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Impacts of Residential Garden Practice on Bird and Butterfly Communities in Southeast Kansas

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IMPACTS OF RESIDENTIAL GARDEN PRACTICES ON BIRD AND BUTTERFLY COMMUNITIES IN SOUTHEAST KANSAS

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An Abstract of the Thesis by
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Ecological research indicates that global species richness is declining due to a combination of urbanization and human population growth that fragments and simplifies the landscape. As these rates continue to grow, the value of urban greenspaces increases. If managed properly, residential greenspaces can help to maintain species richness and mitigate landscape simplifications. However, residential greenspaces are often the result of a number of individual management decisions that are vastly different from historically native vegetation. Additionally, management decisions are closely related to a number of sociodemographic factors such as age, education, home ownership, and income that influences management behaviors. I surveyed residential birds, butterflies, and vegetation to determine local community characteristics. I also conducted landowner surveys to assess the links tied to management decisions and to determine which garden variables were the most related to species richness. I found that the species richness of both birds and butterflies responded positively to habitat features such as complex vegetation, water availability, and native vegetation. Social variables that explained species richness included ownership status of the residents, supplemental feeding practices, and wildlife-friendly gardening. By demonstrating a relationship between specific management practices in residential properties and increases in species richness, this study highlights that even small-scale garden features can mitigate habitat fragmentation and homogenization that stems from population and urbanization growth.

By understanding the relationships that drive homeowner management and preferences that ultimately influence bird and butterfly communities, we can educate both homeowners and future city planners on how much residents can impact global biodiversity.

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Impacts of Residential Garden Practices on Bird and Butterfly Communities in Southeast Kansas

Introduction

A growing body of interdisciplinary literature indicates that residential landscapes are becoming more homogenized and simplified due to a variety of management decisions, social influences, sociodemographic factors (Blaine et al., 2012; Cook et al., 2011; Wheeler et al., 2017), and shifts to urban living (Seto et al., 2012). Residential landscapes account for a substantial amount of greenspace within cities (Chamberlain et al., 2004; Lerman and Warren 2011) and the vegetation within them is valuable for its ecosystem services (Pataki et al., 2011), areas of wildlife refugia (Hall et al., 2017), as well as for supplying sources of nearby nature for residents (Kaplan et al., 1989). The management and design of residential landscapes is something that millions of Americans both invest in and value (Blaine et al., 2012), but social pressures to maintain a well-manicured lawn often lead to management goals of aesthetic neatness, such as weed elimination. Management for garden aesthetics often include increases in chemical applications (Robbins et al., 2001), mowing frequency (Halbritter et al., 2015; Socher et al., 2012), and the introduction of exotic, non-native vegetation (Garbuzov and Ratnieks

2014). These behaviors and management choices may have both intended or unintended impacts on the diversity and species richness of the residential ecosystem.

The simplification of residential vegetation refers to a spatial heterogeneity that unevenly distributes landscape components and often results in the removal of sub-canopy and shrub layers which are important sources of cover, food, and nesting habitat for many avian species (Rousseau et al., 2015). Simplifying the strata of residential vegetation results in less diverse, non-native bird communities (Murthy et at., 2016) in comparison to rural counterparts (Aronson et al., 2014). Additionally, these simplifications have the potential to remove nectar and larval host plants required by many butterfly and moth (Lepidoptera) species as well as other herbivorous insects important to the food web (Burghardt et al., 2008; Matteson & Langellotto 2010; Fleishman et al., 2005). These simplifications stem from landowner preferences, management behaviors, as well as the desire to conform to social expectations of neighborhood landscapes (Locke et al., 2018a). Because residential lawns are often viewed as a reflection of the homeowner, an unkempt landscape may reflect poorly on a homeowner's character or indicate a lack of care (Nassauer et al., 2009). These plant preferences and social pressures often result in many suburban yards resembling "park-like" landscapes composed of ground cover that mainly consists of cool-season, non-native grasses and a canopy layer of either native or non-native trees (Burghardt et al., 2008; Polsky et al., 2014).

In addition to the removal of vegetation strata, the increased use of exotic, non-native vegetation in residential areas has the potential to negatively impact the species richness and further contribute to homogenization (Lockwood et al., 2013; Burghardt et al., 2008). Many of the plants selected for residential landscapes are purchased at large chain stores (Yue & Behe, 2008) where plant availability is based on novelty, pest resistance, physical attributes, ease of growing, and affordability (Avolio et al., 2018). The physical, aesthetic attributes of flowering plants are a key driver for plant selection (Garbuzov and Ratnieks, 2013), resulting in urban landscapes highly dominated by exotic plants. Many studies find that a landscape dominated by exotic vegetation results in a decline of overall species richness, diversity, and the availability of quality forage that is required in a healthy ecosystem (Lerman et al., 2012; Gaerttner et al., 2009; Hejda et al., 2009).

In addition to a broad range of diversity in landowner preferences and management goals, residents are engaged in a variety of behaviors that can influence habitats and negatively or positively impact wildlife diversity (Lepczyk et al., 2004). Birds have frequently been used as a model system for indicating a healthy habitat based on their life history traits and their correlated food and habitat requirements. In addition to their aesthetic and intrinsic value, birds are ecologically important for the many ecosystem services they provide such as seed dispersal, pollination, and the recycling of nutrients (Kang et al., 2015). Anthropogenic factors such as supplying artificial nest boxes or supplemental feeding influence the diversity and evenness of bird communities in residential areas. Resident participation in these behaviors may be linked to factors such as economic status, education, and overall attitude towards wildlife (Tryjanowski et al., 2015).

Reductions in residential bird diversity occur from either the extirpation of local populations (Fleishman et al., 2005), or by the replacement of specialist birds with more generalist, urban exploiter species (Lepczyk et al., 2004). While feeding birds and other wildlife can be beneficial and viewed as a positive human-nature interaction, some negative aspects associated with this behavior can be observed. These factors include increased competition both within and between species, higher densities of birds which results in increases of disease transmission, and the additional success of unwanted species such as the European starling (*Sturnis vulgaris*) and house sparrow (*Passer domesticus*; Galbraith et al., 2015). Some research indicates that only the densities of birds already present in an area may be increased by artificial feeding, and it is unlikely that a species not currently occupying a site would benefit from the supplemental food source without the additional presence of quality habitat (Fuller et al., 2008; Carbó-Ramírez et al., 2010). However, the knowledge of how these actions affect a variety of wildlife species is important for future conservation efforts and city planning. Research aiming to understand what factors impact urban bird communities have found that even small small-scale vegetation characteristics were positively correlated with bird diversity, indicating the importance of even small-scale urban gardens (Luck et al., 2013).

In addition to the loss of important bird habitat, butterfly abundance and diversity is also reduced by landscape change when exotic plants dominate a landscape and specialist feeders are replaced by generalist species (Dallimer et al., 2012; Fontaine et al., 2016). In addition to the removal of nectar and larval host plants, the decline of overall butterfly species richness in many urban areas occurs due to the fragmentation of habitat (Concepción et al., 2016). Similar to birds, butterflies are suitable study models because of their varied degree of specialization, dispersal abilities, habitat requirements, and sensitivity to landscape change (Niell et al., 2007). Butterflies are vital for their ecosystem services, serving as pollinators and prey species for many other organisms (Fontaine et al., 2016). In addition to their declines in abundance from habitat loss, the increased use of pesticides in both urban and farmland areas have resulted in large declines in species abundance (Van Dyck et al., 2009). However, both bird and butterfly diversity were shown to increase with the use of native vegetation in residential areas (Burghardt et al., 2008), and impacts of landscape change have been mitigated through butterfly-friendly gardening practices regardless of the level of surrounding urbanization (Fontaine et al., 2016).

Many studies have already observed the negative impacts of landscape simplification on the diversity of bird and butterfly communities in residential areas; however, much of this research was conducted along the urban-rural gradient within larger cities. Information associating species diversity to the landscape preferences and management behaviors of residents in a micropolitan city is lacking. It is important to see if the same trends linking species diversity to sociodemographic factors in large cities are also present in smaller, more rural communities. This study focused on a micropolitan city in Southeast Kansas, which is located in a unique area of the state along an ecotone of prairie and oak/hickory forest, surrounded by agricultural land uses.

This study aimed to understand which variables of residential gardens best predict species richness in bird and butterfly communities. I assessed the following garden habitat variables that the literature suggests will have an impact on diversity: native vs. exotic vegetation, plant diversity, canopy density, and management practices such as the application of chemicals and frequency of mowing. I predicted that as the complexity of vegetation and the use of native plants increase, so too will the species richness of both birds and butterflies. I predicted that even small residential gardens will prove to be important sites of refugia for native wildlife when specific host plants, sources of food and nectar, and diverse vegetation are present. Additionally, I predicted that that abundance of birds will be greater at properties with supplemental feeding in comparison to those not feeding birds, but richness will not be affected.

Methods

Study Site

I conducted this study at 47 residential properties located within Pittsburg, Kansas (37°24′37″N 94°41′59″W; Figure 1). Considered a micropolitan area, Pittsburg has a population of 20,216 residents across a 33.4 km^2 area in southeastern Kansas (American Community Survey, 2017). Pittsburg sits within the highly biodiverse Cherokee Lowland physiographic region of the state (Ecoregions of the State, 2017). Pittsburg has a humid continental climate resulting in hot, humid summers and cold winters. The mean annual temperature of this region is 13º C and it receives an annual precipitation of 1,143 mm, significantly more than the western most portion of the state.

Pittsburg was founded in 1876 following the installation of a railway line and the economic growth opportunities resulting from a coal mining industry in the region. Historically, the vegetation of this region was tallgrass prairie, but a combination of agricultural practices, strip mining for coal, and urbanization caused the removal and fragmentation of the prairie and grasslands. Currently, forested habitats characterize the area around the city. Another key feature of the city is its centrally located university of approximately 7,000 students. Currently there are 7,727 homes located within Pittsburg, of which 46% are owner-occupied and 54% are rental-occupied making this a unique city to study.

Site Selection

To obtain data on yard biodiversity, I mailed informative fliers requesting volunteers from a large socioeconomic status range for the study. I mailed fliers to the homes of 1,732 Pittsburg residents using three United States Postal Service routes that spanned low to high median household incomes and ranging from the city's center to its edge (Figure 2 & Table 1). I also passed out fliers (Figure 3) at various events and locations around Pittsburg to attract any volunteers that either own or rent their home. To encourage participation in the study, I offered two $25 gift cards as an incentive to be drawn at random. Of the 50 residents that responded to the flier, I selected a subset of single property homes, totaling 47 residential yards, to ensure a broad socioeconomic and spatial gradient across the city. To reduce the potential for multiple counts of individual birds and butterflies, the homes selected were required to be a minimum of 250 m apart (Ralph et al., 1995).

Bird Survey

I conducted a total of three, 5-minute unlimited radius point count surveys at each of the 47 properties (Bibbly et al., 1992). These surveys took place during the breeding season (May-August) of 2017 and all surveys took place within four hours of sunrise to coincide with peak bird activity, weather permitting (i.e. sunny, warm, low wind). Each sample occurred a minimum of 14 days apart. Prior to each count, I conducted a three-minute settling down period to mitigate any disturbance of my arrival. During this three-minute period, I recorded the following variables that have the potential to impact detectability: wind speed, temperature, cloud cover, time of observation, and Julian date. The point counts included all birds seen or heard within the property but did not include those flying high overhead as those birds were not actively utilizing the food or habitat of the specific residential locations. I recorded approximate distances to each bird in the following distance categories: 0-5 m, 5-10 m, 10-20 m, 20-40 m, 40+ m, and noted the direction of travel.

