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Sustaining Urban Forests in Post-Industrial Cities: Place Attachment, Ecology, and Stewardship Potential

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People value urban green spaces for enjoying nature and socializing with friends, family, and other park users. However, overgrown urban forests without clear access points can be perceived as dark, dangerous, and wild places. As many cities experience reduced budgets, they struggle to maintain green spaces established in more prosperous times. We conducted a descriptive analysis of how constrained parks budgets and subsequent city decisions about maintenance are associated with patterns of forest use, place attachment, and social capital and their impacts on the potential for stewardship of forested parks. We selected Springfield, Massachusetts for our study because it is typical of former industrial cities with highly constrained budgets. We used both qualitative and quantitative analyses of field observations and interviews with park users and nearby residents. We found that access to forests and park use were the strongest predictors of place attachment, and that on-site services, access, and maintenance level were the strongest predictors of use rather than surrounding socioeconomic conditions. Users valued the ecology of the sites, even while park managers highlighted invasive plants as a major maintenance issue. Even though many sites had low levels of use, there remains a strong sense of ownership, community, and safety. Taken together, there is a great deal of untapped stewardship potential in the city, with few organized avenues for users and residents to engage in stewardship. The findings support the hypothesized 'virtuous circle' whereby higher levels of maintenance and access beget greater use and attachment, which motivates stewardship. Alternatively, the more neglected forested parks become, the less use they will have, and the more unknown and unloved they will become. In high use sites, some outreach may be all that is needed to move into the 'virtuous circle,' while greater interventions will be needed in low use sites with no facilities, and these sites are the ones at greatest risk. Since the long-term sustainability of urban forests requires that local residents appreciate, use, and steward them, Springfield and other post-industrial cities need to find creative models for supporting greater involvement of residents in park stewardship while recognizing these residents frequently inhabit communities under stress.

Keywords

Urban forests, place attachment, stewardship, management, post-industrial cities, forest users, urban ecology

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Alicia Coleman conducted initial land use planning and spatial analysis of the urban forests, as well as summarized the interview data for a project report to the City of Springfield. PhD student Evan Kuras worked on analyzing interview themes along with graduate student Anne McSweeney. Summer 2017 field work including surveys and data analysis were conducted by graduate student, Julia Rittershausen and undergraduate Madison (Sonny) Kremer. PhD student Aaron Grade helped with statistical analysis. Vegetation transects were conducted by the student team of Jonathan Bronenkant, William DeVore, Connor Meoli, and Melanie Tapia.

INTRODUCTION

Urban parks and green space play an important role in the social and ecological life of cities (Konijnendijk et al. 2013; McKinney 2002; Sushinsky et al. 2013). People value urban green spaces as places for enjoying nature and socializing with friends, family, and other park users. In regions where forests are the dominant ecosystem type, parks and conservation land with forest areas provide park users with primary access to native biodiversity for city residents (Blair 1999; Aronson et al. 2017; Archer et al. 2019). Access to urban green space including forests provides multiple benefits for human well-being including physical, mental, and socio-emotional benefits (Carrus et al. 2015; Fuller et al. 2007; Hartig et al. 2014; Keniger et al. 2013; Kondo et al. 2018), and forested green spaces also contribute to indirect benefits such as cooling summer temperatures, cleaner air, and stormwater regulation (Pataki et al. 2011, Pickett et al. 2011). However, overgrown urban forests without clear access points can be perceived as dark, dangerous, and wild places (Bixler and Floyd 1997; Ryan 2005; Brownlow 2006; Andrews and Gatersleben 2010). There are many well-established best practices for making forested green spaces into amenities rather than disamenities (Bell et al. 2005; Ward Thompson et al. 2013), but these practices all require staffing and other financial investment. As many cities experience reduced tax revenue and tightening budgets, they find themselves struggling to maintain networks of green spaces established in more prosperous times (Barrett et al. 2017; Fulton 2012; McCormick 2020). What happens to the ecological conditions of forested green spaces when city budgets are under stress? And what are the implications for people's use, attachment to, and willingness to care for these spaces?

In response to declines in city budgets, particularly in the United States, parks departments typically either raise new fee revenue or lower park maintenance, with each strategy having a different set of associated effects. Fees create barriers to access, particularly in economically stressed communities. Or cities choose to reduce the number of maintained parks, such as in chronically underfunded cities like Flint and Detroit in Michigan, who made the decision to stop maintaining parts of the city, essentially letting them go wild (City of Flint 2019; McGraw 2019). Similar patterns of neglect have played out in fiscally stressed cities and are disproportionately concentrated in a city's minoritized communities and reflect legacies of racialized land policies and segregation (Grove 1996; Heynen 2003; Brownlow 2006; Whitehead 2009; Lubbe et al. 2010).

There are both direct and indirect effects of increased fees and reduced maintenance on park users' experiences, and we suggest these effects can reduce the potential for engaging park users in stewardship (Fig. 1). When city park budgets do not allow for maintenance land becomes overgrown with abandoned trails and run-down picnic areas and recreation areas. If no one intervenes to support maintenance, former park users may shift their usage to other parks or reduce their use of parks altogether. When this occurs, it lowers the place attachment that residents have for public parks (Ryan 2005; Low, Taplin, and Scheld 2009). Place attachment is an emotional connection between people and place that has been found to foster pro-environmental attitudes and motivate advocacy and stewardship of urban parks (Shumaker and Taylor, 1983; Scannell and Gifford, 2010; Ryan, 2005; Romolini et al., 2019). With fewer people using the parks, particularly forested parks, they can be perceived as, or indeed become, a dangerous place thus reinforcing negative impacts on place attachment and reduced usage (Ryan

2005; Romolini et al. 2019). Previous studies have also shown that vandalism and other signs of neglect negatively impact users' place attachment to urban natural areas (Eder and Arnberger 2012).

Figure 1. Potential factors influencing stewardship potential by visitors to green spaces in Springfield via their use and perceptions. Lines connect hypothesized relationships. Photo credits (clockwise from top left): R.L. Ryan, R. L. Ryan, P.S. Warren, Urban Ecology Institute (Boston, MA).

Lower maintenance also has ecological effects (Aronson et al. 2017; Rega-Brodsky et al. 2018; Brown et al. 2020), which can in turn affect use, further reducing place attachment or a sense of safety (Fig. 1). For example, reduced maintenance can lead to invasive plants overtaking native vegetation with the impact of reduced richness of both plant and animal diversity (Burghart et al. 2009; Narango et al. 2018). Reductions in some forms of maintenance, such as mowing, can instead yield an increase in flowering plant diversity, with associated increases in pollinator richness (Gardiner et al. 2013; Lerman et al. 2018). When reduced maintenance is intentional, green space users may respond positively to these more biodiverse landscapes (Southon et al. 2017). Reduced mowing in some sections of a green space while maintaining distinct edges and installing signage are among the "cues to care" that can make un-manicured areas that the public perceives as weedy or 'messy' more acceptable to users and passersby

(Nassauer 2004, Li and Nassauer 2020). Without these signs of management, however, more biodiverse unmaintained settings can be perceived as disamenities (Nassauer 2004; Rega-Brodsky et al. 2018).

If residents use parks less, communities that support rules and norms of behavior also are diminished, along with feelings of safety and prosocial behaviors in parks (e.g., helping someone in need, willingness to enforce users' dog waste or trash pickup) (Helliwell et al. 2017). Parks within a city generally operate with a set of similar formal rules (e.g., no alcohol, litter disposal, hours, etc.), but there can be significant variation in the "rules-in-use" (Ostrom 2005). For example, it may be culturally acceptable to play loud music at one park whereas at another it would be viewed as disturbing others' enjoyment of the park. Social capital refers to the "the shared knowledge, norms, rules and networks that facilitate collective experience within a neighborhood" (Vemuri et al. 2011). There can be high levels of prosocial behaviors at one park that help to build social capital that contributes to greater well-being (Helliwell et al. 2017) but low levels at other parks. Emerging literature examines norms of behavior governing how people interact with nature and engage with one another while using the resource (Ostrom 2005; Noonan et al. 2016; Bushouse et al. 2016). Understanding the rules-in-use governing park users' behavior can help explain which parks have high levels of prosocial behaviors. It can also help explain where prosocial behavior breaks down and people feel unsafe and may stop enjoying the resources, thereby decreasing park users' social capital and, without another park may reduce well-being (Helliwell et al. 2017).

One solution to the challenges imposed by reduced budgets is to enlist citizens in co-stewardship of green spaces with city staff (Low, Taplin and Scheld 2009, Krasny and Tidball 2012, Krasny et al. 2014, Fors et al. 2019). Residents' stewardship of urban green spaces is important for the long-term survival of these spaces. Stewardship operates on several different levels, from the informal stewardship of individuals taking action to maintain green spaces to formal stewardship "friends of the park" groups to major stewardship organizations like non-profit conservancies that co-manage parks (Krasny and Tidball 2012, Krasny et al. 2014, Gazley et al. 2018).

There are some complex issues and challenges with enlisting citizens in co-stewardship as a solution to budget constraints. It is unclear to what extent factors like reduced maintenance, declining access to green spaces, reduced place attachment, and levels of social capital among users might harm the potential for cities to harness citizen-based stewardship as compensation for declining budgets. If reduced maintenance in parks is either inequitably distributed or perceived as biased toward marginalized communities, then a call for citizen-based stewardship of neglected spaces might itself constitute an injustice and further exacerbate distrust of municipal authorities (Carmichael and McDonough 2018). On the other hand, Whitehead (2009) argues that reclamation of neglected spaces is the moral responsibility of a community that "extends far beyond the realms of municipal government and policing." His analysis cautions against an over-reliance on "formal governance structures of park guards and police authorities." Brownlow (2006), by contrast, highlights the importance of social control - and the absence of both formal and informal social control - in generating "hazardous and 'unsafe' urban ecologies," which can limit engagement with urban green spaces in racialized and gendered ways. Here, we examine the potential for co-stewardship to address some of the issues facing cash-strapped cities, while recognizing that when done badly, the implementation of co-

stewardship may perpetuate harm to already stressed communities (Low, Taplin, and Scheld 2009, Carmichael and MacDonough 2018).

