IMPACTS OF LAND MANAGEMENT PRACTICES ON BREEDING BIRD AND PLANT COMMUNITIES IN AN URBAN RESIDENTIAL AREA

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The undersigned, appointed by the dean of the Graduate School, have examined the [thesis or dissertation] entitled

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ABSTRACT

Our research establishes a base of knowledge which contributes to our understanding of the factors that determine how residents in Columbia, Missouri make management decisions in their yard and how these decisions benefit natural resources in urban areas. The values residents place on their properties play an important role in influencing their land management strategies, the biodiversity associated with their yard, and their overall wellbeing. Additionally, with shifting environmental conditions due to global climate change likely to affect communities throughout Missouri, this research will contribute to our understanding of factors that enhance resiliency to climate change within Columbia, Missouri.

Introduction

Shifting environmental conditions due to global climate change are likely to affect communities throughout Missouri (Wuebbles and Hayhoe, 2003; Kunkel et al., 2013). According to the most comprehensive climate projections of the Midwest region of the United States, as well as Missouri specifically, climate change will potentially bring longer, hotter summers in Missouri, and cause periods of drought and flooding to become progressively more severe and frequent (Walker et al., 2012; Kunkel et al., 2013; Wuebbles and Hayhoe, 2003). These conditions will increase the stresses put on human communities due to the degradation and changing in the natural resources of the area (Walker et al., 2012; Wuebbles and Hayhoe, 2003). With water availability being the most significant environmental limitation on plants in Missouri, and potential longer, hotter summers intensifying the pressures put in plant communities by increased drought, the vegetative community will undoubtedly be affected (Walker et al., 2012). These changing conditions present challenges to residents and property owners who have been, and need to continue adapting to climate change (Mendelsohn, 2000; Tompkins and Eakin, 2012; Scyphers and Lerman, 2014; Dale, 1997).

On agricultural lands, farmers have been altering their crop species selection, irrigation intensity, and the timing of the management (Mendelsohn, 2000). To adapt to climate change, public institutions are having to pass new building codes, shift water use, and manage public lands with greater intensity, and with new strategies (Mendelsohn, 2000). Though a good deal of research has been conducted to determine what these adaptations will be in agriculture and the public sector, the literature is lacking when it comes to adaptions of yard management being made by residents in urban areas (Pandley et al., 2003; Bradley et al., 2011). Due to land use change, and expanding urbanization, these areas are becoming increasingly important in maintaining regional biodiversity (Gil et al., 2007; Goddard, 2010; Tompkins and Eakin, 2012). Well adapted residential urban areas can contribute to community resilience to climate change by improving ecosystem services such as air and water quality, aesthetic value, and mitigating flood risk (Gil et al., 2007; Goddard, 2010; Larson et. al, 2015; Tompkins and Eakin, 2012).

In order to determine how people will adapt the management of their yards to shifting conditions due to climate change it is important to consider the factors that play into why people manage their yards the way that they do. The physical and social environments of an area determine motivations for managing and values people place on their yards (Clayton, 2007; Harris et al., 2013; Kendal et al., 2012; Zmyslony and Gagnon, 1998). Both overarching cultural values and small scale social interactions contribute to the social environment that plays a role in determining values and management practices in yards (Clayton, 2007; Harris et al., 2013; Zmyslony and Gagnon, 1998). For these reasons, we compared different communities within Columbia defined by social areas analysis, which uses socio-economic data to identify the underlying variables which differentiates communities in a population.

Appreciation for nature also plays a significant role in driving some management practices in yards (Clayton, 2007). People value the presence in their yard of animals more than plants, and vertebrates more than invertebrates (Martín-López, 2007). People tend to place a high value to birds in particular, when compared to other species (Martín-López, 2007). Because of the value people place on bird communities, in addition to the fact that birds work well as an environmental indicator, I chose bird community data to gauge how people value natural elements in their yards, as well as evaluating management practices effects on overall biodiversity (Gregory and Strien, 2010; Blair, 1999; Martín-López, 2007).

It is important to understand how management strategies of residential urban yards effect the associated natural communities in order to understand how residents can manage for resilience under changing climate conditions. Recommendations can be extended to those who want to increase biodiversity in their yards for its own sake, as well as for the benefits that are associated with increased biodiversity. Biodiversity in urban spaces can provide physiological benefits, environmental services, such as a reduction in flood damage risk, and has been shown to correlate with an increase in human health and wellbeing (Scyphers and Lerman, 2014; Fuller et al., 2007; Savard et al., 2000; Thompson and Eakin, 2012).

This research connects social and biological sciences in a human dimensions framework, using birds as lens to connect and communicate with communities, as well as a way to examine how the decisions residents make about their yards the connect to the natural community. We aimed to improve our understanding of how residents make decisions about how they manage their yards, and how these decisions impact natural resources within the community. This has contributed to our understanding of how resilient communities within Columbia are currently, and with an improved understanding of how residents will manage their property under future climate change scenarios, can help us understand the factors that enhance resiliency to climate change within Columbia.

Aims and Objectives

The goal of this study was to develop an understanding of how residents make decisions regarding the management of their yards, and to determine how these management practices can interact with the breeding bird and plant communities in and around those yards. Additionally, this project gathered pilot data which can be used in the future to assess how these land management practices will change in response to global climate change models that predict a warming climate for the Midwest. Finally, I have looked at the relationship between the values people place on their yard, their management activities, and the associated bird and plant communities. In order to accomplish these goals it was necessary to assess how yards are currently being managed, how these management practices shape the landscape bird communities associate with, and what the motivations and drivers of these management practices are. In working to achieve these goals, this project attempted to achieve the following objectives:

- To identify the current land management practices in residential urban yards in Columbia, Missouri.
- To determine how the management practices of residents, and the breeding bird and plant communities differ between yards and neighborhoods located within different social areas in Columbia, Missouri.
- To determine the relationship of management practices, and the breeding bird and plant communities in Columbia, Missouri.

- To provide information which contributes to our understanding of factors that enhance resiliency to climate change within Columbia, Missouri.
- To inform institutions and policy makers of ways they can engage residents to promote resiliency to climate change within Columbia, Missouri.

Methods

Social Areas

Our study took place in Columbia, Missouri. I used social areas analysis as a tool to compare the different yards, transects, bird communities, and plant communities sampled throughout Columbia. Social area analysis uses socio-economic data to identify underlying variables differentiating communities in a population (Shevky and Bell, 1955; Spielman and Thill, 2008). It is a tool which has been used to examine the association of social and ecological structures in urban environments (Martin et al., 2004; Grove and Birch, 1997; Grove et al., 2006). Social areas in Columbia, Missouri were previously defined by using census tract block group variables for the 2010 census that describe race/ethnicity, social status, and economic status (median household income, median home value, percent owner occupied housing units, percent single family detached homes, percent black residents, percent > 25 where highest degree is high school degree, percent housing units built 1990-1999). A principal components analysis (PCA) of this variables found that three components explained 79% of the variance among the census tract block group variables. PC 1 had strong loadings for median household income, median home value, percent owner occupied homes, and percent single family detached homes. PC 2 had strong loadings for percent black residents and percent of residents older than 25 with a maximum of a high school degree PC 3 had strong loadings for percent housing units built between 1990 and 1999. A K-Means cluster analysis to group the block groups into social areas based on the principal component scores for each block group. Social areas and their general location in the city were described as:

1. Social Area 1- New housing and rental property- north and east
2. Social Area 2- Black Residents, less education,- central city and north east of central city
3. Social Area 3 - Upper income, single family homes- south west
4. Social Area 4 - Renters, students- south and east

Site Selection

Given the species richness variances between points of similar studies (14.4 (Hadidian et al., 1997), 17.4 (Ortega-Álvarez and MacGregor-Fors, 2009)), 100 transects are sufficient to analyze the data. These 100 transects were selected out of the approximately 1100 transects which are possible to fit in the area of interest, representing approximately a 9% sample of the study area. The transect selection was stratified so that there is an equal distribution amongst social areas. The points were stratified to ensure that there was not a sampling bias for one particular social area, as these socio-economic factors are likely to have the most influence on land owner practices (Clayton, 2007; Harris et al., 2013; Zmyslony and Gagnon, 1998) (Figure 1). Once the points were selected they were ground proofed and moved to the nearest street so that they could be realistically surveyed (i.e., not in the middle of a lake). If these conditions were not met, the points were moved to the nearest locations where it is possible to conduct the surveys, and appropriate survey conditions are present (Burghardt et al., 2009; Ralph et al., 1995). In each transect a number of surveys were conducted to sample the bird communities, plant communities, yard structure, and management strategies and preferences of the residents (Table 1).

Bird Community Sampling

I used strip transects 100m long and 100m wide. 100 points with four repetitions were sampled with one observer over the time frame of May to June. (Ralph et al., 1995; DeGraff et al., 1991). I used strip transects instead of points in order to associate the densities and species richness with a slightly larger and more heterogeneous local landscape than is possible with point counts (Fernández-Juricic, 2002; White et al., 2004). Strip transects also reduce the problems associated with variable levels of noise and visibility that can be a problem in urban surveys (DeGraff et al., 1991). A transect width of 50m on each side provides reliable estimates of bird densities that only slightly underestimate actual densities, allows for detectability differences among multiple habitat types, and allows for accurate estimations of species richness (Carrascal et al., 2008; DeGraaf et al., 1991; Fernández-Juricic, 2002; White et al., 2004). A length of 100m has been shown to be appropriate in accounting for bird abundances in cities (DeGraaf et al., 1991; Degraaf and Wentworth, 1985; Goddard et al., 2013). This method is consistent with sampling strategies used in similar studies (Burghardt et al., 2009; Rottenberry, 1985; Bolger at al., 2007; Ralph et al., 1995) (Appendix 1).

I analyzed these data by calculating species richness, total abundance and Shannon diversity index of the transects in each social area. I chose these factors because the abundance contributes to how many birds residents can see, the species richness show the diversity of what they can see, and the diversity index shows the actual diversity of what they are likely to see. I then preformed a single factor ANOVA on all of these variables to determine if there were differences amongst the social areas. For all of the variables which showed significant differences in these tests, I ran a post-hoc TukeyHSD to determine if there were true significant differences between specific social areas. Because of the problems associated with using multiple comparisons, we used Boole's Inequality equation to determine an adjusted critical alpha of 0.02 for each MANOVA explained below.

I then preformed a Bray-Curtis dissimilarity test on the individual transects to show the differences between the bird communities observed at each transect. Bray-Curtis ordinations quantify the compositional dissimilarity between communities and are commonly used to assess differences in bird communities in urban environments (White et al., 2005; Ortega-Álvarez and MacGregor-Fors, 2009; Parsons et al., 2003). Transects are projected in an ecological space with those further apart showing greater dissimilarity. With the transects projected in the ecological space, I labeled all of the transects with their respective social area and visually inspected them to determine if the transects in each social area differed from one another, and thus was associated with a different bird community. I identified birds which correlated with the first two ordination axes to identify species correlated with the ordination. I then performed a single factor ANOVA to determine if there were differences in the abundance of these birds amongst the social areas. For all of the birds which showed significant differences in these tests, I ran a post-hoc TukeyHSD to determine if there were true significant differences between specific social areas.

To determine which environmental factors were associated with the different bird communities, I used a Poisson regression of abundance of the birds which correlated with the first two ordination axes, using the environmental variables which had significant correlation with the ordination of the transects by bird community (Cameron and Trivedi, 1998; Jones et al., 2013). For the species whose counts were zero inflated, I used a negative binomial Poisson regression of the bird's abundance, using the environmental variables which had significant correlation with the ordination (Cameron and Trivedi, 1998; Jones et al., 2013). I also ran these tests using management intensity scores and principal component scores of the responses received from the questionnaire as factors to determine the relationships of management and attitudes with the bird community.

Site Characteristics

I collected data on ground cover percentages, shrub and canopy coverage, and dominant species using a visual line intercept survey (Caratti, 2006; Sung et. al., 2011). This method allowed us to collect data on the structure and composition of the vegetation of all of the transects. To conduct this survey I walked the central line of each transect, and visually estimated percent cover estimates for each vegetative strata, ground cover percentages, identification of dominant shrub and canopy plants perpendicular to the central line every 5 meters. These estimates covered either the 50m width of the transect, or as far as I could see if my line of vision was obstructed. Additionally, I counted the number of bird feeders that were visible from the street and categorized them as either hummingbird feeders or regular bird feeders. The full survey protocol can be found in Appendix 2. This survey was conducted from the street and conducted on every transect. The information gathered this was mostly for front and side yards as those tend to be visible from the street.

I quantified the amount of cover represented by, impervious surfaces, trees and shrub, lawn and water within each transect using ArcGIS. To do this, I created polygons representing each cover type, as well as the transect as a whole. These area of the polygons for each cover were combined and a percent cover was calculated using an automated script. In addition to this, the code creates more accurate polygons than those created using the field marked GPS points for each transect by making each exactly one hectare, and contouring exactly to the bends of the roads. The script for this is located in Appendix 3.