Butterfly Survey

I used a checklist survey method to conduct three, 10-minute butterfly surveys at each of the properties between June and August 2017 and recorded only adult life stage individuals. The checklist survey method is used to analyze the presence/absence and number of individuals at a location (Pollard 1977 & Royer et al., 1998). This survey method is valuable for this study because no ongoing monitoring is taking place beyond this season. Surveys were a minimum of two weeks apart and took place between 10:00 a.m. and 3:00 p.m., weather permitting. During each butterfly survey, I walked multiple transects along the entire property actively seeking all butterflies. I identified all observed butterflies to species when possible. When individuals in flight were difficult to identify, a standard butterfly net was used to capture and obtain important field markings. During the in-field identification period of a difficult to identify species, the 10-minute timer was paused until the survey resumed. The known life history traits of each butterfly species were used to categorize individuals as either a generalist or specialist, as well as indicating their habitat requirements, dispersal ability, voltinism (number of generations per year), and larval resource breadth (range of host plants used by larvae; Lizee et al., 2016). Prior to each survey, I recorded the following variables that have the potential to impact detectability: wind speed, temperature, cloud cover, time of observation, and Julian date.

Vegetation Survey

To determine how each backyard served as bird and butterfly habitat, I conducted five, one-meter quadrant vegetation surveys at each residential property using a Daubenmire frame (Coulloudon et al., 1999). Plants within each quadrant were identified to species and noted as either native or exotic based off of USDA PLANTS Database classifications (USDA, 2006). When properties had limited diverse vegetation, potted plant were recorded (Thompson et al., 2003). In addition, I measured the following vegetation variables to quantify the total property's habitat availability and structure: ground cover composition (classes: artificial, grass, bare soil, shrubs, trees, water), ground cover height, and canopy density, tree species richness and tree abundance. I also recorded the dominant species of tree, shrub, and flowering plants along with their origin as native or exotic. I used a diameter tape to measure the diameter at breast height (DBH) of all trees measuring above 0.5 m that were within 11.3 m from the center of the yard (James et al., 1970). I used a spherical densiometer to measure canopy density and a Biltmore stick to obtain measurements of canopy height.

Even though new findings have indicated residents manage their front and backyards differently due to conflicting gardening preferences and social norms (Locke et al. 2018a), I was limited to only survey either the front or backyards of residents due to access and resident's needs. For example, one resident required sampling in their front yard due to their dogs located in their backyard. For the majority of homes, only the backyards were sampled for plants (96%), yet birds and butterflies were assessed across the property with residents' permission. Residential homes were classified into three distinct landscape styles based on vegetation structure, including percent cover and plant height: "traditional lawn" properties consisted of mostly turfgrass and simple vegetation strata, "mixed lawn" properties" consisted of a combination of open grassy areas with flower beds composed of either native or non-native plants, and "natural lawn" properties which consisted of the most complex vegetation strata and included mostly native vegetation into its design (Figure 4).

Data Analysis

To assess the impacts of the detection variables on the observed bird and butterfly species richness for each site visit, I conducted Pearson's correlation analyses. If any detection variable was correlated ($r > 0.5$; $r < -0.5$) with species richness, the variable was included in the final model. The three site visits for birds and butterflies conducted at each of the properties was treated independently by totaling all individual detections into final individual site totals for both species richness and abundance. I checked the normality of variable data using a Shapiro-Wilk's test and log-transformed any variables that did not meet the normality assumptions. I used program R to conduct generalized linear model testing and Akaike Information Criterion corrected for small sample size (AICc) using stepwise procedures for my model selection process. I constructed models including the *a priori* predictor variables that had the most impact on species richness. The landscape model variables included native plant abundance, percent ground cover type (shrub, tree, water, bare soil, grass, artificial), tree species richness, tree abundance, ground cover height, canopy density and canopy height. The demographic and management variables included age, education, income, mowing frequency, supplemental feeding and chemical application (Chapter Two). I first built a global and null model, and then used AICc to identify the most parsimonious model for predicting species richness. Any variables indicating collinearity, such as tree abundance and canopy density, were removed. In order to avoid overfitting in my final model, the models were limited to 2-5 predictor variables. The top model was assessed for fit using Nagelkerke R^2 in program R. The AICc models were ranked and top models (ΔAICc ≤ 2), those with the most explanatory power, were reported.

Results

I recorded a total of 1,845 birds across 47 species (2 non-native and 45 native) (Table 2). The observed species richness of sites ranged from 6 to 21 species (mean 11.2 ± 3.2 SD) and the total bird abundance of sites ranged from 20 to 79 (mean 37.5 ± 11.8 SD). The most common birds recorded were the European starling (24%), followed by the American robin (16%), Northern cardinal (14%) and house sparrow (9%). A Pearson's correlation test indicated that none of the detection variables (Julian date, wind, cloud cover, temperature) were correlated with the observed species richness of birds. Generalized linear models indicated that bird species richness was best explained by tree abundance and shrub ground cover. Species richness was negatively correlated with canopy density and percent artificial ground cover. The observed bird abundance was best explained by shrub ground cover (Table 3).

I recorded 434 total butterflies across 27 species (Table 4). The observed species richness of sites ranged from 1 to 11 (mean 4.7 ± 2.5 SD). The total butterfly abundance of sites ranged from 1 to 28 (mean 9.5 ± 6.8 SD). The most common butterflies recorded were the Eastern tailed-blue (17%), painted lady (15%), and fiery skipper (13%). A Pearson's correlation test indicated that none of the detection variables (Julian date, wind, cloud cover, temperature) were correlated with the observed species richness of butterflies. Generalized linear models indicated that butterfly species richness was best explained by tree species richness, shrub ground cover, percent native vegetation and percent water cover (Table 5). These four variables all had a positive relationship with species richness.

The dominant vegetation recorded across the 47 properties included 14 species within the canopy layer (Table 6), 15 species within the shrub layer (Table 7), and 25 species within the flowering plant/ground cover layer (Table 8). I recorded 74 plant species (40 native and 34 non-native) within the Daubenmire frame across all sites (Table 9). On average, properties had a tree species richness of 2.2 (SD ± 1.4), tree abundance of 3 (SD ± 2.2), and average canopy height of 18.1 m. (SD ± 4.5) within the sample plot where bird surveys took place and vegetation variables were recorded. Ground cover height across all properties averaged 7 cm (SD ± 2.6) and was not found to be significant in any of the models.

Average bird (ANOVA: F = 9.6, $P < 0.001$) and butterfly species (F = 10.2, $P < 0.001$) differed across the three lawn management styles. The largest differences in richness occurred across "traditional lawn" and "natural lawn" management styles (Tukey HSD; Bird, $P = 0.001$; Butterfly, $P = 0.001$). There was also a difference between "traditional lawn" and "mixed lawn" styles for butterfly richness (Tukey HSD: $P = 0.044$; Figure 5).

Discussion

By measuring residential garden variables at the level of the individual garden, my goal was to understand what vegetation characteristics were the most important to explaining bird and butterfly communities and to identify which resources within the residential landscape could be linked to increases in species richness. With regards to increasing species diversity, residential gardens have widely been found to play an important role in supplying refugia, improving connectivity of habitats, and supplying human-nature experiences (Goddard et al., 2009). The results indicate that all landowners are involved in a multitude of management activities that can impact species diversity either positively or negatively and many of the same trends found in larger cities overlap with a micropolitan-sized city. Complex vegetation which included both shrub and canopy layers was important in explaining species richness among residential bird communities and further demonstrates that management goals for traditional lawn style can negatively impacts local bird communities. Likewise, residential butterfly communities responded to diversity among vegetation as well as the increased use of native vegetation. With very few study participants managing mostly native landscapes, we can conclude that butterflies are benefiting from even small patches of diverse, native vegetation.

Apart from a few properties, most surveys took place relatively near the city center at homes of similar plot size where bird communities could easily be identified as utilizing the different management styles among residents. The birds identified during this study are both common and abundant within this range; however, in addition to several native, shrub-nesting species, a few more specialized birds such as the pileated woodpecker were recorded. Cavity nesting species such as this may be limited in urban landscapes due to the removal of dead trees from residential properties. Trends in species richness showed birds were responding positively to increased tree abundance and shrub ground cover, which are typical of the nesting requirements for many of the recorded species (Rousseau et al., 2015).

In addition to habitat availability, food resource limitations in urban gardens have been highlighted in many similar studies. These studies indicate fewer insect species are being supported by non-native vegetation and ultimately results in decreased resource availability for insectivorous birds (Tallamy 2004; Flanders et al., 2006; Burghardt et al., 2008). However, native plant abundance was not significant to bird richness in our study. A significant increase in both bird species richness and abundance across all sites was found for properties who provide supplemental food (Chapter Two). The participation in feeding birds was found across all property types, ownership status, and income ranges, which indicates that even when diverse, native vegetation is not utilized in landscape style, easy access to food resources is still being supplied and ultimately influencing the bird community. While both birds and butterflies are considered suitable study models for assessing responses to landscape change, birds are slightly more tolerant to disturbances (Blaire 1999) and many species are even recognized as urban exploiters due to their high success within cities and close proximity to humans. The disproportional benefit of supplemental feeding to urban exploiter species, such as the non-native European starling, can be found in many studies (Fuller et al., 2008). Similar to these studies, the European starling accounted for nearly one quarter of the observed recordings in gardens that provided bird feeders.

Even though no rare species of butterfly were identified during this study, I did record the presence of specialist species across multiple properties, such as the monarch. The presence of butterflies at residential properties is valuable ecological knowledge that indicates larval host plants are being utilized at some locations (Halbritter et al., 2015). Even common species of butterfly can undergo extreme population fluctuations from year to year and further, long-term monitoring would be needed to draw conclusions about regional species population trends. I was able to accept my hypotheses that properties with more diverse vegetation and an increased use of native vegetation would support larger and more diverse butterfly communities than traditional lawn style management. Surprisingly, water cover in the sample plots was significant across all models for butterfly species richness and abundance; however, this pattern may have emerged based on a few properties in close proximity to lakes that also managed their properties with pollinator and butterfly-friendly gardening goals.

Diverse vegetation communities were more often recorded at owner-occupied properties than rental-occupied both for Daubenmire frame species as well as dominant tree, shrub, and flowering plants. I expected to see simpler vegetation diversity and structure among rental properties based on landlord restrictions that limit the management practices of residents. However, all resident survey responses (Chapter Two) indicated that residents were making the management decisions for their property regardless of ownership. It is plausible that rental-occupied properties contained simpler, more homogenized vegetation due to the lack of long-term investment that characterize owner-occupied properties. Many of the participants reported practicing wildlife-friendly gardening goals regardless of ownership; however, most homes were still managed in the "traditional lawn" style and very few contained mostly native vegetation (13%).

While I did not compare differences between front and back yards, management goals between the two can differ based on preferences and social pressure to maintain a tidier, more socially acceptable front yard. The management goals of back yards often include a more utilitarian purpose such as food cultivation or supplying habitat for wildlife as well as recreation (Locke et al., 2018a,b). I predicted that this trend would continue across a smaller sized city, thus all surveys with the exception of two took place in back yards where, based on other research findings should occur.

