EXPLORING THE RELATIONSHIP BETWEEN THE URBAN FORESTRY AND COMMUNITY SUSTAINABILITY PROGRAMS OF TREE CITY USA MUNICIPALITIES IN INDIANA

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ABSTRACT

The benefits of urban forests and the contributions of the extent and quality of the urban forest to the tangible sustainability and environmental quality of a city are well documented. Because the traditions of urban forestry and tree planting have a longer history than the more recent trend of community sustainability programs, there may be a potential for strong, successful urban forestry programs to catalyze broader sustainability movements. This study attempts to gain a better understanding of the connection between urban forest programs and broader sustainability programs. Two sets of indicators to assess urban forestry and sustainability program strength of Tree City USA communities in Indiana were developed. We used factor analysis to produce index scores representing the strength of each program in each city. Regression of index scores revealed a significant correlation between urban forestry and community sustainability program strength. We hypothesize that one reason for this is that community sustainability and urban forestry efforts are thematically related, and cities with an interest in one might naturally take an interest in the other. This and other predictions will have to be tested in future research to fully address all the factors that may influence the strength of these programs.

KEYWORDS

community sustainability, indicators, sustainability assessment, Tree City USA, urban forest sustainability, urban forestry, urban forestry programs

INTRODUCTION

Urban greening efforts such as tree planting and creation of parks, gardens and open spaces are probably some of the earliest examples of labors to make urban areas in the United States more sustainable. These efforts arose in the U.S. at the turn of the 20th century out of a combined desire for a more 'sanitary' city as well as a more enjoyable place for the increasing number of urban residents (Ricard 2005). Today, as the number of urbanites outnumbers the number of people living in rural areas for the first time in history (Grove 2009), 'greening the city' becomes important not only to improve the quality of life for city dwellers, but also an important component of global sustainable development (Devuyst et al. 2001).

Much research has been done to assess the contributions of the extent and quality of the urban forest to the sustainability and environmental quality of a city, and the benefits of urban forests are well documented (e.g., Bell et al. 2008; McPherson 2006; Nowak et al. 2007; Wolf 2008; see arrows 2 and 3 in Figure 1). However, the linkages between the program elements of urban forestry and community sustainability are less well known (dashed arrows, labeled 5, in Figure 1). Because the traditions of urban forestry and urban tree planting have a longer history (Jorgensen 1967, 1993; Ricard 2005) than the more recent trend of community sustainability programs, there may be a potential for strong, successful urban forestry programs to catalyze broader sustainability movements. This study attempts to gain a better understanding of the connection between urban forest programs and broader sustainability programs, in order to understand how urban forest programs may be used to promote community sustainability programs (or, perhaps, vice versa). Using indicators to assess urban forestry and sustainability programs, this study analyzes the relationship between these programs of communities in Indiana achieving the designation of Tree City USA by the Arbor Day Foundation.

Context of community sustainability and urban forestry programs

In a world facing the challenges of population explosion, increasing urbanization, environmental degradation, increasing poverty, growing scarcity of natural resources, the perils of climate change, and an economic recession (among many other environmental, social and economic crises), significant changes in the way humans live are critical to create a sustainable world. Since the adoption of the Agenda 21 principles and actions for sustainable development by the United Nations Commission on Sustainable Development (UNCSD) at the 1992 Rio Earth Summit, however, little has been done on international or national levels to promote the significant shift in global and regional activities that would result in the realization of Agenda 21 sustainability (Lafferty 2001). Nevertheless, many local governments and communities have taken it upon themselves to follow up on the mandate of a single chapter from Agenda 21: Chapter 28, also called "Local Agenda 21" (LA21; Bell and Morse 2008).

LA21 and its companion movement, "Local Action 21," set forth a fairly simple mandate to local communities: to begin a dialogue for sustainable development and promote action towards this end at the local level (Lafferty 2001). LA21 stipulates that because "so many of the problems and solutions being addressed by Agenda 21 [poverty, consumption patterns, natural resources and their sustainable management, etc.] have their roots in local activities," local authorities have an important role to play in promoting sustainable development (United Nations 1993, as quoted in Lafferty 2001). In the United States, because of the lack of national action for sustainable development, the actions of local

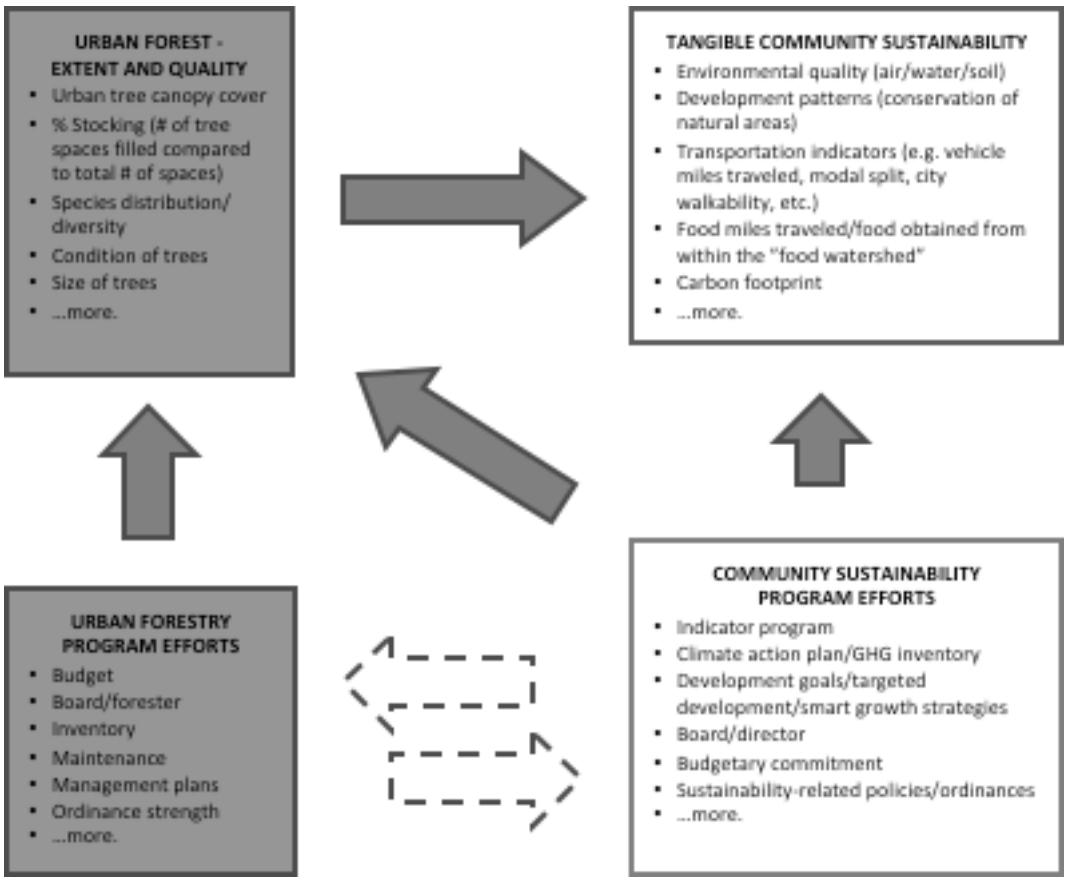

Figure 1. Model of the interaction between urban forestry and community sustainability. The upper two boxes represent tangible aspects of the city; the lower two boxes represent human efforts to influence those tangible aspects. Solid arrows indicate connections between components that are a fairly well documented in existing research. The arrow between urban forest extent and quality and tangible community sustainability (arrow 1) represents in part the benefits of the urban forest to the environmental quality and quality of life in a city; the arrow from urban forestry program efforts to urban forest quality and extent (arrow 2) represents research on the program components critical to a sustainable urban forest; and, the arrow between community sustainability program efforts and tangible community sustainability (arrow 3) represents research into best practices for sustainable urban operations. The diagonal arrow from community sustainability program efforts to urban forest extent and quality (arrow 4) represents direct and indirect efforts of community sustainability programs to improve the urban forest. The dotted arrows (arrows 5) indicate the less-documented interactions between the programmatic elements of urban forestry and community sustainability that are the focus of this study.