We mailed residents asking for access to their back yard, and conducted a second field survey where access was granted, which the protocol was approved by the University of Missouri Internal Review Board (Project #2003563). We measured percent cover estimates for each vegetative strata and ground cover percentages, and also recorded individual plant identities within five ten meter transects. These transects were representative of different micro-garden cover in each back yard to account for the size differences amongst the yards (Davoren et al., 2015). Using these methods I quantified species present, dominant species in vegetative strata, vegetation diversity, percent cover in vegetative strata, and the percent cover of each micro-garden type in each back yard. The full protocols for these methods can be found in Appendix 4.

I analyzed the site characteristic data by determining the most commonly observed, and most dominant species in each and determining if there were differences between the social areas in the prevalence of these species. Species richness and the percentage of native species of the points were calculated in each social area. A single factor ANOVA was performed on these variables, as well as the cover estimates obtained from line intercept surveys, back yard surveys, and GIS estimates to determine if there were differences amongst the social areas. For all of the variables which showed significant differences in these tests, I ran a post-hoc TukeyHSD to determine if there were significant probability levels between specific social areas. I performed a Bray-Curtis dissimilarity test on the each transect and each back yard to show the differences between the cover estimates and species composition. I labeled all of the transects and back yards with their respective social area and visually inspected them to determine if the points in each social area differed from one another.

Because I had information form every transects, the line intercept coverage and composition data, as well as the GIS data were combined, and plotted on the bird community ordination as environmental variables. The variables which had correlations with the ordination of $r>0.2$ were used as factors in the regressions of select bird abundance as explained in the section above.

For the back yards which were granted access, and had returned questionnaires from the household, we preformed multiple linear regression of back yard structure and composition with management scores and principal component scores of the questionnaires. This allowed us to determine the relationship of back yard structure and composition to management intensity and residents attitudes.

Resident and Property Owner Surveys

With approval from the University of Missouri Internal Review Board (Project #2003563), I distributed a questionnaire by mail to all of the residents whose land occurs on the transects I sampled. I asked questions concerning preferences for yard appearance/type, the primary uses of the yard, the wildlife they would like to see, and general management practices in regard to mowing, gardening and use of chemicals (Appendix 5).

I analyzed this data by calculating the percent of respondents who answered each question the same way. In the case of the "other" category for uses of their yard, I qualitatively looked at each of the 14 responses to look for any patterns. Management intensity scores were calculated by assigning a score of 0-2 for how often residents mowed, watered, weeded, and applied chemicals and fertilizers to their yard, and summing these values for each questionnaire.

A principal component analysis with verimax rotation was conducted using the statistical software PC-ORD to determine the grouping of questions which explained the majority of the variation between the responses (Maguire et al., 2013; McCune and Mefford, 2011). I then used the scores for each component to compare the surveys from each social area using a single factor ANOVA. I chose to use principal components in my analysis which had eigenvalue scores of greater than 1 (Jolliffe, 2002). I determined questions to have a significant loading on a particular component if their eigenvectors were greater than +0.4 (McCune and Mefford, 2011). For all of the components which showed significant differences in these tests, I ran a post-hock TuckeyHSD to determine if there were true significant differences between specific social areas. I ran a linear regression of management scores and principal component scores to determine if preferences have a relationship with management intensity.

Results

Bird Community

One hundred species were identified on the transects in 2015 and 2016, with a total observation of 24781 individual birds (9.95+/-2.82 species per count, 30.98+/-16.40 individuals per count) (Table 2). The most abundant species were American robin (n=2737), black-capped chickadee (n=1115), brown-headed cowbird (n=688), chimney swift (n=633), common grackle (n=1505), European starling (n=3835), house finch (n=788), house sparrow (n=4830), mourning dove (n=836), and northern cardinal (n=1736).

There were significant differences ($p<0.02$) in abundance of birds among the social areas ($F=5.06$, $df=3, 96$ $p= 0.003$). However there were no significant differences in species richness ($F=2.26$, $df=3, 96$ $p= 0.08$) and diversity ($F=2.85$, $df=3, 96$ $p= 0.05$) among the social areas. (Table 3).

The Bray-Curtis Dissimilarity ordination (Figure 2) showed a great deal of variation of the bird community among the transects. The birds positively correlated with the first axis were eastern wood-peewee and tufted titmouse, while European starling and house sparrow were negatively correlated. The birds positively correlated with the second axis were barn swallow, and red-winged blackbirds, black-capped chickadee, eastern wood-peewee, and northern cardinal were negatively correlated. All of the species with correlations with the first two axes of the ordination greater than $r=0.45$ are shown in Table 4. A cutoff value of $r=0.45$ was chosen, because many of the points had similar communities, and lowering the cutoff from the standard $r=0.5$ allowed me to show more variables which correlated with the axis.

There were significant differences ($p<0.02$) among social areas in abundance of some of the species which correlated with the first two axes of the ordination (Table 5). There were differences in European starling ($F=5.06$, $df=3, 96$ $p= 0.003$) abundance. Barn swallow, ($F=5.06$, $df=3,96$ $p= 0.03$), black-capped chickadee ($F=1.04$, $df=3,96$ $p= 0.38$), eastern wood-peewee ($F=1.25$, $df=3,96$ $p= 0.30$), house sparrow ($F=2.99$, $df=3,96$ $p= 0.03$), northern cardinal ($F=0.45$, $df=3,96$ $p= 0.72$), red-winged blackbirds ($F=2.07$, $df=3,96$ $p= 0.11$), and tufted titmouse ($F=0.80$, $df=3,96$ $p= 0.50$) abundances were not different among the social areas.

Site Characteristics: Line Intercept and GIS

Line intercept surveys were conducted in September and early October of 2015. Seventy-two species were detected in the shrub layer, and 69 species were detected in the canopy. The transects average ground coverages for each ground cover category can be found in Table 8. The dominant ground cover types were artificial surface with 36.1+/-13% per transect and grass with 50.3+/13.0% per transect. Transects averaged 9.91+/-4.3 species, and 63.3+/-17.2% native species. There was an average of 4.4+/-4.3% percent shrub cover per transect. The 10 most dominant plants in the shrub layer (with percentages showing percent of shrub coverage) were bush honeysuckle (52.39%), eastern red cedar (5.96%), multiflora rose (5.53%), boxwood (4.43%), yew spp. (2.74%), eastern white pine (1.62%), juniper spp. (1.25%), eastern redbud (1.10%), grape spp. (0.03%), and blackberry spp. (0.89%) (Table 9). There was an average of 21.1+/-16.6% percent canopy cover per transect. The 10 most dominant plants in the canopy layer (with percentages showing percent of canopy cover) were pin oak (14.62%), silver maple (7.83%), red oak (6.14%), Norway maple (5.87%), Bradford pear (5.20%), white oak (4.76%), red maple (4.43%), sweetgum (4.31%), eastern redbud (3.80%), and American sycamore (3.67%) (Table 10).

There were differences among the social areas in grass ground cover (F=5.37, df=3, 96 p= 0.002) and artificial surface ground cover (F=7.02, df=3, 96 p<0.001). However, there were no differences among the social areas in bare ground (F=0.557, df=3, 96 p= 0.645), forb (F=2.59, df=3, 96 p= 0.057), leaf litter (F=0.45, df=3,96 p= 0.72), woody litter (F=0.81, df=3,96 p= 0.493), tree (F=2.90, df=3,96 p= 0.039), shrub (F=0.04, df=3,96 p= 0.99), vine (F=0.90, df=3,96 p= 0.445), rock (F=1.87, df=3,96 p= 0.14), or water (F=0.62, df=3,96 p= 0.617) ground cover. There were also no differences in percent shrub cover (F=1.59, df=3, 96 p= 0.197), or percent canopy cover (F=1.06, df=3, 96 p= 0.369) (Table 11).

The one hectare area containing transects average 28.1+/-19.3% tree and shrub cover, 33.4+/13.1% impervious surface cover, 38.4+/-15.1% lawn cover, and 0.10+/-0.63% water cover. There were differences between the social in concerning Impervious cover (F=4.09, df=3, 96 p= 0.009), and lawn cover (F=4.42, df=3, 96 p= 0.006). There were no differences among the social areas in tree and shrub cover (F=1.28, df=3, 96 p= 0.286), and water cover (F=0.80, df=3, 96 p= 0.496) (Table 12).

The Bray-Curtis ordination of transects using land cover variables (Figure 3) was characterized by a first axis with a positive correlation with the percent impervious and lawn cover, and a negative correlation with leaf litter cover, tree ground cover, shrub ground cover, and percent cover in the canopy. The second axis has a positive association with artificial surface, and a negative association with grass cover. All of the variables with correlations with the first two axes of the ordination greater than r=0.45 are shown in Table 13.

The transects in social areas 1 and 3 tend towards a negative relationship with the second axis, and a generally positive association with the negative axis. Social area 2 also has a generally positive association with the both axes. Social area 4 seems to contain the most diverse points in this ecological space, but its points still trend positively with the first axis.

We analyzed the relationship of these environmental variables with the abundance of the key bird species. Barn swallow, eastern wood-peewee, red-winged blackbirds, and tufted titmouse all had zero inflated distributions, so their abundance was associated with environmental variables using a negative binomial regression. Black-capped chickadee, European starling, house sparrow and northern cardinal abundance were not zero inflated, so their abundance was associated with environmental variables using a Poisson general linearized model. The environmental variables from these surveys which correlate with the bird community ordination having an r value greater than +/-0.2, were canopy cover observed from line intercept surveys (r=-0.383), tree and shrub cover observed from GIS (r=-0.296), lawn cover observed from GIS (r=0.268) and woody shrub species richness detected in the line intercept survey (r=-0.272). Barn swallows abundance was significantly associated with less lawn cover (p=0.005) (Table 33). Black capped abundance was significantly associated with more tree and shrub cover (p=0.007), and greater woody plant species richness (p=0.011) (Table 34). House sparrow abundance was significantly associated with less lawn cover (p<0.001) and less tree and shrub cover (p<0.001) (Table 35). Northern cardinal abundance was significantly associated with greater woody plant species richness (p=0.002) (Table 36).

Site Characteristics: Back Yard Surveys

Surveys of 170 back yards were conducted in May and June of 2016. One hundred and seventy species were identified as a dominant species in the shrub layer of at least one yard, 87 species were identified as a dominant species in the canopy of at least one yard, and a total of 240 species were detected. Yards averaged 15.1+/-5.0 species, and 47.1+/-18.3% native species. The dominant ground cover type was grass with 48.3+/25.1% cover per yard. The dominant micro-garden type was lawn with 64.1+/-26.3% cover per yard. The average cover for each ground cover category can be found in Table 14, and the average cover for each micro-garden type can be found in Table 15. There was an average of 15.5+/-14.8% percent shrub cover per yard. By far the most dominant plant in the shrub layer was bush honeysuckle (41.08%), with the majority of the rest being woody flowering bushes, or evergreens. A list of the 10 most commonly detected dominant plants in the shrub layer can be found in Table 16. There was an average of 31.5+/-27.8% percent canopy cover per yard. There were no trees that represented more than 7.5% of the canopy cover across all yards, however the most dominant tree in back yards was shagbark hickory (7.30%). Additionally, maples and oaks represented five of the next eight most dominant trees. A list of the 10 most commonly detected dominant plants in the canopy layer can be found in Table 17. The majority of yards contained turf grass (95.3%), miscellaneous forbs (62.9%), and bush honeysuckle (61.2%). The most common plants other than these were various forbs, and commonly planted ornamental vegetation. A list of the 10 most commonly detected plants can be found in Table 18.

The Bray-Curtis ordination (Figure 4) of yards using land cover and micro-garden cover variables was characterized by a first axis with a positive correlation with forest micro garden cover, leaf litter ground cover, woody litter ground cover, tree ground cover, shrub ground cover, vine ground cover, and canopy cover and a negative correlation with lawn micro garden cover, and grass ground cover. The second axis has a positive correlation with shrub ground cover, ornamental micro garden cover, and artificial surface ground cover, and a negative correlation with lawn micro garden ground cover. All of the variables with correlations with the first two axes of the ordination greater than r=0.45 are shown in Table 19.

The social areas tended to associate with both axis in unique ways. The yards in social area 1, 2 and 3 all tend to have and negative association the first axis. The yards in social areas 1 and 2 vary widely in terms of their relationship with axis 2, while the yards in social area trended to be negatively associated with the second axis. Yards in social area 4 trends to be slightly positively associated with the first axis, and very strongly negatively associated with the second axis. Even with the differences in trends, the majority of the yards in the city tend to be associated negatively with both axes.

There were differences between the social areas (p<0.02) in leaf litter ground cover (F=4.04, df=3, 166, p= 0.008). There were no differences among the social areas in artificial surface (F=0.1.79, df=3, 166 p= 0.152), bare ground (F=0.178, df=3, 166 p= 0.153), forb (F=2.19, df=3, 166 p= 0.012), grass (F=1.25, df=3, 166 p= 0.292), woody litter (F=0.01, df=3, 166 p= 0.998), tree (F=0.96, df=3, 166 p= 0.412), shrub (F=1.25, df=3, 166 p= 0293), vine (F=0.17, df=3, 166 p= 0.916), rock (F=0.72, df=3, 166 p= 0.54), or water (F=0.36, df=3, 166 p= 0.782) ground cover. There were also no differences in percent shrub cover (F=1.14, df=3, 166 p= 0.334), or percent canopy cover (F=2.65, df=3, 166 p= 0.051) (Table 20). There were also no difference among the social areas in ornamental (F=3.20, df=3, 166 p= 0.025), vegetable (F=0.53, df=3, 166 p= 0.665), lawn (F=0.54, df=3, 166 p= 0.653) , managed no plants (F=0.77, df=3, 166 p= 0.514) , forest (F=1.43, df=3, 166 p= 0.237) , or open native (F=1.30, df=3, 166 p= 0.277) micro-gardens (Table 21).