By demonstrating a relationship between wildlife-friendly management of residential properties and increases in species diversity, I am providing evidence that even small-scale garden features can mitigate habitat fragmentation and simplifications that stems from population and urbanization growth. By understanding the relationships that drive homeowner management and preferences and ultimately influence bird and butterfly communities, we can educate both homeowners and future city planners on how to increase species richness within cities. While trends to manage properties with wildlife-friendly gardening are increasing, social norms to maintain traditional lawns still remain and need to be addressed in future studies.

Chapter II

Human Dimensions of Gardening Practices: Impacts on Local Bird and Butterfly Communities

Introduction

Prior to the emergence of urban ecology as a discipline, cities were understudied and not recognized as important components of the overall ecosystem. Previous research focused on natural landscapes with little human influence (Liu 2001), but these pristine locations are quickly being transformed to supply human needs (Walker et al., 2009). This shift in ecological research that first excluded human impacts within a system now recognizes that humans are both important components of every ecosystem, as well as the leading drivers of landscape change (Niemela et al., 2011; Lepczyk et al., 2004). These landscape changes stem from an increasing human population as well as rates of urbanization (Seto et al., 2012) and the resulting homogenization of vegetation and wildlife across cities worldwide (Aronson et al., 2014). Changes to the native landscape contribute further to declines in overall global biodiversity (Barnosky et al., 2011) through the removal and fragmentation of habitat (Lowenstein and Minor 2016), overall reducing its quality. However, the inclusion of human impacts into ecological research has also been fundamental in determining the value of cities as habitat sources for many native species of wildlife (Hall et al., 2017) as well as indicating that diverse residential gardens can help to mitigate the effects of urbanization when diverse, wildlife-friendly vegetation is provided (Cerra & Crain 2016; Lowenstein & Minor 2016; Sanderson & Huron 2011).

As cities continue to grow and become denser, residential properties have come to represent a significant amount of the available greenspace within cities (Torres-Camacho et al., 2017). These highly managed landscapes are vastly different both at the neighborhood and individual property scale and are often the result of a number of individual management decisions (van Heezik et al., 2013), as compared to public green spaces like city parks (Kinzig et al., 2005). The resident’s selection for, or elimination of, certain plants directly impacts the composition of residential plant communities (Leong et al., 2018).

Management behaviors are often influenced by a variety of factors such as social, cultural, floral, food, and wildlife-friendly gardening goals (Goddard et al., 2013; Grove et al., 2006). Additionally, these management goals and behaviors are found to be shaped by number of sociodemographic factors such as age, income, education, (Hope et al., 2003; Nassauer et al., 2009; Grove et al., 2006), as well as city or neighborhood regulations (Fraser et al., 2016), and the influence of social pressures to maintain socially acceptable lawns (Goddard et al., 2013). Differences in residential vegetation management across properties results in a heterogeneous landscape, providing uneven habitat resources for wildlife across the city (Lowenstein & Minor 2016).

Other factors that influence the composition and diversity of a residential garden are driven by top-down constraints on the residential land manager (Walker et al., 2009). These factors include restrictions imposed on residents either through city or neighborhood regulations (Fraser et al., 2016; Walker et al., 2009) or limitations on residential plant choices provided by nursery trade, frequently offering fewer native species as well as limiting the overall number of trees and flowering plants available to residents (Avolio et al., 2018; Walker et al., 2009). Limitations such as these directly impact neighborhood tree composition, canopy size (Torres-Camacho et al., 2017; van Heezik et al., 2014), as well as the nectar and larval host plants important for supplying resources for many wildlife species (Chapter One). Aesthetic value has been identified as a primary driver for plant selection (Garbuzov & Ratnieks 2013), which often results in the use of many non-native species being implemented into garden design. Preferences to include non-native plants into residential garden design does have the potential to increase plant species diversity as well as extend the flowering season (Salisbury et al., 2015); however, this may come at a cost. Many non-native plants negatively impact diversity by outcompeting native vegetation (Shapiro 2002), reducing insect diversity (Burghardt et al., 2009), as well as supporting fewer wildlife species (Burghardt et al., 2009; Chapter One).

Additional top-down garden management actions stem from both city and neighborhood regulations. For example, homeowners associations (HOAs) that currently govern neighborhoods are regulating 20% of the population in the United States (Fraser et al., 2016) and their regulations often serve to reinforce cultural norms of maintaining neat, turf-grass lawns that frequently require potentially negative chemical treatments and result in simplified and species-poor landscapes (Milesi et al., 2005; Larson et al., 2009). Several studies indicate additional influence on the residential landscape stems from the concept of perceived care. This idea suggests that residents who do not maintain a tidy landscape are exhibiting a lack of care of their property (Kaplan 2001), even when biologically diverse native landscapes have been identified as looking messy by residents in comparison to the traditional lawn (Nassauer 2004; Gobster and Hull 2000). In addition to aesthetic appearance, large lot size for recreation has been identified as an important factor for residents who have children (Varady 1990). Thus, managing residential landscapes with the goal of increasing species diversity must also consider the occupant's needs for recreation and activities (Walker et al., 2009).

Landscape decisions may also be influenced by the ownership status of the residential property. Owner-occupied properties have greater investment stakes and risk of negatively influencing property values compared to rental-occupied properties. Consequently, rental properties might be less likely to implement native vegetation gardening practices due to its perceived messiness (Rodriguez et al., 2017) or may not have the resources to invest in a temporary location. Even so, trends to implement native vegetation are on the rise (Blaustein, 2013) and neighborhood norms might be more malleable if information indicating the wildlife benefits of native vegetation is provided to occupants (Rodriguez et al., 2017).

In relation to ownership status, income level also has the potential to influence the plant composition of residential properties. The concept of the luxury effect was first proposed by Hope and colleagues (2003), suggesting higher income status and more affluent neighborhoods maintain higher plant diversity than lower income groups. Though this concept has been scrutinized for its generalization across all cities (Leong et al., 2018), it has been observed in many similar studies (Lowenstein and Minor 2016; Martin et al., 2004; Mennis 2006).

Closely linked to income status, education and environmental attitude are also factors found to have influence on the plant diversity and composition of residential landscapes (Kirkpatrick et al., 2007). One study found that residents with more education had gardens with greater structural diversity, even while plant species diversity was not significantly linked to education status (van Heezik et al., 2013). The education status of the resident was an important factor, but their attitude was found to be more positive towards wildlife as well (van Heezik et al., 2013; Kellert 1984), further supporting these trends in habitat diversity in gardens.

Overall, garden management may be the result of many personal and top-down factors at play for a resident. Management can result in a gradient of a simplified garden, dominated by lawn and exotic plants, to a structurally complex, diverse garden, causing direct impacts on the biodiversity of a city. Knowledge of how these factors that influence gardening behavior and decision-making is valuable in maintaining diversity as well as for future city planning. While many studies have focused on the relationship between these sociodemographic factors and the resulting species diversity (Kinzig et al., 2005; Kirkpatrick et al., 2007; etc.), few have considered the differences between owner and rental occupied properties. Additionally, many studies focused on the impacts of urbanization are conducted along the urban-rural gradient in much larger cities and identifying similar trends in micropolitan cities is lacking. I question if homeownership status and the geographical location of our study result in trends similar to other studies conducted on the human dimensions of gardening practices.

The objective of this study was to identify which resident variables best explained garden management practices and preferences. Particularly, I was interested in the demographic and preference variables associated with gardening for diverse vegetation and wildlife-friendly behaviors. My research goal was to determine if the trends of larger cities are similar to those of a micropolitan city while also comparing differences between rental and owner-occupied properties. I predicted that owner-occupied properties would be more biodiverse than renter-occupied due to the greater time and personal stake invested in homeowner gardens. Those homeowner gardens should consequently support greater bird and butterfly diversity due to larger property sizes and greater plant diversity. Additionally, I predicted that occupants with higher levels of income and positive attitudes towards the environment will be more prone to participate in wildlife-friendly behaviors such as feeding and supplying habitat for birds and butterflies through the use of diverse, native vegetation.

Methods

Study Site and Demographics

Pittsburg is a micropolitan city with a population of 20,216 and a median age of 26 years divided equally among male and female residents. Population projections for Pittsburg indicated an increase of 1.1% in micropolitan growth over the next five years. While these projections are slower than both state and national growth rates, the city has invested millions into infrastructure, recreation, and housing programs to persuade new residents to move to the city (Pitt Econ Profile). Reported rates of education indicate that 90% of residents 25 years and older have received a high school degree and 34% have received a bachelor’s degree or higher. The per capita income of Crawford County residents, including those living in Pittsburg, ranks below both state and national averages (Pitt Econ Profile) and the current median income is $31,948. However, future income projections suggest a 14.7% increase will occur over the next five years compared to 14.3% for the state of Kansas (Pitt Econ Profile). Regardless of these increases, poverty rates for Pittsburg remain at 28.6% compared to 11.9% for the state and 12.3% nationwide (US Census, 2016.

Residential Survey

Following the data collection of biotic features at each residential property, letters of general findings (i.e. most abundant species of bird and butterfly as well as species richness) were mailed to the 47 single property homes who participated in the bird, butterfly, and vegetation surveys (Chapter One). In addition, an invitation to complete a survey (Appendix B) regarding occupant demographics, landscape preferences, and management behaviors was mailed to participants (Pittsburg State University Institutional Review Board approval #2371612). The survey consisted of 41 questions broken into three sections: demographics, property management, and environmental attitude using the New Ecological Paradigm (NEP revised edition questions; La Trobe & Acott 2000).

The first section of the survey included sociodemographic questions such as ownership status (rental or owner-occupied), age, income and education, which have been linked to landscape and management behaviors in previous research. These questions were also used to describe the survey sample, in comparison to the city's population demographics. The second section of the survey focused of management behaviors such as frequency of mowing and chemical application as well as how much time residents were spending in their gardens during the spring and summer seasons. Personal preference questions were also used to assess which features of their property were most important to them and why. Additionally, residents were asked about the actions they took in garden management, such as supplying bird houses, supplemental feeding, as well as wildlife-friendly management to attract butterflies. Finally, residents were asked to rank four landscape styles from most to least preferred (Figure 6). The photos selected for the survey represented varying levels of management intensities as well as the increasing use of native vegetation. All photographs were downloaded off Google Images, rather than photographs of homes in Pittsburg to avoid any personal connections with local homes. Picture A represented a property with mature trees and increased potential for a diverse bird community. Picture B represented a highly simplified, mostly turf-grass property of the highest management intensity and lowest wildlife value. Picture C represented a medium-intensity management style of both open lawn and tidy flower beds composed of either native or non-native flowering plants. Picture D represented a natural management style consisting mostly of native vegetation with increased potential for the species richness of birds and butterflies, but lacks the neatness associated with perceived care. An open-ended question asking residents why they preferred this landscape style concluded this survey section.

Section three of the survey consisted of two-point, yes or no response questions focused on environmental issues. Fifteen questions were borrowed from the revised edition NEP scale (La Trobe & Acott, 2000), a commonly used method to measure environmental concern (Stern et al., 1995). The 15 NEP questions that were selected were the most relevant to this study and were used to assess the residents’ overall environmental attitude and concern.

