	population density	15398	11187	13485
MED.AGE	median age	35.432	6.317	35.500
AVE.HH.S	average household size	2.5	0.5	2.6
MED.HH.INC	median household income	31453	16704	29795
P.OWNOCC	percent of owner occupied housing	0.523	0.247	0.542
P.OCC	percent of housing occupied	0.843	0.153	0.885
P.VAC	percent of housing vacant	0.146	0.125	0.112
P.SFDH	percent of housing that is single family detached homes	0.148	0.213	0.054
P.TH	percent of housing that is townhomes	0.556	0.309	0.608
MED.VAL	median home value	69204	46783	63050
P.HS	percent of adult population that is high school graduates	0.655	0.170	0.661
P.AFAM	percent of population that is African American	0.656	0.369	0.849
P.PROT	percent of land that is public parks or other protected open space	0.075	0.144	0.005
YRSOLD	median house age	55.456	9.633	58.000
CRIMEIND	crime index based on composite of all crime types, where 100 equals the national average	357	124	359
P.MARRIED	percent of population that is married	0.281	0.146	0.179
Boxes define membership in variable set corresponding with PRIZM segmentation/theory: population density, social stratification and lifestyle respectively.				

Table 6: Continuous regression models

Model name	Response Variables	Explanatory variables (all by block group)
PSS1* (social stratification)	Possible Stewardship	Population density, median household income, median home value, percent building vacancy, percent African American, percent high school graduate, normalized national crime index, house age, (house age)^2
PSS2**	Possible Stewardship	Population density, percent building vacancy, normalized national crime index, median home value, house age, (house age)^2
PSS3**	Possible Stewardship	Population density, percent building occupancy, crime index, house age, median household income, house age, (house age)^2
RLS1* (Lifestyle)	Realized Total Stewardship (Grass plus trees)	Population density, median household income, median home value, percent building vacancy, percent African American, percent high school graduate, normalized national crime index, house age, (house age)^2, average household size, percent owner occupied, percent single family detached homes, percent townhomes, percent married, percent park and protected open space land in block group.
RLS2**	Realized Total Stewardship	Population density, percent building vacancy, percent African American, percent high school graduate, normalized national crime index, house age, (house age)^2, average household size, percent owner occupied, percent single family detached homes, percent townhomes, percent park and protected open space land in block group.
YLS1*	Yard expenditures	Same as RLS1
YLS2**	Yard expenditures	Median household income, median home value, percent African American, median age, average household size, percent owner occupied, percent single family detached homes
TLS1*	Realized Tree Stewardship	Same as RLS1
TLS2**	Real Tree Stewardship	Population density, median household income, percent African American, percent high school graduate, house age, (house age)^2 , crime index, percent single family detached homes, percenthomes, homes, percent protected open space land in block group
GLS1*	Realized Grass Stewardship	Same are RLS1
GLS2**	Realized Grass Stewardship	Population density, median household income, percent African American, percent high school graduate, house age, (house age)^2 , percent owner occupied, percent single family detached home, percent protected open space land in block group
*includes all variables expected to be significant **includes only significant variables		

Table 7: Regression model AIC scores and R-squared values

Model Name	**AIC**	**Model rank**	**Akaike Weight**	**R-squared**
PSS1	-1027	2	28%	.602
PSS2	-1029	1	72%	.601
RLS1	-706	2	10.8%	.631
RLS2	-710	1	89.2%	.627
YLS1	7781	2	2.9%	.789
YLS2	7774	1	97.1%	.787
TLS1	-1137.09	2	36.0%	0.559
TLS2	-1138.24	1	64.0%	0.551
GLS1	-1173	2	0.8%	0.372
GLS2	-1182.53	1	99.2%	0.366

Table 8: Possible stewardship model results (PSS2)

Term	**Value**	**t value**	**Sig**
(Intercept)	0.47332382	7.15	**
MED.VAL	0.00000021	2.13	*
POPD	-0.00000870	-21.21	**
P.VAC	-0.39688957	-10.76	**
CRIMEIND	-0.00017052	-4.57	**
YRSOLD	0.01597495	5.94	**
I(YRSOLD^2)	-0.000200437	-7.26	**

* significant at the 95% confidence level
** significant at the 99% confidence level