In this paper, we used a case-study approach to explore how constrained parks budgets and subsequent city decisions about maintenance are associated with patterns of forest use, place attachment, and social capital and their impacts on the potential for stewardship of forested parks in financially stressed cities, such as the post-industrial cities of the United States, where traditional industry is a declining part of the economy. During prosperous times, residents enjoyed well-maintained public parks in these cities (Cranz 1982; Herwitz 2001). But for many cities, the economic boom times ended decades ago, leaving behind economically depressed cities with limited potential for tax revenue. Our case study location, Springfield, Massachusetts is an economically struggling city, typical of former industrial towns and Midwestern rust belt cities whose fortunes changed in the 20th century, leaving them with expansive park infrastructures but little revenue to support maintenance (City of Springfield 2015 2017a; City of Flint 2019; Barrett 2017). Springfield has a network of large and small forested parks and conservation areas. In a representative sample of these sites, we pursued the following objectives:

1. Assess the primary goals for green space management and challenges faced by managers of Springfield's urban forested green spaces.
2. Quantify green space conditions and model relationships among conditions, frequency of use, and users' place attachment.
3. Examine the potential for social capital to influence stewardship potential, by analyzing users' perceptions of green space conditions, sense of safety and community, and prosocial behaviors.
4. Explore willingness to engage in stewardship to serve as a co-productive solution to constrained park budgets as influenced by social factors.

Taken together, this descriptive case study analysis of Springfield yields broadly applicable insights into both the challenges and potential solutions for green space management and stewardship for other cities under economic stress.

CASE STUDY AREA

Springfield, Massachusetts is typical of mid-sized cities in the Northeastern US, which suffer declining industrial economies, shrinking government funding, and shifting demographics of white wealth outward and impoverished communities of color inward. The city is located along the Connecticut River and is the 3rd most populous city in the Commonwealth of Massachusetts with a population in the city proper of 155,032 and 631,652 in the metropolitan statistical area and a land area of 31.9 square miles. Springfield is a regional employment center for western New England and is surrounded by more affluent suburbs and smaller cities. The population is minority-majority (67%) with Hispanic (44%) and Black (21%) as the two largest race/ethnicities. Springfield's poverty rate (29%) is greater than twice that of the Commonwealth of Massachusetts (11%), has half the median household income ($37,118) of the state ($74,167), and is also well below the national median income level ($57,652). Springfield residents have

lower levels of educational attainment (77% high school, 18% college) relative to the state (90% high school, 42% college) (U.S. Census Bureau 2010).

Springfield's more prosperous past is reflected in its extensive park system with over 2,000 acres of parkland, which is mostly forest cover (City of Springfield 2015). Over half of this acreage is in four major parks including Forest Park, the 735-acre centerpiece of the park system. The city also has 600 acres of conservation land divided among 60 parcels. The city is overall highly forested (37% canopy cover), which is between the canopy levels for Boston (28%) and Worcester (40%), the two largest cities in the state (Bloniarz et al. 2014).

The Springfield Parks, Building and Recreation Department experienced a steep decline in budget and staffing. From 2008 to 2015, the annual budget declined by 45% from approximately $20 million dollars to $11 million dollars; adjusting for inflation, the difference becomes even more stark – a 50% decline from $26 million to $13 million dollars. The full-time staff declined by about one-third during this period from 150 to 105 employees (City of Springfield 2008; 2015). The department's duties encompass maintenance of city buildings, parks, and recreation facilities. The Conservation Commission, an elected commission reporting to the Office of Planning and Economic Development that oversees and protects natural lands and water bodies, has an even more limited budget and minimal staff (City of Springfield 2017a).

METHODS

Study Sites

We identified nine forested green space sites varying in the degree of public participation in management and managing entities but controlled for forest type and topography. Five of the sites are managed by the Parks and Recreation Department and four are managed by the Conservation Commission (Table 1). The parks (managed by the Parks and Recreation Department) are a mix of active recreation and playgrounds, along with forested natural areas that are the focus of our study interest. The conservation lands (managed by the Conservation Commission) are passive natural areas that vary in the condition of trails and access. Two parks charge parking fees (Forest and Blunt Parks); vehicle fees were instituted at Forest Park in 1992 and in the 2000s at Blunt Park (exact year not recorded). Since these fees potentially limited users' access to these sites, we grouped sites into "parks with fees," "parks without fees," and "conservation" sites to assess how these different types of sites were maintained and viewed by visitors (Table 1). One site, Wesson Park, was historically managed by the Parks Department but is now a passive- use wooded area; thus, we classified it as a "conservation area" in analyses of users' perceptions.

Objective 1: Current green space management, goals, and challenges

To characterize the current state of green space management in Springfield, we interviewed park and conservation land managers and analyzed the City of Springfield's Open Space and Recreation Plan (2015). The plan provided information on existing evaluations and goals for the green space study sites, as well as overall park planning trends, maintenance and budget trends,

and historical context. These plans are required by municipalities to apply for state funding, an important source of capital improvements to parks. Based on this review, we generated an interview protocol and conducted semi-structured interviews with 7 municipal staff in the City Parks and Recreation, Conservation, and Planning Departments, who are the chief actors involved in governing the green spaces in our study. Interviewees were invited to comment on the key challenges they encounter in managing the green spaces. We documented the interviews in transcribed audio recordings and field notes.

Table 1. Characteristics of the forested parks and conservation areas in Springfield, Massachusetts included in the study. Facilities refers to whether the woodland was within a park with recreational facilities or a conservation area with no facilities. Park size was derived from the Open Space Plan (City of Springfield 2015). Access to woodland (maximum = 5) and maintenance level (maximum = 30) scores were extracted from the field evaluations using the Woodland Audit Tool (WIAT; Ward Thompson et al. 2007). Invasive plants reflect the number of stems of invasive plants counted within transects along woodland trails. Forest use and place attachment scores were derived from park user interviews (details in Methods).

Park	Facilities	Size (ha)	Access to woodland	Maintenance level	Invasive plants (stems)	Forest use	Place Attachment
Blunt Park	Park w/ fees	65.4	3.0	19	190	3.1	5.0
Forest Park	Park w/ fees	297.5	4.8	28	26	3.4	10.0
Hubbard Park	Park	26.6	3.4	24	545	3.6	7.0
Van Horn Park	Park	46.7	4.8	29	311	3.5	8.0
Wesson Park*	Conservation	8.0	1.6	9	867	1.2	3.0
Abbey Brook	Conservation	15.9	1.2	11	915	1.8	2.0
Entry Dingle	Conservation	7.2	1.0	15	65	1.6	3.0
Labelle	Conservation	9.3	1.0	16	0	1.3	1.0
Woodland	Conservation	15.8	1.4	11	72	2.1	4.0

*Wesson Park is officially part of the park system but is managed as passive woodland with no recreation amenities.

Table 2. Summary of methods used to address each of the study objectives.

Objective	**Data collection**	**Analytical approach**
1. Assess **goals and challenges** for Springfield's urban forested green spaces	Analysis of public documents Expert interviews	Descriptive summaries of goals/challenges Key themes from interviews used in formation of surveys for Obj 3-4
2. Quantify **green space conditions** and relationships with use and place attachment	Field assessments: Woodland Audit Tool, invasive plant surveys MassGIS land use data; US Census data Semi-structured interviews with green space users: indices of use and place attachment	Quantitative analyses of factors associated with use and place attachment, using linear models and model selection
3. Examine potential for social capital to influence stewardship potential, by analyzing **users' perceptions of green spaces**	Semi-structured interviews with green space users Focus groups with 3 neighborhood councils (Blunt Park, Forest Park, Hubbard Park)	Qualitative analysis of coded themes, with focus on: ● perceptions of and attitudes toward green spaces ● sense of safety and community ● engagement in prosocial behaviors
4. Explore willingness to engage in **stewardship**	Semi-structured interviews with green space users	Qualitative analysis of coded themes, with focus on: ● Engagement in stewardship

Objective 2: Green space conditions and relationships to use and place attachment

We conducted assessments of site-level conditions at the nine parks and conservation areas, including maintenance levels, accessibility, ecological conditions, and surrounding land use (Table 1). The measures are derived from previous literature (Ward Thompson et al. 2007) and from issues identified during manager interviews. The measures we used to quantify green space conditions included: access to trails, levels of maintenance, ecological conditions, surrounding land use, and socioeconomic status. Measures of place attachment and frequency of use were extracted from semi-structured interviews (see Objective 3). We describe our modeling approach in the Analytical Approaches section.

Access to trails and level of maintenance

Each park was evaluated in the summer of 2015, using a 25-question protocol adapted from the Woodland Audit Tool (WIAT; Ward Thompson et al. 2007). A trained research assistant conducted the WIAT audit (reviewed for accuracy by the research team) for each study site assessing the wooded portions of nine green spaces in terms of user-friendliness, character, and opportunities using a five-point Likert scale for each question. We evaluated site access by rating access to the woodland from nearby homes and streets, visible entrances, quality of path network, handicap accessibility, and signage (maximum score = 25). The access to woodland score was the average of the five WIAT items related to woodland entrances, path quality, and signage, scored on a 1-5 scale with 1=poor to 5=excellent. Maintenance level was also extracted from the WIAT and was a sum of the ratings of vegetation maintenance; amount of litter, graffiti, and vandalism at the site and neighborhood levels; site furnishings; development; and adjacent road quality (maximum score = 30).

Ecological conditions – invasive plants

Significant impacts to the ecology of urban green spaces can occur in urban forests when non-native and/or horticultural plant species propagate in wooded areas and become invasive. We measured the abundance of invasive plant species at the most commonly used trailhead entry points for each of the green spaces. We reasoned that these entry points would be the most highly maintained sectors and therefore a useful indication of the maximum level of invasive plant control for each site. Entry points are also the first thing that potential visitors see upon approaching a green space and may thus play an important role in visitors' decisions about whether to use a space. We conducted 20m long by 10m wide transects, beginning from a typical human entry point to each woodland site, sampling exhaustively for invasive species along the trail edge. Two trained observers conducted surveys, recording the number of stems and identity of each invasive plant species within 5m of the edge of the trail at 2m intervals along the transect. We summarized both the number of stems of each species and the total number of stems per transect (Table S1).