Data Analysis

Garden vegetation, bird, and butterfly community data were assessed for each site and linked to each survey response (Chapter One). To generate hypotheses regarding potential differences in bird and butterfly communities across home ownership status, I conducted a Bray Curtis ordination in PC-ORD (McMune & Mefford, 2016; Figure 7). Survey responses were summarized and compared against the vegetation, bird, and butterfly data using generalized linear models to identify predictor variables that had the most explanatory power for overall species richness and abundance. Additionally, an analysis of variance (ANOVA) was used to determine differences in bird species richness and abundances across categorical sociodemographic variables (i.e. household income). A one-tailed t-test was used to determine differences in bird and butterfly species richness and abundance across homes that lacked vs. provided supplementary feeding for these species. I categorized the words survey respondents used to describe their gardening preferences and behaviors by conducting a content analysis (Weber, 1990). For open-ended questions, the words and phrases residents used to describe their landscape preferences were coded and sorted into thematic categories.

Results

Household Survey: Demographics

A total of 40 resident surveys were returned (response rate of 85%; Table 10). Most residents were female (60%), with a reported average age of 51 years (SD ± 19). Survey responses indicated that residents were more likely to have a college degree (65%), and most were either working full time (55%) or retired (28%). Residents who participated in the study were older and more likely to have a college degree in comparison to Pittsburg overall, but the city's median income of $31,948 falls into the most reported income range of $25,000 – 49,999. Household income was variable, with the most frequently reported combined annual income range of $25,000 – 49,999 (23%). Bird species richness varied significantly across income ranges (F = 3.1, $P = 0.028$), with the middle range income ($25,000 – 49,999) indicating the highest species richness he two mid-level income ranges were also found to have the highest percentage of native plants as the dominant tree, shrub, and flowering plant.

Overall, more participants of the study were living in owner-occupied properties (78%) than rental (22%), in contrast to Pittsburg's overall high rates for rental-occupied properties (54%). Bird species richness was greater at owner-occupied properties than rental (F = 3.1, $P = 0.028$). Butterfly community characteristics were unrelated to residents' sociodemographic variables.

Household Survey: Property Management

Most residents ranked the importance of gardening as "moderate" (38%) or of an "extreme importance" to them (28%). The ease of maintenance, colorful flowerbeds, and an abundance of trees and shrubs were the most important features concerning their properties and most indicated that they found gardening important because it was both a "hobby" and a "source of physical activity/exercise". Concerning the recreational use and activities of resident properties, "enjoying beauty" was ranked most important regardless of property ownership.

On average, residents reported spending 5 hours per week working in their yard/garden during the spring and summer seasons and most reported mowing their lawns 2-3 times per month (60%). Most residents never applied chemicals (i.e. herbicides and pesticides) to their gardens (51%) or only applied them once per year (41%). Fertilizers were also never applied (55%) or only used once per year (35%) by residents.

Most residents, regardless of ownership, reported the plants in their yard as being a mix of native and non-native species (80%) and overall ranked their confidence in this assessment as “moderate” (45%). Compared separately, rental-occupied residents most often reported being “not confident” in this assessment (70%) compared to owner-occupied participants who most often reporting “moderate” confidence in this assessment (5). Overall, fewer properties reported containing “mostly native” (13%) or “mostly non-native” vegetation (8%). Even so, the plant communities were relatively similar in their species composition across residents’ ownership status, education, and income (Figure 7).

Even when city regulations or neighborhood restrictions were not in place, social pressure from neighbors to maintain yards in a certain way was reported by many residents (33%). Mary (age 32) suggested that she feels social pressure from neighbors “because the neighbor’s yards are very well maintained.” Similarly, Wendy (age 22) indicated that she felt social pressure because “the neighbors have a very well-maintained yard and mow a lot.” Many stated that they felt indirect or internal pressure from neighbors and most indicated the frequency of mowing as a key theme for feeling social pressure. Even so, some residents rebelled against social pressures. Sarah (age 25), whose home fell under the restriction of HOA regulations, stated “I live in an HOA, but we ignore the rules since only about half have perfect lawns. I love my dandelions!” (Sarah age 35). The landscape style most preferred by residents was highest for style C, a mixture of open lawn and flowers followed by landscape style A, a mature wooded lot (Figure 6). Landscape style B, open lawn was the least preferred among residents.

Across all properties, just over half of residents reported having bird houses on their properties (55%), and most indicated that they provided bird feeders (65%). For those who fed birds, there was an average of 3 (SD ± 2) bird feeders per property and most indicated feeding birds 10-12 months out of the year (42%). The main reason residents indicated feeding birds was to “provide food and habitat” and because they were “fun to watch”. The total abundance of birds at each property whose resident participated in supplemental feeding was greater than residents who did not provide bird feeders ($P = 0.03$). Additionally, the total species richness of birds at each property whose resident participated in supplemental feeding was higher than residents those who did not ($P < 0.01$; Table 11).

Similarly, most residents reported trying to attract butterflies to their yard (65%) and residents indicated that providing “food and habitat” as well as being “fun to watch” were the main reasons for attracting butterflies. The total abundance of butterflies at each property whose resident reported trying to attract them through wildlife-friendly management was greater than properties at which residents did not report a willingness to attract butterflies ($P < 0.01$). The total species richness of butterflies at each property whose resident reported trying to attract them through wildlife-friendly gardening management was also greater than residents those who did not ($P = 0.04$; Table 11).

Household Survey: Environmental Attitude

New ecological paradigm (NEP) questions assessed environmental attitudes of residents. Overall, the answers to NEP questions varied minimally, with most residents answering in similar way (Table 12). For example, most residents felt that when humans interfere with nature, it often produces disastrous consequences (85%), and that humans are seriously abusing the environment (88%). Most agreed that the balance of nature is easily upset (80%) and that if things continue on their present course, we will soon experience ecological catastrophe (78%).

Discussion

The objective of this study was to gain a better understanding of residential garden management and behaviors that influence the local bird and butterfly communities. Additionally, my goal was to assess the sociodemographic variables of residents that best explained garden management practices. The relatively high response rate of residents who were previously participating in wildlife-friendly management and valued environmental principles may indicate that those not interested in gardening or wildlife did not respond to the invitation to participate. Thus, the study may not reflect a true sample population of Pittsburg. Even so, I found significant support for our hypothesis that some of the same sociodemographic trends in urban bird and butterfly diversity are present in a micropolitan city, similar to the trends found in larger cities.

Despite the relatively large portion of participants who valued gardening and participated in behaviors to attract wildlife, the number of residents who reported landscaping their properties with mostly native vegetation was low (13%). Similarly, survey responses indicated a low preference for the landscape style composed of mostly native vegetation ranked in the survey responses (Figure 6). The social pressure to maintain private gardens and properties in the traditional lawn management style and the tendency for native vegetation to appear messy might have contributed to this finding. Even if residents ranked the natural landscape style higher, their gardening practices clearly did not always adhere to this garden preference. This may also be a consequence of the Ecology of Prestige, when management decisions are influenced by the desire to uphold neighborhood conformity (Zhou et al., 2009) and expectations for what their yards should look like, even when this runs counter to the resident's preference (Larson et al., 2009; Harris et al., 2012).

Owner-occupied properties were found to have greater bird species richness, yet ownership status did not explain differences in the butterfly community. This finding supports our hypothesis that owner-occupied properties were supported more bird species than rental-occupied potentially due to the higher investment stakes of property owners. Even so, I was surprised to not find this trend for butterflies, as their host specificity would have potentially been a stronger relationship than bird habitat associations. This trend in "biodiversity ownership" is not one commonly discussed in the literature, yet may have large impacts in areas that are dominated by rental properties, like university and college towns. Future research should detail the variation in rental property biodiversity with larger sample sizes and broader socioeconomic gradients throughout cities nationwide.

While age and education were not significant in explaining species diversity in our models, we did find that income was a strong predictor for the species richness of birds. Similar studies indicate a “luxury effect” relationship, linking wealth with higher plant diversity in residential areas and offers the increased potential for more diverse wildlife communities. However, we found that both the highest bird species richness and the highest frequency of native plants were found at the mid-level income range. The most diverse butterfly communities were found at homes within the highest income range, though this finding was not significant, and I found no other links between socio-demographics characteristics of residents and butterfly species richness. Even so, residents who reported attempting to attract butterflies to their yard had both a higher abundance and species richness of butterflies.

Regardless of income, age, or education level, we found no significant differences in the environmental attitude assessment portion of the survey. All participants responded similarly to questions and were environmentally conscience about the negative impacts occurring in nature. This may be a consequence of the survey population rather than Pittsburg residents overall. Even though the selection of our residential homes were randomized, those who responded to my research inquiry may have valued biodiversity at a greater rate than those who did not respond to my requests. The residents who participated in the study would theoretically be the ones to enact changes in their gardens with more information regarding wildlife-friendly practices, so the data we collected about their practices are still informative.

My results indicated that nearly two-thirds (65%) of study participants were engaging in behaviors that can directly influence the local bird community, such as the provision of supplemental feeding. Feeding patterns reported by residents indicated these behaviors are long-term with most residents supplying food 10-12 months out of the year.

My findings mirror those of other studies that also found that two out of three landowners were feeding birds as well as supplying food nearly year-round (Lepczyk et al., 2004). A number of studies report that this nearly constant access to food resources directly benefits bird communities by increasing the carrying capacity and enhancing the survival rates of over-wintering birds (Chamberlain et al., 2005). However, the spread of disease, increased competition, and increases in the abundance of unwanted species may also arise (Anderson et al., 1997). The most abundant bird recorded in my survey was the European starling (24%), a non-native, urban-exploiter species. This finding suggests a disproportionate benefit to exotic species over other native birds. Multiple studies find that supplemental feeding only increases the overall abundance of birds in an area but does not impact the species richness (Fuller et al., 2008). My study found that both species richness and abundance were higher at properties that offered supplemental feeding; however, I did not control for density of feeders or differences in nearby quality habitat that may influence the presence or absence of a species. Although I did not assess the use of bird houses in our study, I noted that over half of the residents were participating in this wildlife-friendly behavior. This provision of bird houses in residential areas additionally influences the bird community by potentially aiding in the success of breeding pairs (Lepczyk et al., 2004) and supplying habitat for many cavity-nesting species.

Similarly, my results indicated that more than half (60%) of the study participants were engaging in behaviors that may influence the butterfly community, such as the provision of nectar and larval host plants. Supplying refugia to butterflies within cities and residential areas is becoming increasingly more important as human population and urbanization rates continue to grow. In addition to habitat fragmentation and chemical use, simplified landscapes are negatively impacting the migration routes of many species. The provision of diverse, native vegetation can help to mitigate this problem when migratory species are able to utilize residential areas as important stop-over sites during migration.

Residential gardens are highly managed landscapes that vary drastically based on a number of private landowner decisions and sociodemographic characteristics. Residential properties are valuable sources of nearby nature (Kaplan 2001) and the most common setting of human-nature interaction (Cook et al., 2012). We found that residents valued experiencing nature and providing habitat resources for both birds and butterflies and that gardening with complex vegetation provided important sources of habitat, particularly for birds, across socioeconomic and educational gradients. I recognize that these relationships linking residential behaviors with species diversity are complex, yet patterns in habitat and food provisions were strongly linked to homeowner actions and values. Overall, this study indicated that most residents valued their gardens for relaxation and enjoyment and found gardening to be a hobby rather than a necessity.

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APPENDIX

Appendix A. Full model results for bird and butterfly species richness and abundance across residential yards in Pittsburg, KS. Table includes number of parameters (K), Akaike's Information Criterion adjusted for small sample sizes (AICc), difference in AIC values compared to the top ranked model (ΔAICc), adjusted R2 values, and Shapiro–Wilk values for normality.