Table 9: Total realized stewardship (RLS2) model results

Term	**Value**	**t value**	**Sig**
(Intercept)	-0.341663	-3.78	**
POPD	-0.000004	-8.50	**
P.VAC	-0.140972	-2.64	**
P.HS	0.240351	5.95	**
P.AFAM	0.118017	6.09	**
CRIMEIND	-0.000100	-2.07	*
YRSOLD	0.029235	8.52	**
I(YRSOLD^2)	-0.000328	-9.29	**
AVE.HH.SZ	0.047279	2.71	**
P.OWNOCC	0.096386	2.38	*
P.SFDH	0.303694	5.81	**
P.TH	-0.136351	-3.59	**
P.PROT	0.422776	10.78	**

Table 10: Realized tree stewardship (TLS2) model results

Term	**Value**	**t value**	**Sig**
(Intercept)	-0.13099992	-2.12	*
POPD	-0.00000297	-7.11	**
MED.HH.INC	0.00000151	4.12	**
P.HS	0.11428937	3.71	**
P.AFAM	0.05445916	4.27	**
CRIMEIND	-0.00008384	-2.34	*
YRSOLD	0.01219537	4.84	**
I(YRSOLD^2)	-0.00014002	-5.40	**
P.SFDH	0.19155867	6.66	**
P.TH	-0.09872569	-5.64	**
P.PROT	0.28966948	10.01	**

Table 11: Grass Stewardship Models

Term	Value	t value	Sig
(Intercept)	-0.16615144	-2.75	**
POPD	-0.00000175	-4.33	**
MED.HH.INC	-0.00000093	-2.54	**
P.HS	0.10157780	3.47	**
P.AFAM	0.08756758	7.31	**
YRSOLD	0.01748895	7.10	**
I(YRSOLD^2)	-0.00019754	-7.82	**
P.OWNOCC	0.10353972	4.99	**
P.SFDH	0.16406300	6.93	**
P.PROT	0.13881195	4.97	**

Table 12. Yard expenditure models

Term	Value	t value	Sig
(Intercept)	-67.485	-3.34	**
MED.HH.INC	0.003	12.75	**
MED.VAL	0.001	9.95	**
P.AFAM	-43.298	-5.78	**
MED.AGE	2.442	6.22	**
AVE.HH.SZ	43.836	7.57	**
P.OWNOCC	96.622	7.56	**
P.SFDH	46.294	3.72	**

Figure Captions

Figure 1: Visualization of possible and realized stewardship
Figures 2a-c: Box plots of possible stewardship against PRIZM classes
Figures 3a-c: Box plots of realized total stewardship against PRIZM class
Figure 4: Housing age versus percent possible stewardship
Figure 5: Housing age versus percent realized stewardship