Surrounding land use and socioeconomic status

Land use in the area around each park was extracted from the Commonwealth of Massachusetts' 2005 land use data layer (Office of Geographic Information 2009) using ArcMap 10.4 (ESRI 2016). We calculated the percentage of low-density residential, high-density residential, and natural lands in 500m (0.31 mile) buffers around each site (Table S2). In addition, forested land-use class was also used to calculate the size of the forest patch within each park or conservation area (Table S2). We characterized the socioeconomic status of the neighborhoods surrounding the sites using the metric percentage of households below the Massachusetts median income (Table S2), extracted from the U.S. Census at the block group level (U.S. Census Bureau 2010).

Indices of green space use and place attachment

We extracted quantitative measures of frequency of use and place attachment from semi-structured interviews with green space users (see Objective 3). Frequency of use was derived from interview responses using a 4-point numeric scale from 1=never 2=rarely (less than 2 times a month, 3=sometimes (at least two times in one month, 4= often (daily or several times a week). Place attachment measures for each park were quantified by summarizing interview questions on place attachment and familiarity using a 10-pt. scale from 1=unknown/no attachment/familiarity to 10=widespread attachment and familiarity. Place attachment used the question, "Do you feel any special connection or appreciation for XX park, or its wildlife, plants, or trees?" and familiarity, "How familiar are you with XX park?" The index was created by the research team based on quantification of interview responses to these questions and verified using inter-rater reliability measures.

Objectives 3 and 4: Social capital and willingness to engage in stewardship.

We conducted on-site interviews and focus groups to assess the effects of constrained budgets and reduced levels of maintenance on the experience of green space visitors and their willingness to engage in stewardship. Specifically, we quantified park users' frequency of use, place attachment, and measures of prosocial behaviors and sense of community.

Semi-structured interviews

The research team conducted semi-structured interviews in the summers of 2015 (n=101) and 2017 (n=39) at all nine Springfield parks, on at least two visits per site at varying times of day to capture a representative array of users. These interviews asked residents' attachment to their local parks that contain forests, their use of these parks, and perceptions about management. They were also asked about their willingness to engage in park stewardship, as well as park rules and "rules-in-use." Questions about rules were derived from an evaluation of the park rules from policy documents, the city's official website, and signage at park entrances (City of Springfield 2017b). Since interviews were conducted both within the parks and on their periphery, we were able to interview people who were less frequent or non-park users in order to control for non-response bias. The second field season of interviews (n=39) focused on themes from the first set of interviews using a refined semi-structured interview form with open and close-ended questions related to park use, rules-in-use, and place attachment with a new set of questions to

assess prosocial behaviors among park users. Individual interviews were recorded on standardized intake forms, and researchers wrote verbatim quotes when participants elaborated extensively on a theme. Since this second field season had fewer participants, we combined both data collections on place attachment in the analysis rather than analyzing it separately.

In 2015 the research team led three focus groups with the neighborhood councils for Blunt Park (n=8), Forest Park (n=30), and Hubbard Park (n=3), a sufficient number to reach thematic saturation (Guest et al. 2016). Focus groups were facilitated with questions to elicit participants' typical ways of visiting, using, and enjoying their local park, personal memories, knowledge of park resources and rules, and problems they observed in the park. Focus group discussions were audio-recorded and transcribed. Focus group participants were members of the neighborhood councils who are advisory boards to the city made up of local citizens. In the case of Forest Park, this also included other neighborhood residents. While these focus groups are representative of neighborhood leadership and diversity, the participants were older on average than the populations in their neighborhoods as a whole.

Coding of transcribed interviews

The research team developed the following list of etic, thematic codes deductively derived from the questions in the interview and focus group protocols: Attachment (memories and regular leisure patterns linked to the green space), Challenges (problems observed), Familiarity (users' familiarity with the park or green space), Future (what users would like to see in the future), Management (how the park is maintained and governed), Rules (knowledge of the official rules and whether users respect and observe these), Stewardship (activities to preserve aesthetic and ecological features), Uses, and Wildlife (participants' ways of interacting with wild animals). One research team member used NVivo software to code qualitative data from the 2015 interview notes and focus group transcriptions, and another team member reviewed the code applications to ensure consistency; team members reviewed the coded text that were most relevant to their area of expertise. We analyzed over 1,250 coded text excerpts, grouped by theme, to determine patterns in users' perceptions of and attitudes toward different green spaces in Springfield. We analyzed the 2015 and 2017 interview responses on place attachment and additional questions on social capital.

Analytical Approaches

We used a mixture of quantitative and qualitative approaches to address our four research objectives. To address objective 1, we extracted key themes from the text of our manager interviews and related them to the cities' management plans. We summarized the goals for green space management and challenges faced by the municipal land managers.

To address objective 2, we conducted quantitative analyses of potential factors associated with frequency of use and users' place attachment for forested green spaces. We used standard linear models and model selection approach (using AIC) to examine potential factors associated with frequency of use and place attachment (Fig. 1): Our model specified predictor variables as site type (fee/service status), access to trails (Woodland Audit scores), maintenance level (Woodland Audit scores), ecological conditions (invasive plant cover) and potential covariates

(surrounding land use from GIS cover classes, and socioeconomic status from U.S. Census data). Response variables in the model were: forest use and place attachment (quantified as indices from the user interviews). As an initial screening of the variables, we conducted model selection on all potential single variable models and discarded variables with $p>0.05$ (Appendix S3-4). Then, on this subset of variables, we conducted model selection comparing null model, single variables, combinations of up to two variables, and two-way interactions. This process identified the variables most likely to predict park use and place attachment. We then used the variables from the top models in multiple regression to examine the relative effect sizes of each key factor while controlling for the others. As Springfield's largest and most well-known park, Forest Park was a potential outlier; we conducted analyses including and excluding this site. We assessed violations of model assumptions by examining quantile-quantile plots (Q-Q plots), which show deviations from normal distributions. When Q-Q plots appeared skewed, we ran the models with transformed data. In all cases, this eliminated the skew, and did not substantially change the results. We report the untransformed model results for greater ease of interpretation.

To address objectives 3 and 4, we analyzed the themes from the coded semi-structured interviews (Appendix S5). For objective 3, we focused on patterns in users' perceptions of and attitudes toward different green spaces in Springfield as well as their sense of safety and community and their engagement in prosocial behaviors in different green spaces. We also analyzed the 2015 and 2017 survey responses on place attachment and additional questions on social capital. For objective 4, we focused on the variation in and prevalence of users engaging in stewardship. In 2017, our on-site interviews included four survey questions specifically addressing user's stewardship activities and willingness to engage in future stewardship. Sample sizes for the 2017 questions were too small to compare across sites and were summarized for the total pool of interviewees.

RESULTS

Objective 1: Current green space management, goals, and challenges

The City of Springfield's current green space management goals, per the adopted Open Space and Recreation Plan and its updates, include implementing a vegetation management program for non-native/invasive plants and "trail and hazard tree maintenance on existing properties" (City of Springfield 2008; 2015). The City plans to continue the restoration of high-use facilities such as playgrounds in parks in densely populated neighborhoods and appears to place a lower priority on maintenance of the underutilized forest patches (City of Springfield 2015, p. 4). Specifically, four parks in our study (Van Horn, Blunt, Hubbard, and Forest Parks) are listed for five-year path restoration actions in response to the overgrown nature of formerly managed forest land, trails, and picnic areas along with the prevalence of non-native invasive plants.

Exploratory analyses of manager interviews supported the plan goals and revealed concerns about invasive plants and overgrown conditions of recreational areas on the sites, as well as illegal dumping, vandalism, and off-road vehicle use in some conservation areas that erode soil. All interviewees commented on limited budgets and staffing. In response to these constraints, the City of Springfield Open Space and Recreation Plan focuses attention on maintaining existing resources. To address maintenance costs, the city instituted automobile

entrance fees for Forest Park and Blunt Park with plans to expand these fees in the future to generate revenue (City of Springfield 2015).

There is little participation in stewardship through "friends groups" of volunteers with the exception of Forest Park. Our second set of interviews (2017) identified interest from residents in volunteering to support their neighborhood parks.; however, there is no infrastructure through the city for supporting the development of these groups. According to interviewees, the City hopes to develop an "Adopt-A-Park" program through neighborhood councils.

Objective 2: Green space conditions and relationships to use and place attachment

Access to forested areas and levels of maintenance

The Woodland Audit revealed key features influencing site access, such as visible and well-signed entrances to forested areas, well-maintained trails, and universal access. Generally, the parks with forested sections were rated more highly than conservation areas in this analysis (Table 1). Several of the conservation areas were missing signs identifying them as public land as well as clear entry points into densely forested areas. This was true even for conservation areas with well-worn path systems. We generally observed higher use in sites with a diversity of spaces and amenities such as benches, well-maintained paths, and water bodies, such as ponds or streams. The Woodland Audit included observing the amount of trash, vandalism, and other signs of misuse, which was more prevalent in forested areas with limited access. Forest peripheries near public roads and/or homes had the most litter.

