

Activating landscape ecology: a governance framework for design-in-science

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Abstract

Context In response to predominantly local and private approaches to landscape change, landscape ecologists should critically assess the multiscalar influences on landscape design.

Objectives This study develops a governance framework for Nassauer and Opdam’s “Design-in-Science” model. Its objective is to create an approach for examining hierarchical constraints on landscape design in order to investigate linkages among urban greening initiatives, patterns of landscape change, and the broader societal values driving those changes. It aims to provide an integrative and actionable approach for landscape sustainability science.

Methods This framework is examined through an ethnographic study of public policy processes surrounding the urban tree initiatives in Boston, MA; Philadelphia, PA; and Baltimore, MD.

Results These initiatives demonstrate the impact of political and economic decentralization on urban landscape patterns. Their collaborative governance approach incorporates diverse resources to implement

programming at a fine-scale. The predominant tree giveaway program fragments the urban and regional forest.

Conclusion Spatial and temporal fragmentation undermines the long-term security of urban greening programs, and it suggests reconsideration of the role of state regimes in driving broad scale spatial planning.

Keywords Landscape sustainability science · Landscape ecology · Policy · Governance · Design-in-science · Urban ecology · Urban forest · Boston · Philadelphia · Baltimore

Introduction

Urban trees are a key element of urban green infrastructure, which is an important urban climate adaptation strategy (Amati and Taylor 2010). Trees contribute to green infrastructure in a myriad of ways: they enhance air, water, and soil quality; mitigate water flows and surface temperatures; protect habitats; and provide a host of recreational, psychological, and real estate benefits (Dwyer et al. 2003). In particular, urban tree initiatives are one domain of green infrastructure that has scaled up to the level of the city in the United States (Young 2011). However, the trend in U.S. cities has been one of tree loss, rather than tree growth (Nowak and Greenfield 2012). Moreover,

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urban trees have generated widespread concern about the equity of public service provision. Although a decade of these programs has passed, the attempts of government agencies to achieve equitable urban tree cover distributions have been severely challenged (Schwarz et al. 2015). This gap between the normative sustainability goals of cities and their performance brings together the science and politics of landscape change.

The impact of political processes on landscape patterns is widely recognized by landscape ecologists (Beunen and Opdam 2011; Wu 2015), although it is poorly understood and merits further investigation (Johnston and Wescoat 2008). Nassauer and Opdam's "Design-in-Science" framework (2008) powerfully advances these conversations in landscape ecology. It establishes that landscape design fundamentally mediates between landscape process and landscape pattern. Landscape design both forms the basis for understanding process/pattern interactions as well as the ground of adaptive management. This framework holds great potential for consolidating an actionable landscape sustainability science. However, this potential integration requires much greater clarity around the specific mechanisms driving design processes.

Landscape ecologists have used experimentation to test the ecological values of landscape patterns for decades (Franklin and Forman 1987). In the contemporary frame of landscape sustainability science, it is important to understand linkages between political processes and landscape patterns, and such investigation requires experimental, comparative, and spatially-explicit methods (Wu 2013). Design is effective in establishing natural experiments (Ahern 2011). In a clever extension, Nassauer and Opdam's (2008) framework identify "societal goal setting" as shaping the design processes that drive changes in landscape patterns. If landscape ecological outcomes and sustainability hinge on experimentation, then it matters how political systems set the parameters for experimentation.

A synthetic understanding of science-policy linkages requires "theory building and empirical research in the interface between landscape ecology and social sciences" (Opdam et al. 2018, p. 6). In particular, understanding the hierarchical drivers of landscape processes has been foundational in establishing the field of landscape ecology (O'Neill et al. 1986). Despite this fact, contemporary ecologists and

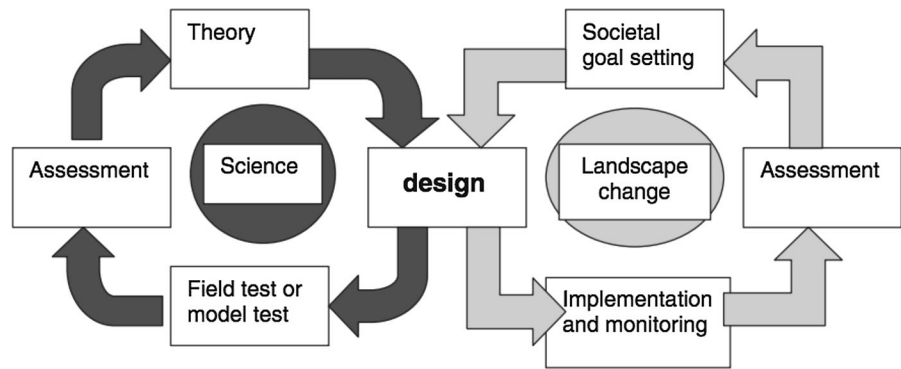
landscape planners tend to focus on interventions at the "private and local" scales (Nassauer 2006), rather than investigate the broader political processes driving such interventions. Ethnographies of public policy processes would contribute significantly to understandings of how landscape design is transformed by governance contexts more broadly (Evans 2011).