governments can have a substantial effect in improving environmental quality (particularly local environmental quality), mitigating the effects of climate change, and improving the quality of life for people in the community (Lafferty 2001). In urban and metropolitan areas in particular, promoting sustainable development and LA21 can profoundly affect the overall environmental impact and long-term sustainability of a city. In the United States, local government at all levels (town, city, county) can implement policies and programs that foster local sustainability through smart growth and development strategies, energy and resource conservation efforts, waste and pollution mitigation projects, and programs to build a better quality of life for city residents.

One aspect that can influence the sustainability and environmental quality of a city is its urban forest. According to Clark, et al. (1997), a sustainable urban forest is defined as "the naturally occurring and planted trees in cities which are managed to provide the inhabitants with a continuing level of economic, social, environmental and ecological benefits today and into the future." A large, healthy urban forest can increase local urban air quality and mitigate carbon dioxide emissions (e.g., McPherson 2006; Nowak et al. 2007); decrease temperatures elevated by the urban heat island (UHI) effect and decrease associated energy costs (e.g., McPherson and Simpson 2003); increase city walkability (e.g., Wolf 2008); provide stormwater retention services including decreased peak flow and increased water quality (e.g., McPherson 2006); contribute to economic prosperity through increased job opportunities and increased retail sales in urban areas with trees (e.g., Wolf 2005a, 2005b); as well as many other benefits that increase the overall quality of the urban environment and the quality of life for urban residents (McPherson 2006).

In the United States, tree planting, along with the tradition of city parks, is arguably one of the oldest efforts to improve the quality of life in the city for urbanites (Ricard 2005). Urban forestry as an institutionalized effort to systematically improve city life and environmental quality, however, is a much more recent phenomenon. Beginning in full force with the passing of the 1990 U.S. Farm Bill, which appropriated funds for the establishment of state urban and community forestry (U&CF) programs (which would then pass along dollars to cities and towns), U&CF program efforts expanded greatly in the next twenty years (Hauer et al. 2008). State U&CF coordinators became empowered to disseminate information on best practices and benefits of the urban forest, provide technical assistance to communities seeking to start programs, and distribute federal funds to local programs. Though there had been a few programs prior to the 1990 Bill, U&CF efforts began to be taken much more seriously as soon as extensive federal funding became available (Hauer et al. 2008).

Those cities and towns that did have urban forestry programs prior to the 1990 Farm Bill may have been spurred to those efforts by the existence of the Arbor Day Foundation's Tree City USA program. Started in 1976 and sponsored by the USDA Forest Service and the National Association of State Foresters (ADF 2010), the Tree City USA distinction requires that communities meet four requirements (see Box 1; ADF undated). In 2009, approximately 3400 cities in the US were recognized as Tree Cities USA, including 67 cities in the state of Indiana (ADF undated). Because of the history and longevity of the Tree City USA program, many communities in the U.S. have been a Tree City USA for two or three decades or more, and hence had urban forestry programs for a number of years prior to the extension of federal funds for U&CF programs via the 1990 Farm Bill.

Box 1. Tree City USA requirements. In order to become a Tree City USA, a municipality must have the following four elements. *Source:* Arbor Day Foundation.

1) A tree board, commission, or department
2) A tree ordinance
3) At least $2 per capita budget for urban forestry
4) An annual Arbor Day educational celebration

However, it is widely recognized that the standards cities must meet for Tree City USA (Box 1) recognition are only a bare minimum (e.g., Fazio 2003), and that strong, sustainable urban forestry programs have many more components that contribute to a healthy, extensive urban forest. (Thus, this

study develops a list of indicators of strong programs, which is discussed in detail in the next section. For sake of brevity, this paper will not address the definition of "urban forest sustainability," but many others have covered this topic in great detail. See, for example: Abbey (2008); Dwyer et al. (2003); Clark et al. (1997); Elmendorf et al. (2003); Fazio (2003); Thompson et al. (1994); and Tree Trust and Bonestroo (2007).) In their frequently cited model of a sustainable urban forest, Clark et al. (1997) address three primary components of a city's urban forest that contribute to its sustainability: the *vegetative resource* (extent and quality of the urban forest), *strong community framework* (support and cooperation from government, institutions, private citizens and other stakeholders for urban forestry), and *appropriate resource management practices* (management plans, funding and staffing resources, etc.). Of the components of their model, the first deals with the actual quality and quantity of the urban natural resource (see also Figure 1), while the latter two address the programmatic elements (e.g., outreach, management programs) of urban forestry. Dwyer et al. (2003) echo Clark et al. (1997), adding to the programmatic factors that influence the management and sustainability of an urban forest the following components: 1) management goals and objectives; 2) the program's means (specific programs or structures necessary to meet desired goals); 3) the information available (including inventory data, survey results, and external research); and 4) the social context in which the program operates (community condition). Clearly, a city's urban forestry program must go above and beyond meeting the Tree City USA requirements in order to create a healthy, extensive urban forest that improves the environmental quality of the city, and the quality of life of city dwellers.

The use of indicators in sustainability and urban forestry

In order to assess the relationship between urban forestry programs and community sustainability programs, a method of assessing program strength must be developed. The concept of indicators is useful to this end. "Indicators," according to the widely used Redefining Progress Community Indicators Handbook, are "information signals," "education and evaluation tools," and "an accounting system" (Smolko 2006). Indicators are widely used in ecology and environmental science as proxy measures for larger trends, or to indirectly assess overall environmental condition (Alberti 1996; Hák 2007; Valentin and Spangenberg 2000). In program assessment, indicators are the specific elements included in an index, which measures progress against some ideal standard or the assessment of a specific trend over time. Moldan and Dahl (2007) frame the concept this way: Optimal sustainability indicators, "capture the essential characteristics of the system and show a scientifically verifiable trajectory of maintenance or improvement in a system." Well-designed indicators and indices can be useful tools because they provide snapshots of the conditions of a social, environmental or economic system through time (Hák 2007; Smolko 2006).

This study uses indicators of urban forestry and community sustainability programs to assess 'strength' of a program. Several authors have worked to identify those components of urban forestry and sustainability programs that are most likely to yield a strong and successful program (i.e., those program elements that contribute most to the actual sustainability of a city or the actual extent and quality of an urban forest; see Figure 1). In urban forestry, for instance, the aforementioned work by Dwyer et al. (2003) included an extensive discussion of the factors that influence the management of an urban forest and identified program components that are likely to yield a strong and successful program, including the existence of inventory data, sufficient resources, and management goals and objectives. Similarly, the Arbor Day

Foundation's Handbook for Tree Board Members highlights the importance of planning to a successful urban forestry program, including recommending the development of a long-range plans for visioning the future of an urban forest, an annual operational plan based on the long-range plan, as well as plans of work for day-to-day use with detailed tasks and timetables (Grey 1997). As a final example, the American Planning Association's report Planning the Urban Forest identifies over a dozen general planning and design principles for a strong urban forestry program, including, ensuring financial stability through budgeting and grant-seeking; incorporating urban forest vision statements into the larger community planning process; creating a strong tree ordinance that is consistent with the zoning and development codes; and, using adaptive management to plan for the maintenance and persistence of the urban forest (Schwab 2009).