Resident and Property Owner Surveys

Of the 1000 surveys sent out, we received 224 completed surveys. Fifty-seven of the responses came from social area 1, forty-two from social area 2, sixty-six from social area 3, and fifty-nine from social area 4. Eighty-three of the 100 transects were represented in the responses. In regards to preferences for yard appearance/type, and the primary uses of the yard, at least 80% of all respondents said that every factor asked about was either somewhat important or very important to them. With the exception of frequency of mowing, which 99.5% of the respondents preformed at least 1-2 times a month, the frequency of application of fertilizers and chemicals, of watering, and of weeding, were all relatively evenly distributed among the frequency categories provided. When asked about their yard type, a majority (52.9%) responded that their yards were primarily native and non-native plants. Out of the 14 respondents who filled in the other category for important uses of their yard, 5 mentioned pet use, 4 mentioned the cultivation of fruits and vegetables, 2 mentioned wildlife feeding and viewing, one mentioned a fire pit, one mentioned social interactions, and one mentioned having a neat and clean yard. Respondents had an average management score (scale of 0-10, zero being never doing any of the management practices listed, 10 would be doing them all at the highest frequency listed) of

5.4+/-2.8. The full survey results can be seen in Table 22, and the comments can be found in Table 23.

The principal component analysis identified, six components with eigenvalues greater than 1 which accounted for 62.6% of the variance between respondents. The full results of the PCA can be found in Table 24. The most significant questions contributing to the components were those with loadings greater than 0.4, and less than -0.4 (Maguire et al, 2013; McCune and Mefford, 2011). The first component explained 19.6% of the variance and had negative loadings with the respondents finding habitat for wildlife, flowering plants, cultivation of fruits and vegetables, environmental value of their yard, wildlife use of their yard, using their yard for exercise, decoration, experiencing nature, relaxation, and social activities, and having flowers and woody vegetation on their lawn to be important. The second component explained 14.3% of the variance and had significant negative loadings with the respondents finding a mowed lawn, using their yard for decoration, relaxation, and social activities, and having a lawn without weeds and with open lawn to be important. It had significant positive loadings with those who found having habitat for wildlife on their yard, the environmental value, and wildlife use of their yards to be important. The third component explained 9.3% of the variance and had significant negative loadings with the respondents finding ornamental vegetation and flowering plants in their yard, and having a lawn without weeds and with flowers to be important. It had significant positive loadings with those who found using their yards for exercise to be important. The fourth component explained 7.4% of the variance and had significant negative loadings with the respondents finding the use of their yards for decoration and experiencing nature to be important. It had significant positive loadings with those who found having space for recreation, and cultivating fruits and vegetables in their yards as well as the ease of maintenance of their yards to be important. The fifth component explained 6.3% of the variance, and had significant positive loadings with respondents finding mowed lawn to be an important element of their yard. The sixth component explained 5.6% of the variance, and had significant positive loadings with respondents finding ornamental trees and shrubs to be an important element of their yard. It had significant negative loadings with those who found ease of maintenance to be an important characteristic of their yard.

There were differences between the social areas ($p<0.02$) in management scores ($F=5.52$, $df=3, 220$, $p= 0.001$) (Table 25). We found that all principal components except for component one, four and five had significant associations with management scores. Additionally, all of the component scores were negatively associated with management scores, with component 2 having the strongest relationship (-0.83+/-0.09, $p<0.001$), followed by component 3 (-0.61+/-0.11, p=<0.001), then component 4 (-0.39+/-0.12, $p=0.002$). The full result of this regression can be seen in Table 26.

We analyzed the relationship of the management intensity and yard preferences of the residents with the abundance of the key bird species. Barn swallow, eastern wood-peewee, red-winged blackbirds, and tufted titmouse all had zero inflated distributions, so their abundance was associated with the scores using a negative binomial Poisson regression. Black-capped chickadee, European starling, house sparrow and northern cardinal abundance were not zero inflated, so their abundance was associated with the scores using a Poisson general linearized model. We had at least one response from 83 of our 100 transects, and for those which had more than one response, the scores were averaged. The only two species' abundances which showed a significant association with the scores were European starling, and northern cardinal. European starling abundance was negatively associated with management scores (-6.04+/-1.85, p= 0.002), and component 3 scores (-11.03+/-3.27, p<0.001) (Table 6). Northern Cardinal abundance was negatively associated with component 4 scores (-1.94+/-0.80, p=0.017) (Table 7).

We had 99 yards for which we had both back yard surveys and returned questionnaires. To determine relationships between these surveys, we ran a multiple linear regression of back yard structure and composition using the management and component scores as factors. Ornamental micro-garden coverage was negatively associated with component 4 (-3.11+/-0.96, p=0.002) (Table 27). Lawn micro-garden coverage was negatively associated with component 2 (-5.91+/-1.66, p=0.002) and positively associated with component 4 (5.64+/-2.01, p=0.006) and component 5 (5.67+/-2.11, p=0.008) (Table 28). Forest micro-garden coverage was positively associated with component 2 (4.04+/-1.16, p<0.001) (Table 29). Both species richness (1.08+/-0.37, p=0.005) (Table 30) and percent native species (4.14+/-1.24, p=0.001) (Table 31) were positively associated with component 2. We ran a linear regression of the score residents gave of their perceived amount of native vegetation in their yards with the actual native vegetation percentage, and there was no relationship ($p=0.14$, $r^2=0.02$) (Table 32).

Discussion

There was a great deal of variation between the individual transects in regards to both bird community, and vegetation structure and composition. The four different types of transect composition we found in our surveys were transects dominated by artificial surface cover, those dominated by lawn cover, those with a mixture of lawn and ornamental shrub cover, and those with high level of forest cover. The transects with more forest cover had the highest native percent native plant composition, and along with transects with the lots of ornamental shrub cover, had the highest species richness. The first bird community could be represented by northern cardinal, eastern wood-peewee, tufted titmouse and black-capped chickadees. This community associated with high forest and shrub cover and was the most diverse. The bird community represented by barn swallows, and red-winged blackbirds associated with transects which were more open in structure. The bird community represented by European starlings and house sparrow were associated with transects with high levels of artificial surface and had the highest bird abundance.

Individual yards showed a great deal of variation, and differed from one another based on their structural composition. We found these yards types could be defined as those with high amounts of lawn cover, those with high amounts of forest cover, and those with high amounts of impervious surface and ornamental micro-garden cover. The yards with more forest cover had the highest plant species richness and percent native plants.

The principal components of our questionnaires identified four groupings of questions which explained the variation in the participants' responses. The first component separated those who found many elements and uses of their yards to be important from those who did not. This can be thought of as the caring component. The second component separated respondents who prefer neater yards and use them for social activities from those who prefer the natural aspects of yards. This can be thought of as the social vs. natural component. The third component separated those who use their yard for decoration from those who use it for recreation. This can be thought of as the first aesthetic vs use component. The fourth component separated those who found actively using, and easily maintaining their yard important from those who found aesthetic aspects of their yard to be important. This can be thought of as the second aesthetic vs use component. The fifth component separated respondents finding mowed lawn to be an important element of their yard from those who did not. This can be thought of as the lawn component. Finally, the sixth component separated respondents who said ornamental trees and shrubs were an important element of their yard from those who valued the ease of maintenance of their yard. This can be thought of as the gardening vs ease of maintenance component. When comparing these components to the management scores, we found respondents who valued their yard for decorative purposes managed more, while those who valued natural aspects, active use, and ease of maintenance in their yard managed less.

We found trends in each social area in relation to our surveys. Transects in social area one tended to have a wide range of bird communities. Transects and yards were most diverse in this social area, but tended towards having more lawn with grass (as opposed to forbs), with more ornamental micro-garden and forest cover. Respondents tended to use intensive management practices less. Social area two tended to have the highest bird abundance, but the bird community were generally those associated with European starlings and house sparrows. Transects and yards tended to have more lawn with grass and forbs and high ornamental tree and shrub cover. Respondents tended to use intensive management practices less. Social area three had low bird abundance, but the bird community tended to be represented by the most diverse community, the forest birds. Transects and lawns tended to have high levels of impervious surface, ornamental micro-garden, and tree and shrub cover. Respondents tended to use intensive management practices more. Social area four also had low bird abundance, and a bird community represented by both the forest birds, and European starlings and house sparrows. These transects and lawns were fairly diverse in their structure, but tended slightly towards more artificial surface cover, and less forest cover. This idea that communities defined by their geographic distribution and social areas show trends in management, yard structure, and natural communities fits in with the idea that socio-economic factors, social interactions, and geographic patterns are valuable in determining the management practices in, and the values residents place on their yards (Clayton, 2007; Harris et al., 2013; Kendal, et al, 2012; Zmyslony and Gagnon, 1998).

The bird community, yard and transect structure, and respondents showed interesting relationships with one another. We saw that the bird communities which associate with more open areas associated with transects with more lawn cover, while communities which are generally described as forest birds associated with transects with more tree and shrub cover, and higher woody plant species richness. This community also associated with yards where residents prefer the natural yards. Bird communities which generally associate with more built areas did not associated with artificial surface cover directly, but did have negative associations with both lawn cover and forest cover. These birds also associated with yards where residents manage less, and find the aesthetics of their yard to be important. We also found yards with greater ornamental and forest micro-garden cover and greater plant species richness and native plant percentage are associated with residents who found the natural aspects important. Yards with more lawn cover are related to the yards of residents who do not.

Synthesizing these relationships, we found that residents who value the natural aspects of their yard tended to manage less intensively, have yards with more abundant, diverse and greater percentage native tree and shrub cover and have a greater diversity of birds associating with their yards. Residents who value aesthetic aspects of their yard tended to manage more intensively, have yards with less abundant, diverse and lower percentage native tree and shrub cover have less diversity of birds associating with their yards. However, there is a disconnect with what they think about their yard, and the actual composition as shown by the lack of relationship of actual and perceived native plant cover. This means that we can help enhance the resiliency of communities both by communicating with residents about their yard preferences, and by educating them about what is in their yard. These results are consistent with past research in showing that individual preference can contribute to the structure of, and the associated biodiversity of the natural community in yards (Kurz, and Baudains. 2010). Additionally, due to the direct and indirect effect of resident values on the factors that shape resiliency to climate change, cities and institutions would be well served to put effort into discussing the values of residents in vulnerable communities. With the importance of social interaction in determining values of and management practices in yards these outreach efforts could reverberate throughout communities.

These results establish a base of knowledge which contribute to our understanding of the factors that determine how residents in Columbia make management decisions in their yard and how these decisions benefit natural resources in urban areas. However, it is likely that many of the relationships we observed suffered from omitted variable bias. The strength of our assertions can be improved, as well as the identifications of other important associations by including some socio-economic or landscape variables with future modeling efforts (Barreto and Howland, 2006).

Conclusions

We found residents in Columbia tended to manage their properties differently based on whether they valued the aesthetic aspects or the natural aspects of their yards more, and this impacted the natural community associated with these yards. Those who valued natural aspects, tended to have a more diverse, abundant and higher percent native plant and bird communities, which can make their yards more resilient to the impacts of climate change. Institutions and policy makers can engage residents about what they value about their property, and use these results to show them how specific changes they can make in the management of their yards will help them accomplish their goals.

Recommendations

Further research can be done to specifically address the resiliency of individuals and communities in Columbia. Though this research contributes to our knowledge about resilience in Columbia, it does not directly address it. Looking at the socioeconomic variables used to define social areas, further research will improve our understanding of individuals and communities are more resilient to the effects of climate change. With more research devoted to improving our understanding of how residents will manage their property under future climate change scenarios, and the motivations behind the aspects and uses of yards residents find important, this research will contribute to our understanding of factors that enhance resiliency to climate change within Columbia. Additionally, because all of this data is spatially explicit, further research could use this data to map the resiliency of specific areas of Columbia to determine vulnerable neighborhoods, communities, and individuals.

For institutions and policy makers, the most important idea that this research reinforces is the usefulness of community outreach to accomplish sustainability and resilience goals, and to help residents accomplish their goals for their properties. Because of the disconnect of native species composition and perceived native species composition on individual yards, engaging residents to help them understand what is actually in their yard can be an important tool in accomplishing these goals. With many residents finding both aesthetic and natural aspects of their yards to be important it is necessary to ask residents exactly what aesthetic they find important for their yard. We can then use this information to help them understand that by having more diverse and abundant plant species in their yards, and preforming high intensity management practices less frequently, they can achieve a yard that is both aesthetically pleasing, and environmentally friendly. Though these specific data and relationships are specific to Columbia, Missouri, the ideas and methods described in this research can be applied to any community wishing to understand the factors that enhance resiliency to climate change within their community.

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Appendix

Appendix 1. Protocol for the bird strip transects surveys.