This study builds upon the Design-in-Science framework in order to characterize more sharply and clearly the hierarchical constraints that governing processes place on design projects. Using Nassauer and Opdam's (2008) definition of design as any intentional change in landscape pattern, it examines changes in tree patterns resulting from urban tree planting initiatives in three U.S. cities. Specifically, it conducts an institutional ethnography of tree planting initiatives in Boston, MA, Philadelphia, PA, and Baltimore, MD, with the lead author embedded at different times in the Forest Service, the Mayor's Office, and a municipal parks department. By investigating the governance drivers of urban tree planting, it aims to elucidate the hierarchical constraints shaping the volume, pace, and patterns of tree cover change. In this way, its goal is also to further integrate the long-segregated domains of the science and politics of landscape change. The following sections provide background context and theoretical justification for the conceptual framework.

Design-in-science as activating landscape sustainability science

Nassauer and Opdam's (2008) "Design-in-Science" framework (Fig. 1) illustrates how design synthesizes theory and practice for improved landscape sustainability science. On one hand, a design intervention represents the culmination of "societal goal setting", and management of the parcel feeds back into an evaluation informing future management. On the other, socio-ecological theories provide the backdrop against which design interventions are understood. Field or model tests of the built designs, when conducted, similarly feed back into socio-ecological theory development (similar to Lenzholzer et al. 2013). Landscape design not only connects pattern and process, but it also links science with landscape change. Design creates "'possibility spaces' within which desirable and feasible futures can be shaped

Fig. 1 ‘Design in Science’. Reproduced with Permission from Nassauer and Opdam (2008)



through design and management, and tested through scientific evaluation” (Swaffield 2013, p. 1194).

The Design-in-Science framework creates the significant potential for actionable landscape sustainability science. However, activating this framework requires better understanding of the political systems in which acts of design are embedded. The role of ecological theory is to identify the causal mechanisms and explore relationships in changing landscapes (Levin 1992). Because most landscapes are hierarchically structured, the scale of focus and intervention is very important in identifying the drivers of changing landscape patterns (Urban et al. 1987). Often causal mechanisms are located at different levels than that on which they are observed (Allen and Hoekstra 1992). If a problem is studied at an inappropriate scale, its actual mechanisms and constraints will be concealed (Wiens 1989), and patterns will become “artifacts of scale” (Li and Wu 2004, p. 397). Analyses must identify “ecologically relevant” processes, rather than use easily available data (Li and Wu 2004, p. 391).

Some studies attempt to address this problem by incorporating multiple causes of landscape change. For example, studies by Grove et al. (2006) and Lerman and Warren (2011) create a tiered method in order to evaluate the relative influences of (a) landscape plantings, urban gradient, and socio-economic factors, and (b) population, lifestyle behavior, and social stratification, respectively, on ecological patterns. Both studies begin with the premise that socio-ecological processes occur at different levels of organization; thus different modes of explanation may provide complementary insights into the nature of urban environments (Grove et al. 2006). However, these studies are constrained for the reasons outlined by Li and Wu (2004) above. They express a mismatch

between their temporal and spatial scales of observation and analysis. Lerman and Warren used data from a single year; Grove et al. used US Census or PRISM (marketing-oriented) data for 2–3 years. The annual time scale will not yield accurate information about the impact of social structure on urban vegetation because the socio-economic factors selected to characterize social structure are not ecologically relevant in these studies in the following ways. Their indicators overly rely on available data that describe current conditions related to residential profiles, and they do not explain the mechanisms driving changes in urban neighborhood patterns.