In community sustainability, there have also been efforts to identify those components of sustainability programs that are most likely to increase the tangible sustainability and improve the environmental quality of a city. However, because of the breadth of the topic of sustainability, widely varying conceptions of its meaning, and a focus on the more tangible aspects (e.g., environmental quality, carbon footprint, and quality of life), there have been fewer comprehensive indicator frameworks specifically addressing the programmatic aspects of sustainability. One such widely used indicator framework is Portney's "Taking Sustainable Cities Seriously Index" (2003). Portney's work asks the questions: 1) what components and conditions contribute to more effective sustainability programs or intiatives?; and, 2) "how seriously are cities taking the pursuit of sustainability?" Portney's definition of a sustainable city, then, rests not on the environmental conditions or carbon footprint of the city, but instead on the programmatic, or operational, elements of sustainability; a sustainable city is "a city that is working hard to promote some operational version of sustainability." Portney develops a list of 34 indicators of whether or not a city is "taking sustainability seriously" (from which we draw extensively in the creation of a community sustainability index for this study), including the following seven categories, or components: 1) sustainable indicators project; 2) Smart Growth activities; 3) land use planning and policies; 4) transportation planning and policies; 5) waste and pollution reduction; 6) energy and resource efficiency; and, 7) institutional aspects. In this study, we build upon to Portney's indicator framework, drawing from additional literature to develop a comprehensive index of community sustainability program strength.

Lafferty (2001) also attempts to identify criteria for assessing and evaluating efforts towards community sustainability, specifically, in the context of fulfilling the aforementioned Local Agenda 21. Lafferty's six criteria include: 1) a "conscious attempt" to connect environmental quality to political and economic policies; 2) an "active effort" to connect local decisions to their global effects; 3) a "focused policy" for integration across sectors of environmental and development concerns and goals; 4) efforts to "increase community involvement" and connect stakeholder groups with one another and with the process of planning and implementation; 5) a commitment to systemic thinking and intergenerational timeframes; and, 6) identification with Agenda 21 principles (Lafferty 2001). These program components resonate with Portney's above, as well as with other research efforts (e.g., AtKisson 1996; Global Ecovillage Network undated; Innes and Booher 2000; Reed et al. 2006; Seymoar 2004).

METHODS

This study developed two sets of variables, or indicators, in order to derive measures of urban forestry and sustainability program strength. The two sets of indicators formed the basis for surveys of urban forestry and sustainability programs in cities in Indiana receiving the designation Tree City USA by the Arbor Day Foundation. The items from these surveys were used to produce a list of significant variables for a factor analysis, which produced factor scores (treated as index scores, to align with the initial creation of sets of indicators) for each individual city included in analysis. These factor scores are then regressed on one another to summarize the relationship between urban forestry and community sustainability programs. Figure 2 shows a model of the methodological process used in this study.

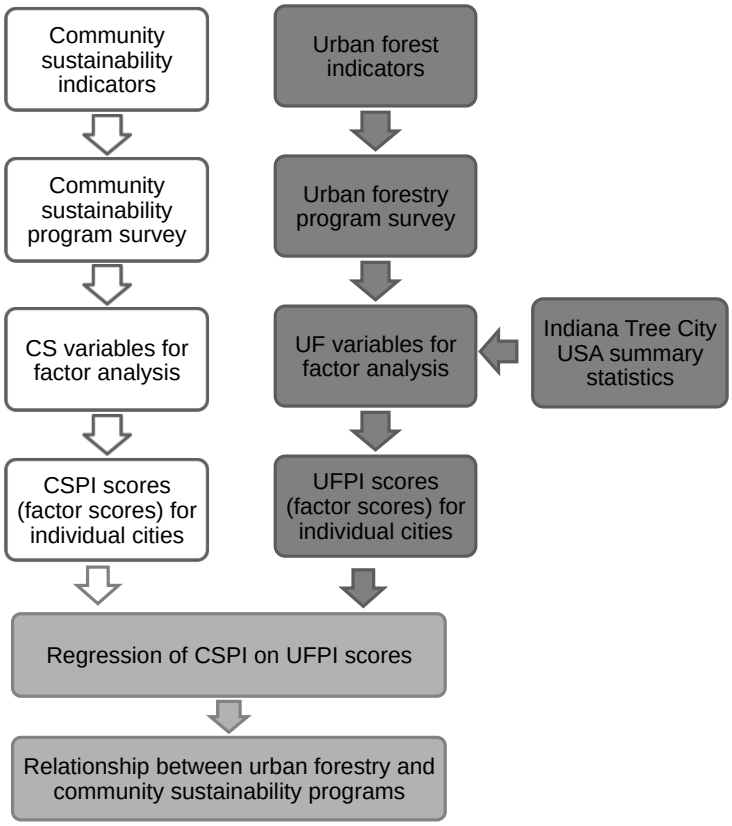

Figure 2. Model of study methodology. List of indicators are translated into surveys of community sustainability and urban forestry programs. The survey results are then used to create a list of significant variables for inclusion in the factor analysis, which produces factor scores (treated as program index scores) for each city. The urban forestry program index (UFPI) and community sustainability program index (CSPI) scores for the cities are then used in a regression analysis to summarize the relationship between urban forestry and community sustainability programs.

Indicators

Urban Forestry Program Index (UFPI)

As mentioned above, there appears to be a fair degree of consensus in the literature about those components that are most crucial to the success, strength, and sustainability of an urban forest. Pamela C. Louks, the State Community and Urban Forestry Coordinator for Indiana, summarized as follows in an email to the authors:

> "A good [urban forestry] program is going to spend dollars on care, maintenance, removals, and planting. It will have a staff person dedicated to the management of the trees…, it will have a citizen advisory group. It will have an inventory and work plan to carry out the needs indicated by the inventory. And, there will be a management plan for the actual care and sustenance of the resource. A good program will also have a strong educational component to generate awareness and build support…" (P.C. Louks, personal communication, 18 Mar 2010)

The first column of Table 1 lists the urban forestry indicators selected for use in this study. A total of 25 different indicators in 5 categories were assessed: institutional organization; planning and monitoring; funding, longevity and recognition; legal basis; and, tree maintenance, planting and removal. Criteria for inclusion of an indicator included availability of data or feasibility of collection of data in addition to the aforementioned distillation of important components from the literature.

Community Sustainability Program Index (CSPI)

Development of community sustainability indicators drew heavily on Portney (2003), as discussed above, with consultation of additional literature. The first column of Table 2 lists the CSPI indicators selected for use in this study. A total of 40 indicators of sustainability programs were assessed in 9 different categories: sustainable indicators project; land use planning and growth policies; transportation planning; waste, energy and resources; institutional organization; greenspace; food security; energy descent and climate change initiatives; and building social capital. There are substantially more indicators associated with sustainability programs than urban forestry programs because the array of activities and issues covered by sustainability programs is much broader than that generally covered by urban forestry programs.