Figures

Figure 1. Visualization of possible and realized stewardship

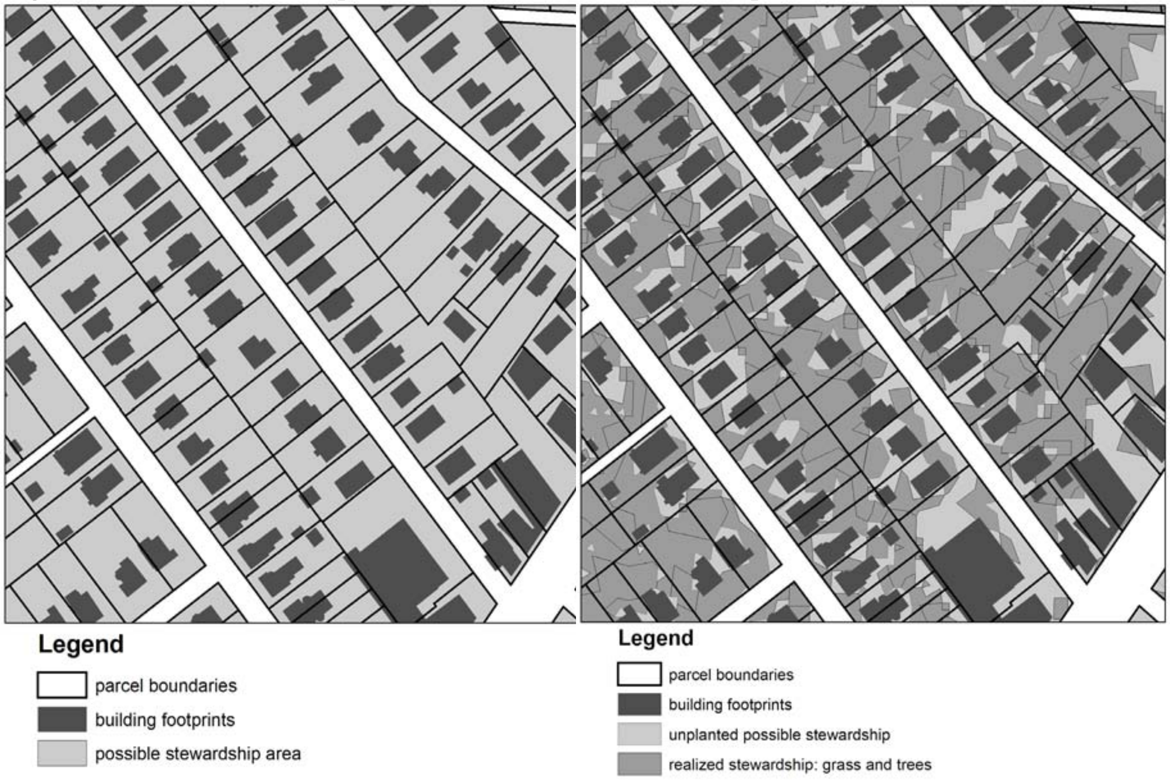
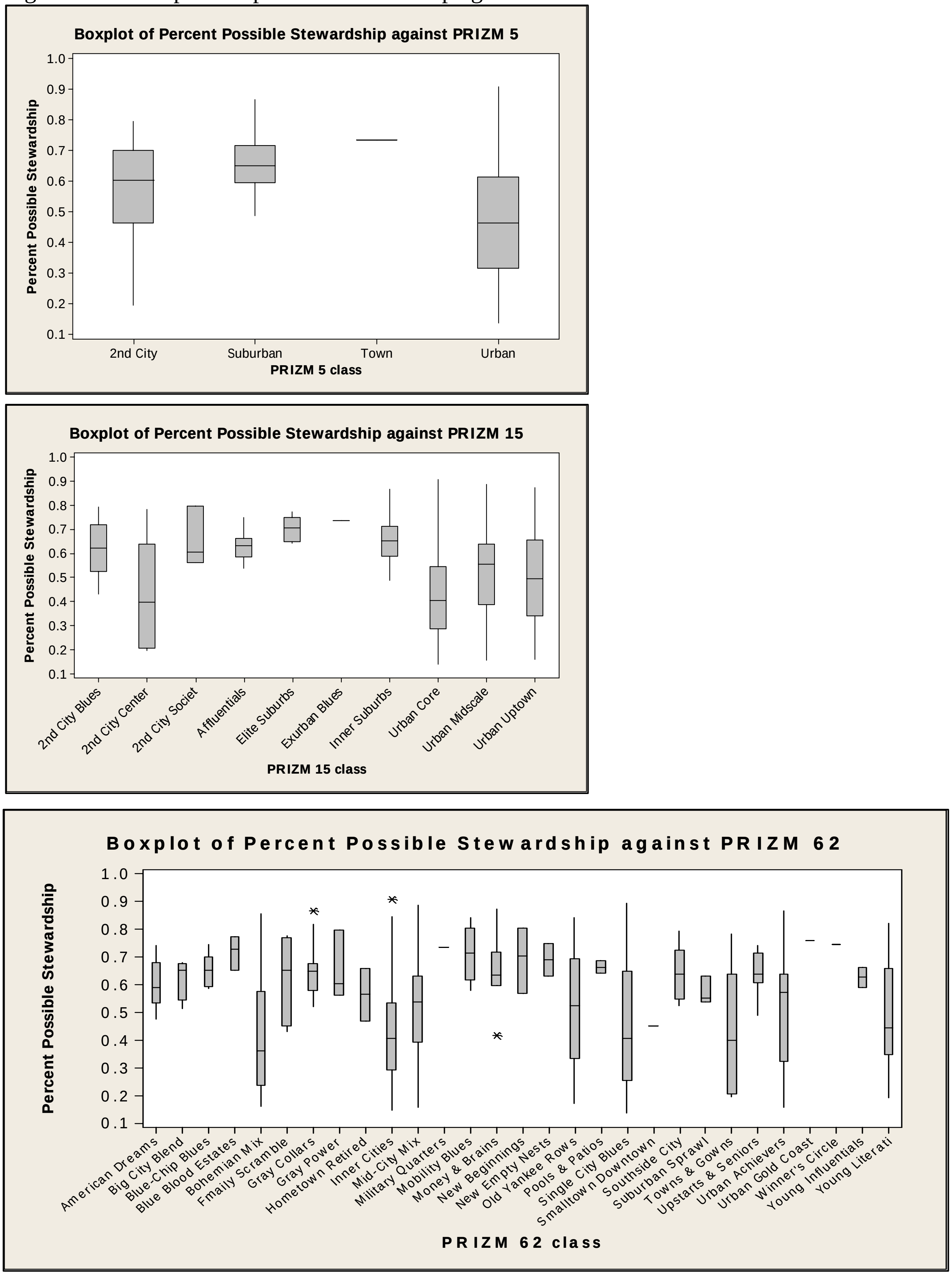