Response Variable	Model	AICc	ΔAICc	K	Adjusted R^2	Shaprio-Wilks
Bird Richness	TreeAb + Shrub	248.1	0	2	0.05	0.3
	Canopy_Avg	249.6	1.5	1	0.001	0.92
	GC_T + GC_Shrub	252.5	4.4	2	0.03	0.93
	GC_T	250.4	2.3	1	0.001	0.93
	GC_Height	249.7	1.6	1	0.001	0.95
	Canopy_Height	250.0	1.9	1	0.007	0.94
	Tree_R + Shrubs	252.6	4.5	2	0.03	0.03
Bird Abundance	Shrub	365.9	0	1	0.08	0.9
	Tree_R + GC_Shrub	368.1	2.2	2	0.06	0.92
	TreeAb +GC_Shrub	368.3	2.4	2	0.06	0.92
	Tree_R	371.1	5.2	1	0.02	0.9

Appendix A. Continued.

Response Variable	Model	AICc	ΔAICc	K	Adjusted R^2	Shaprio-Wilks
Butterfly Richness	Shrub + TreeRich + Water + PercNative	94.6	0	4	0.82	0.8
	GC_W + TreeRich + GC_Shrub + PercNative	138.2	43.5	4	0.24	0.7
	GC_W +TreeAb +GC_S + PercNative	121.9	27.3	4	0.5	0.8
	GC_W + GC_T + GC_S	202.7	108	3	0.3	0.7
	TreeRich + GC_S	320	225	2	0.003	0.8

Appendix B. Householder Questionnaire

Pittsburg Backyard Nature Project Survey

Section One: Demographics

1. Do you own or rent your home?
   - ☐ Own
   - ☐ Rent

2. Do you make the landscaping decisions for property?
   - ☐ Yes
   - ☐ No, because:

     ____

     ____

     ____

     ____

     ____

3. What is your gender?
   - ☐ Male
   - ☐ Female
   - ☐ Prefer not to say

4. What year were you born?

   ____

5. What is the highest level of education competed?
   - ☐ Some high school, no diploma
   - ☐ High school or equivalent (GED)
   - ☐ Some college, no diploma
   - ☐ College degree (Associates/Bachelors) or above

6. What is your current employment status?
   - ☐ Full-time
   - ☐ Part-time
   - ☐ Homemaker
   - ☐ Unemployed
   - ☐ Retired
   - ☐ Student

7. What is your household's combined annual income?
   - ☐ $0-24,999
   - ☐ $25,000-49,999
   - ☐ $50,000-74,999
   - ☐ $75,000-100,000
   - ☐ $100,000+

Section Two: Property Management

8. Indicate which of the following is important to you concerning your property. **Check all that apply.**
   - ☐ Ease of maintenance
   - ☐ Open, grassy lawn
   - ☐ An abundance of trees and shrubs
   - ☐ Tidy flower beds
   - ☐ Colorful flowerbeds
   - ☐ Fruit and vegetable gardens
   - ☐ Environmental value
   - ☐ Wildlife value
   - ☐ Other, please describe: ___________________________

9. How important is gardening to you?
   - ☐ Not important
   - ☐ Slightly important
   - ☐ Moderately important
   - ☐ Extremely important

10. Why is gardening important to you? **Check all that apply.**
    - ☐ Hobby
    - ☐ Source of physical activity/exercise
    - ☐ Mental health
    - ☐ It makes my yard look beautiful
    - ☐ Important source of fresh fruits/vegetables
    - ☐ Environmental or wildlife value
    - ☐ Other: __________________
    - ☐ Gardening is not important to me

11. On average, how many hours per week do you spend working in the yard/garden during the spring and summer season?

Hours: ______________

12. "Native" plants are those that are originally from southeast Kansas, while "non-native" plants originated elsewhere in the country or outside of the country. The plants in your yard are:
    - ☐ All native species
    - ☐ Mostly native species
    - ☐ A mixture of native and non-native
    - ☐ All non-native species
    - ☐ Mostly non-native species

13. Please rank how confident you are in your assessment of native species in your yard (question #12).
    - ☐ Not confident
    - ☐ Slightly confident
    - ☐ Moderately confident
    - ☐ Extremely confident

14. How often do you apply chemicals (herbicides or pesticides) to your property?
    - ☐ Never
    - ☐ Once a year or less
    - ☐ More than once a year

15. How often do you apply fertilizer to your property?
    - ☐ Never
    - ☐ Once a year or less
    - ☐ More than once a year

16. How frequently do you mow your lawn?
    - ☐ Less than once a month
    - ☐ Once a month
    - ☐ 2 – 3 times a month
    - ☐ Weekly or more often

17. Have you ever felt social pressure from neighbors to maintain your yard in a certain way?
    - ☐ No
    - ☐ Yes

If yes, please explain:

____
____

18. Are there bird houses on your property? If so, how many?
    - ☐ Yes. Number of bird houses: ____
    - ☐ No

19. Are there bird feeders on your property? If so, how many?
    - ☐ Yes. Number of bird feeders: ____
    - ☐ No. Please skip to **Question 24**.

20. If you feed the birds on your property, how many months out of the year do you feed them?
    - ☐ 1-3
    - ☐ 4-6
    - ☐ 7-9
    - ☐ 10-12

21. What season(s) do you feed the birds on your property? **Check all that apply.**
    - ☐ Spring
    - ☐ Summer
    - ☐ Autumn
    - ☐ Winter

22. What type of bird feeders do you have on your property? **Check all that apply.**
    - ☐ Tube
    - ☐ Tray
    - ☐ Hummingbird
    - ☐ Other. Please describe: ________________________ ________________________

23. Select **up to 3 reasons** for why you feed birds:
    - ☐ To watch birds for fun
    - ☐ To keep records of what bird species are in my yard
    - ☐ To learn more about the bird species in my yard
    - ☐ To attract birds for insect control
    - ☐ To pollinate my flowers
    - ☐ It makes my yard look beautiful
    - ☐ To provide food and habitat for birds
    - ☐ Other: ________________________

24. Do you try to attract butterflies to your yard?
    - ☐ Yes
    - ☐ No. Please skip to **Question 26**.

25. Select **up to 3 reasons** for why you try to attract butterflies:
    - ☐ To watch butterflies for fun
    - ☐ To keep records of what butterfly species are in my yard
    - ☐ To learn more about the butterfly species in my yard
    - ☐ To provide a food source for other wildlife (e.g. birds, bats, mammals)
    - ☐ To pollinate my flowers
    - ☐ It makes my yard look beautiful
    - ☐ To provide food and habitat for butterflies
    - ☐ Other: ________________________

26. Rank the importance of the following activities concerning the use of your yard from most (1) to least (4) important.

____ Relaxation
____ Enjoying its beauty
____ Experiencing nature/wildlife
____ Exercise and/or recreation

27. Rank the following landscape styles in terms of what you would prefer for your yard, from most preferred (1) to least preferred (4):

___ 

___ 

___ 

___ 

28. Please describe ***why*** you selected your preferred yard in Question 27.

____

____

Is there anything else you would like to tell me concerning your property management?

____

____

Table 1. Postal route codes used for this study, indicating socioeconomic range and number of households per route.

USPS Route Number	Number of Homes	Average Household Income ($)
66762-RO04	610	67,810
66762-CO13	571	36,560
66762-CO14	551	Below 25,000

Table 2. Bird species observed across 47 residential sites in Pittsburg, Kansas.

Common name	Latin name	Common name	Latin name
American crow	*Corvus brachyrhynchos*	House wren	*Troglodytes aedon*
American goldfinch	*Spinus tristis*	Indigo bunting	*Passerina cyanea*
American robin	*Turdus migratorius*	Mississippi kite	*Ictinia mississippiensis*
Blue jay	*Cyanocitta cristata*	Mourning dove	*Zenaida macroura*
Brown thrasher	*Toxostoma rufum*	Northern bobwhite	*Colinus virginianus*
Canada goose	*Branta canadensis*	Northern cardinal	*Cardinalis cardinalis*
Carolina chickadee	*Poecile carolinensis*	Northern flicker	*Colaptes auratus*
Carolina wren	*Thryothorus ludovicianus*	Northern mockingbird	*Mimus polyglottos*
Chimney swift	*Chaetura pelagica*	Northern parula	*Setophaga americana*
Chipping sparrow	*Spizella passerina*	Pileated woodpecker	*Hylatomus pileatus*
Common grackle	*Quiscalus quiscula*	Purple finch	*Haemorhous purpureus*
Downy woodpecker	*Picoides pubescens*	Red-bellied woodpecker	*Melanerpes carolinus*
Eastern bluebird	*Sialia sialis*	Red-headed woodpecker	*Melanerpes erythrocephalus*
Eastern kingbird	*Tyrannus tyrannus*	Red-shouldered hawk	*Buteo lineatus*
Eastern meadowlark	*Sturnella magna*	Red-tailed hawk	*Buteo jamaicensis*
Eastern phoebe	*Sayornis phoebe*	Red-winged black bird	*Agelaius phoeniceus*
Eastern wood-pewee	*Contopus virens*	Ruby-throated hummingbird	*Archilochus colubris*
European starling	*Sturnus vulgaris*	Scarlet tanager	*Piranga olivacea*
Fish crow	*Corvus ossifragus*	Sharp-shinned hawk	*Accipiter striatus*
Gray catbird	*Dumetella carolinensis*	Tree swallow	*Tachycineta bicolor*
Great horned owl	*Bubo virginianus*	Tufted titmouse	*Baeolophus bicolor*
Hairy woodpecker	*Leuconotopicus villosus*	White-breasted nuthatch	*Sitta carolinensis*
House finch	*Haemorhous mexicanus*	White-throated sparrow	*Zonotrichia albicollis*
House sparrow	*Passer domesticus*		

Table 3. Top generalized linear model selection output for bird species richness and abundance. The top model for bird species richness included tree abundance (TreeAb) and percent shrub ground cover (Shrub). Percent shrub cover was the only informative covariate to predict bird abundance. All model results can be found in Appendix A.

	AICc	K	R^2	Adjusted R^2	*P*-value	Shapiro-Wilks
Richness (TreeAb+Shrub)	248.1	2	9.95e-02	0.05	0.09	0.3
Abundance (Shrub)	365.9	1	1.06	0.08	0.02	0.9

Table 4. Butterfly species observed across 47 residential sites in Pittsburg, Kansas.

Common name	Latin name	Common name	Latin name
Black swallowtail	*Papilio polyxenes*	Monarch	*Danaus plexippus*
Clouded sulfur	*Colias philodice*	Painted lady	*Vanessa cardui*
Cloudless sulphur	*Phoebis sennae*	Pearl cresent	*Phyciodes tharos*
Common buckeye	*Junonia coenia*	Pipevine swallowtail	*Battus philenor*
Common sootywing	*Pholisora catullus*	Red-banded hairstreak	*Calycopis cecrops*
Dainty sulphur	*Nathalis iole*	Red-spotted purple	*Limenitis arthemis astyanax*
Eastern comma	*Polygonia comma*	Silvery checkerspot	*Chlosyne nycteis*
Eastern tailed-blue	*Cupido comintas*	Silver-spotted skipper	*Epargyreus clarus*
Eastern tiger swallowtail	*Papilio glaucus*	Summer azure	*Celastrina neglecta*
Firey skipper	*hylephyla phyleus*	Variegated fritillary	*Euptoieta claudia*
Gray hairstreak	*Strymon melinus*	Zebra swallowtail	*Eurytides marcellus*
Harvester	*Feniseca tarquinius*	Skipper sp.	