Survey

In order to assess the strength of community sustainability and urban forestry programs according to the indicator framework developed above, individuals in City government in communities in the state of Indiana achieving the designation of Tree City USA by the Arbor Day Foundation were surveyed. Indiana Tree Cities USA provide a good sample population for testing the methodology developed as the Tree City designation results in screening for cities with minimal components of an urban forestry program. Two separate surveys were developed: one survey based on the urban forestry indicators and sent to city urban forestry professionals or (for cities lacking an urban forestry professional) the party responsible for submitting materials for the Tree City USA application; and a second survey based on the

community sustainability indicators, sent to City professionals in one of the following areas or departments (in order of preference) sustainability or environment, community or economic development, planning, or mayor/town manager office. Urban forestry program contacts were obtained from Pamela C. Louks, Community & Urban Forestry Coordinator, Indiana Department of Natural Resources. Community sustainability program contacts were obtained from individual city websites.

For both surveys, questions asked paralleled the program indicators (see again Figure 2). The urban forestry survey contained predominantly yes-no questions about whether the city engaged in a certain activity or possessed a certain program. For example, a question on the urban forestry program survey asked, "Does your city have a city forester?" and then a follow-up question asked, "How many years has the city had a city forester?" Supplementary data on additional urban forestry program variables (e.g., annual per capita urban forestry budget, ratio of trees planted to trees removed annually, number of Tree City USA Growth Awards, etc.) was obtained from Pamela C. Louks and included in the factor analysis (see Figure 2). The community sustainability program survey contained entirely yes-no questions for the program indicators mentioned above. The first round of surveying emailed form versions (PDF) of the surveys to contact email addresses. A second round of surveying – aimed at increasing sample size – called individuals in those cities who had not responded to the first round of surveying to obtain permission to email them a link to an online version of the survey. Neither the wording of questions nor the order of questions was changed between the first and second rounds of surveying. Online surveying utilized Qualtrics software (c2010) under license to Indiana University.

Responses to survey items were coded largely as binary responses to questions about program components. A "yes" response to a question was coded as a 1 and a "no" response as a 0. For some questions on the urban forestry survey, responses were coded as a fraction of 1 (e.g., 0.5 for cities that answered that they possessed a partially complete inventory of city street trees). Additionally, responses to the urban forestry survey were supplemented with program information provided by Pamela C. Louks (see Figure 2), including budget information, trees planted and removed, number of reported awards and grants, and the number of years the municipality has been designated a Tree City USA.

Factor analysis and regression

Cronbach's alpha was computed for each variable from the surveys and used to produce two shorter lists of variables for use in factor analysis (see Figure 2). Cronbach's alpha measures the degree to which all items in a list of variables (survey questions plus supplementary data) assess the same underlying concept (Cody and Smith 2006). In the case of community sustainability variables, this underlying concept is the strength of a community sustainability program; for urban forestry variables, the strength of the urban forestry program. Variables that were not well correlated with the total (alpha of lower than 0.15 for urban forestry and lower than 0.25 for community sustainability) were excluded from factor analyses because they are likely not very good measures of the underlying concept in our sample.

Factor analyses were then performed on the community sustainability and urban forestry variables separately, resulting in factor scores for each city included in the analyses. Factor scores (considered urban forestry program index (UFPI) and community sustainability program index (CSPI) scores; Figure 2) for cities that turned in both surveys were then used in a regression of CSPI scores on UFPI scores to

capture the relationship between urban forestry and community sustainability scores. All statistical analyses were performed using SAS software, Version 9.2 of the SAS System for PC (SAS Institute Inc., Cary, NC) and Microsoft Office Excel 2008 and 2010 for Macintosh (Microsoft Corporation, Redmond, WA).

RESULTS

Survey responses

Surveys were sent to 67 Indiana cities achieving the designation of Tree City USA. Thirty-five cities completed the community sustainability survey (53% response rate), while 47 cities completed the urban forestry survey (71% response rate). These responses yielded 27 cities that turned in both surveys (41% of all cities surveyed). See Figure 3 for a graphic representation of sample response rates.

Selected results from items in the urban forestry survey are presented in Figure 4. Variables for which results are displayed include: years the city has been a Tree City USA, grants and awards, ordinance strength, and inventory type and use. Results shown are for those variables that yielded significant results in factor analysis (see Factor Analysis below). (Note that not all results for the urban forestry survey can be displayed due to space constraints.)

Complete results from the community sustainability survey are presented in Figure 5. Of the 40 total survey items, the following were possessed by over 75% of cities who responded: targeted development policies, hazardous waste recycling in the city, a master plan that addresses sustainability, a regularly scheduled farmer's market, and participatory public planning. The following items were possessed by fewer than 10% of respondent cities: an eco-industrial park or the equivalent, a dedicated budget item for sustainability, an energy descent or peak oil strategy, and a climate change action plan.

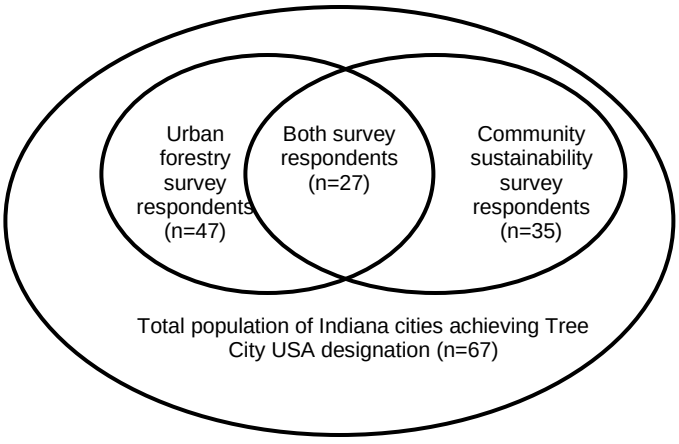

Figure 3. Visual representation of total population (all Indiana cities with designation of Tree City USA; n=67) and survey respondents (sample groups). Not to scale.

Table 1. Urban forestry factor analysis results, showing factor loadings (correlation between the ariable and the factor), scoring coefficients (for assessing factor scores), and communalities (proportion of the variance in a variable explained by the single retained factor), for the 14 variables included in factor analysis. The 25 variables are listed in the order of items on the survey. Six variables have factor loadings with 2-tailed significance at the α=0.10[a] level, and are indicated in **bold. (**Variables with no loadings, coefficients or communality scores were not included in the factor analysis because Cronbach's alpha did not reveal that these variables were significantly correlated with other variables to warrant inclusion.)

Urban forestry program variables	***Factor loadings***	***Scoring coefficients***	***Communality***
Institutional organization			
Tree board or commission	0.23	0.08	0.05
Tree board required by city ordinance	--	--	--
Tree board meets frequently	--	--	--
Number of years the city has had a city forester	**0.49**	**0.16**	**0.24**
Nonprofit dedicated to trees	0.38	0.13	0.14
Planning and monitoring			
Complete or partial inventory	0.31	0.10	0.10
Regular use and updating of the inventory	0.38	0.13	0.14
City Master Plan addresses the urban forest significantly	--	--	--
Strategic plan for the urban forest	0.19	0.06	0.04
Operational plan for the urban forest	--	--	--
Trees a part of the emergency management plan	--	--	--
Ordinance			
Ordinance protects ROW and private trees	--	--	--
Tree ordinance has a provision for penalties	**0.54**	**0.18**	**0.29**
Penalties are actively enforced	**0.81**	**0.27**	**0.66**
Frequency of penalty enforcement in the past year	0.44	0.14	0.19
Fines from penalties go into a specific fund for trees	0.28	0.09	0.08
Maintenance			
Regular maintenance planned for city trees	--	--	--
City is legally responsible for maintenance	--	--	--
City or professional arborists actually perform maintenance	--	--	--
Ratio of trees planted to trees removed in 2009	--	--	--
Funding, longevity and recognition			
Dollars per capita spending on urban forest	--	--	--
Number of grants received in the last 5 years	**0.52**	**0.17**	**0.27**
Number of awards received in the last 5 years	0.36	0.12	0.13
Tree City USA Growth Awards received	**0.59**	**0.19**	**0.34**
Number of years the city has been a Tree City USA	**0.59**	**0.19**	**0.34**

[a] An alpha of 0.10 was chosen because it was decided that including variables that were not actually significant *(Type II error)* was less problematic than not including variables that actually are significant *(Type I error).* Thus, it is better to use a larger alpha. In surveying, it is better to collect more information, including variables that turn out not to be important, than to collect too little information and not include all the variables that actually are important.