- Counts are to be conducted within 4 hours of local sunrise.
- Three counts will be conducted at each point in the months of May and June

ADDITIONAL OBSERVERS

Joint count: Both observers should be listed on the data sheet. Observations made by both observers should be recorded. However, care should be taken to make sure that individual birds are not counted twice.

COUNT CONDITIONS

- Transects should be started no earlier than local sunrise, and should be finished no later than 4 hours past local sunrise.
- Do not count in steady or heavy rain. It is okay count in light, intermittent drizzle, but be sure to make note of this on the data sheet.
- Do not count in steady winds above 20 mph.
- Do not count in extreme noisy conditions

BEFORE THE COUNT

Calibrate your distance estimations against known distances. There are a variety of ways to do this. You might take a measuring tape and determine your typical pacing distance. You might also try estimating distances to particular landmarks and then pace off the actual distance to test you.

CONDUCTING THE COUNT

- Walk each transect line slowly at a steady pace (every 100m should take about 5 mins).
- Record all the birds seen or heard.
- For each observation note the following in the appropriate column of the datasheet.

Species

- Use the AOU code if known, or write down the complete common name.
- If the species cannot be positively identified, use the closest taxonomic affiliation.
- It is better to record something as “unknown” rather than to guess.

Number of individuals and distance

- Usually, a single individual bird will be recorded per line.
- Only record a number greater than one on a single line if birds of the same species are observed very close together, such as a flock or family group.
- If a mixed flock is observed put each species on a separate line and write in the “Notes” column that they were part of a mixed flock.
- Record estimated flock sizes only if you cannot count them all. For example 10-20 or 15+. (But really try to count them all)

- Distances are measured as a distance from the center of the transect line, not as a distance to the observer. Write the number of individuals observed in the appropriate distance columns. Don't forget to regularly recalibrate our distance estimates against known landmarks.
- If a bird moves during the court record only the distance at which it was first observed.
- Try to be aware of bird movement to minimize double-counting birds.

Fly-through (FT)

- If a bird is seen flying through the count area below the tallest structure or vegetation, but not observed taking off or landing, record it in the "FT" column. Do not record it in one of the distance columns.
- Higher-flying birds can be noted in the "Notes" column if they are likely "aerial screeners" using the habitat, such as a hawk circling 100 feet overhead.
- Write observations of unusual fly-overs, such as rare migratory species, in the "Notes" column.

Seen (S) or Heard (H) Columns

- Place a check mark in the appropriate column to indicate whether sight or sound or both identified the bird. Use caution with similar-sounding birds or with mimics like mockingbirds or starlings.

ADDITIONAL INSTRUCTIONS

- Wear drab clothing and avoid bold patterns that might scare away some birds or attract other ones.
- Do not pish, squeak, or use any other methods to encourage birds to show themselves. This would artificially inflate the bird densities recorded and invalidate the data collected.
- Make a note to an interruption of the count by more than 30 seconds in the "Notes" column and record the additional time on the count in the "end time" column.

Appendix 2. Protocol of the vegetation visual line intercept surveys**.**

- Surveys are to be conducted when plants are leafing
- One complete round of surveys will be conducted on each transect from the road.
- One set of measurements should be taken every 5m on alternating sides of central line

Before the survey:

Locate the exact start and end points of the central line, and measure distance to the side of the road on either side. Record this distance and place markers where at the start and end of the central lines on both sides of the road. Use 100m rope, marked with 5m intervals and stretch between the end points. Fill in the transect information at the top of each sheet.

Conducting the Survey:

- Stop at each 5m mark, look perpendicular to the central line. Use a rangefinder to measure the distance you lose visibility up to 50 m. Record this distance under transect length. If there are no obstructions, record the transect length as 50m
- Estimate the percent cover of each category under ground cover
- Estimate the percent cover of the shrub layer (0.5-2m).
- Record up to 5 dominant species in the shrub layer, and the percentage of the shrub layer they occupy.
- Estimate the percent cover of the canopy (>5m).
- Record up to 5 dominant species in the canopy, and the percentage of the canopy they occupy.
- Record each species of tree which falls on the transect, and count the individual stems which fall into each DBH category.
- If a plant is unable to be identified, use a dichotomous key, and/or take pictures. Make sure to record the exact picture numbers on the data sheet, and identify as soon as possible.

After the Survey

Make sure all of the equipment is accounted for and all of the data is appropriately recorded.

Appendix 3. Code that automates percent cover of premade polygons within a transects using ArcGIS.

```
# Import necessary modules
import arcpy
from arcpy import env
import os
# Set environmental variables, and overwrite
env.overwriteOutput = True
env.outputCoordinateSystem = arcpy.SpatialReference(26915)
# Define the root folder, the desired name of the geodatabase,
# the desired name of the output feature class, and the location
# of the text file with all the station locations
rootFolder = "F:\\Final\\"
FileGDBName = "final.gdb"
points= "Points.shp"
roads= "ClippedRoads.shp"
### set geodatabase to be the workspace
env.workspace = os.path.join(rootFolder, FileGDBName)
#creating a copy of points for me to work on, including seperate ones for both ones to be snapped an ones not to be
newpoints = os.path.join(env.workspace, "newpoints")
arcpy.FeatureClassToFeatureClass_conversion (points, env.workspace, "newpoints")
arcpy.FeatureClassToFeatureClass_conversion (points, env.workspace, "newroadpoints")
arcpy.FeatureClassToFeatureClass_conversion (points, env.workspace, "newnotroadpoints")
inroadpoints= os.path.join(env.workspace, "newroadpoints")
inpointnotroad= os.path.join(env.workspace,"newnotroadpoints")
#deleating extra fields
arcpy.DeleteField_management(newpoints, ["Shape*", "Dist", "AvgSpd", "Descriptio", "Icon", "IconScale", "IconAltitu",
"IconHeadin", "IconColor", "LineStrin","HideNameUn","Field15"])
arcpy.DeleteField_management(inroadpoints, ["Shape*", "Dist", "AvgSpd", "Descriptio", "Icon", "IconScale", "IconAltitu",
"IconHeadin", "IconColor", "LineStrin","HideNameUn","Field15"])
arcpy.DeleteField_management(inpointnotroad, ["Shape*", "Dist", "AvgSpd", "Descriptio", "Icon", "IconScale", "IconAltitu",
"IconHeadin", "IconColor", "LineStrin","HideNameUn","Field15"])
#defining buffered roads (both disolved and as sperate polygons)
arcpy.Buffer_analysis (roads, "buffroadmerged", "28", "", "Round","ALL")
arcpy.Buffer_analysis (roads, "buffroad", "28", "", "Round")
buffroadmerged= os.path.join(env.workspace, "buffroadmerged")
buffroad= os.path.join(env.workspace, "buffroad")
#disolveing the roads into one polygon
arcpy.Dissolve_management (roads, "rdsmerged")
arcpy.CopyFeatures_management("rdsmerged","roadsmerged")
roadsmerged= os.path.join(env.workspace, "roadsmerged")
#measuring how far the point is from road
arcpy.Near_analysis(inroadpoints,roads,"","LOCATION","NO_ANGLE")
arcpy.Near_analysis(inpointnotroad,roads,"","LOCATION","NO_ANGLE")
#creating a feature layer to select points far from road and deleting them, then converting back to faeture class
arcpy.MakeFeatureLayer_management(inroadpoints,"inroadpointslyr")
arcpy.SelectLayerByAttribute_management("inroadpointslyr","NEW_SELECTION",' "NEAR_DIST" >= 28 ')
arcpy.DeleteRows_management("inroadpointslyr")
arcpy.FeatureClassToFeatureClass_conversion ("inroadpointslyr", env.workspace, "roadpoints")
roadpoints=os.path.join(env.workspace, "roadpoints")
#creating a feature layer to select points close to road and deleting them, then converting back to faeture class
arcpy.MakeFeatureLayer_management(inpointnotroad,"inpointnotroadlyr")
arcpy.SelectLayerByAttribute_management("inpointnotroadlyr","NEW_SELECTION",' "NEAR_DIST" < 28 ')
arcpy.DeleteRows_management("inpointnotroadlyr")
```

```
arcpy.FeatureClassToFeatureClass_conversion ("inpointnotroadlyr", env.workspace, "pointnotroad")
pointnotroad=os.path.join(env.workspace, "pointnotroad")
#export attribute table with proximity to roads
pointscsv = os.path.join(env.workspace, "roadpoints.csv")
# Export Feature Attribute
arcpy.ExportXYv_stats(roadpoints, "Name;lat;long;PointID;NEAR_X;NEAR_Y;pntord","COMMA",pointscsv,
"ADD_FIELD_NAMES")
# take new XY given in attribute table file into a feature layer ("Display XY data")
inputcsv= pointscsv
arcpy.MakeXYEventLayer_management(inputcsv,"NEAR_X","NEAR_Y", "pointsnaped")
arcpy.CopyFeatures_management("pointsnaped","pointroad")
pointroad = os.path.join(env.workspace, "pointroad")
#checking for error (searching all points snapped to road, and shecking all roads to see if a point is close to two
ptcursor = arcpy.da.SearchCursor(roadpoints,["SHAPE@", "POINTID"])
for row in ptrdcursor:
    roadCount = 0
  rdcursor = arcpy.da.SearchCursor(buffroad,["SHAPE@"])
  for rdrow in rdcursor:
    if row[0].within(rdrow[0]) == True:
      roadCount += 1
        if roadCount >= 2:
          print "possible error in placing point "row[1]]
  del rdcursor
del ptcursor
#merging the set of points that were snaped and those that were not
arcpy.Merge_management([pointnotroad, pointroad], "mergedpoints")
mergedpoints= os.path.join(env.workspace,"mergedpoints")
#creating polylines out of points that are representing the same transect
arcpy.PointsToLine_management(mergedpoints, "transectLines", "PointID", "pntord")
transectLines= os.path.join(env.workspace, "transectLines")
#creating the polygons for each transect
arcpy.Buffer_analysis (transectLines, "transects", "50", "", "Flat")
transects= os.path.join(env.workspace, "transects")
#calculating percent cover
treeshrub= os.path.join(env.workspace, "treeshrub")
water=os.path.join(env.workspace, "water")
impervious=os.path.join(env.workspace, "imperv")
#creating uniquie names for each layer type area cover, and adding neccesary fields for calculations
arcpy.AddField_management(treeshrub, "SHAPE_AreaTS", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(treeshrub, "SHAPE_AreaTS", "!SHAPE_Area!", "PYTHON_9.3")
arcpy.AddField_management(treeshrub, "SHAPE_AreaW", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(treeshrub, "Shape_AreaW", "0", "PYTHON_9.3")
arcpy.AddField_management(treeshrub, "SHAPE_AreaI", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(treeshrub, "Shape_AreaI", "0", "PYTHON_9.3")
arcpy.AddField_management(water, "SHAPE_AreaW", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(water, "SHAPE_AreaW", "!SHAPE_AREA!", "PYTHON_9.3")
arcpy.AddField_management(water, "SHAPE_AreaI", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(water, "Shape_AreaI", "0", "PYTHON_9.3")
arcpy.AddField_management(water, "SHAPE_AreaTS", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(water, "Shape_AreaTS", "0", "PYTHON_9.3")
arcpy.AddField_management(impervious, "SHAPE_AreaI", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(impervious, "SHAPE_AreaI", "!SHAPE_AREA!", "PYTHON_9.3")
arcpy.AddField_management(impervious, "SHAPE_AreaTS", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(impervious, "Shape_AreaTS", "0", "PYTHON_9.3")
```

```
arcpy.AddField_management(impervious, "SHAPE_AreaW", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(impervious, "Shape_AreaW", "0", "PYTHON_9.3")
arcpy.AddField_management(transects, "SHAPE_AreaTS", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(transects, "SHAPE_AreaTS", "0", "PYTHON_9.3")
arcpy.AddField_management(transects, "SHAPE_AreaW", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(transects, "SHAPE_AreaW", "0", "PYTHON_9.3")
arcpy.AddField_management(transects, "SHAPE_AreaI", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(transects, "Shape_AreaI", "0", "PYTHON_9.3")
#combining the cover layers, and disloving into one
arcpy.Merge_management([transects,treeshrub,water,impervious],"transectswithcovernotdis")
transectswithcovernotdis= os.path.join(env.workspace,"transectswithcovernotdis")
arcpy.Dissolve_management(transectswithcovernotdis, "transectswithcover","POINTID",[["POINTID","FIRST"],
["SHAPE_AreaTS","SUM"], ["SHAPE_AreaI","SUM"], ["SHAPE_AreaW","SUM"]])
transectswithcover= os.path.join(env.workspace,"transectswithcover")

#creating fields for percent cover, and calaculating them
arcpy.AddField_management(transectswithcover, "PercentCoverTS", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(transectswithcover, "PercentCoverTS", "!SUM_SHAPE_AreaTS!/!SHAPE_Area!*100",
"PYTHON_9.3")
arcpy.AddField_management(transectswithcover, "PercentCoverI", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(transectswithcover, "PercentCoverI", "!SUM_SHAPE_AreaI!/!SHAPE_Area!*100",
"PYTHON_9.3")
arcpy.AddField_management(transectswithcover, "PercentCoverW", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(transectswithcover, "PercentCoverW", "!SUM_SHAPE_AreaW!/!SHAPE_Area!*100",
"PYTHON_9.3")
arcpy.AddField_management(transectswithcover, "PercentCoverL", "DOUBLE", "", "", "", "", "NULLABLE")
arcpy.CalculateField_management(transectswithcover, "PercentCoverL", "(!SHAPE_Area!-
(!SUM_SHAPE_AreaTS!+!SUM_SHAPE_AreaI!+!SUM_SHAPE_AreaW!))/!SHAPE_Area!*100", "PYTHON_9.3")
#convering to an excell file for further analysis
percentcovercsv = os.path.join(env.workspace, "percentcover.csv")
arcpy.ExportXYv_stats(transectswithcover,
"PointID;PercentCoverTS;PercentCoverI;PercentCoverL;PercentCoverW","COMMA",percentcovercsv, "ADD_FIELD_NAMES")
```

Appendix 4. Protocol for back yard vegetation sampling.