Table 5. Top generalized linear model selection output for butterfly species richness. The top model included percent shrub ground cover (Shrub), tree species richness (TreeRich), percent water ground cover (Water), and percent native vegetation (PercNative). All model results can be found in Appendix A.

	K	R^2	Adjusted R^2	*P*-value	Shapiro-Wilks
Richness Shrub+TreeRich+Water+PercNative	4	0.83	0.82	2.69e-12	0.8

Table 6. Dominant tree species recorded across 47 residential properties in Pittsburg, Kansas.

Common name	Latin name
American elm	*Ulmus americana*
Black hickory	*Carya texana*
Black walnut	*Juglans nigra*
Callery pear	*Pyrus calleryana*
Eastern red bud	*Cercis canadensis*
Eastern redcedar	*Juniperus virginiana*
Green ash	*Fraxinus pennsylvanica*
Hackberry	*Celtis occidentalis*
Northern catalpa	*Catalpa speciosa*
Osage orange	*Maclura pomifera*
Pin oak	*Quercus paulustris*
Red maple	*Acer rubrum*
Silver maple	*Acer saccharinum*
Sweetgum	*Liquidambar styraciflua*

Table 7. Dominant shrub layer species recorded across 47 residential properties in Pittsburg, Kansas.

Common name	Latin name
American holly	*Ilex opaca*
American pokeberry	*Phytolacca americana*
Black cherry	*Prunus serotina*
Boxwood	*Buxus sempervirens*
Bridal wreath spiraea	*Spiraea prunifolia*
Common fig	*Ficus carica*
Crape myrtle	*Lagerstroemia indica*
Eastern redcedar	*Juniperus virginiana*
Hackberry	*Celtis occidentalis*
Japanese barberry	*Berberis thunbergii*
Knockout rose	*Rosa radrazz*
Lilac	*Syringa vulgaris*
Oriental bittersweet	*Celastrus orbiculatus*
Rose of Sharon	*Hibiscus syriacus*
Trumpet vine	*Campsis radicans*

Table 8. Dominant flowering plant species recorded across 47 residential properties in Pittsburg, Kansas.

Common name	Latin name
American pokeberry	*Phytolacca americana*
Big leaf hydrangea	*Hydrangea macrophylla*
Black-eyed susan	*Rudbeckia hirta*
Canna lily	*Canna indica*
Common morning-glory	*Ipomoea purpurea*
Common sunflower	*Helianthus annuus*
Common zinnia	*Zinnia elegans*
Chinese hibiscus	*Hibiscus rosa-sinensis*
Crape myrtle	*Lagerstroemia indica*
Four o'clocks	*Mirabilis jalapa*
Garden phlox	*Phlox paniculata*
Iris sp.	*Iris sp.*
Knock-out rose	*Rosa radrazz*
Lambs-ear	*Stachys byzantina*
Lantana	*Lantana camara*
Lemon daylily	*Hemerocallis lilioasphodelus*
Love-lies-bleeding	*Amaranthus caudatus*
Mexican marigold	*Tagetes erecta*
Petunia	*Petunia × atkinsiana*
Purple coneflower	*Echinacea purpurea*
Rose of Sharon	*Hibiscus syriacus*
Rose sp.	*Rosa sp.*
Soapweed	*Yucca glauca*
Tropical milkweed	*Asclepias curassavica*
Trumpet vine	*Campsis radicans*

Table 9. Ground cover species recorded within Daubenmire frame samples at the 47 residential properties in Pittsburg, Kansas.

Common Name	Latin Name
4 O'clock	*Mirabilis jalapa*
American pokeweed	*Phytolacca decandra*
Arrowwood	*Arrowwood viburnum*
Bamboo	*Bambusoideae sp.*
Bee Balm	*Monarda didyma*
Begonia	*Begonia x semperflorens-cultorum*
Bermuda grass	*Cynodon dactylon*
Blackberry	*Rubus sp.*
Black-eyed susan	*Rudbeckia hirta*
Boxwood	*Buxus sp.*
Broadleaf plantain	*Plantago major*
Butterfly bush	*Buddleja davidii*
Caladium	*Caladium × hortulanum*
Canna lily	*Canna indica*
Cherry	*Prunus sp.*
Columbine	*Aquilegia canadensis*
Common milkweed	*Asclepias syriaca*
Common violet	*Viola soroia*
Common zinnia	*Zinnia elegans*
Crabgrass	*Digitaria sp.*
Creeping Charlie	*Glechoma hederacea*
Dandelion	*Taraxacum officinalis*
Daylily	*Hemerocallis sp.*
Dayflower	*Commelina communis*
Dianthus	*Dianthus sp.*
Eastern redbud	*Cercis canadensis*
Eastern red cedar	*Juniperus virginiana*
Euphorbia sp.	*Euphorb sp.*

Table 9. Continued

Common Name	Latin Name
Grape sp.	*Grape sp.*
Hackberry	*Celtis occidentalis*
Henbit	*Lamium amplexicaule*
Hickory	*Carya sp.*
Hosta	*Hosta sp.*
Hydrangea	*Hydrangea macrophylla*
Iris sp.	*Iris germanica*
Jacob's ladder	*Polemonium caeruleum*
Japanese honeysuckle	*Lonicera japonica*
Lamb’s-ear	*Stachys byzantina*
Lantana	*Lantana camara*
Love-lies-bleeding	*Amaranthus caudatus*
Liriope grass	*Liriope muscari*
Love grass	*Eragrostis sp.*
Marigold	*Tagetes sp.*
Mexican hat	*Ratibida columnifera*
Mimosa	*Mimosa pudica*
Morning glory	*Ipomoea purpurea*
Moss rose	*Portulaca grandiflora*
Moss sp.	*Bryophyta sp.*
Mulberry	*Morus nigra*
Mum	*Chrysanthemum xgrandiflorum*
Periwinkle	*Catharanthus roseus*
Petunia	*Petunia xatkinsiana*
Phlox	*Phlox paniculata*
Pin oak	*Quercus paulustris*
Purple coneflower	*Echinacea purpurea*
Raspberry sp.	*Rubus idaeus*
Red maple	*Acer rubum*
Rose sp.	*Rose sp.*
Russian sage	*Perovskia atriplicifolia*
Salvia	*Salvia sp.*
Sedge sp.	*Carex sp.*
Sedum	*Sedum sp.*
Soapweed	*Yucca glauca*
Spiraea	*Spirara prunifolia*
Strawberry sp.	*Fragaria x ananassa*
Sweet potato vine	*Ipomoea batatas*

Table 9. Continued.

Common Name	Latin Name
Sycamore	*Platanus occidentalis*
Tickseed coreopsis	*Coreopsis L.*
Trumpet vine	*Campsis radicans*
Turf grass	*Poaceae sp.*
Virginia creeper	*Parthenocissus quinquefolia*
White clover	*Trifolium repens*
Wintercreeper	*Euonymus fortunei*
Yellow wood sorrel	*Oxalis stricta*

Table 10. Descriptive statistics of demographic characteristics of the survey properties.

Variable	Class	Frequency	Percentage
Gender	Female	23	57.5%
	Male	17	42.5%
Age (years)	Min	22	
	Max	86	
	Mean ± SE	51 ± 19	
Education	High School	6	15%
	Some college	7	17.5%
	College degree	26	65%
	No response	1	2.5%
Income	$0-24,999	6	15%
	$25-49,999	9	22.5%
	$50-74,999	7	17.5%
	$75-100,000	6	15%
	100,000+	8	20%
	No response	4	10%
Employment status	Full-time	22	55%
	Part-time	2	5%
	Homemaker	2	5%
	Retired	11	27.5%
	Student	1	2.5%
	No response	2	5%
Ownership	Own	31	77.5%
	Rent	9	22.5%

Table 11. Differences in bird and butterfly communities across properties that supply and do not supply supplemental feed via bird seed or gardening practices.

	Supplemental Feeding			No Supplemental Feeding				
	n	Mean	SD	n	Mean	SD	t	*P*
Bird								
Abundance	22	40.4	14.3	18	33.8	8.1	1.82	0.03
Richness	22	12.1	2.6	18	8.8	2	2.56	< 0.01
Butterfly								
Abundance	24	5.7	2.9	16	3.8	1.7	2.56	< 0.01
Richness	24	11.3	7.86	16	7.6	5.1	1.81	0.04

Table 12. Environmental attitude assessment responses using the New Ecological Paradigm (NEP) questions.

New Ecological Paradigm (NEP) Survey Questions	Yes%	No%	No response%
We are approaching the limit of the number of people the Earth can support.	65	20	15
Humans have the right to modify the natural environment to suit their needs.	28	65	7
When humans interfere with nature it often produces disastrous consequences.	85	7.5	7.5
Human ingenuity will ensure that we do not make the Earth unlivable.	13	45	12
Humans are seriously abusing the environment.	88	5	7
The Earth has plenty of natural resources if we just learn how to develop them.	55	33	12
Plants and animals have as much right as humans to exist.	93	2	5
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	13	73	14
Despite our special abilities, humans are still subject to the laws of nature.	93	2	5
The so-called “ecological crisis” facing humankind has been greatly exaggerated.	15	75	10
The Earth is like a spaceship with very limited room and resources.	63	25	12
Humans were meant to rule over the rest of nature.	23	65	12
The balance of nature is very delicate and easily upset.	80	13	7
Humans will eventually learn enough about how nature works to be able to control it.	15	70	15
If things continue on their present course, we will soon experience a major ecological catastrophe.	78	13	9

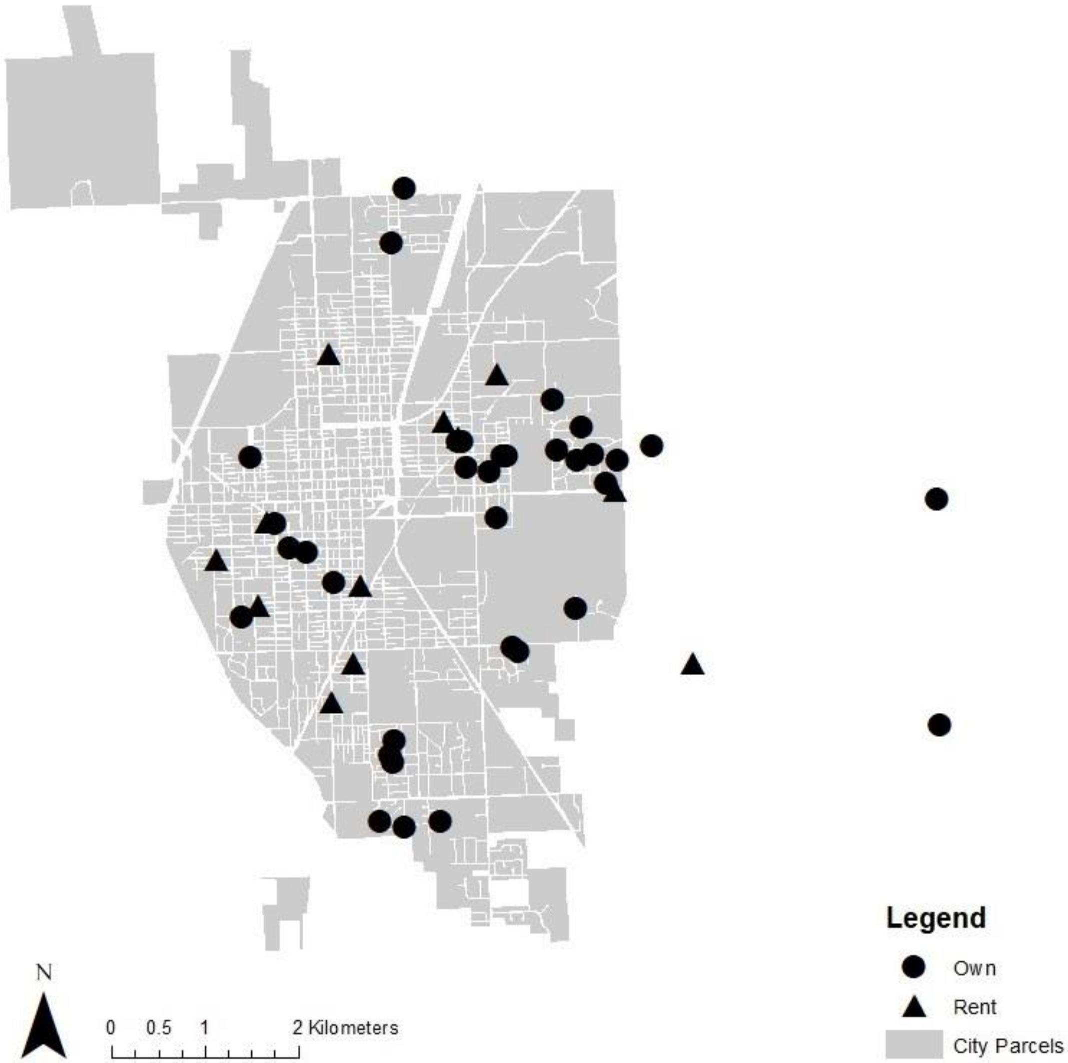


Figure 1. Locations of the 47 survey sites within Pittsburg, Kansas, and their ownership status.