Table 2. Community sustainability factor analysis results, showing factor loadings (correlation between the variable and the factor), scoring coefficients (for assessing factor scores), and communalities (proportion of the variance in a variable explained by the single retained factor) for the 29 variables included in factor analysis. The 40 variables are listed in the order of items on the survey. Nine variables had factor loadings with 2-tailed significance at the $\alpha=0.10^{a}$ level, and are indicated in **bold.** (Variables with no loadings, coefficients or communality scores were not included in the factor analysis because Cronbach's alpha did not reveal that these variables were significantly correlated with other variables to warrant inclusion.)

Urban forestry program variables	***Factor loadings***	***Scoring coefficients***	***Communality***
Sustainable indicators project			
Active indicator project	**0.74**	**0.18**	**0.56**
Indicator project accompanied by an action plan	--	--	--
Land use planning and growth policies			
City has an eco-industrial park or equivalent	--	--	--
Targeted development or redevelopment activities	**0.61**	**0.08**	**0.37**
Zoning designating environmentally sensitive areas	0.39	0.05	0.15
Land use plan includes environmental issues	**0.61**	**0.08**	**0.38**
City provides tax incentives for eco-friendly development	--	--	--
Transportation planning			
Regularly scheduled public transportation	0.36	0.05	0.13
Part of city vehicle fleet is alternatively-fueled	--	--	--
Facilitation of bicycle commuting	0.52	0.06	0.27
Waste, energy and resources			
Curbside household recycling provided by City	0.48	0.06	0.23
Recycling services extended to business and industry	--	--	--
Hazardous waste recycling available within the city	0.54	0.07	0.29
Recycled purchasing policy for city government	0.55	0.07	0.30
Renewable electricity used by City	--	--	--
Green building program/incentives	0.53	0.07	0.27
Energy conservation effort	0.31	0.04	0.09
Water conservation effort	0.33	0.04	0.11
Institutional organization			
Unified sustainability efforts (single responsible party)	--	--	--
Master plan within last 5 years addresses city sustainability	--	--	--
Involvement of the business community	**0.69**	**0.09**	**0.47**
Sustainability board or commission	**0.75**	**0.00**	**0.56**
Sustainability coordinator or director	**0.74**	**0.09**	**0.55**
Sustainability incorporated into city ordinance	0.43	0.05	0.19
Dedicated budget item for sustainability efforts	**0.63**	**0.06**	**0.20**
Greenspace			
Commitment to no net-loss of greenspace	**0.63**	**0.08**	**0.40**
City greening programs (e.g., habitat/corridor acquisition)	**0.69**	**0.09**	**0.48**
Involvement in regional greening programs	0.50	0.06	0.25
Food security			
CSA available in city limits	0.40	0.05	0.16
Regularly scheduled farmer's market	0.45	0.06	0.20
Local food movement (co-op grocery, Slow Food, etc.)	0.54	0.07	0.29
Energy descent and climate change initiatives			
City strategy for dealing with energy descent and peak oil	--	--	--
City has a climate change action plan (CCAP)	--	--	--
Transition task force or crises planning initiative	0.50	0.06	0.25
GHG or energy inventory/ecological footprint analysis	0.46	0.06	0.21

Urban forestry program variables	*Factor loadings*	*Scoring coefficients*	*Communality*
Signatory of MCPA[b] or other similar agreement	0.29	0.04	0.09
Building social capital			
Visioning or backcasting planning effort	0.31	0.04	0.10
Participatory public planning	0.55	0.07	0.30
Membership in a collaborative sustainability organization	0.37	0.05	0.14

[a] An alpha of 0.10 was chosen because it was decided that including variables that were not actually significant *(Type II error)* was less problematic than not including variables that actually are significant *(Type I error).* Thus, it is better to use a larger alpha. In surveying, it is better to collect more information, including variables that turn out not to be important, than to collect too little information and not include all the variables that actually are important.

[b] Mayor's Climate Protection Agreement; another similar agreement is Sierra Club's Cool Cities.

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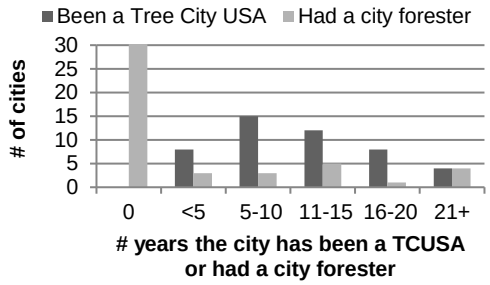

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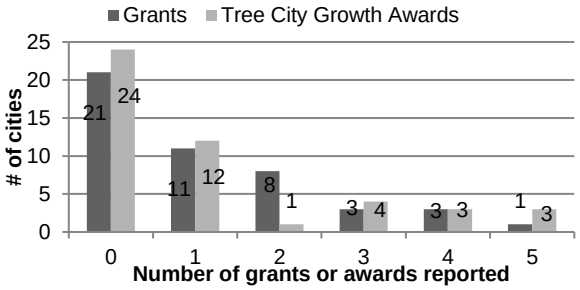

C

Survey item	*% of cities*
Ordinance protects both ROW and private trees (n=46)	20%
**Ordinance contains a provision for penalties (n=47)	74%
**Penalties in ordinance are enforced (n=35)	54%
*Penalties enforced in last year[a] (n=19)	63%
*Penalties go into a specific fund for trees (n=34)	82%

[a] Of the 19 cities reporting penalty enforcement in the past year, the average reported number of enforcements was 2 per year.

D

Figure 4. Select urban forestry survey results by category (n=47). **(A)** Longevity of Tree City USA status (n=47) compared to the number of years the city has had a city forester (n=47). Most cities (24 of 47) have been a Tree City for 10 or more years, while few cities have had a city forester for that long (10 of 47) **(B)** Funding, longevity and recognition category. Histogram of the distribution of the number of grants and Tree City USA Growth Awards received by cities. The bulk of cities surveyed received no grants and no Growth Awards. **(C)** Ordinance category. Asterisks (* or **) indicate the ordinance survey items included as variables in the factor analysis; double asterisks (**) indicate the variables that had significant factor loadings. **(D)** Planning and inventory category. Breakdown of the use or purpose of the inventory by the type of inventory completed by cities. "Reg updated," indicates regular use and updating of the inventory by the city; "snapshot," indicates use of the inventory as only a static picture of the urban forest, with no regular updating or use of the inventory; "not used," indicates a city that does not use their inventory, or that an inventory does not exist. Note that while both the complete or partial inventory survey item and the regular use and updating of the inventory survey item were included as variables in the factor analysis, neither variable yielded significant factor loadings.