Ecological conditions

All the common invasive species targeted by the survey were detected in at least one site. However, round-leaved bittersweet (*Celastrus orbiculatus*), a species of climbing vine that has the potential to kill trees, was clearly the dominant invasive species in the sample. It occurred in all sites and had the highest number of stems detected overall, with Norway maple (*Acer platanoides*) and multiflora rose (*Rosa multiflora*) in second and third place behind it, respectively. Invasive vines drove the patterns for invasive species overall: the strongest correlation with total number of invasive stems was with number of vine stems, rather than shrub or tree stems (Table S1). Multiflora rose, an invasive that can function as either a vine or a shrub, occurred in significant numbers at 3 parks (Abbey Brook, Hubbard Park, and Wesson Park), and was strongly correlated with abundance of bittersweet (correlation coefficient=0.93, $p<0.0001$). Norway maple dominated at Wesson Park, Entry Dingle, and Van Horn Park, but also occurred in significant numbers at Abbey Brook. Garlic mustard (*Alliaria petiolata*), an herbaceous ground cover species, was the most numerous invasive at Van Horn. Virginia Creeper (*Parthenocissus quinquefolia*), a pernicious native vine, was abundant at Hubbard Park. The dominance of this invasive plant community by bittersweet and other species that climb on trees, fences, and other human structures makes the variation among sites in invasive species highly visible to both site managers and green space users.

Modeled relationships among site conditions, use, and perceptions

We used model selection to identify the variables most strongly associated with the frequency of use of the green spaces and users' place attachment. We report here only the top models, but information on all models is provided in the supplementary materials (S3 and S4).

Frequency of use was most strongly associated with the site type - highest use at sites with recreational facilities and no fees, lowest use at sites with no facilities. The top model included this categorical variable and no others (Table S3) and was strongly significant (adjusted R^2=0.89, p=0.0005). Two other models were within Delta AICc < 6, both of which were single variable models, including forest access (adjusted R^2=0.74, p=0.002) and maintenance level (adjusted R^2=0.72, p=0.002). Usage was greater in sites with greater access and higher levels of maintenance.

Access was the variable most strongly associated with place attachment; the top model of place attachment was a single variable model including this variable (adjusted R^2=0.88, p<0.0001. Sites with greater access to forested areas - clearly marked trails, well-maintained trail entrances - had visitors with stronger place attachment. All other models within Delta AICc < 6 included forest access and one other non-significant variable, except for one (Table S4). This was a single variable model including frequency of use (adjusted R^2=0.78, p=0.001). Place attachment was greater in sites with great usage.

None of the top models in model selection for either use or place attachment included surrounding land use and socioeconomic variables (Table S2).

Table 3. Summary of key findings from quantitative and qualitative analyses of factors influencing use, place attachment, and stewardship in forested parks in Springfield, Massachusetts. Key influential factors were strongly supported by model selection analysis or were dominant themes in interviews.

	Key influential factors	**Other potential factors**
Frequency of use	● Models found the highest levels of use at sites with recreational facilities, better access to forests, and higher maintenance levels. ● High user community safety ratings were more common in interviews at sites with higher rates of use.	● Surrounding land use and socioeconomic status were not significantly associated with use in models. However, park fees were mentioned as a barrier to usage in the case of Blunt Park, a park with many low-income residents in the surrounding area. ● Invasive plants were not in the top quantitative models but were mentioned frequently in interviews.
Place attachment	● Access to forests was the dominant factor in models of place attachment. ● In interviews, place attachment was weakest at conservation areas lacking in recreational facilities. ● Low maintenance levels and overgrown vegetation were mentioned in interviews as contributing to weaker place attachment at some parks.	● Surrounding land use and socioeconomic status were also not significantly associated with place attachment in models. ● Park fees, however, may be leading to diminished place attachment at Blunt Park, as users describe relocating family events to avoid fees.
Stewardship	● Interest in stewardship and prosocial behaviors were high across all sites (e.g.,70% said "yes" to volunteering) ● Interviewees commented frequently about the lack of opportunities to engage in stewardship activities. ● Limited sample size prevented the use of quantitative models of the drivers of stewardship or prosocial behaviors.	● The only site with an active friends' group (Forest Park) was also the only site where formal and informal trash clean ups regularly occurred. ● Money was frequently mentioned as a barrier though users indicated a willingness to engage in fundraising.

Objective 3: Green space users' experiences, perceptions, and social capital

To understand how the user's experiences and social capital affect park users' willingness to steward, we extracted key themes from our coded semi-structured interviews related to place attachment and forest use, users' perception of environmental conditions, perceived safety and sense of community, and prosocial behaviors. Table 3 summarizes the key findings from these interviews.

Place attachment and forest use

Overall, the level of access and availability of services predicted the amount of forest use which was also associated with higher levels of place attachment. Sites with recreational facilities have much greater place attachment than those without them. Park users cited many reasons for visiting, but all related to enjoying recreational space alone or with friends and family:

"I come to the park for fresh air and to get out of the house - to relax."
"To walk in the woods."
" I bring the kids to the park to play or use water park."

Park users throughout Springfield expressed special attachment to Forest Park, designed by Frederick Law Olmsted who also designed New York City's Central Park: *"We call it our big backyard."* Forest Park elicited the strongest attachment from both on-site users, as well as participants interviewed at other forest sites who called it the *"crown jewel"* of the park system.

In other city parks, users expressed more ambivalent feelings of attachment. Van Horn Park, which has well-maintained wooded trails and a pond, had a strong attachment from site users. Hubbard and Blunt Park, two other large parks with a mix of active recreation and wooded areas received mixed reviews. Residents appreciated the well-used playgrounds and recreation fields but bemoaned the overgrown condition of the wooded areas of the parks. They mentioned having a stronger attachment to these places before the picnic areas and pathways became overgrown and perceived as unsafe. On-site interviews, in general, indicated a stronger attachment to natural aspects of the park, including, "*That was MY spot as a kid. We used to pick berries, climb trees, swing from vines across the stream. So many memories*." Significant memories were also associated with special events such as family picnics, sports-related events, or concerts.

Respondents expressed much weaker place attachment to the conservation areas with forests without services as well as those with more limited access to the forest. Many respondents were unfamiliar with these spaces, and very few participants stated that they visited them. Those who did visit appreciated close encounters with deer, birds, and nature*: "Freedom. Quiet. Birds. Trees"* and *"I like the trees, especially when they are covered in snow and ice and the light hits them."* Other interviewees complained of a no-service forest: *"It is an overgrown mess."* There was much greater use of the active recreation areas, picnic areas, and playgrounds in the parks than the nearby wooded areas. As noted by a staff person, *"Rec areas get used a lot, forests not so much. In some conservation lands, people will not have any idea they even exist and therefore do not have users."* Staff perceptions were supported in the on-site interviews. Forest use was primarily for walking and dog-walking, and some fishing. Some park users noted that while they visited the "park" areas, they did not use the wooded areas, except in Forest Park

and Van Horn Parks which have wide, well-maintained paved and unpaved trails with benches and other amenities. Reasons for not using the woods included safety concerns and fear of getting lost. One respondent noted, *"The woods are pretty deep and you could get lost,"* and another warned us, *"It's dangerous in the woods--drunks, motorcycles."* Several people contrasted the overgrown aspect and abandonment of facilities in the woods to the more well-used sports and playground areas: *"The rec facilities get used all the time. The forest is not used as much as it should be. There used to be picnic tables and grills in the woods for people to use."*

Finally, the two parks with user fees had differing effects on users. At Forest Park, with a surrounding wealthy area and a friends group, parking fees did not seem to impact the level of use or place attachment; however, users had strong negative assessments of Blunt Park, the latter having recently instituted fees to support maintenance for the large athletic complex in the park while not maintaining the forested area. Respondents perceived the park as poorly maintained. Respondents also talked about local residents relocating large family gatherings to avoid fees, indicative of an unequal impact due to socio-economic status: *"The park used to be used for family reunions, picnics, and games. The lack of maintenance and the vehicle storage fee has caused a decline in use."*

Users' perception of ecological conditions

Ecological conditions of the sites engendered both positive and negative responses from the users and residents. For some people, the possibility of encountering wildlife and enjoying greenery drew them to parks and conservation areas. Most users interviewed took obvious pleasure in listing the wildlife species they had observed in urban green spaces, including deer, snakes, raccoons, rabbits, skunks, squirrels, chipmunks, and cats. Users especially liked seeing birds, including hawks, ducks, blue jays, turkey, storks, barred owls, mourning doves, and Canada geese. Some users also mentioned fishing and catching tadpoles in public ponds as a way of enjoying wildlife; however, pond eutrophication was mentioned as a problem: *"[there's] no duck pond in Blunt [Park], only a mosquito pond."*

With respect to invasive species, "overgrown" vegetation was raised by participants at several of the green spaces in the study, suggesting that invasive plants are likely affecting both perception and usage of these public open spaces. Few species were identified in this context, but mention was made of poison ivy (which is native but very often co-occurs with invasive vines like round-leaved bittersweet and other non-natives) and of aquatic invasive plants impacting ponds. In several other parks and conservation areas, walking and biking paths in wooded areas are underutilized due to "overgrowth." Overall, the comments suggest that management of invasive plants would make the trails more accessible, safe, and inviting. At Woodland Park, appreciation was expressed about the recent removal of overgrowth in the woodland habitats. At other green spaces, there was evidence that users have negative views about removal of vegetation, including the invasive species "burning bush" (*Euonymous alatus*) and other non-natives, objecting to aesthetic appearance of the cleared woodlands and worrying that vegetation was removed as a precursor to permanent development or conversion of open space. This suggests a potential need for increased public communication and awareness about the goals of the management activities.

Sense of safety and community

In 2015, users discussed major challenges related to safety, policing, and management, even with respect to Forest Park. Long-time residents were nostalgic for a past that was perceived as safer: *"Old-timers...grew up around the park when it was better than what it is. Safer. There is a stigma about Springfield. People still [think the park] is dangerous."* Many residents feel that parks are dangerous, *"especially if you have kids"* due to crime, theft, and improper use of space such as dirt bikes. Participants complained about people littering and playing loud music in parks. Sanctioning sometimes occurs, but mostly *"people are sometimes afraid to approach people, for good reason."* Some request for there to be more police presence, but it also seems like individuals are not fully reporting problems to the authorities and/or the authorities are not responding to people's complaints. Particularly for minoritized communities, resorting to calling the police was not an option because of the history of policy violence prevalent in the U.S. Some users avoided the forested areas of urban parks, complaining that *"homeless people live down there, and you never know what you are going to run into."* One woman said she would not *"walk in the park alone or recommend any other woman walk there alone."*

The 2017 data collection included additional questions to assess park users' perception of safety ("I feel safe" and "Others would help me") and sense of community ("I feel a sense of community," I meet up with friends," I meet new people"), see Appendix S5. Using a seven-point Likert scale, park users (n=39) indicated a median rating of 6 ("agree") to all four questions and median scores ranging from 4.8 to 5.6. We interpret this data as indicating that park users feel a sense of community at the parks, and they feel safe while they are at the park both for their personal safety and the perception that others would help them if needed.