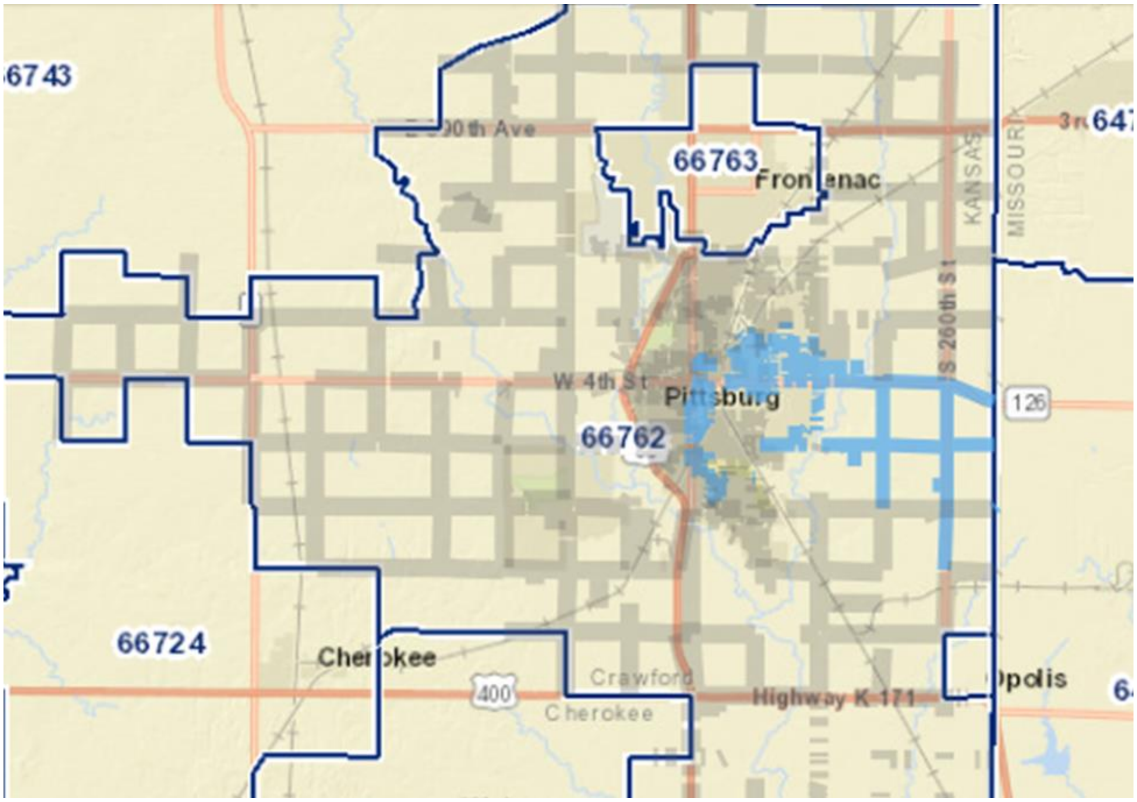


Figure 2. Location of three postal routes in Pittsburg, Kansas where postcards were sent (highlighted in blue). Route ID numbers: 66762-CO13 (571 addresses), 66762 CO-14 (551 addresses), R004 (610 addresses).

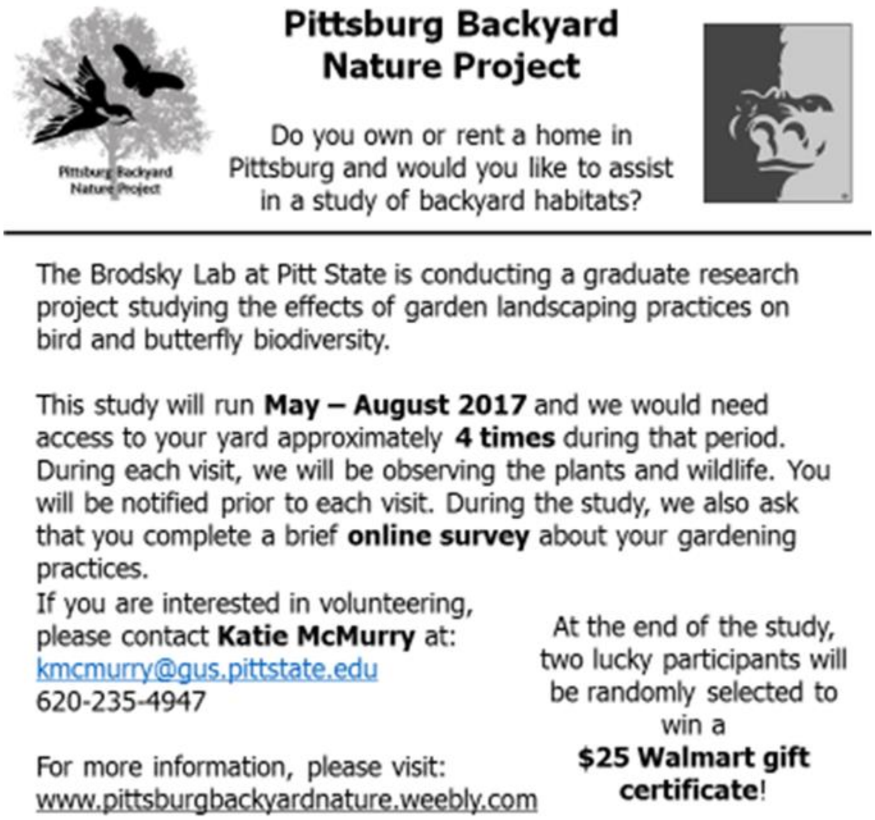


Figure 3. Image of flier and mailer used to recruit volunteers.

Figure 4. Traditional lawn, mixed lawn, and natural lawn management styles (L-R).

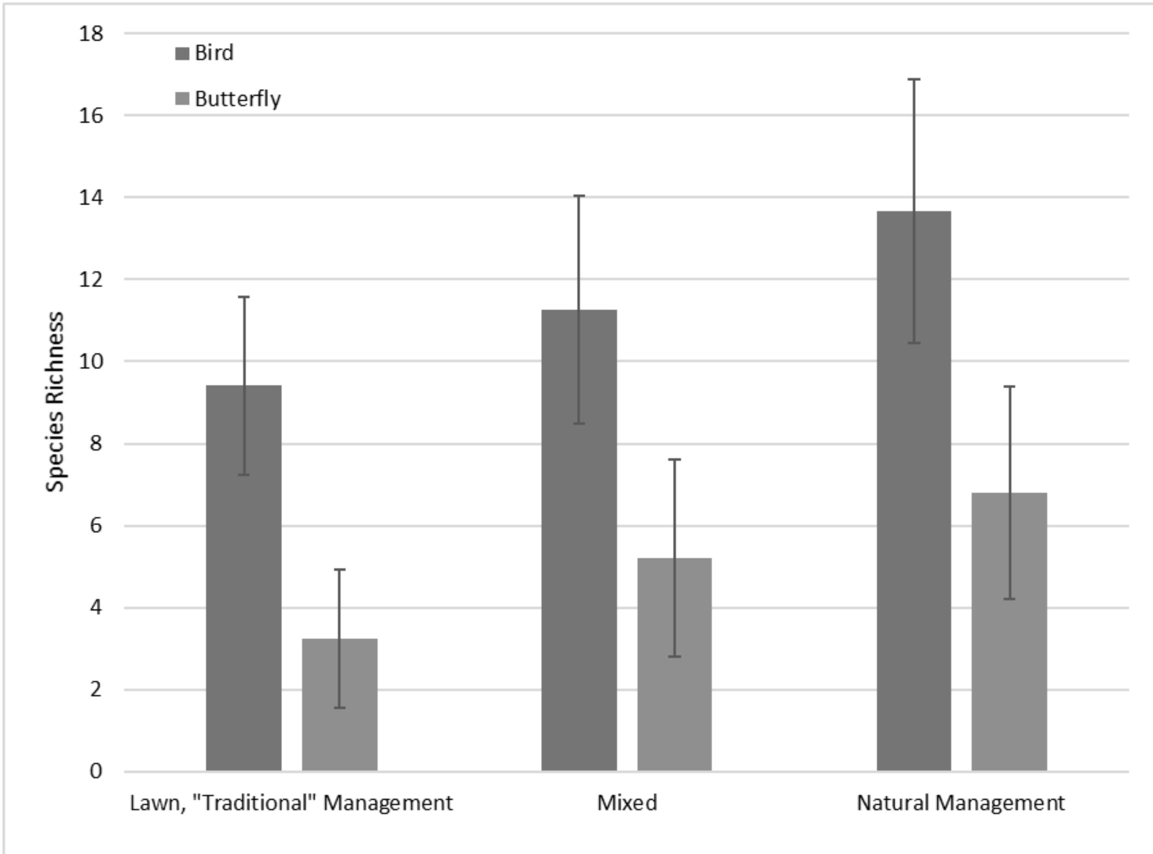


Figure 5. Average bird (ANOVA: F = 9.6, *P*< 0.001) and butterfly species (F = 10.2, *P*<0.001) differed across the three lawn management styles.