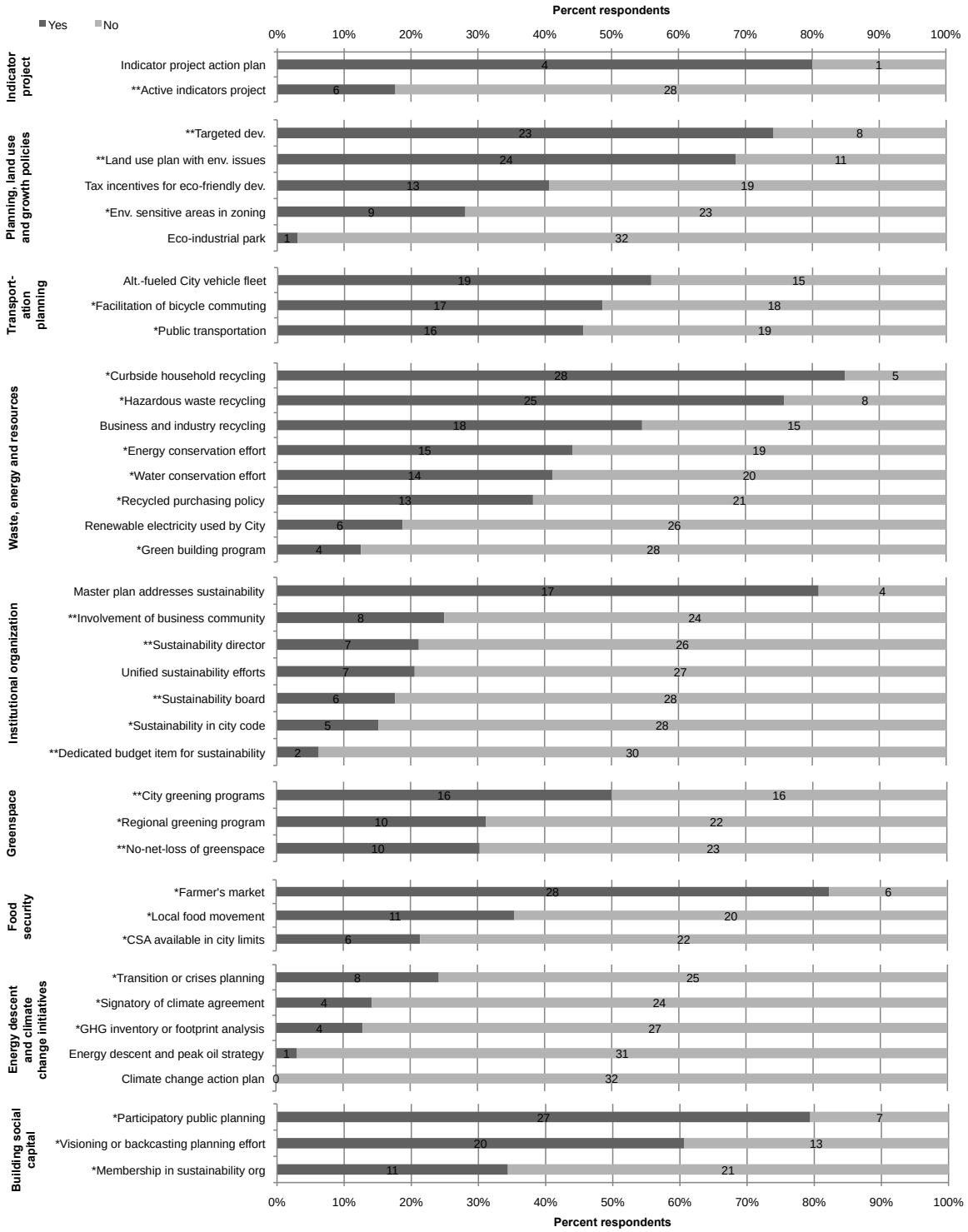

Figure 5. Community sustainability survey results by category. Responses (n=35 for most items) to each of the 40 items on the community sustainability survey, listed from most common (higher percentage of respondents answering "yes" to survey item) to least common program element. Dark colored portions of bars represent "yes" answers, while light colored bars indicate "no" answers. Asterisks (* or **) indicate the 29 items included as variables in the factor analysis; double asterisks (**) indicate the 9 variables that had significant factor loadings.

Factor Analyses

Urban forestry factor analysis

Cronbach's alpha correlation of all urban forestry survey items for all cities returning an urban forestry program survey (n=47) revealed 14 of 25 total variables with a correlation with the total of greater than 0.15 (R^2 values). Factor analysis of these 14 urban forestry variables resulted in a single factor that accounted for 22% of the total variation observed in all variables (Table 1); a second factor accounted for only an additional 13% of the variation, so only the first factor was retained by the n-factor criterion. Six of the 14 variables included in the factor analysis had significant factor loadings (correlation between the variable and the factor; Table 1). The factor scores resulting from this analysis for each city are treated as the urban forestry program index scores, where a factor score of 0 represents a program of average strength, and the standard deviation of all scores is 1 (Table 3).

Community sustainability factor analysis

Cronbach's alpha correlation of all community sustainability survey items for all cities returning a community sustainability program survey (n=35) revealed 29 of the 40 total variables with a correlation with the total of greater than 0.25 (R^2 values). Factor analysis of these 29 variables resulted in a single factor that accounted for 27% of the total variation observed in all variables (Table 2); a second factor accounted for only an additional 11% of the variation, resulting in retention of only the first factor. Nine of the 29 variables included in the factor analysis had significant factor loadings (correlation between the variable and the factor; Table 2). The factor scores from this analysis for each city are treated as the community sustainability program index (CSPI) scores, where a factor score of 0 represents a program of average strength, and the standard deviation of all scores is 1 (Table 4).

Table 3. Urban forestry program index (UFPI) scores (factor scores) for 47 Indiana Tree Cities USA. A score of 0 represents an average program, positive scores represent above average, and negative below average, with the actual score corresponding to the number of standard deviations above or below the mean. Cities in **bold** are those 27 cities that turned in both an urban forestry survey and a community sustainability survey and were included in final regression of factor scores.

City	*UFPI score*	*City*	*UFPI score*	*City*	*UFPI score*
Anderson	**0.76**	**Goshen**	**0.89**	**Rising Sun**	**-1.08**
Angola	0.38	**Greencastle**	**-0.97**	Rochester	-0.94
Avon	0.20	**Grissom ARB**	**-0.94**	Russiaville	-1.34
Beech Grove	-0.66	Hartford City	-1.00	**Salem**	**-0.57**
Bloomington	**1.30**	**Huntington**	**-0.97**	South Bend	-0.50
Carmel	0.64	Indianapolis	1.60	**Syracuse**	**-0.02**
Chesterton	0.99	**LaPorte**	**0.68**	**Terre Haute**	**2.11**
Columbia City	0.11	Madison	0.34	Tipton	-0.54
Crown Point	**-0.72**	**Mishawaka**	**-0.38**	Valparaiso	0.36
Decatur	-0.24	**Muncie**	**1.25**	**W. Lafayette**	**0.96**
Dyer	**-1.18**	**Nappanee**	**-1.39**	**Wakarusa**	**-1.68**
East Chicago	0.01	New Harmony	-0.91	Westfield	-1.21
Edgewood	**0.36**	**Noblesville**	**2.18**	**Whiting**	**-0.19**
Evansville	0.80	**N. Manchester**	**0.46**	**Winamac**	**-0.15**

Fort Wayne	**2.30**	**Rensselaer**	**0.00**	**Zionsville**	**-1.00**
Franklin	**-0.75**	Richmond	0.67		

Table 4. Community sustainability program index (CSPI) scores (factor scores) for 35 Indiana Tree Cities USA. A score of 0 represents an average program, positive scores represent above average, and negative below average, with the actual score corresponding to the number of standard deviations above or below the mean. Cities in **bold** are those 27 cities that turned in both an urban forestry survey and a community sustainability survey and were included in final regression of factor scores.