Sample sizes within each site were too small in 2017 to make statistical comparisons among sites, though qualitatively, we noted that all sites with high levels of perceived community safety were also sites with higher levels of use, except at Wesson Park, which is a low- use site that had relatively high levels of perceived safety. This is intuitively logical: if people feel safe and have a sense of community at the parks they use, they will return and use them more frequently.

Prosocial Behaviors

The city parks in Springfield have a uniform set of rules but often vary in the norms of behavior that support enforcement of the rules. We asked respondents seven questions to understand what were acceptable behaviors (rules-in-use norms), ones that would cause a park user to take passive action (ignore, change location in park) and active actions that are self-governing (ask to stop behavior) or externally enforcing (contact park official or police). We also asked which behaviors would lead the person to leave the park. Springfield is an urban area like many around the country with a mix of races, ethnicities, and immigrant history. What is acceptable for one set of users may not be acceptable for another. A rule-in-use norm of playing loud music was held by over half of respondents (56%) agreeing with "OK with this" and only 2 (5%) responding that they resort to external enforcement by calling police. Four questions elicited a majority action self-governing response indicating a willingness to enforce prosocial behaviors. First, a perennial

problem in parks is when dog owners do not clean up their dog's feces. Over half (n= 18/38, 53%) responded that they would ask the dog owner to stop the behavior. Similarly, 23 of 37 (59%) reported that they would ask the person to stop leaving trash, 18 (46%) would ask to stop harming wildlife, and 18 of 38 (47%) would ask to stop harming nature. Of the 38 respondents to the question, when a park user harms park facilities, there were two main responses: Self-governing (ask to stop) (n=14, 37%) and external response (call park official or police) (n=17, 45%). Despite being a small sample, the responses indicate a willingness to engage in prosocial behaviors to steward the park. The findings are promising for parks as catalysts for social capital creation among park users.

Objective 4: Willingness to engage in stewardship

Interviews from 2015 and 2017 examined both stewardship activities at the sites and interest in future stewardship users and residents. For Springfield parks in general, there appears to be very little active stewardship by users except for some picking up trash on an informal basis and formal trash clean up days in two of the parks (Hubbard Park, Forest Park): *"If I see trash on the ground, I'll pick it up and put it in one of the receptacles if I can find one. Sometimes it can be hard to find one"*. In the no-service forest sites, people who use the sites mentioned only occasional, spontaneous stewardship efforts: *"We walk around the neighborhood and pick up trash, litter, newspapers."* One neighbor mentioned that she has called officials to report dumping and requested the town put up "no dumping" signs at the end of her street and they did. Three users mentioned vegetative maintenance on the edge of the park with one cleaning up an open lot.

Forest Park is the only Springfield park with a friends group that actively stewards the park and advocates for park maintenance and improvements. As one would expect, Forest Park had the most comments regarding users' stewardship: *"…there's not a day that I don't see someone picking trash as they walk around. I mean I do as a matter of course, and I would say half of people, maybe not half, but quite a bit of people do. And yes, there's litter, but I'm not going to walk past it. I'm going to pick it up."* A few of the other urban parks have neighborhood civic associations but lack organized stewardship, as stated at one 2015 focus group: *"There is no advocacy for the park. There is no friends group for the park."* At one point, the neighborhood council for Hubbard Park conducted monthly site visits and made recommendations to the Parks and Recreation Department, but those no longer occur. Users mentioned the need for more community engagement, in particular: *"The two schools that abut the park should use it for ecological and science studies. Make the kids more aware of what they have."* Most on-site interviewees had not been asked to participate in organized stewardship, as one noted: *"No, [I] was never asked to participate in any sort of clean up."*

The 2017 data collection included four questions on park users' willingness to (1) voluntarily help care for park on their own, (2) volunteer with others, (3) donate money, (4) help raise money. The responses were resoundingly positive. On a four-point Likert scale, over 70 percent of respondents said "yes" to volunteering on their own or in a group. Only 2.6% said no to volunteering with others. Even with the small sample size of park users, these results indicate a willingness to steward. While park users may be willing to donate their time to caring for the

park, the low overall income composition of park users limits financial donations. Even though the majority responded "yes" (47%) or "probably" (34%), for some there was a conditional statement, "if I had money" (N=3). Nevertheless, 84 percent expressed willingness to fundraise (50% "yes" and 34% "possibly"), indicating potential for stewardship if there was an entity to organize volunteer efforts. Combined with the prosocial behavior findings, these findings on volunteering indicate there is social capital among some users, and the other responses indicate the potential for more engagement with the potential for building increased social capital.

DISCUSSION

Overview

This research in the urban forests of a mid-sized post-industrial city found that urban forest patches are often hidden and unknown to local residents, especially if not associated with a more active recreation park. Local residents' lack of awareness about the forests provides a key challenge to urban forest managers which we will address later in this section. The major features of the green spaces that appear to influence stewardship and use revolve around the type and quality of the access, as well as associated recreation features. Those forests with better access, well-signed and maintained paths and trails, as well as other features including water bodies and streams were more used by local residents. The results also showed that site type, those forests with on-site services, and with more maintenance were used more frequently by local residents. Local residents' attachment to these urban forests was also greater in those sites with greater access and use. Surrounding land uses, including residential density and socio-economic characteristics of the surrounding neighborhoods were not significant factors in predicting forest use or of place attachment, potentially due to the lack of variability in socio-economic characteristics and land use across this predominantly low-income city. Forest access was the most significant predictor of place attachment. Residents reported more frequent use of and stronger attachment to forests with well-maintained pathways, clear entry points, and signage. Despite the urban setting of these forests, users indicated a strong sense of community and general safety in these sites overall. In addition, they were willing to take action in response to rule violations, such as when observing others littering. These results emphasize the key role that forest management plays in fostering residents' connection to nearby urban forests.

The survey respondents showed a strong willingness to engage in stewardship of these urban forests, despite lacking formal organizations or mechanisms to foster stewardship, except in Forest Park. In contrast to previous studies (Ryan 2005; Romolini et al. 2019), stewardship in Springfield was not predicted by more forest use, access, maintenance, or place attachment. Future research with additional data at the individual level is needed to conclusively present motivations for engaging in urban forest stewardship. These findings also support the City's "adopt a park" potential for volunteer support for stewardship. Park planners are interested in promoting more stewardship of the City's parks but are concerned about the lack of staff to organize and manage volunteers. Additionally, there is concern regarding volunteers' ability to do the work needed in the parks and potential conflicts with existing park maintenance staff who may perceive volunteers as a threat to their jobs and responsibilities

These study results support previous research in which more use of green space is associated with stronger levels of place attachment (Ryan 2005; Romolini et al. 2019) and a recent international study showing that urban parks and other green spaces are residents' favorite places (Subiza-Perez et al. 2021). A unique aspect of the current study is that it focuses on urban woodlands rather than previous studies of national parks (Eder and Arnberger 2012) and greenway trails (Moore and Graefe 1994). Our study shows that place attachment is associated with locations that have more park-like facilities and better access, and not all urban forests are well-loved. The latter is a challenge for managers seeking to promote woodland conservation areas that do not have good access, facilities, and maintenance. Perceptions of safety can lessen park use and consequently place attachment, which supports previous research conducted in other settings (i.e., urban gardens in Ryan and Buxton 2015) and parks (Ryan 2005; Romolini et al. 2019). Previous research in Austria found that settings with higher levels of place attachment were more sensitive to negative signs of environmental change, neglect, and vandalism (Eder and Arnberger 2012), and our results support this interpretation. Although many of our respondents were people of color, we were unable to analyze our results according to race or gender. This is a significant gap in our findings since it is well known that safety and sense of community in green spaces is experienced differently according to race and ethnicity and is a particularly acute issue for Black people and women (Gobster 1998, Low, Taplin, and Scheld 2009, Finney 2014.)

Ecological conditions are not a predictor of use and place attachment

Park managers cited invasive plants as a major maintenance issue. However, forest access and maintenance levels were neither correlated with measures of invasive plants, nor with measures of use and place attachment by residents and users. Interview data, on the other hand, demonstrated consistently that forest users valued the ecology of the sites. Furthermore, people are not "loving parks to death." Our results run somewhat counter to the common forest management paradigm where human access is seen as a negative to biodiversity and natural areas preservation especially in urban areas (Aronson et al. 2017). We found that sites with higher access and greater use did not have concomitantly increased levels of plant invasions. Analysis of bird counts conducted in a related study (Klein 2023) suggests that if anything, bird species richness is higher in sites with greater access. Two of these, Van Horn and Forest Park, are also listed as birding hotspots in eBird, a crowdsourced tool for tracking the presence of birds. Thus, actions that increase users' place attachment might have greater benefits than costs in terms of ecological conditions. While certainly continued decline in public investment and maintenance of these urban forests is one likely trajectory for the future that may have some positive biodiversity benefits (i.e., less disturbance for wildlife and vegetation), the prevalence of invasive plant species and overgrown nature of these forests also suggests the potential for decreases in biodiversity and species richness from the ecological perspective if invasive plants are left unchecked.

Untapped stewardship potential and volunteer potential through friends groups

Our interviews with residents found that they were willing to be stewards of urban forests in Springfield, despite the current lack of opportunities to do so. Greater place attachment was also associated with greater willingness to steward these areas. Together these findings suggest that

residents are an untapped resource for helping steward vulnerable urban forests. Sonti and colleagues (2020) also found a relationship between stewardship and use of natural areas in New York City parks, and they suggested that a sense of safety was an important factor in a willingness to steward for some groups (e.g., women users), an issue that may also play a role in some of the parks we studied.