- Surveys are to be conducted when plants are leafing
- One complete round of surveys will be conducted on properties where access was granted.
- Surveys are only to be conducted in the back yards of these properties

Before the survey:

If the resident specified to contact them before using their property make sure to make the appropriate contact before going to the property. Before doing anything on a property, knock on the residents doors, introduce yourself, and let them know what you will be doing.

Conducting the Survey:

- Estimate the percent cover of each category under ground cover
- Estimate the percent cover of the canopy (>5m).
- Record up to 5 dominant species in the canopy, and the percentage of the canopy they occupy.
- Identify all of the different micro-gardens on the property, and score their presence/ absence, and proportion each micro-garden occupies in the yard.
- Choose transects that are representative of the micro-garden (or part of) that the transect will run through. If possible have at least one transect (or part of) run though each types of micro-garden. If there are less than five micro-gardens, the number of transects should represent the proportions of micro garden in each yard.
- Run 10m line meter tape as close to the ground as possible where you decided the first transect will be.
- In each transect, record and identify the nearest tree, shrub, grass, and herbaceous (non-grassy) species at 1 m intervals along the tape measure (10 points = 10 m).
- At each 1 m interval, record individuals directly underneath or adjacent to the tape measure. If no individual was in the vicinity of the tape measure, the nearest individual within a block measuring 0.5 m forwards and backwards and 2 m left and right of the tape was recorded.
- However, if no vegetation is found in this block, record the point as bare ground.
- If a plant is unable to be identified, use a dichotomous key, and/or take pictures. Make sure to record the exact picture numbers on the data sheet, and identify as soon as possible.
- If there is a structure blocking the running the line, measure the distance already completed and the width of the object, and continue with the remaining 10m on the other side of the object.
- Repeat this process for all five transects.

After the Survey

Make sure all of the equipment is accounted for and all of the data is appropriately recorded. When everything is cleaned up, leave the provided note to the resident in the appropriate mailbox.

Appendix 5. Cover letter and questionnaire sent to residents.

Cover Letter

University of Missouri

School of Natural Resources
302 Anheuser-Busch Natural Resources Bldg.
Columbia, MO 65211

November 4, 2015

RESIDENT

I am a graduate student in the School of Natural Resources, University of Missouri-Columbia. My work is part of larger research project which aims to understand how residents and land managers make decisions about managing their yards and gardens. I invite you to complete the short survey included with this letter to better understand how landowners and land managers currently manage their property. The answers to this survey will help us understand how residents of Columbia manage land and how these landscapes can be used to benefit wildlife. **Your participation is greatly appreciated.**

Your identity in this study will remain confidential. Survey participants will be identified by a unique code that is kept in a separate file from any information that will identify individuals participating in this study. Completed surveys will be securely stored in a locked file cabinet and electronically stored with password protection. All data generated will be used for the purpose of analysis for this project and may be used again in the future to help answer alternative questions based on this project.

If you decide to participate, you are free to not answer questions or to end your participation in the survey at any time. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. When you have completed the survey, please return it in the provided, prepaid envelope. If you have any additional questions concerning the study please contact me at (433) 690-7879 or via email at ef24d@mail.missouri.edu. If you would like to speak with the principle investigators of this project you can contact Dr. Charles Nilon (573-882-3738, NilonC@missouri.edu) or Dr. Robert Pierce (573- 882-4337, PierceR@missouri.edu).Questions regarding the rights of research subjects may be directed to the University of Missouri Campus Institutional Review Board, (573) 882-9585.

Thank you for your time and consideration.

Sincerely,

Eric Fishel

Graduate Research Assistant

Survey Questions

1) In your opinion, how important are the following elements in a yard?

	Very Important	Somewhat Important	Not Important At All
Mowed lawn			
Ornamental shrubs and trees			
Space for recreation			
Habitat for wildlife			
Flowering plants			
Cultivation of Fruits and Vegetables			

2) If you have a lawn, how often do the following occur?

Fertilizing	More than once a year	Once a year	Never
Watering	More than 3 times a month	1-2 times a month	Never
Mowing	More than 3 times a month	1-2 times a month	Never
Weeding	More than 3 times a month	1-2 times a month	Never
Application of Chemicals	More than once a year	Once a year	Never

3) How important are the following uses of your yard?

	Very Important	Somewhat Important	Not Important At All
A place for exercise			
A decorative space			
A place to experience nature			
A place to relax			
A place for social activities			
other			

4) How important are the following characteristics of a yard to you.

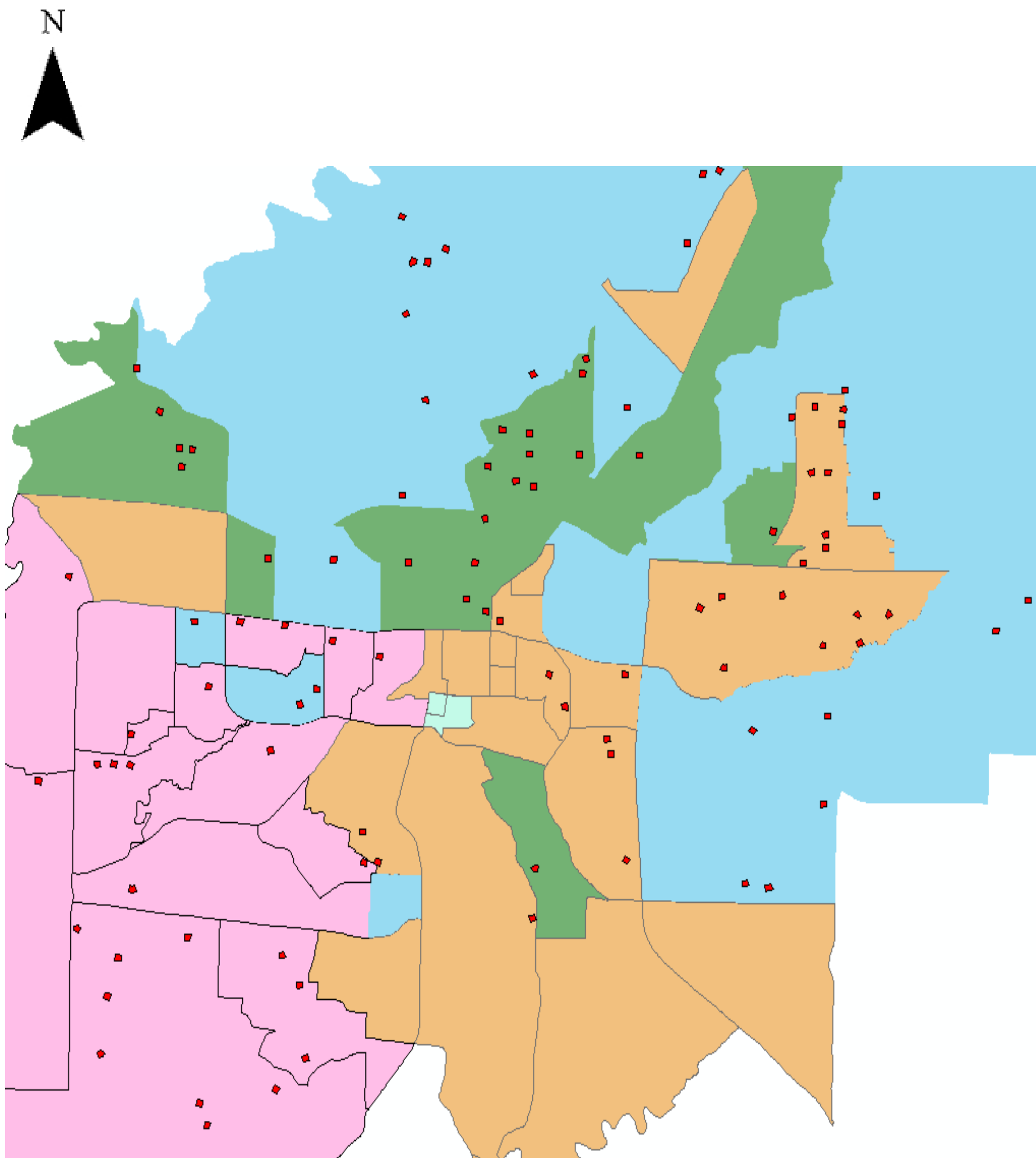
	Very Important	Somewhat Important	Not Important At All
A lawn without weeds			
Ease of maintenance			
Flowers on the lawn			
Open grass without trees and shrubs			
Lots of trees and shrubs			
Environmental value			
Wildlife use of the yard			

5) What types of plants are present in your yard (circle one)

All native	Mostly native	Native and non-native	Mostly non-native	All non-native	I don't know

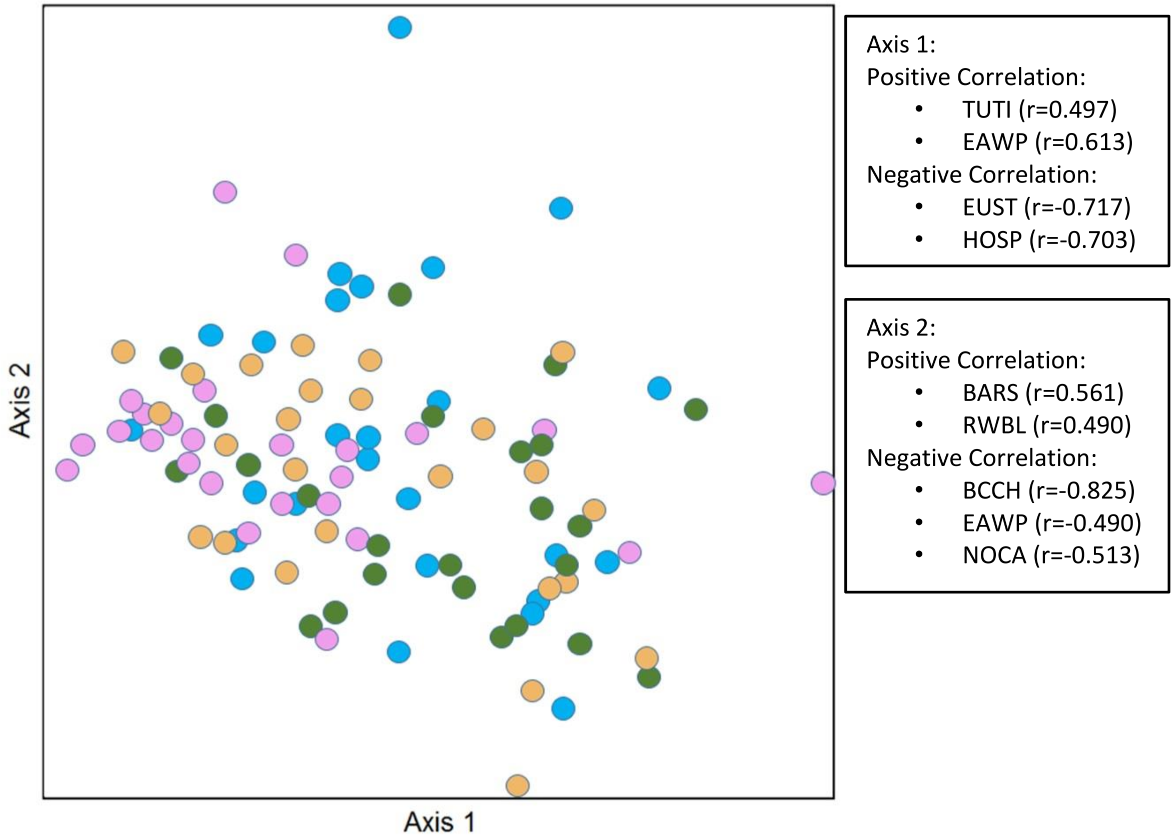
Figures

Figure 1. Map of social areas and randomly selected points.