City	*CSPI score*	*City*	*CSPI score*	*City*	*CSPI score*
Anderson	**-0.99**	**Greencastle**	**1.46**	**N. Manchester**	**-0.62**
Bedford	-0.72	Greenfield	-0.09	**Rensselaer**	**0.76**
Bloomington	**2.36**	**Grissom ARB**	**-0.80**	**Rising Sun**	**0.40**
Crown Point	**-0.74**	**Huntington**	**0.06**	**Salem**	**1.03**
Dyer	**-0.50**	Kendallville	-0.63	**Syracuse**	**-1.25**
Edgewood	**-1.31**	**LaPorte**	**-0.12**	**Terre Haute**	**0.58**
Elkhart	0.09	Michigan City	0.15	**W. Lafayette**	**0.16**
Fishers	-0.74	**Mishawaka**	**-0.62**	**Wakarusa**	**-1.30**
Fort Wayne	**2.52**	**Muncie**	**0.46**	**Whiting**	**0.65**
Franklin	**0.21**	Munster	0.25	**Winamac**	**-0.94**
Fremont	-1.54	**Nappanee**	**-1.00**	**Zionsville**	**0.64**
Goshen	**0.54**	**Noblesville**	**1.56**		

Regression of index scores (factor scores)

Regression of CSPI scores on UFPI scores for those cities who turned in both surveys and thus had scores on both indices (n=27) revealed a highly significant correlation between UFPI and CSPI scores (R^2=0.2387, p = 0.0097; see Figure 6). When population and median household income were added to the regression model (to reflect candidate socio-economic variables), no additional variation in community sustainability scores was explained.

DISCUSSION

To date, little published research has been conducted on cities designated a Tree City USA by the Arbor Day Foundation. (A June 2010 inquiry to the Arbor Day Foundation by one of the authors (BCF) revealed no known publications studying specifically the characteristics of Tree Cities USA. A subsequent Google Scholar search in December 2010 for "Tree City USA" and "urban forest" yielded only 194 results, compared to over 13,500 hits for the phrase "urban forest" alone. Most of the results containing reference to Tree City USA referred merely to the programs existence.) Though the Tree City program is 35 years old and well recognized and established, researchers have not yet investigated the characteristics of the urban forestry programs in Tree Cities. As such, this study provides a format for future evaluation and assessment of urban forestry and community sustainability programs in Tree Cities. It also provides a platform for understanding how the Tree City USA program might catalyze community sustainability programs. Though the indicator assessment methodology used in this paper cannot provide an indication or direction of causation between urban forestry and community sustainability programs, it does indicate that there is a significant correlation between the strength of urban forestry and the strength of community sustainability programs, as strength is determined by the set of indicators in this analysis. As we discuss

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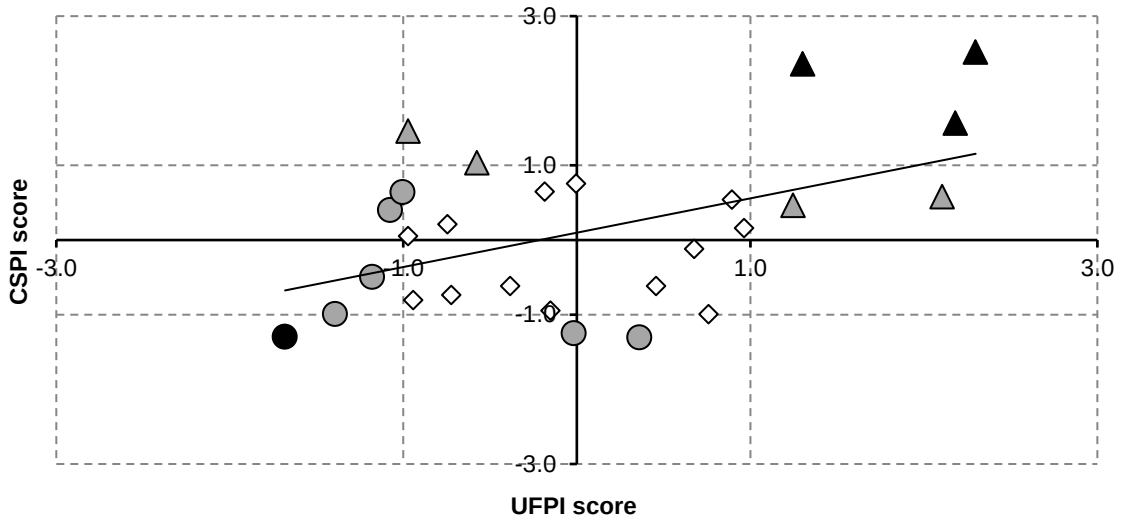

B

Regression equation:	*CSPI score =*	***(0.460)** UFPI score*	*+*	*(0.099)*
p-values:		**0.0097**		0.594

Figure 6. (A) Scatter plot of urban forestry program index (UFPI) scores (x-axis) and community sustainability program index (CSPI) scores (y-axis) for a sample of Indiana cities achieving the designation of Tree City USA (n=27). On both axes, 0 represents an average program score, and the axes represent the number of standard deviations above or below the mean. Cities that fall greater than 1.0 standard deviation from the mean are considered to have "strong" (score > 1.0) or "weak" (score < -1.0) programs. Black triangles represent those cities with strong community sustainability and strong urban forestry programs; gray triangles represent those cities with either strong sustainability or strong urban forestry programs. Black circles represent those cities with weak sustainability and weak urban forestry programs; gray circles represent those cities with either weak sustainability programs or weak urban forestry programs. No cities possessed one strong program and one weak program. **(B)** Regression equation for the regression of UFPI scores on CSPI scores. Regression coefficient **(bolded)** was significant at the $\alpha = 0.01$ level. The regression coefficient indicates that for every 1 standard deviation unit increase in urban forestry program scores, community sustainability program scores increase by less than one-half standard deviation. Note that the intercept is not significantly different from an intercept of 0.

in this section, perhaps this can be the start of future research to assess the potential of the Tree City USA program to catalyze community sustainability efforts.

Significant variables from factor analyses

Results from the factor analysis of urban forestry program variables revealed 6 of 14 variables that were significantly correlated with the index scores (Table 1). Results from the parallel factor analysis of community sustainability program variables revealed 9 of 29 significant variables (Table 2). It is worth noting that these variables, because they appeared as most strongly correlated with the final index scores of the municipalities, could provide insight into future urban forestry and sustainability program assessments. Because it is often time-consuming or costly to gather significant amounts of data – particularly when this data relies on the return of a survey by an overworked municipal employee – looking to these most significant variables as a sub-set of variables able to characterize the strength of

urban forestry programs could significantly lower the amount of data collection necessary for adequate program assessment. The small sample size and geographical limitation to the state of Indiana limit the appropriateness of application of the set of variables deemed significant in this study to other studies. However, this study creates a useful methodological framework for future larger-scale studies.

Correlation between strength of urban forestry and strength community sustainability programs

The results of the regression analysis indicate that urban forestry and community sustainability program strength were positively correlated with one another. According to the index scores resulting from the factor analysis, 3 of 27 cities had both strong sustainability and strong urban forestry programs, while only 1 of 27 cities had both a weak sustainability program and a weak sustainability program (Figure 6). No cities had both a weak program of one type and a strong program of the other. We hypothesize the following explanations for why this occurs.