Local stewardship can come in the form of "friends of" organizations or coordinated volunteer efforts. These volunteer-driven efforts work alongside governmental agencies and can provide fundraising, advocacy, infrastructure maintenance, programming, and volunteer engagement (Low, Taplin, and Scheld 2009, Krasny and Tidball 2012, Gazley et al. 2018). Our findings from the 2017 interviews revealed a willingness of Springfield park users to volunteer and/or engage in fundraising for the parks. Only Forest Park had a friends group at the time of our interviews. Unlike the other parks in our study, Forest Park is surrounded and supported by financially well-off residents with the professional capability to create a nonprofit organization. This aligned with Holifield and Williams (2014) finding that friends groups were more likely to be sustained in wealthier, predominantly white neighborhoods in Milwaukee, Wisconsin, though most parks, regardless of neighborhood race or income, lacked a friends group. The challenge for the remaining parks in Springfield and other post-industrial cities is that the collective action required to start a new group requires someone or organization (e.g., neighborhood association, conservation organization, group of residents) to catalyze the community action (Holifield and Williams 2014).

For cash-strapped cities that do not have the capacity to increase park and recreation budgets, friends groups may provide a pathway for multiple benefits including increased place attachment and social capital built through stewardship activities, fundraising, and advocacy. However, city reliance on friends groups may have potential pitfalls. Perceived differences in expert knowledge between park managers or city planners and residents and volunteers can lead to poor engagement with residents (Low, Taplin, and Scheld 2009). These gaps can be racialized when city officials are predominantly white and parks are in communities of color (Low, Taplin, and Scheld 2009; Carmichael and McDonough 2018). Recent research also found that park-supporting charity expenses have a decreasing effect on government spending (Cheng 2019). If private efforts replace public spending, does that decrease pressure for city governments to allocate funds for park budgets? There is no data available on the long-term effects on local government budgets when nonprofit friends groups support parks. An important issue for future research is the unequal resources between higher and lower income neighborhoods to create friends groups and whether the work of friends groups complements or substitutes future city park budgets, particularly whether there is intersectionality with race and income in the city government's responses.

Even if friends groups are successfully developed in all nine Springfield parks, a question remains about the focus of volunteer contributions. In Springfield, forested urban parks were not used as much as those parks with playgrounds, ball fields/courts, and picnic shelters. Would friends groups focus their energy on the biodiversity/conservation needs of the urban forest? Interview respondents indicated that they would volunteer to fundraise for park infrastructure rather than forest management per se. Whether support would extend to trail maintenance,

invasive control, or other biodiversity- or conservation-enhancing activities remains an open question for future research.

Future research directions

This research suggests the need for urban forest managers to take a more holistic approach to management beyond removal of invasive plants and other vegetative management that have been the focus of many urban park districts including our Springfield case study (Aronson et al. 2017). By re-framing around an adaptive management approach, managers could align their goals with ecological restoration, park maintenance, community use and community stewardship. Removing overgrown invasive plants and restoring trails and other access points will increase public access as a means to build a stronger connection (place attachment) between residents and their nearby forested areas. Future research is needed to determine whether increasing awareness of these forests and their resources leads to stewardship, and what strategies might increase public awareness of these often-hidden forest areas. In addition, the relationships we found between biodiversity, forest use, and access need further exploration, both across more cities and longitudinally.

In Springfield and other post-industrial cities, much work remains to increase physical access to urban forests in a manner that directs users to safe, cleared paths and trails, while discouraging illicit use, such as trash dumping. Increased signage could show that these forests are publicly owned and managed (e.g., Nassauer 2004, Li and Nassauer 2020). Developing recognition of these forests, at both the neighborhood and city-level, is critical to developing a shared appreciation for the unique resources that they shelter and the opportunities they provide for residents to experience nature close to home. With a holistic approach, park users may be more interested in volunteering to support forested areas and friends groups could include support for park facilities and also for the forested areas.

Beyond improving access, it is important to show visitors biodiversity that might not be readily apparent. Design interventions can be useful tools for developing engaged groups of stakeholders (Felson et al. 2013; Douglas 2014). Expressive signage, innovative educational kiosks, and interactive structures can facilitate the education and outreach necessary to create place attachment (Walker. 2011). For example, bird boxes serve as a visible sign to visitors that there is bird diversity in wooded areas (Kaplan et al. 1998) and provide “cues to care,” as described by landscape architect Joan Nassauer (1995). Land management agencies can use design interventions to engage the public, communicate a message, or garner support. Paired with stewardship projects, design interventions may create a dedicated space for engagement, contributing to enhanced management and improved ecological functioning to support biodiversity (Ward Thompson et al. 2013).

CONCLUSIONS

Creating opportunities for environmental stewardship is a major challenge for urban forests in economically distressed cities. If increasing public awareness while providing better access to these forests leads to increased use, we would also expect an increase in the number of local residents who develop a place attachment and contribute to building social capital through prosocial behaviors. In this “virtuous circle,” those with stronger place attachment would be

more willing to get involved as stewards if programs are in place or are developed. Stewardship activities that include trash clean-up, trail clearing, and/or invasive species removal, may increase biodiversity, as measured by species richness. Moreover, community engagement in invasive plant species removal could provide an opportunity for park users to see immediate results of stewardship while also connecting with the forested areas in their local green spaces. While friends groups are one potential strategy to increase stewardship, the importance of civic funding of urban forest management should not be minimized, particularly in economically depressed cities.

The more neglected these forests become, the fewer users they attract, and the more unknown and unloved they become. Without local advocates for urban forests, maintenance budgets will continue to decline, and forests may even be redeveloped as public facilities, traded away as part of public-private land swaps, or made into sites for new infrastructure corridors for utilities or road projects. This can exacerbate already large disparities in access to nature in cities (Miller 2005; Kuras et al. 2020; Schell et al. 2020). The very long-term sustainability of urban forests requires that local residents appreciate, use, and steward them, either directly as part of stewardship programs, or as advocates for them in the political process for funding parks and conservation departments and planning processes when development pressures impact them.

APPENDICES

Appendix S1. Invasive species detections

Table S1. Invasive plants detected at the parks and conservation areas, reporting the number of stems of of each species counted within trailside transects at each site.

Taxonomic group	**Blunt Park**	**Forest Park**	**Hubbard Park**	**Van Horn Park**	**Wesson Park**	**Abbey Brook**	**Entry Dingle**	**Labelle**	**Woodland**
Total # invasive stems	190	26	545	311	867	915	65	0	72
Vines (total # stems)	164	26	754	13	353	862*	31	0	26
Bittersweet	155	26	362	13	173	524	8	0	26
Multiflora rose	9	0	177	0	180	336	0	0	1
Virginia Creeper	0	0	215	0	0	0	23	0	0
# Shrubs	0	0	10	9	4	0	1	0	41
Barberry	0	0	0	0	1	0	0	0	0
Burning bush	0	0	1	4	2	0	1	0	4
Bush honeysuckle	0	0	1	0	1	0	0	0	0
Common buckthorn	0	0	4	5	0	0	0	0	41
All other species	26	0	4**	289***	510	53	56	0	0
Norway Maple	0	0	0	103	510	51	56	0	0
Garlic Mustard	0	0	0	148	0	0	0	0	0
Japanese knotweed	26	0	0	15	0	2	0	0	0

*Includes 2 stems of Japanese honeysuckle. **Includes 4 stems of staghorn sumac. ***Includes 3 stems of cork tree and 20 stems Japanese stilt grass

Appendix S2. Land use and sociodemographic context of the study sites

Table S2. The composition of surrounding land use and the socioeconomic and racial composition of the surrounding neighborhoods for the 9 focal green spaces. None of these measures was included in the top models for forest access, forest use, or place attachment. Forest patch sizes and the percentage of land use types (high density residential, low density residential, recreation, and natural lands) within a 500m buffer were extracted from were extracted from the Commonwealth of Massachusetts' 2005 land use data layer (Office of Geographic Information 2009). Similarly, for the census block groups within a 500m buffer, we calculated the total population size, the percent of the population from minoritized racial/ethnic groups, and the percentage of households below the Massachusetts median income were extracted from the U.S. Census (2010).

Park Name	Forest Patch Size (acres)	High Density Residential	Low Density Residential	Recreation	Natural Lands	Total population	Percent Minoritized	Percent of state median household income
Blunt Park	108.6	6.7	0.1	21.7	63.1	658	82.8	43.0
Forest Park	1018.6	0.8	0.0	9.3	73.5	155	41.7	34.6
Hubbard Park	44.0	45.9	0.0	6.5	27.2	1711	49.2	65.9
Van Horn Park	93.3	45.1	0.0	6.0	1.2	2857	61.3	83.4
Wesson Park	23.2	74.0	0.3	0.7	14.3	3610	72.1	65.6
Abbey Brook	173.8	26.7	0.4	2.9	40.3	1132	48.8	66.0
Entry Dingle	1018.6	70.9	0.1	3.4	63.1	2561	48.8	66.8
Labelle	84.1	41.4	2.4	2.1	45.1	1248	27.1	105.2
Woodland	401.8	6.8	0.0	0.0	91.6	1572	41.7	89.3

Appendix S3. Model selection for forest use

The top model included only the fee type (fee, no fee, and no services). All other models had a delta AICc>2. Details of this model are as follows:

Call: lm(formula = use_comb_yrs ~ fee_type, data = springfield.data)

Coefficients:

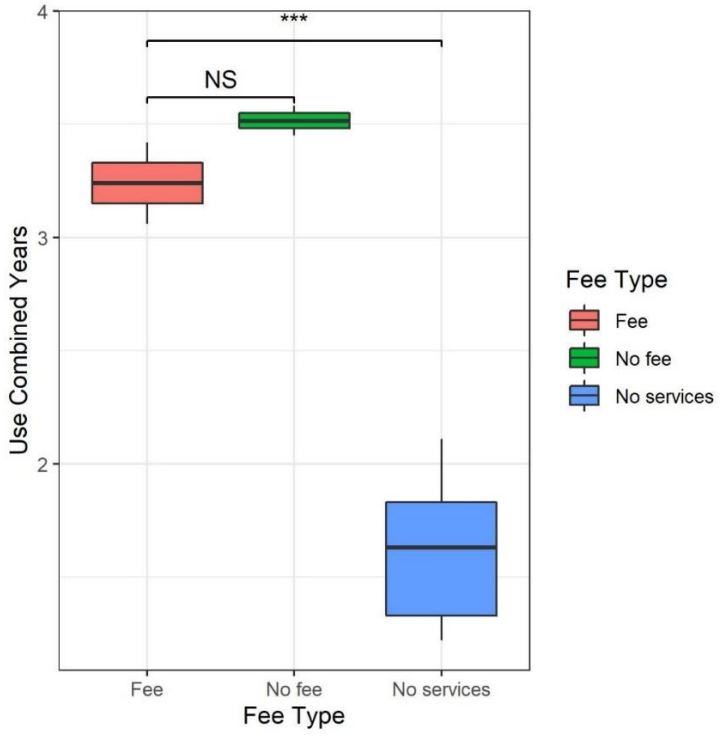
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	3.2400	0.2239	14.471	6.83e-06	***
fee_typeNo fee	0.2750	0.3166	0.868	0.418505	
fee_typeNo services	-1.6160	0.2649	-6.100	0.000884	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3166 on 6 degrees of freedom
Multiple R-squared: 0.9199, Adjusted R-squared: 0.8932
F-statistic: 34.45 on 2 and 6 DF, p-value: 0.000514

Fee Type:

Contrasts	Difference	Lower CI	Upper CI	p-val adjusted
No fee – Fee	0.275	-0.697	1.247	0.6779
No services – Fee	-1.616	-1.616	-2.429	0.0021444
No services – No fee	-1.891	-2.704	-1.078	0.0009298



Two other models were within Delta AICc < 6. These were a model of forest access only and maintenance level only.

Model of forest use with forest access as the predictor variable

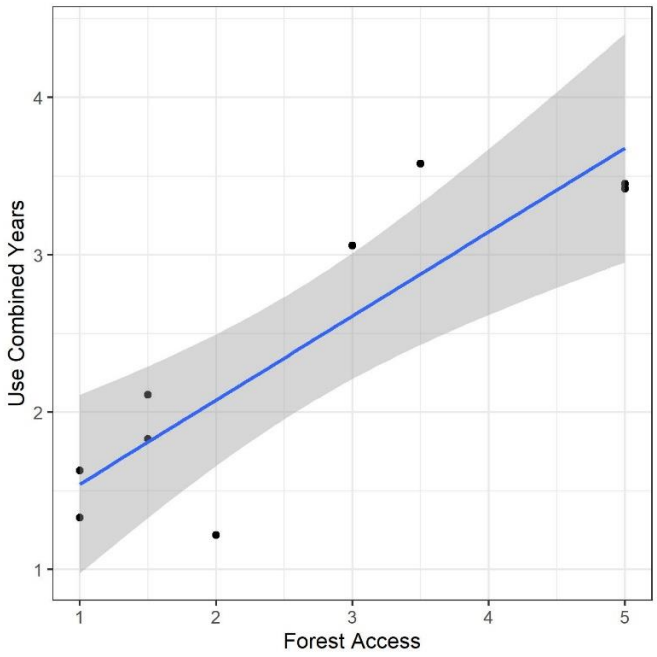
Call: lm(formula = use_comb_yrs ~ forest_access, data = springfield.data)

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.0085	0.3281	3.073	0.01798	*
forest_access	0.5342	0.1089	4.907	0.00174	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4916 on 7 degrees of freedom
Multiple R-squared: 0.7747, Adjusted R-squared: 0.7426
F-statistic: 24.08 on 1 and 7 DF, p-value: 0.00174



Model of forest use with maintenance level as the predictor variable

Call: lm(formula = use_comb_yrs ~ maint_level, data = springfield.data)

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.38013	0.46547	0.817	0.44102	
maint_level	0.11240	0.02407	4.670	0.00229	**

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5106 on 7 degrees of freedom
Multiple R-squared: 0.757, Adjusted R-squared: 0.7223
F-statistic: 21.81 on 1 and 7 DF, p-value: 0.002288

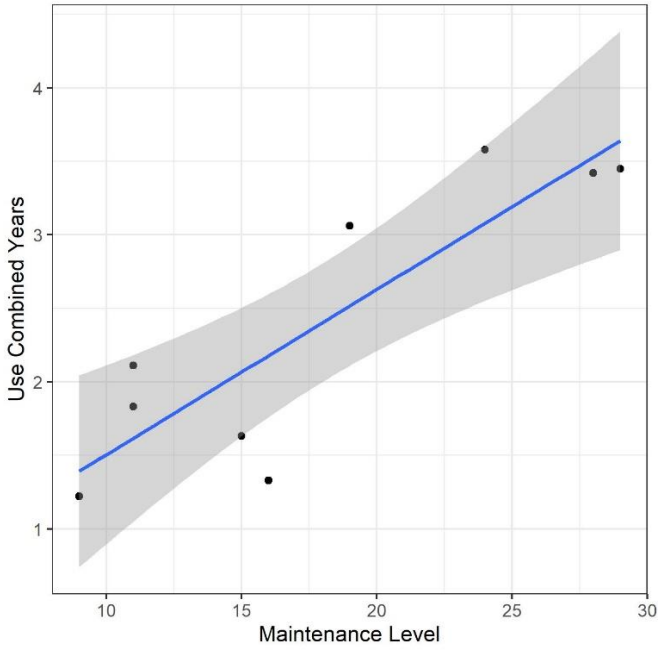


Table S3. All models of forest use used in the model selection process, showing the model structure K, Corrected Akaike Information Criterion, delta, model likelihood, AICc weight, log likelihood, and cumulative weight. Model numbers (first column) are arbitrary codes assigned in order to keep track of the different models. The top model (and the only one with Delta AICc<2) is shown in boldface.

Model	Model Structure	K	AICc	Delta_AICc	ModelLik	AICcWt	LogLik	Cum.Wt
m2	**fee_type**	**4**	**19.19**	**0**	**1**	**0.59**	**-0.6**	**0.59**
m3	forest_access	3	21.3	2.11	0.35	0.21	-5.25	0.8
m4	maint_level	3	21.98	2.79	0.25	0.15	-5.59	0.95
m10	forest_access + recreational_perc_buff500	4	26.46	7.26	0.03	0.02	-4.23	0.97
m9	forest_access + maint_level	4	26.87	7.68	0.02	0.01	-4.44	0.98
m11	maint_level + recreational_perc_buff500	4	27.15	7.95	0.02	0.01	-4.57	0.99
m1	intercept.use	2	29.91	10.72	0	0	-11.96	0.99
m8	fee_type + recreational_perc_buff500	5	30.06	10.87	0	0	-0.03	0.99
m5	recreational_perc_buff500	3	30.87	11.68	0	0	-10.04	1
m6	fee_type + forest_access	5	31.03	11.83	0	0	-0.51	1
m7	fee_type + maint_level	5	31.12	11.93	0	0	-0.56	1
m15	forest_access x maint_level	5	35.46	16.27	0	0	-2.73	1
m16	forest_access x recreational_perc_buff500	5	37.85	18.66	0	0	-3.93	1
m17	maint_level x recreational_perc_buff500	5	38.43	19.24	0	0	-4.22	1
m13	fee_type x maint_level	7	125.82	106.63	0	0	0.09	1
m14	fee_type x recreational_perc_buff500	7	125.88	106.69	0	0	0.06	1
m12	fee_type x forest_access	7	125.94	106.75	0	0	0.03	1

Appendix S4. Model selection for place attachment

The top model among all the models assessed for predictors of place attachment included forest access and no other variables. All other models had a delta AICc>2. Details of this model are as follows:

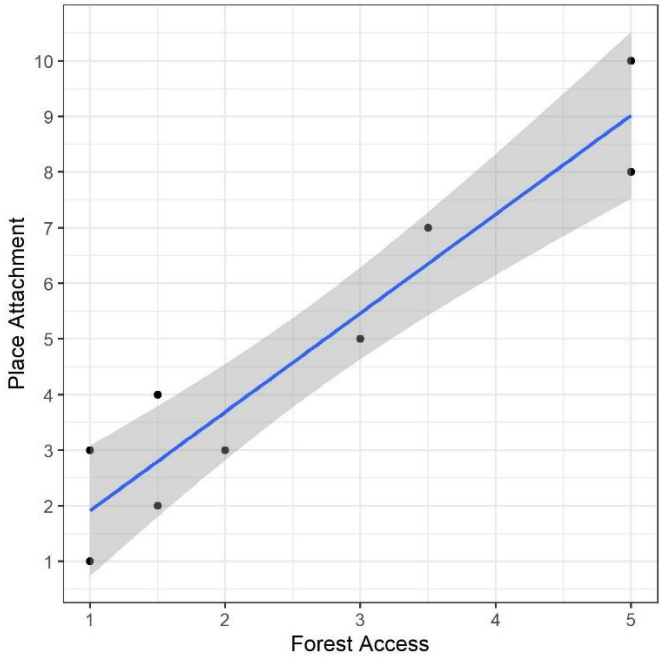
lm(formula = place_attachment ~ forest_access, data = springfield.data)

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.1390	0.6771	0.205	0.843	
forest_access	1.7766	0.2247	7.907	9.82e-05	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.014 on 7 degrees of freedom
Multiple R-squared: 0.8993, Adjusted R-squared: 0.8849
F-statistic: 62.53 on 1 and 7 DF, p-value: 9.818e-05



Other models

All other models within Delta AICc < 6 included forest access and one other non-significant variable, except for one. This one included forest use (use_comb_yrs), which was significant and within Delta AICc < 6.