Figure 2a-c. Box plots of possible stewardship against PRIZM classes



Figures 3a-c. Box plots of realized total stewardship against PRIZM class

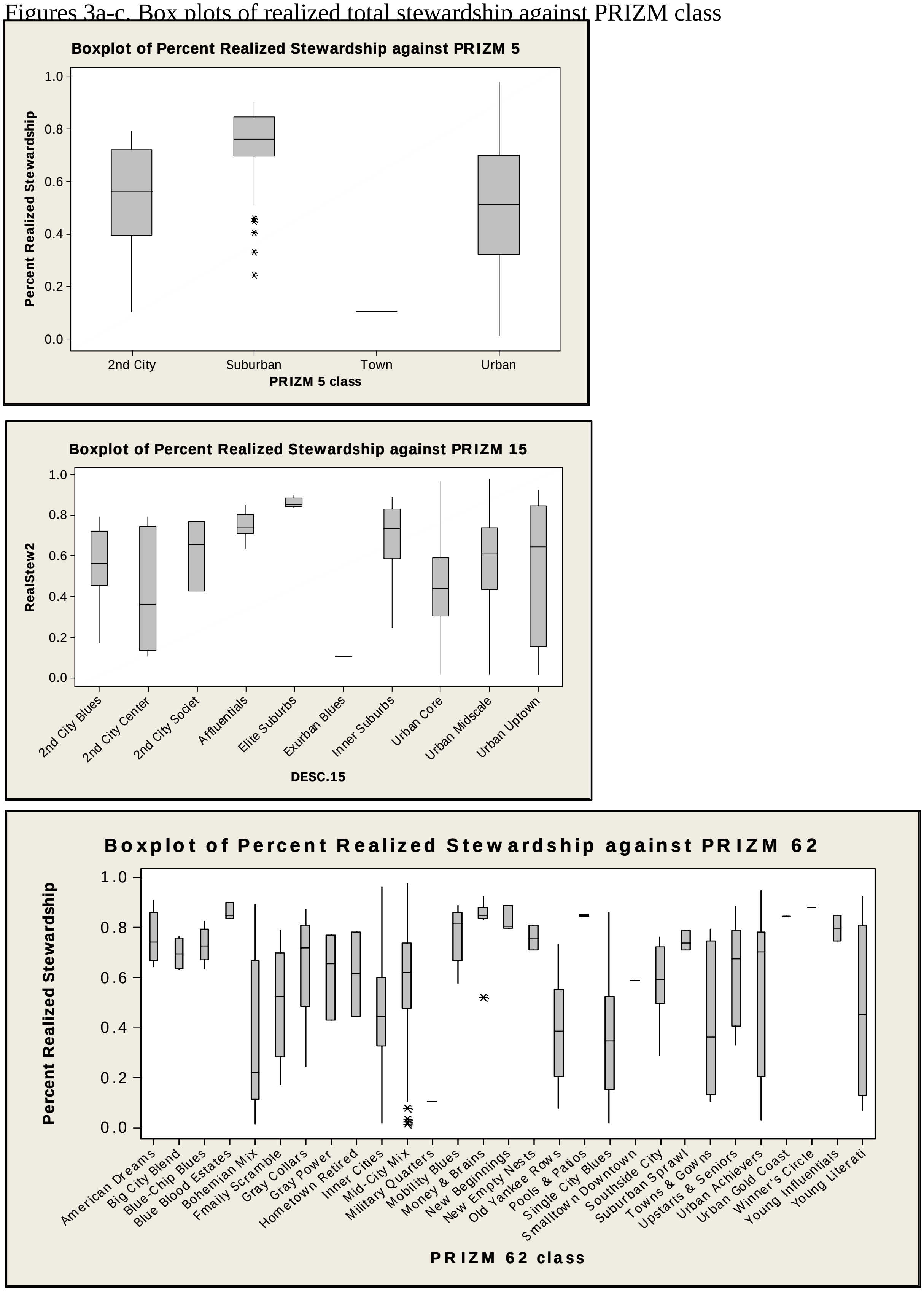


Figure 4: Housing age versus percent possible stewardship

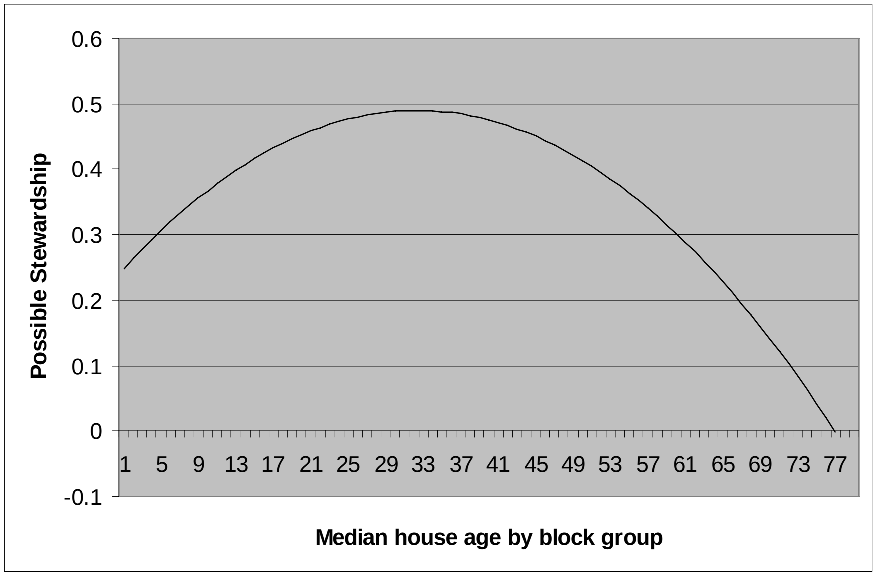
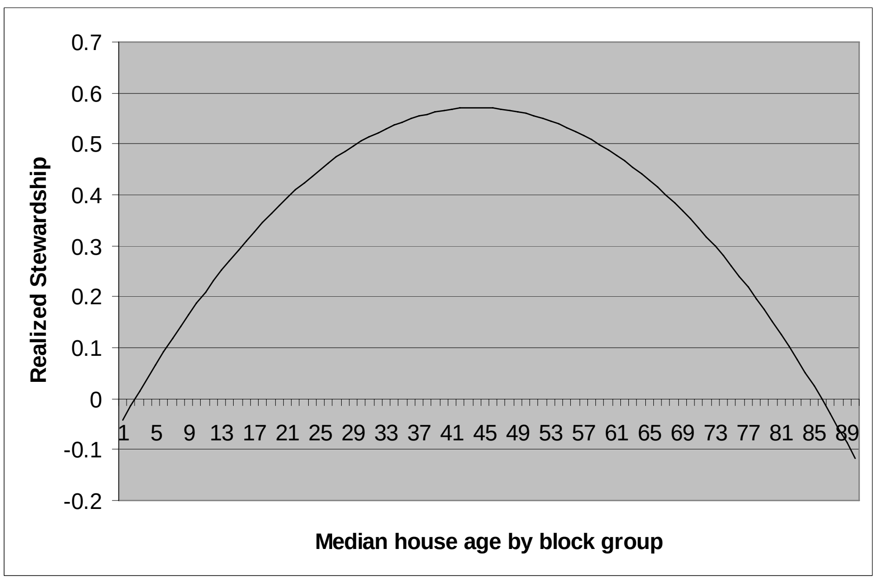