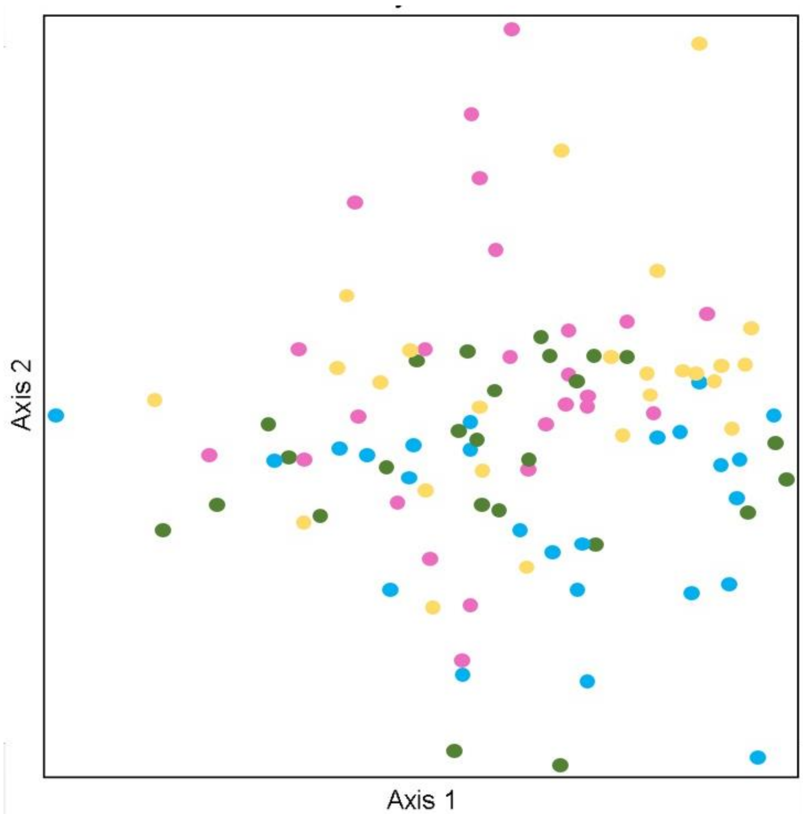
Social Area	
Social Area 1	Blue
Social Area 2	Pink
Social Area 3	Green
Social Area 4	Tan

Figure 2. Ordination of transects using bird communities



Social Area	
Social Area 1	**Blue**
Social Area 2	**Pink**
Social Area 3	**Green**
Social Area 4	**Tan**

Figure 3. Ordination of transects using vegetation cover and composition observed from line intercept surveys and GIS.



Axis 1:
Positive Correlation:

- GIS impervious(r=0.537)
- GIS lawn(r=0.762)

Negative Correlation:

- Leaf litter, tree, and shrub ground cover (r=-0.546, -0.534,-0.540)
- Shrub and canopy cover (r=-0.627, 0.871)
- GIS tree and shrub cover (r=-0.962)

Axis 2:
Positive Correlation:

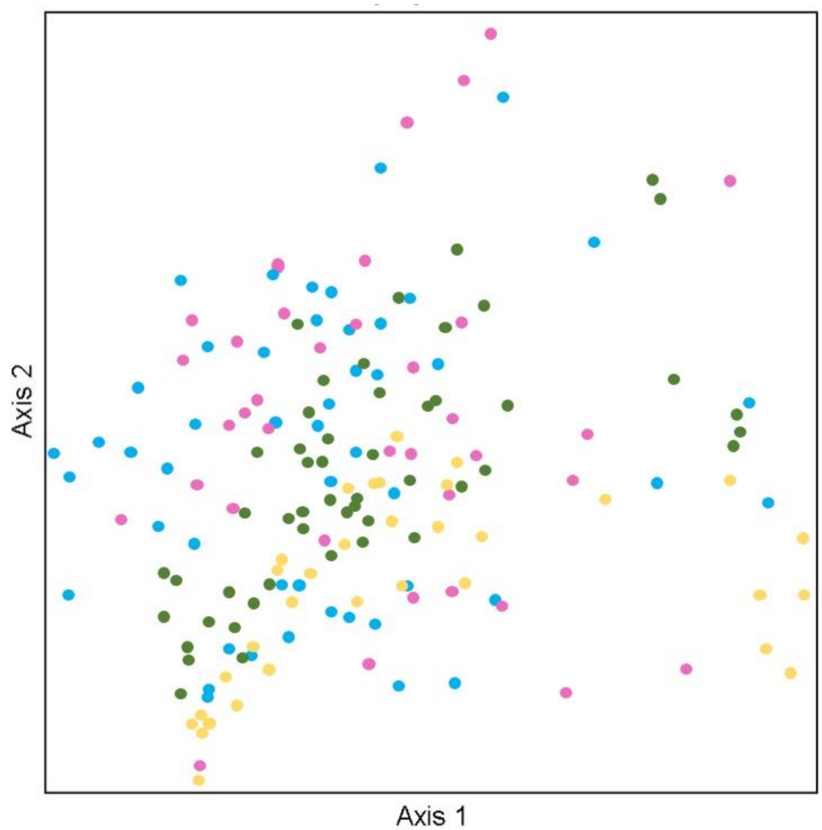
- Artificial surface ground cover (r=0.942)
- GIS impervious (r=0.770)

Negative Correlation:

- Grass ground cover (r=-0.825)
- GIS lawn (r=-0.490)

Social Area	
Social Area 1	Blue
Social Area 2	Pink
Social Area 3	Green
Social Area 4	Tan

Figure 4. Ordination of transects using vegetation cover and composition, and micro-garden cover observed from back yard surveys.



Axis 1:
Positive Correlation:

- Forest micro-garden cover (r=0.699)
- Leaf litter, woody litter, tree, shrub and vine ground cover (r=0.613, 0.706, 0.623, 0.528, 0.520)
- Shrub layer, and canopy cover (r=0.690, 0.780)

Negative Correlation:

- Lawn micro-garden cover (r=-0.895)
- Grass ground cover (r=-0.861)

Axis 2:
Positive Correlation:

- Shrub ground cover (r=0.585)
- Ornamental micro-garden cover (r=0.596)
- Artificial surface ground cover (r=0.496)
- Managed without plants micro-garden cover (r=0.462)

Negative Correlation:

- Lawn micro-garden cover (r=-0.449)

Social Area	
Social Area 1	**Blue**
Social Area 2	**Pink**
Social Area 3	**Green**
Social Area 4	**Tan**

Tables

Table 1. Overview of surveys preformed within each transect.

Sampling Method	Description
Strip transect surveys of the bird community	4 strip transect surveys running the full length of each transect were preformed in the months of May and June in 2015 and 2016 for every transect.
Line intercept vegetation sampling	Ground cover, vegetation strata percent cover, and dominant species in the shrub and canopy were estimated visually perpendicular to the road every 5 meters running the full length of every transect.
Back yard vegetation sampling	Ground cover, vegetation strata percent cover, micro-garden percent cover, dominant species in the shrub and canopy were visually estimated in the back yards of properties we were given permission to access. Five 10 meter transects were laid out proportionally representing micro-garden cover, and the plant species present was recorded every 1 meter
Mail questionnaire	A brief questionnaire regarding land management practices, and preferences was mailed to all residents whose homes fell within any one of our transects.

Table 2. Total abundance of all bird species detected for all counts and all transects.

Species	**Common Name**	**AOU Code**	**Abundance**
Empidonax virescens	Acadian Flycatcher	ACFL	12
Corvus brachyrhynchos	American Crow	AMCR	160
Spinus tristis	American Goldfinch	AMGO	294
Falco sparverius	American Kestrel	AMKE	4
Setophaga ruticilla	American Redstart	AMRE	3
Turdus migratorius	American Robin	AMRO	2737
Strix varia	Barred Owl	BADO	1
Riparia riparia	Bank Swallow	BANS	3
Icterus galbula	Balitmore Oriole	BAOR	15
Hirundo rustica	Barn Swallow	BARS	526
Coccyzus erythropthalmus	Black-billed Cuckoo	BBCU	2
Poecile atricapillus	Black-capped Chickadee	BCCH	1115
Megaceryle alcyon	Belted Kingfisher	BEKI	39
Polioptila caerulea	Blue-gray Gnatcatcher	BGGN	3
Molothrus ater	Brown-headed Cowbird	BHCO	688
Cyanocitta cristata	Blue Jay	BLJA	609
Toxostoma rufum	Brown Thrasher	BRTH	28
Branta canadensis	Canada Goose	CANG	298
Thryothorus ludovicianus	Carolina Wren	CARW	153
Bombycilla cedrorum	Cedar Waxwing	CEDW	197
Spizella passerina	Chipping Sparrow	CHSP	300
Chaetura pelagica	Chimney Swift	CHSW	633
Petrochelidon pyrrhonota	Cliff Swallow	CLSW	20
Quiscalus quiscula	Common Grackle	COGR	1505
Accipiter cooperii	Cooper's Hawk	COHA	3
Chordeiles minor	Common Nighthawk	CONI	9
Geothlypis trichas	Common Yellowthroat	COYE	3
Spiza americana	Dickcissel	DICK	17
Picoides pubescens	Downy Woodpecker	DOWO	54
Sialia sialis	Eastern Bluebird	EABL	94
Tyrannus tyrannus	Eastern Kingbird	EAKI	32
Sturnella magna	Eastern Meadowlark	EAME	4
Sayornis phoebe	Eastern Phoebe	EAPH	112
Pipilo erythrophthalmus	Eastern Towhee	EATO	17
Contopus virens	Eastern Wood-pewee	EAWP	334
Streptopelia decaocto	Eurasian Collared-dove	EUCD	16
Sturnus vulgaris	European Starling	EUST	3835
Spizella pusilla	Field Sparrow	FISP	19
Ardea herodias	Great Blue Heron	GBHE	14
Myiarchus crinitus	Great Crested Flycatcher	GCFL	20
Dumetella carolinensis	Gray Catbird	GRCA	41

Ardea alba	Great Egret	GREG	1
Anser anser	Graylag Goose (Domestic)	GRGO	10
Butorides virescens	Green Heron	GRHE	6
Picoides villosus	Hairy Woodpecker	HAWO	59
Haemorhous mexicanus	House Finch	HOFI	788
Passer domesticus	House Sparrow	HOSP	4830
Troglodytes aedon	House Wren	HOWR	611
Passerina cyanea	Indigo Bunting	INBU	50
Charadrius vociferus	Killdeer	KILL	57
Tringa flavipes	Lesser Yellowlegs	LEYE	2
Melospiza lincolnii	Lincoln Sparrow	LISP	1
Parkesia motacilla	Louisiana Waterthrush	LOWA	2
Anas platyrhynchos	Mallard	MALL	4
Cistothorus palustris	Marsh Wren	MAWR	1
Ictinia mississippiensis	Mississippi Kite	MIKI	1
Zenaida macroura	Mourning Dove	MODO	5
Oreothlypis ruficapilla	Nashville Warbler	NAWA	836
Colinus virginianus	Northern Bobwhite	NOBO	6
Cardinalis cardinalis	Northern Cardinal	NOCA	1786
Colaptes auratus	Northern Flicker	NOFL	34
Mimus polyglottos	Northern Mockingbird	NOMO	200
Setophaga americana	Northern Parula	NOPA	106
Stelgidopteryx serripennis	Northern Rough-winged Swallow	NRWS	10
Oreothlypis celata	Orange-crowned Warbler	OCWA	1
Icterus spurius	Orchard Oriole	OROR	7
Seiurus aurocapilla	Ovenbird	OVEN	1
Dryocopus pileatus	Pilleated Woodpecker	PIWO	1
Progne subis	Purple Martin	PUMA	47
Pheucticus ludovicianus	Rose-breasted Grosbeak	RBGR	1
Melanerpes carolinus	Red-bellied Woodpecker	RBWO	346
Vireo olivaceus	Red-eyed Vireo	REVI	11
Melanerpes erythrocephalus	Red-headed Woodpecker	RHWO	11
Columba livia	Rock Pigeon	ROPI	20
Buteo lineatus	Red-shoulderd Hawk	RSHA	8
Buteo jamaicensis	Red-tailed Hawk	RTHA	19
Archilochus colubris	Ruby-throated Hummingbird	RTHU	36
Agelaius phoeniceus	Red-winged Blackbird	RWBL	221
Calidris pusilla	Semipalmated Sandpiper	SESA	2
Melospiza melodia	Song Sparrow	SOSP	2
Actitis macularius	Spotted Sandpiper	SPSA	1
Accipiter striatus	Sharp-shinned Hawk	SSHA	4
Tyrannus forficatus	Scissor-tailed Flycatcher	STFL	1
Piranga rubra	Summer Tanager	SUTA	16

Catharus ustulatus	Swainson Thrush	SWTH	12
Oreothlypis peregrina	Tennessee Warbler	TEWA	3
Tachycineta bicolor	Tree Swallow	TRSW	173
Baeolophus bicolor	Tufted Titmouse	TUTI	227
Cathartes aura	Turkey Vulture	TUVU	25
Empidonax spp	Empidonax spp	UEFL	2
Vireo gilvus	Warbling Vireo	WAVI	1
Sitta carolinensis	White-breasted Nuthatch	WBNU	108
Zonotrichia leucophrys	White-crowned Sparrow	WCSP	5
Vireo griseus	White-eyed Vireo	WEVI	5
Empidonax traillii	Willow Flychatcher	WIFL	8
Hylocichla mustelina	Wood Thrush	WOTH	5
Zonotrichia albicollis	White-throated Sparrow	WTSP	16
Icteria virens	Yellow-breasted Chat	YBCH	13
Coccyzus americanus	Yellow-billed Cuckoo	YBCU	10
Setophaga petechia	Yellow Warbler	YEWA	22
Setophaga coronata	Yellow-rumped Warbler	YRWA	15

Table 3. Mean (SD) of bird community descriptors in each social area means within the same column with different letters have statistically different ($p<0.02$) according to TukeyHSD comparisons

Social Area	Abundance	Species Richness	Shannon Diversity Index
1	245.8(16.0)A	26.6(1.1)	2.51(0.06)
2	275.2(14.0)AB	22.5(1.2)	2.25(0.8)
3	217.7(12.0)AC	24.2(1.1)	2.46(0.07)
4	214.4(9.6)AC	23.8(1.1)	2.31(0.09)

Table 4. Bird species which correlate with ordination axes in the ordination of bird communities.