Call:
lm(formula = place_attachment ~ use_comb_yrs, data = springfield.data)

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  -1.8775     1.3252  -1.417  0.19947
use_comb_yrs  2.7692     0.5154   5.373  0.00104 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.412 on 7 degrees of freedom
Multiple R-squared:  0.8048, Adjusted R-squared:  0.7769
F-statistic: 28.87 on 1 and 7 DF,  p-value: 0.001038
```

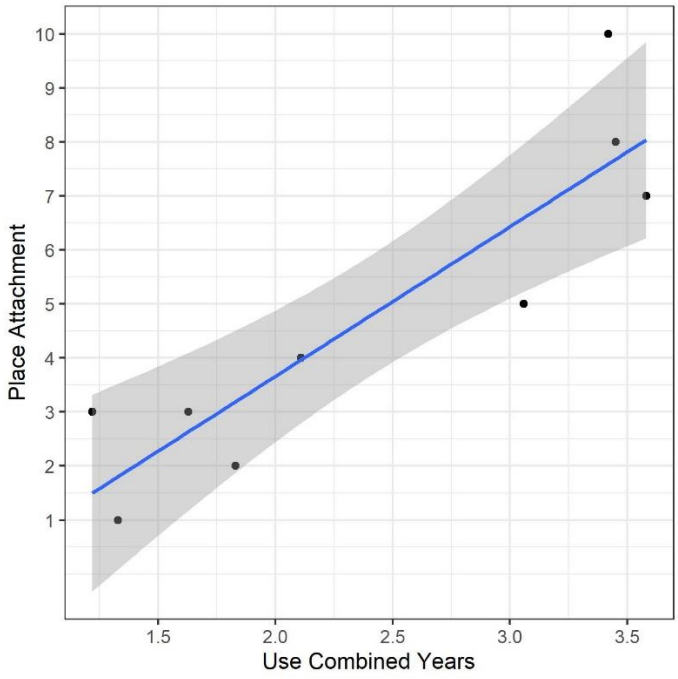


Table S4. All models of place attachment used in the model selection process, showing the model structure K, Corrected Akaike Information Criterion, delta, model likelihood, AICc weight, log likelihood, and cumulative weight. Model numbers (first column) are arbitrary codes assigned in order to keep track of the different models. The top model (and the only one with Delta AICc<2) is shown in boldface.

Model	Model Structure	K	AICc	Delta_AICc	ModelLik	AICcWt	LogLik	Cum.Wt
m4	**forest_access**	**3**	**34.34**	**0**	**1**	**0.7**	**-11.77**	**0.7**
m19	forest_access + low_density_resid_buff500	4	38.88	4.54	0.1	0.07	-10.44	0.77
m18	forest_access + park_size	4	39.59	5.26	0.07	0.05	-10.8	0.82
m9	use_comb_yrs + forest_access	4	39.84	5.5	0.06	0.04	-10.92	0.86
m2	use_comb_yrs	3	40.3	5.96	0.05	0.04	-14.75	0.9
m21	maint_level + low_density_resid_buff500	4	40.41	6.07	0.05	0.03	-11.2	0.93
m11	use_comb_yrs + park_size	4	41.26	6.92	0.03	0.02	-11.63	0.95
m17	forest_access + maint_level	4	41.33	6.99	0.03	0.02	-11.66	0.98
m5	maint_level	3	42.66	8.32	0.02	0.01	-15.93	0.99
m34	forest_access * low_density_resid_buff500	5	44.35	10.01	0.01	0	-7.17	0.99
m10	use_comb_yrs + maint_level	4	46.07	11.74	0	0	-14.04	0.99
m12	use_comb_yrs + low_density_resid_buff500	4	46.56	12.22	0	0	-14.28	0.99
m20	maint_level + park_size	4	46.57	12.23	0	0	-14.29	1
m26	use_comb_yrs * park_size	5	47.29	12.95	0	0	-8.64	1
m6	park_size	3	47.73	13.39	0	0	-18.47	1
m3	fee_type	4	49.88	15.54	0	0	-15.94	1
m1	intercept	2	50.2	15.86	0	0	-22.1	1
m22	park_size + low_density_resid_buff500	4	50.49	16.15	0	0	-16.24	1
m15	fee_type + park_size	5	50.65	16.31	0	0	-10.32	1
m7	low_density_resid_buff500	3	51.18	16.85	0	0	-20.19	1
m33	forest_access * park_size	5	51.53	17.19	0	0	-10.76	1
m24	use_comb_yrs * forest_access	5	51.72	17.38	0	0	-10.86	1
m36	maint_level * low_density_resid_buff500	5	52.34	18	0	0	-11.17	1
m25	use_comb_yrs * maint_level	5	52.78	18.44	0	0	-11.39	1
m27	use_comb_yrs * low_density_resid_buff500	5	52.91	18.58	0	0	-11.46	1
m13	fee_type + forest_access	5	53.26	18.92	0	0	-11.63	1
m32	forest_access * maint_level	5	53.32	18.98	0	0	-11.66	1
m35	maint_level * park_size	5	58.56	24.22	0	0	-14.28	1
m8	use_comb_yrs + fee_type	5	59.11	24.77	0	0	-14.55	1
m16	fee_type + low_density_resid_buff500	5	59.23	24.89	0	0	-14.61	1
m14	fee_type + maint_level	5	59.9	25.56	0	0	-14.95	1
m37	park_size * low_density_resid_buff500	5	62.08	27.74	0	0	-16.04	1
m31	fee_type * low_density_resid_buff500	6	65.19	30.85	0	0	-5.59	1
m29	fee_type * maint_level	7	143.61	109.27	0	0	-8.8	1
m23	use_comb_yrs * fee_type	7	143.72	109.38	0	0	-8.86	1

m28	fee_type * forest_access	7	144.86	110.53	0	0	-9.43	1
m30	fee_type * park_size	7	146.24	111.9	0	0	-10.12	1

Appendix S5. Interview questions (2015)

Interviewer____ No._____

Resident- Mini-Interview Questions

INTRO: We are researchers from the University of Massachusetts-Amherst who are working on a study of Springfield's parks and urban forests. We are studying the relationship between park use and nature, such as birds and wildlife. The goal of our 10-15 minute discussion is to get your perspective on your local park, and how the overall quality of the park experience might be improved. (This interview is anonymous and we won't use your name. If you don't want to answer any questions, you don't have to, we can skip them. We have an information sheet with details about our project).

BACKGROUND: How many years have you lived/worked in the neighborhood?
FAMILIARITY: Are you familiar with Blunt Park?
USE: Do you use Blunt Park including the pond and woods? Yes_____ No_____ If so, how often? What is your main reason for visiting <u>or not</u> visiting? [FOR NON-USERS: Are there other parks in Springfield that you use more often and why?]
MANAGEMENT: What are the things you like or don't like about the park and what things would you like changed/or need improvement?
STEWARDSHIP: Have you worked on any projects to help plan or improve the park, either with a formal group or just on your own? Are there any little things you do when you visit the park to help keep it nice?

RULES: Do you know the type of activities that are allowed in the park and those that are not allowed? Are their types of activities or uses of the park that you think are occurring that are not allowed? (Prompt: such as….)
ATTACHMENT: Do you feel any special connection or appreciation for Hubbard Park, or its wildlife/ plants/ trees? Are there specific places that you like to go in the park/ a little spot you think of as your own? Are there other parks in Springfield that you use more often and why?
WILDLIFE: Do you like to observe and/or feed birds and wildlife in the Park?
HERITAGE: Are there any special uses of the park or events that you do now that you did/learned from your parents or other older people?
FUTURE: Should this park be changed in any way and if so how?
OTHER: Do you know anybody that uses the park that we should talk to about the park?
DEMOGRAPHICS: Age/ Gender/ Ethnicity We would like some background on the people that we talk to today. If you don't mind me asking, could you please tell us your age? AGE_____ GENDER: M_____ F_____ How would you describe your ethnicity?_____

THANKS SO MUCH FOR YOUR TIME!

Appendix S6. Interview questions (2017)

Background

1. Do you live or work in the neighborhood? (check all that apply)
    - Yes, live in neighborhood
    - Yes, work in neighborhood
    - No, do not live or work in neighborhood
2. How often do you come to _____ park?
    - Often (Daily or several times during one week)
    - Sometimes (at least two times in one month)
    - Rarely (less than 2 times in one month)
    - Never [If checked, please specify reason]
3. What is your main reason for visiting this park?

Place Attachment

4. Do you feel any special connection or appreciation of this park for each of the following [check all that apply]:
    - Observe animals
    - Observe birds
    - Plant life (e.g., trees, flowers, other plants)
5. What other parks do you visit? [for each answer, ask why visit that park]

Social Capital (attachment to park due to social interaction)

6. Answer the following on a 7-point scale

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slight agree	Agree	Strongly agree
I feel a sense of community with others at this park							
I meet up with friends at the park							
I talk with strangers while at park							
I feel safe at this park							
Others would help me if I needed it in this park							

Pro-Social Behaviors (willingness to engage in behavior to govern the commons)

7. What would you do in the following situations in the park?

	OK with this	Ignore but stay in park	Change location in park	Ask to stop behavior	Leave Park	Call Police
Dog owner does not clean up dog feces						

Park user leaves trash						
Park users are playing loud music						
Park user is intoxicated						
Park user harms wildlife (e.g., throwing rocks)						
Park user harms plant life (grass, flowers, trees)						
Park user harms park facilities?						

8. Have you ever voluntarily helped care for the park (e.g., clear paths, pick up trash)?
    - Yes
    - No

    Please specify why yes or no

9. If asked, would you volunteer to help care for park (e.g., maintain trails, landscaping, facilities, playgrounds)?
    - Yes
    - No

    Please specify why yes or no

10. If asked, would you donate money to help care for the park?
    - Yes
    - No

    Please specify why yes or no

11. If asked, would you raise money to help care for the park?
    - Yes
    - No
    - If no, why?

Demographics

12. What is your age?
13. What is your gender identity?
    - Male
    - Female
    - Other
14. How would you describe your ethnicity?

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