Figure 5: Housing age versus percent realized stewardship



Appendix 1: Description of PRIZM 15 and 62 classes

PRIZM 15 Nickname	PRIZM 62 Nickname	SER	HH Median Income	Family Type	Adult Age	Edu-cation	Occu-pation	Housing	Race/Ethnicity W	B	A	H	I
Elite Suburbs	Blue Blood Estates	1	$135,900	Fam/Cpl	45-64	CG	Exec	Single	[]		•		
	Winner's Circle	2	$90,700	Fam/Cpl	45-64	CG	Exec	Single	[]		•		
	Pools & Patios	9	$67,100	Cpl	45+	CG	Exec	Single	[]		•		
	Kids & Cul-de-Sacs	10	$68,900	Fam/Cpl	35-54	SC/CG	WC/Exec	Single	[]		•		
Urban Uptown	Urban Gold Coast	3	$73,500	Sgl	25+	CG	Exec	Hi-Rise	[]		•		
	Money & Brains	5	$67,500	Cpl	45+	CG	WC/Exec	Single	[]		•		
	Young Literati	6	$63,400	Sgl	25-44	CG	Exec	Hi-Rise			•		
	American Dreams	14	$59,000	Fam/Cpl	Mixed	SC/CG	WC	Single		•	•	•	
	Bohemian Mix	17	$38,500	Sgl	25-44	CG	Exec	Hi-Rise		•	•	•	
2nd City Society	Gray Power	16	$41,800	Sgl/Cpl	55+	SC/CG	WC/Exec	Single	[]				
The Affluentials	Young Influentials	12	$51,700	Sgl/Cpl	25-44	CG	Exec	Multi	•		•		
	New Empty Nests	15	$51,400	Fam/Cpl	45+	SC/CG	WC/Exec	Single	[]				
	Suburban Sprawl	24	$46,400	Mixed	25-44	SC	WC	Mixed		•	•	•	
	Blue-Chip Blues	30	$47,500	Fam/Cpl	35-64	HS/SC	WC/BC	Single	[]				
Inner Suburbs	Upstarts & Seniors	28	$35,600	Cpl/Sgl	Mixed	HS/SC	WC	Multi	[]				
	New Beginnings	29	$35,600	Sgl	18-44	SC/CG	WC	Multi		•	•	•	
	Mobility Blues	41	$33,600	Fam	25-44	HS/SC	BC/Serv	Multi		•	•	[]	
	Gray Collars	42	$34,600	Fam/Cpl	65+	HS	BC/Serv	Single		•			
Urban Midscale	Urban Achievers	22	$40,000	Sgl	Mixed	SC/CG	WC/Exec	Hi-Rise	[]		•	•	
	Big City Blend	32	$39,700	Fam	25-44	HS/SC	WC/BC	Single			•	[]	
	Old Yankee Rows	37	$34,600	Sgl/Fam	Mixed	GS/HS	C/BC/Serv	Multi		•	•	•	
	Mid-City Mix	46	$35,000	Sgl/Fam	25-34	S/HS/SC	WC/Serv	Multi		[]	•		
2nd City Centers	Towns & Gowns	31	$19,700	Sgl	18-34	SC/CG	WC/Serv	Multi	•		•		
Exurban Blues	Military Quarters	40	$32,600	Fam	18-34	HS/SC	WC/Serv	Multi		•			
Urban Cores	Single City Blues	51	$21,200	Sgl	Mixed	GS/HS	WC/Serv	Hi-Rise		•	•	•	
	Inner Cities	61	$16,500	Sgl/Fam	18-34	GS/HS	BC/Serv	Multi		[]		•	
2nd City Blues	Smalltown Downtown	49	$22,800	Sgl/Fam	18-44	HS/SC	WC/BC/Serv	Multi	•			•	•
	Hometown Retired	52	$20,000	Sgl/Cpl	65+	GS/HS	BC/Serv	Mixed	[]				
	Family Scramble	59	$20,600	Sgl/Fam	25-34	GS/HS	BC/Serv	Multi				[]	•
	Southside City	62	$17,000	Sgl/Fam	18-34	GS/HS	BC/Serv	Multi		[]			

Key

SER (socio-economic ranking): 1 highest, 62 lowest

Family Type:

- Fam Married Couples with Children or Single Parents with Children
- Cpl Married Couples (few children)
- Sgl Singles / Unmarried Couples

GS Grade School
HS High School / Technical School
SC Some College
CG College Graduates

Occupation

- Exec Executive, managerial & professionals (teachers, doctors, etc.)
- WC Other White-Collar (technical, sales, admin/clerical support)
- BC Blue-Collar (assembly, trades & repair, operators, laborers, etc.)
- Serv Service (hospitality, food prep, protective & health services, etc.)
- Farm Farming

Race/Ethnicity

- W White
- B Black
- H Hispanic
- A Asian or Pacific Islander
- I Native American, Eskimo, Aleut
- [] Prevalent
- • Above Average

Housing

- Single Mostly SFDUs, some townhomes or duplexes
- Multi Townhomes, Low-rise Condos/apts., some SFDU
- Hi-Rise Mid/Hi-rise, 10+ unit condos/apts., duplexes

Table Adapted from Claritas (1999)