Community sustainability and urban forestry efforts are thematically related, and for this reason, cities with an interest in one might naturally take an interest in the other. Additionally, because sustainability is most often understood in an environmental context (rather than an economic or social context; Saha and Peterson 2006;), cities with strong environmental sustainability programs are also likely to have strong urban forestry programs. As urban forestry programs have evolved over the past quarter century, cities with well-developed urban forestry programs, that have gone beyond solely tree planting and care to consider the social and economic benefits of the urban forest (Clark et al. 1997; Dywer et al. 2003), are in a better place to consider a broader definition of sustainability that includes environmental as well as social and economic components.

An additional hypothesis might be that the organizational position of sustainability and urban forestry programs within a city's government might also impact their strength (Jepson 2004). Sustainability programs could be stronger because they are new and higher profile and more likely to be located in a political office (e.g. the Mayor's office), while more traditional urban forestry programs are likely to reside lower in a city government's hierarchical structure (e.g. a parks department). Sustainability could be thought of as more interdepartmental than urban forestry as a program, or even as a non-environmental program in a few cities. Thus, sustainability program implementation is likely impacted by both its organizational location within city government as well as the government's perspective and intent for the program.

These and other predictions will have to be tested in future research to more fully assess all the factors that may influence the strength of community sustainability or urban forestry programs. Addition variables that could be investigated with future research include: overall city budget, type of governance (e.g., town manager versus mayor and city council; city-county versus city only government), and proximity to a large urban center (e.g., Indianapolis or Chicago), among others.

Population and community sustainability

Given that urban forestry scores explain less than 24% of the variation in community sustainability scores, there are clearly other causes of the observed variation in strength of programs, as one would

expect. Although adding in population, median household income and median home value to the regression model did not account for additional variation in our sample, we acknowledge that the small sample size of this study may be a constraint. That factors such as city population and median household income do not explain variation in sustainability program strength in this study is contrary to a recent account by O'Regan et al. (2009) concerning the effect of city population size on sustainability. These authors found a positive correlation between the population of 79 Irish cities and towns and their relative sustainability as measured by two sets of sustainability metrics: ecological footprint values and a sustainable development index (including indicators related to the environment, socio-economic aspects, transportation, and quality of life; O'Regan et al. 2009). Perhaps adding more cities to our study would reveal an impact for city population size on community sustainability program strength.

Operationalization (program plan or statement) versus implementation (program actions and results)

Alternatively, perhaps the explanation for the lack of population as a significant variable in our research can be found in the differences between measuring tangible community sustainability (in the form of real metrics such as vehicle miles traveled and ecological footprint required, factors measured in the O'Regan et al. (2009) study) as compared to programmatic, or operational sustainability (as measured in our study; see also Figure 1). It is important to recognize that our study looks at the operationalization of sustainability and urban forestry program efforts, that is, the program plans and statements of action made by cities and towns. *Operationalization* implies the incorporation of ideas, norms and values as well as informal rules into formal commitments, agreements, or even into law (Ostrom 2005). In Elinor Ostrom's work on collective action and institutions, she calls this the creation of *operational-level rules* that influence the decisions made and actions taken on a day-to-day basis by individuals and groups within a city (Ostrom 2005, p.58), which ultimately influence the implementation of tangible sustainability of the city. Indeed, there is a profound difference in between 'what you say, and what you do,' as the axiom goes, and city governments are no more insulated from this difference than any other entity. Thus, operationalized sustainability programs do not necessarily translate to tangible, on-the-ground improvements in environmental quality, sustainable development patterns, and the other visible components that are part of a sustainable city. So, while in Figure 1 we may draw arrows 2 and 3 as solid to represent the documented potential connection, perhaps dotted arrows should also be drawn to reflect the uncertain linkage between operational-level constraints (what cities say the programs do) and actions or outcomes (what the programs actually do).

Though this study lacks data about tangible community sustainability, we can make predictions about the potential differences that may exist in the relationship between operationalization and action in existing urban forestry and community sustainability programs (arrows 2 and 3 in Figure 1). Tree City USA is a baseline for urban forestry program efforts, and implies more action than sustainability program efforts may (refer back to Box 1). Communities with a long-standing Tree City USA status have possibly operationalized more programs that can lead to more effective action and ultimately greater contributions of the urban forest to tangible community sustainability. Sustainability programs, however, as nascent attempts to improve the environmental, social and economic quality of a city, are likely not yet to the point of making concrete actions on the sustainability front. In other words, policies relating to sustainability have been made but likely not yet fully implemented in the city.

It takes a change in the way humans think and operationalize concepts to make the shift from conventional urban operations (e.g. sprawling development patterns, polluting industries, automobile-dependent planning) to more sustainable ones (e.g. smart growth city planning, eco-industrial and redevelopment strategies, increased city walkability and public transit options) (Devuyst et al. 2001). Cities may also face tough political egos, a resistant business community, or intense public opposition to sustainability movements, and could have difficulty garnering the much-needed public support for a strong sustainability program (Jepson 2004). If the relative success and strength of a city's urban forestry program can be leveraged toward the cause of community sustainability, there is a substantial potential for a real shift in the tangible sustainability of urban areas.

A baseline set of sustainability requirements

Tree City USA provides a baseline set of requirements that communities must meet in order to be recognized. There is no analogous set of requirements for community sustainability programs. Although some programs (such as the Mayor's Climate Protection Agreement, Indiana Comprehensive Local Environmental Action Network (CLEAN) Community Challenge, and Sierra Club's Cool Cities) and organizations (such as ICLEI-Local Government for Sustainability and the +30 Network) do offer cities an opportunity to 'pledge' themselves to various actions for sustainability, they lack accountability and often have only a single or even no verifiable prerequisites for recognition. Thus, a recommendation emerging from this study is the development of a national certification program with a set of minimum, verifiable requirements for city sustainability programs to enable them to be recognized as a 'Sustainable City USA.' These guidelines, if paralleled with those of Tree City USA, could be the following: (1) a minimum of $5 per capita spent on community sustainability activities and programs (this hypothetical expenditure is greater than the Tree City USA-required $2 per capita because of the greater breadth of activities presumably covered under the umbrella of sustainability); (2) existence of a sustainability board or commission in the city; (3) passage of some type of sustainability or sustainable development ordinance; and, (4) an annual Earth day celebration (or similar yearly day dedicated to sustainability education and awareness). While these requirements are far from sufficient to generate sustainable communities, they would be a starting place for improving the strength of community sustainability programs.

A subsequent recommendation from this study is to develop levels of Tree City USA (and 'Sustainable City USA') certifications, perhaps similar to the widely successful Leadership in Energy and Environmental Design (LEED) Certified, Bronze, Silver, Gold, and Platinum green building certification levels (U.S. Green Building Council 2011). This would be a way of explicitly encouraging cities to strengthen their urban forestry or community sustainability programs by going beyond the minimum requirements.

CONCLUSION

One hundred and thirty five million Americans – more than one-third of the United States population – live in cities that claim the distinction of being a Tree City USA (ADF undated), and millions more people live in cities with some sort of urban forestry efforts. But there lies a great, untapped potential in urban forestry programs to promote broader community sustainability. If a baseline set of standards for

community sustainability programs can be developed similar to those of the Tree City USA program, perhaps community sustainability efforts can become more visible and more transparent, and ultimately, result in a more sustainable world.

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