Axis	**1**	**2**
Species	**r**	**r**
AMGO	.478	-.022
BARS	.138	.560
BCCH	.286	-.594
EAWP	.613	-.557
EUST	-.717	.411
HAWO	.196	-.483
HOSP	-.703	.180
NOCA	.198	-.514
NOMO	207	.464
RWBL	.115	.489
TUTI	.497	-.419

Table 5. Mean (SD) of bird abundance in each social area means within the same column with different letters have statistically different (p<0.02) according to TukeyHSD comparisons.

Social Area	BARS	BCCH	EAWP	EUST	HOSP	NOCA	RWBL	TUTI
1	11.3(19.2)AB	11.1(7.6)	2.6(3.6)	39.4(27.8)A	36.9(28.5)	17.4(7.1)	5.52(13.8)	2.8(2.3)
2	2.5(4.4)AC	9.0(4.4)	2.8(3.6)	56.7(39.4)AB	63.5(45.2)	18.8(8.1)	0.8(3.2)	1.9(1.5)
3	4.5(9.5)A	13.1(9.5)	4.2(3.0)	23.3(23.9)AC	38.7(31.3)	18.5(7.4)	0.5(2.0)	2.4(2.8)
4	2.8(6.1)AC	11.4(6.1)	3.7(3.5)	34.0(31.3)A	54.2(37.9)	16.7(7.4)	2.0(7.0)	2.0(1.8)

Table 6. Maximum likelihood Poisson regression of European starling abundance using questionnaire data.

Variable	Poisson		
	Coefficient(SE)	t value	P Value
Intercept	66.40(10.43)	6.37	<0.001
Management score	-6.04(1.85)	-3.27	0.002
PC1 score	-0.87(2.14)	-0.41	0.69
PC2 score	-4.88(3.08)	-1.58	0.117
PC3 score	-11.03(3.28)	-3.37	0.001
PC4 score	5.97(3.30)	1.81	0.075
PC5 Score	3.93(4.35)	0.90	0.369
PC6 Score	8.02(4.15)	1.93	0.057
Likelihood Ratio χ^2	892.3		
P Value	<0.001		

Table 7. Maximum likelihood of Poisson regression of northern cardinal abundance using questionnaire data.

Variable	Poisson		
	Coefficient(SE)	t value	P Value
Intercept	17.32(2.52)	6.88	<0.001
Management score	0.22(0.45)	0.48	0.631
PC1 score	-0.23(0.52)	-0.45	0.653
PC2 score	1.53(0.74)	2.06	0.043
PC3 score	1.09(0.79)	1.38	0.172
PC4 score	-1.94(0.80)	-2.43	0.017
PC5 Score	-0.45(1.05)	-0.43	0.672
PC6 Score	-0.50(1.00)	-0.50	0.619
Likelihood Ratio χ^2	584.9		
P Value	<0.001		

Table 8. Average percent ground cover observed from line intercept surveys.

Ground Cover type	**Average % (SE)**
Artificial Surface	36.11(13.02)
Bare Ground	2.95(2.20)
Forbs	5.06(3.20)
Grass	50.29(13.01)
Leaf Litter	1.09(1.91)
Woody Litter	0.44(0.78)
Tree	0.72(0.89)
Shrub	2.19(2.15)
Vine	0.59(1.56)
Rock	0.14(0.37)
Water	0.20(1.39)

Table 9. Ten most common plants detected in the shrub layer observed from line intercept surveys.

Common Name	**Scientific Name**	**% of Cover**
Bush Honeysuckle	*Diervilla spp.*	52.39
Eastern Red Cedar	*Juniperus virginiana*	5.96
Multiflora Rose	*Rosa multiflora*	5.53
Boxwood	*Buxus spp.*	4.43
Yew	*Taxus spp.*	2.74
Eastern White Pine	*Pinus strobus*	1.62
Juniper	*Juniperus Spp.*	1.25
Eastern Redbud	*Cercis canadensis*	1.10
Grape Vine	*Vitis spp*	1.03
Blackberry	*Rubus spp*	0.89

Table 10. Ten most common plants detected in the canopy layer observed from line intercept surveys.

Common Name	Scientific Name	% of Cover
Pin Oak	*Quercus palustris*	14.62
Silver Maple	*Acer saccharinum*	7.83
Red Oak	*Quercus rubrus*	6.14
Norway Maple	*Acer platanoides*	5.87
Bradford Pear	*Pyrus calleryana 'Bradford'*	5.20
White Oak	*Quercus alba*	4.76
Red Maple	*Acer rubrum*	4.43
Sweetgum	*Liquidambar styraciflua*	4.31
Eastern Redbud	*Cercis canadensis*	3.80
American Sycamore	*Platanus occidentalis*	3.67

Table 11. Mean (SD) cover variables observed from line intercept transects in each social area means within the same column with different letters have statistically different (p<0.02) according to TukeyHSD comparisons.

Social Area	Artificial Surface	Bare Ground	Forbs	Grass	Leaf Litter	Woody Litter	Trees	Shrubs	Vines	Rock	Water	% Shrub Cover	%Canopy Cover
1	28.3(9.1)AB	3.1(3.1)	5.4(3.6)	57.1(14.0)AB	1.1(1.8)	0.5(0.7)	0.8(0.7)	2.1(2.1)	0.8(2.4)	0.3(0.5)	0.5(2.4)	3.4(3.6)	19.8(17.5)
2	41.4(14.1)AC	2.5(1.6)	6.1(2.9)	45.0(13.3)AC	0.9(2.1)	0.4(0.6)	1.0(1.4)	2.3(2.7)	0.4(0.4)	0.1(0.1)	0.0(0.0)	5.9(6.0)	22.5(14.0)
3	33.5(10.7)A	3.2(1.9)	3.7(2.4)	53.3(10.2)A	1.4(2.3)	0.6(1.2)	0.8(0.7)	2.3(1.7)	1.0(2.0)	0.1(0.2)	0.0(0.2)	4.3(3.2)	24.7(15.1)
4	41.1(13.3)AC	3.0(2.0)	5.0(3.5)	46.2(11.9)AC	0.9(1.5)	0.3(0.6)	0.3(0.4)	2.2(2.1)	0.4(0.7)	0.2(0.4)	0.4(2.0)	3.8(3.6)	17.3(15.5)

Table 12. Mean (SD) of cover data from GIS in each social area means within the same column with different letters have statistically different ($p<0.02$) according to TukeyHSD comparisons.

Social Area	Tree and Shrub	Impervious	Lawn	Water
1	24.6(20.6)	28.5(10.4)	46.7(16.9)AB	0.2(0.8)
2	30.7(14.5)	37.2(15.4)	32.1(11.2)AC	0.0(0.0)
3	32.8(20.7)	29.6(11.1)	37.6(16.3)A	0.0(0.0)
4	24.2(20.4)	38.3(12.8)	37.3(12.3)A	0.2(1.0)

Table 13. Variables that correlate with the axes of the ordination of the transects using line intercept cover and composition, and cover data from GIS.

Axis	1	2
Cover	**r**	**r**
Bare Ground	-.487	.133
Leaf Litter	-.546	-.106
Tree ground Cover	-.534	-.096
Shrub Ground Cover	-.540	-.045
% Shrub layer cover	.627	-.024
% Canopy cover	-.871	-.155
Artificial Surface	.137	.942
Grass	.304	-.825

Table 14. Average ground cover from back yards surveys

Ground Cover type	**Average % (SE)**
Artificial Surface	8.61(10.4)
Bare Ground	6.16(5.84)
Forbs	13.61(13.19)
Grass	48.32(25.15)
Leaf Litter	3.76(7.62)
Woody Litter	1.86(3.02)
Tree	4.15(3.62)
Shrub	8.02(7.58)
Vine	3.34(5.01)
Rock	0.99(2.44)
Water	0.51(1.51)

Table 15. Average micro-garden cover from back yard surveys

Ground Cover type	Average % (SE)
Ornamental	9.92(10.03)
Vegetable	2.86(7.05)
Lawn	64.29(26.36)
Managed no plants	11.05(14.69)
Forest mostly native	9.18(19.10)
Open mostly native	3.11(11.10)

Table 16. Ten most common plants detected in the shrub layer observed from back yard surveys.

Common Name	Scientific Name	% of Cover
Bush Honeysuckle	*Diervilla spp.*	52.39
Privet	*Ligustrum spp.*	5.96
Eastern Red Cedar	*Juniperus virginiana*	5.53
Multiflora Rose	*Rosa multiflora*	4.43
Boxwood	*Buxus spp.*	2.74
Grape Vine	*Vitis spp*	1.62
Wisteria	*Wisteria spp.*	1.25
Day Lily	*Hemerocallis spp.*	1.10
Virginia Creeper	*Parthenocissus quinquefolia*	1.03
Eastern Redbud	*Cercis canadensis*	0.89

Table 17. Ten most common plants detected in the canopy layer observed from back yard surveys.

Common Name	**Scientific Name**	**% of Cover**
Shagbark Hickory	*Carya ovata*	14.62
Silver Maple	*Acer saccharinum*	7.83
White Oak	*Quercus alba*	6.14
Black Walnut	*Juglans nigra*	5.87
Pin Oak	*Quercus palustris*	5.20
Sugar Maple	*Acer saccharum*	4.76
Eastern Redbud	*Cercis canadensis*	4.43
Green Ash	*Fraxinus pennsylvanica*	4.31
Red Oak	*Quercus rubrus*	3.80
American Elm	*Ulmus americana*	3.67

Table 18. Ten most common plants detected in back yard surveys.

Common Name	Scientific Name	# of yards present
Turf Grass	*N/A*	162
Misc. Forb	*N/A*	108
Bush Honeysuckle	*Diervilla spp.*	104
Dandelion	*Taraxacum spp.*	71
Eastern Redbud	*Cercis canadensis*	69
White Clover	*Trifolium repens*	64
Day Lily	*Hemerocallis spp.*	59
Eastern Red Cedar	*Juniperus virginiana*	52
Virginia Creeper	*Parthenocissus quinquefolia*	52
Grape Vine	*Vitis spp*	52

Table 19. Variables that correlate with the axes of the ordination of yards using cover and composition observed in back yard surveys

Axis	**1**	**2**
Cover	**r**	**r**
Microgarden: Lawn	-.895	-.449
Microgarden: forest	.699	-.194
Grass	-.861	-.335
Leaf Litter	.706	-.118
Woody Litter	.623	.058
Tree ground cover	.626	.052
Shrub Ground cover	.528	.585
Vine Ground Cover	.520	.123
Shrub layer cover	.690	.420
Canopy Cover	.780	.028
Microgarden: Ornamental	.187	.596
Microgarden: managed no plants	.358	.462
Artificial Surface	.280	.496

Table 20. Mean (SD) cover variables observed from back yard surveys in each social area means within the same column with different letters have statistically different (p<0.02) according to TukeyHSD comparisons.

Social Area	Artificial Surface	Bare Ground	Forbs	Grass	Leaf Litter	Woody Litter	Trees	Shrubs	Vines	Rock	Water	% Shrub Cover	%Canopy Cover
1	7.9(7.1)	5.0(4.7)	12.4(10.2)	50.7(22.5)	2.4(3.1)AB	1.9(2.7)	4.9(4.4)	6.7(5.5)	3.6(7.9)	1.3(3.4)	0.4(1.6)	11.9(8.8)	23.2(21.8)
2	12.1(19.8)	6.0(7.5)	18.3(15.8)	41.2(24.2)	3.0(4.6)A	1.9(3.7)	3.9(3.5)	8.7(8.0)	3.5(3.2)	0.6(1.2)	0.5(1.4)	15.4(15.4)	37.3(26.1)
3	7.9(4.2)	7.6(5.4)	11.4(13.4)	50.4(25.2)	3.0(4.7)AC	1.8(2.8)	4.0(3.0)	9.3(9.1)	3.3(3.5)	0.8(2.2)	0.7(1.6)	17.1(17.9)	31.2(26.4)
4	6.9(5.1)	5.8(5.8)	13.8(13.1)	49.2(29.2)	7.8(14.6)A	1.8(3.2)	3.6(3.4)	7.2(6.9)	2.8(3.0)	1.2(2.1)	0.5(1.5)	16.0(15.8)	37.9(36.2)

Table 21. Mean (SD) of micro-garden cover observed from back yard surveys in each social area means within the same column with different letters have statistically different ($p<0.02$) according to TukeyHSD comparisons.