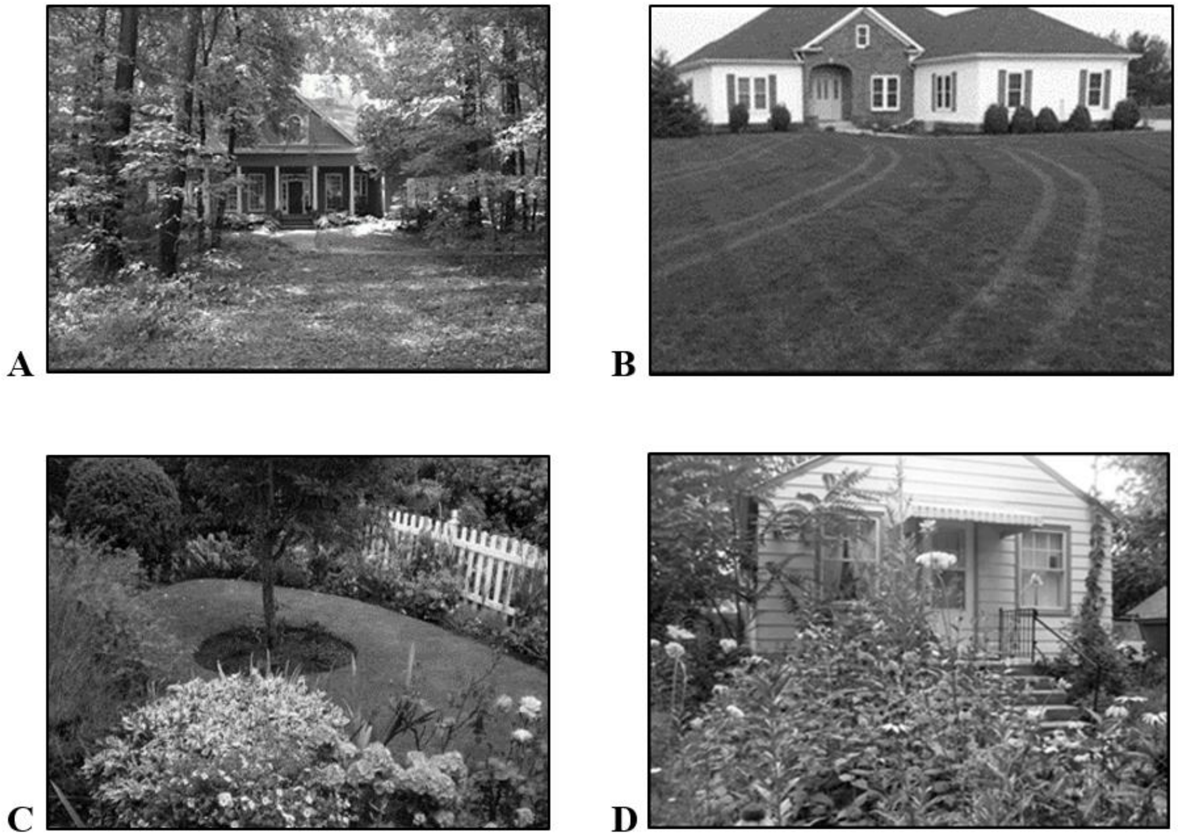
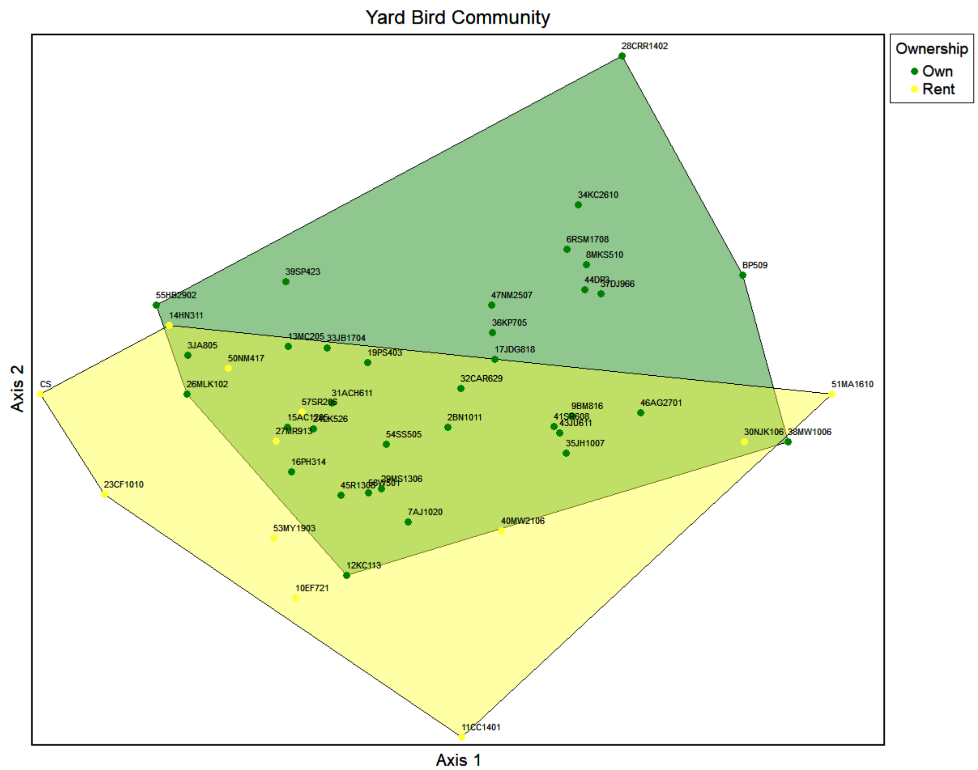
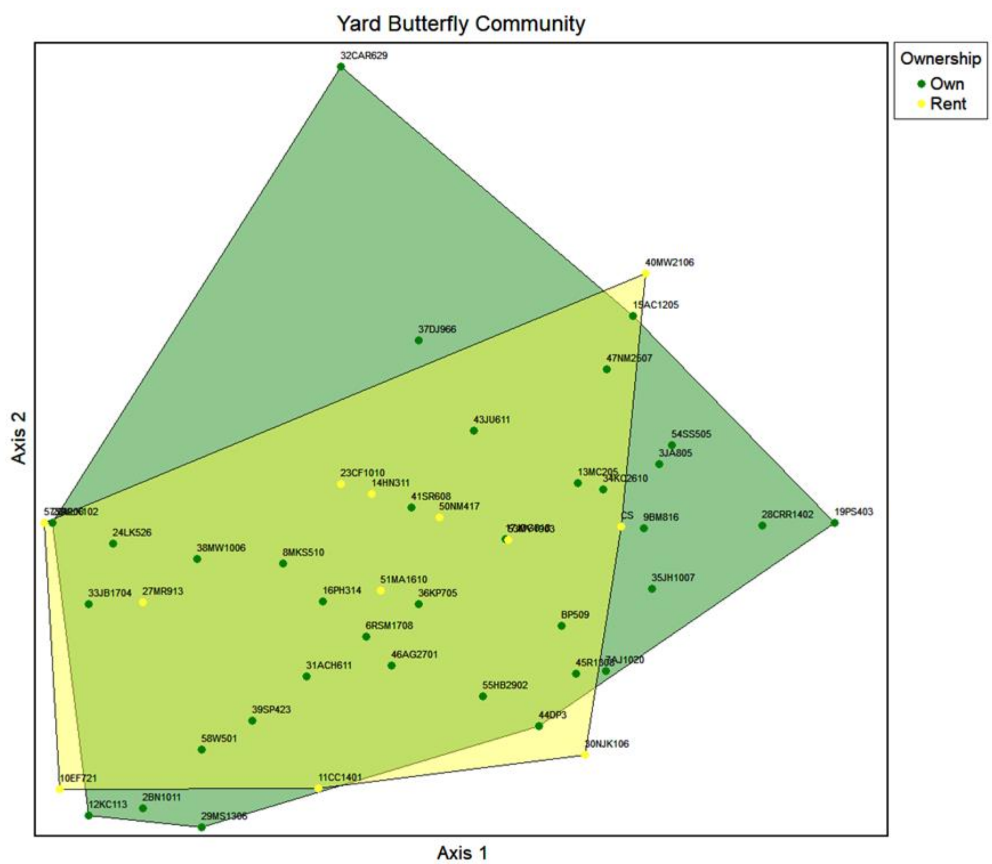


Figure 6. Landscape photos selected for resident survey to assess preference of landscaping style



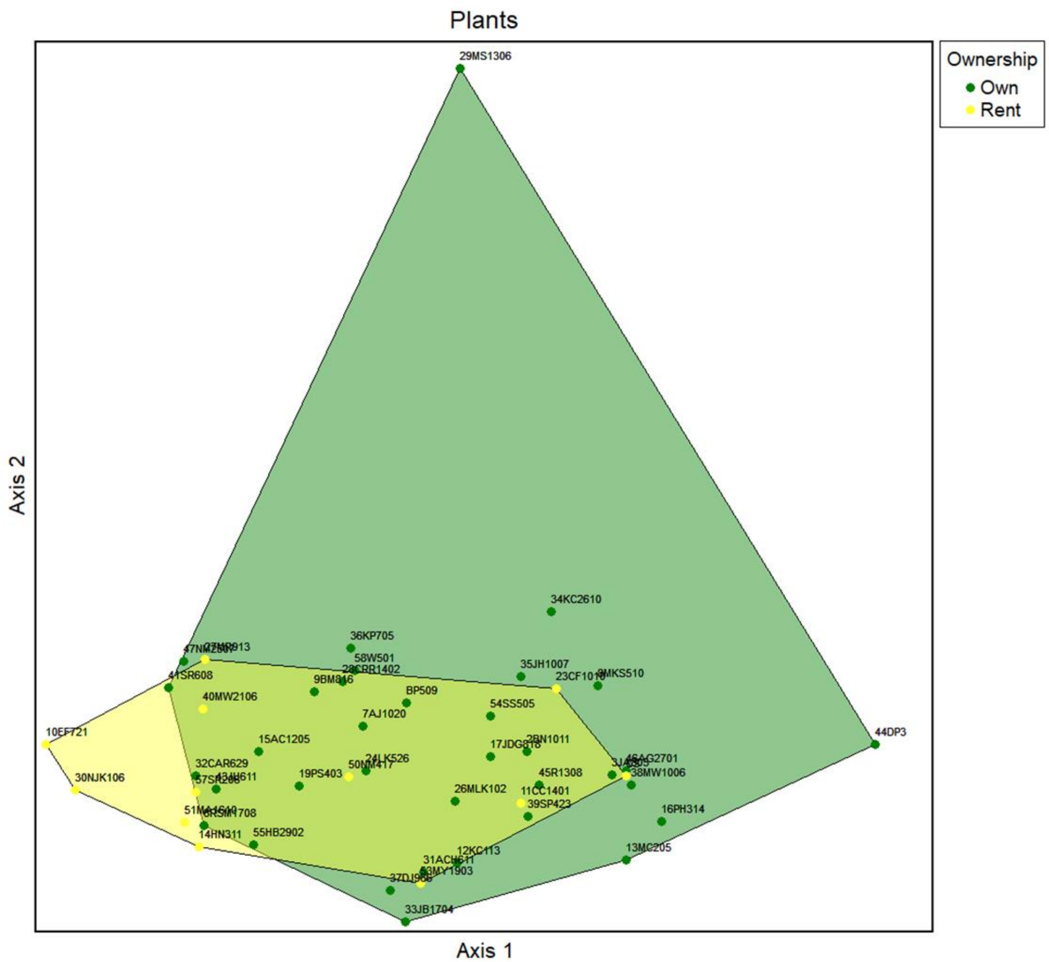
Yard Bird Community
Ownership
Own
Rent
Axis 2
Axis 1

A.



Yard Butterfly Community
Ownership
Own
Rent
Axis 2
Axis 1

B.



C.

Figure 7. Bray-Curtis Ordinations of bird (A), butterfly (B), and ground cover vegetation (C) species composition in regard to resident homeowner status. For all three communities, owner (green) and renter (yellow) properties overlapped, indicating limited differences in community composition for the three taxa. Codes near each data point represent the yard identification code.