Social Area	Ornamental	Vegetable	Lawn	Managed no plants	Forest mostly native	Open mostly native
1	7.8(8.2)	2.6(6.2)	66.8(25.5)	8.8(9.6)	9.6(17.9)	4.2(15.1)
2	8.8(7.6)	4.0(7.4)	62.6(25.0)	13.5(20.5)	6.5(10.4)	4.8(11.9)
3	13.4(13.0)	2.9(9.0)	65.8(24.7)	11.8(14.1)	7.1(17.0)	0.7(3.0)
4	8.9(8.3)	1.9(3.8)	60.0(31.6)	10.5(14.4)	14.8(28.7)	3.5(11.0)

Table 22. Percentages of responses for each question in the questionnaire.

In your opinion, how important are the following elements in a yard?			
	Very Important	Somewhat Important	Not Important At All
Mowed lawn	71.6%	21.33%	7.1090047%
Ornamental shrubs and trees	52.3%	40.65%	7.0093458%
Space for recreation	52.7%	39.19%	8.1081081%
Habitat for wildlife	42.2%	42.15%	15.6950673%
Flowering plants	53.4%	39.01%	7.6233184%
Cultivation of Fruits and Vegetables	24.9%	44.34%	30.7692308%

If you have a lawn, how often do the following occur?			
Fertilizing	More than once a year 48.5981308%	Once a year 25.2336449%	Never 26.1682243%
Watering	More than 3 times a month 28.372093%	1-2 times a month 32.5581395%	Never 39.0697674%
Mowing	More than 3 times a month 66.97247706%	1-2 times a month 32.56880734%	Never 0.458715596%
Weeding	More than 3 times a month 20.83333333	1-2 times a month 50.46296296%	Never 28.7037037%
Application of Chemicals	More than once a year 33.7962963%	Once a year 26.38888889%	Never 39.81481481%

How important are the following uses of your yard?			
	Very Important	Somewhat Important	Not Important At All
A place for exercise	18.26484%	40.182648%	41.552511%
A decorative space	44.79638%	48.41629%	6.7873303%
A place to experience nature	50%	40.909091%	9.0909091%
A place to relax	71.363636%	25%	3.6363636%
A place for social activities	47.963801%	39.366516%	12.669683%
other	66.666667%	18.181818%	15.151515%

How important are the following characteristics of a yard to you			
	Very Important	Somewhat Important	Not Important At All
A lawn without weeds	41.2556%	40.8072%	17.937%
Ease of maintenance	67.1171%	31.0811%	1.8018%
Flowers on the lawn	33.3333%	48.6486%	18.018%
Open grass without trees and shrubs	18.6364%	40.4545%	40.909%
Lots of trees and shrubs	32.7354%	55.157%	12.108%
Environmental value	44.3439%	48.4163%	7.2398%
Wildlife use of the yard	37.9464%	41.0714%	20.982%

What types of plants are present in your yard (circle one					
All native 3.14%	Mostly native 18.8341%	Native and non-native 52.9148%	Mostly non-native 7.6233184%	All non-native 1.793722%	I don't know 15.69507%

Table 23. Comments respondents made on the questionnaire.

this is vacant land, it is minimally maintained. We will build on this land in 1-2 years
fert= use organic materials provided by the lawn company
other=pet use
water, chem and fert=only garden, not grass,
water,mow,weed=as needed
other=food production
other= growing vegtables
weed=flowe beds and garden only
mowing=1-2x/yr
planning to plant the entire front yard using native plants, flowers and grasses this coming winter and spring
long note, other=fruits and vegies, water=1-2x/yr if needed, weed=flower and veg beds only
other=entertaining
fert, chem= occasionaly
other= a place for my dog to chase squirrels
other=growing food
water=rarely, weed=1x/yr
fert= w/ compsot ect
chem=compost and corn gluten only
water,mow,weed=summer, chem=spring and fall
all lawn ocurance= n/a
other=pets
other=view, no lawn
other=feeding birds/butterflies
other(as well as bunch of catagories)=dogs
water= as needed
weed=every 6 weeks
watering only if needed
long note on back, water=rarely
water=only in drought, weed=1-2x/yr
other= whatch birds
lots of small notes
water,mow,weed, chem= when needed
other=clean and neat appearance
water=depends on weather, other= growing food
other= dog area
water=only front yard in drought, weed=only in garden
"I do not have a lawn, flowers for bees and butterflies
water=depends on rain
other=growing herbs and veg
unsure of most due to renting
other=fire pit
water=depends
mow= 1x/2mo, weed=1x/4mo
other= dog, lawn w/o weed= :) and 3 check marks

Table 24. Components from the principal component analysis of questionnaires, with corresponding loadings of questions for the first six components.

AXIS	Eigenvalue	% of Variance	Cum.% of Varience	Eigenvalue
1	3.721	19.585	19.585	3.548
2	2.718	14.303	33.888	2.548
3	1.77	9.314	43.203	2.048
4	1.408	7.408	50.611	1.714
5	1.2	6.314	56.925	1.464
6	1.079	5.681	62.606	1.264
7	0.936	4.928	67.533	1.098
8	0.873	4.595	72.128	0.955
9	0.76	4.001	76.129	0.83
10	0.673	3.54	79.669	0.719

	Eigenvector					
Question	**1**	**2**	**3**	**4**	**5**	**6**
Lawn	0.2048	-0.4361	-0.206	-0.0695	0.4062	0.2804
Tree	-0.221	-0.3533	-0.4735	-0.2217	-0.0765	0.4237
Space	-0.3786	-0.3644	0.1259	0.5230	-0.0565	0.2685
Habitat	-0.5722	0.5478	-0.0406	-0.0152	0.3015	0.0006
Flower	-0.5051	-0.0799	-0.6075	0.0433	-0.2387	-0.0513
Fruit	-0.4612	0.2385	-0.1016	0.4337	-0.2062	0.1453
Exercise	-0.4642	-0.2368	0.4353	0.3103	-0.1139	0.2596
D植or	-0.4433	-0.4592	0.0402	-0.6851	-0.1474	-0.0439
Nature	-0.7091	0.0417	0.2734	-0.4026	0.0579	-0.0734
Relax	-0.6015	-0.4389	0.313	-0.2127	0.0064	-0.2146
Social	-0.5777	-0.474	0.3365	0.0117	-0.0383	-0.0786
Other	-0.2675	0.2073	0.1123	0.2492	-0.0821	-0.2152
NoWeed	0.0007	-0.5269	-0.4516	-0.0427	0.3105	-0.1945
Maintain	-0.0948	-0.3263	-0.1475	0.4586	0.3163	-0.4156
FlowerLw	-0.4213	-0.1358	-0.5107	0.1279	-0.2656	-0.3331
Open	-0.1667	-0.4343	0.0806	0.1502	0.3665	0.2134
Woody	-0.4048	0.2554	-0.3052	-0.2482	-0.0747	0.3246
Environ	-0.5722	0.4356	-0.174	-0.0330	0.2459	0.0155
Animal	-0.5515	0.5756	0.0066	-0.0055	0.3491	0.0137

- positive loadings >0.4
- negative loadings <-0.4

Table 25. Mean (SD) of management and component scores in each social area means within the same column with different letters have statistically different (p<0.02) according to TukeyHSD comparisons.

Social Area	Management Score
1	4.93(2.69)AC
2	4.40(2.98)AC
3	6.39(2.55)AB
4	5.61(2.70)A

Table 26. Multiple Linear regression of management score with component scores.

Model	Beta (SE)	T-value	P-Value
Intercept	5.44(0.15)	36.255	<0.001
PC1	0.15(0.08)	1.987	0.048
PC2	-0.83(0.09)	-9.067	<0.001
PC3	-0.61(0.11)	-5.436	<0.001
PC4	-0.39(0.12)	-3.084	0.002
PC5	0.23(0.14)	1.662	0.098
PC6	-0.04(0.14)	-0.258	0.797

r^2=0.37, p<0.001

Table 27. Multiple linear regression of ornamental micro-garden cover with questionnaire scores.

Model	Beta (SE)	T-value	P-Value
Intercept	13.03(2.95)	4.41	<0.001
Management score	-0.16(0.51)	-0.32	0.750
PC1	-0.93(0.63)	-1.48	0.142
PC2	0.38(0.81()	0.47	0.641
PC3	-1.43(0.90)	-1.59	0.116
PC4	-3.11(0.99)	-3.14	0.002
PC5	0.28(1.44)	0.27	0.789
PC6	1.34(1.07)	1.25	0.214

r^2=0.16, p=0.019

Table 28. Multiple linear regression of lawn micro-garden cover with questionnaire scores.

Model	Beta (SE)	T-value	P-Value
Intercept	68.362(5.98)	11.42	<0.001
Management score	-0.799(1.04)	-0.77	0.444
PC1	1.52(1.28)	1.19	0.237
PC2	-5.91(1.66)	-3.57	<0.001
PC3	-2.52(1.83)	-1.38	0.171
PC4	5.64(2.01)	2.81	0.006
PC5	5.67(2.12)	2.68	0.008
PC6	0.17(2.17)	0.08	0.939

r^2=0.28, p<0.001

Table 29. Multiple linear regression of forest micro-garden cover with questionnaire scores.

Model	Beta (SE)	T-value	P-Value
Intercept	6.95(4.19)	1.66	0.100
Management score	0.04(0.73)	0.06	0.954
PC1	-0.56(0.89)	-0.63	0.531
PC2	4.04(1.16)	3.49	<0.001
PC3	1.76(1.28)	1.37	0.173
PC4	-0.49(1.41)	-0.35	0.726
PC5	-1.57(1.48)	-1.06	0.291
PC6	-3.43(1.52)	-2.26	0.026

r^2=0.26, p<0.001

Table 30. Multiple linear regression of plant species richness with questionnaire scores.

Model	**Beta (SE)**	**T-value**	**P-Value**
Intercept	14.80(1.34)	11.03	<0.001
Management score	0.23(0.23)	0.98	0.328
PC1	-0.42(0.29)	-1.47	0.146
PC2	1.08(0.37)	2.91	0.005
PC3	0.10(0.41)	0.23	0.816
PC4	-0.14(0.45)	-0.31	0.757
PC5	-1.08(0.47)	-2.27	0.026
PC6	0.39(0.49)	0.80	0.427

r^2=0.17, p=0.014

Table 31. Multiple linear regression of percent native plant species with questionnaire scores for amount of native vegetation.

Model	Beta (SE)	T-value	P-Value
Intercept	41.24(4.49)	9.20	<0.001
Management score	0.81(0.78)	1.04	0.303
PC1	0.05(0.96)	0.05	0.962
PC2	4.14(1.24)	3.33	0.001
PC3	0.95(1.37)	0.69	0.491
PC4	-1.92(1.51)	-1.28	0.205
PC5	1.39(1.59)	0.88	0.383
PC6	1.96(1.62)	1.21	0.231

r^2=0.16, p=0.027

Table 32. Linear regression of native score and percent native coverage.

Model	Beta	St Error	T-value	P	R^2
Native Score	-2.367	1.602	-1.478	0.143	0.02

Table 33. Maximum likelihood of negative binomial regression of barn swallow abundance using cover and composition of vegetation observed from line intercept surveys and GIS.

Variable	Negative Binomial		
	Coefficient(SE)	z value	P value
Intercept	2.63(1.54)	1.702	0.089
Line Intercept Canopy Cover	0.01(0.02)	0.419	0.675
GIS Lawn Cover	-0.08(0.03)	-2.787	0.005
GIS Tree and Shrub Cover	-0.02(0.03)	-0.758	0.449
Woody Species Richness	0.08(0.09)	0.942	0.346
Likelihood Ratio AIC	-325.2		
P Value	<0.001		

Table 34. Maximum likelihood of Poisson regression of black-capped chickadee abundance using cover and composition of vegetation observed from line intercept surveys and GIS.

Variable	Poisson		
	Coefficient(SE)	t value	P value
Intercept	-3.55(3.72)	-0.954	0.343
GIS Lawn Cover	0.08(0.06)	1.299	0.197
GIS Tree and Shrub Cover	0.20(0.07)	2.783	0.007
Woody Species Richness	0.58(0.22)	2.612	0.011
Line Intercept Canopy Cover	0.01(0.07)	0.897	0.897
Likelihood Ratio χ^2	658		
P Value	<0.001		

Table 35. Maximum likelihood of Poisson regression of house sparrow abundance using cover and composition of vegetation observed from line intercept surveys and GIS.

Variable	Poisson		
	Coefficient(SE)	t value	P value
Intercept	124.68(20.16)	6.184	<0.001
GIS Lawn Cover	-1.53(0.34)	-4.521	<0.001
GIS Tree and Shrub Cover	-1.84(0.39)	-4.670	<0.001
Woody Species Richness	1.60(1.20)	1.333	0.186
Line Intercept Canopy Cover	0.85(0.39)	2.194	0.031
Likelihood Ratio χ^2	996.4		
P Value	<0.001		

Table 36. Maximum likelihood of Poisson regression of northern cardinal abundance using cover and composition of vegetation observed from line intercept surveys and GIS.

Variable	Poisson		
	Coefficient(SE)	t value	P value
Intercept	6.63(3.63)	1.83	0.071
GIS Lawn Cover	0.04(0.06)	0.652	0.516
GIS Tree and Shrub Cover	0.16(0.07)	2.226	0.028
Woody Species Richness	0.70(0.22)	3.225	0.002
Line Intercept Canopy Cover	-0.07(0.07)	-1.108	0.271
Likelihood Ratio χ^2	653.8		
P Value	<0.001		