Meanwhile, unfortunately many studies explicitly rely on correlation even while emphasizing causal uncertainty. For example, Troy et al. (2012) assessed the relationship between tree canopy and crime levels in Baltimore County, concluding that greater tree canopy “strongly correlated” with diminished robbery, burglary, theft, and shooting rates. At the same time, the article gave a disclaimer that the research team, in fact, had no theory about the drivers of crime. Failure to identify causal relationships before conducting correlation analyses risks the development of “useless or even misleading” conclusions (Li and Wu 2004). Much intellectual labor remains in assessing more accurately the drivers of landscape change.

A governance framework for design-in-science

We expand on Nassauer and Opdam’s concept of “societal goal setting” to consider explicitly the hierarchical constraints shaping landscape change. As with the original diagram, the intentional act of landscape design lies in the center of the framework.

Nassauer and Opdam (2008) define design as inclusive of all intentional changes to landscape pattern. The fundamental component of this definition is intentionality, for the authors emphasize that social values drive changes to landscape pattern. Design is the action marking human intentionality on landscapes, as intention drives landscape change in the modern context of “human-dominated ecosystems” worldwide (Vitousek et al. 1997).

Design encompasses a wide variety of intentional acts, spanning built projects of landscape architects, specific programs of public agencies, or even trends in civic volunteerism. It includes the actions of multifarious individuals and social groups, spanning designers, environmental managers, public administrators, contractors, non-profit activists, lay individuals, and others. Design occurs as changes to landscape pattern in the forms of polygons, lines, or points. In polygon form, design occurs at very large scales, such as through the creation of new districts of rapidly growing Middle Eastern or Chinese cities, or the purchase of large tracts of land for forest conservation in Ghana or Cambodia. It also occurs on very small scales, such as the widespread practice of paving backyards in South Philadelphia or replacing grass with deeply-rooted native plants in the residential yards of Ann Arbor’s Kerrytown neighborhood.

Apart from these polygon-type changes, design also changes landscape patterns in linear forms. The street tree campaigns of the early twentieth century represent a design change that created linear rows of urban vegetation in U.S. cities. Likewise Richard Forman has written extensively about the impact of linear roads on regional ecologies (c.f. 2003). Finally, design occurs as points, such as the placement of rain barrels or trees in a landscape. Parcels, or polygons, of land may also be represented as points for the purpose of spatial analysis. For instance, scholars in the 1980s and 1990s analyzed the spatial distribution of landfills and hazardous waste sites as they relate to disenfranchised social groups, and they found a spatial correlation between the two; this finding led to the establishment of environmental justice research (Hollifield 2001). In general, a design lens focuses study on material changes in spatial patterns and the resulting patch dynamics that they foster for landscapes, cities, and regions.

State Institutions express a hierarchical constraint over discrete acts of landscape design. Institutions are

defined as the formal and informal rules and norms that coordinate behaviors to influence on-the-ground actions (North 1991). Likewise, environmental institutions direct environmental behaviors (Lemos and Agrawal 2006). For example, Nowak shows how rules and norms around urban tree planting changed in Oakland, CA over time. In the nineteenth century, decisions about the locations and species of trees depended on the land purchases made by landholders. In 1903, a citizen committee convinced the city to initiate a street tree campaign (Nowak 1993). In this historical shift, tree planting patterns shifted from clustered tree plantings on large private parcels of land to linear tree plantings on public streets (Fig. 2).

The rules and norms associated with design behaviors are complex, as they are historically and geographically rooted in political economies and cultural norms. To model behaviors, we simplify these societal trends into two forces: political economic relations and social movements. In the Oakland, CA case above, *social movements* changed the rules and norms around the urban tree planting campaigns of the early twentieth century. First, decisions that had previously been made by a few, wealthy landowners became dispersed among numerous citizens. Second, decisions that had previously been made by white male landowners broadened to include white women (Dümpelmann 2015). Thus, changes in the spatial patterns of trees were associated with changes in the rules and norms guiding tree planting. In particular, the suffragette movement brought middle class white women to the forefront of urban ecology advocacy. Understanding the social movements of the time explains these changing tree patterns.

Whereas social movements provide the mechanisms for political change, *political economic relations* pose a higher-level constraint over the institutional arrangements in societies related to the environment (Bridge and Perreault 2009). Different incentive structures create and distribute financial resources to divergent types of actors and actors at different scales. Political economic relations have wide-ranging causal influences on state institutions, including the size of government, centralization of political power, class structure, racial/ethnic composition and diversity, and others.

In a United States context, two contrasting political economic relations of the last century are the

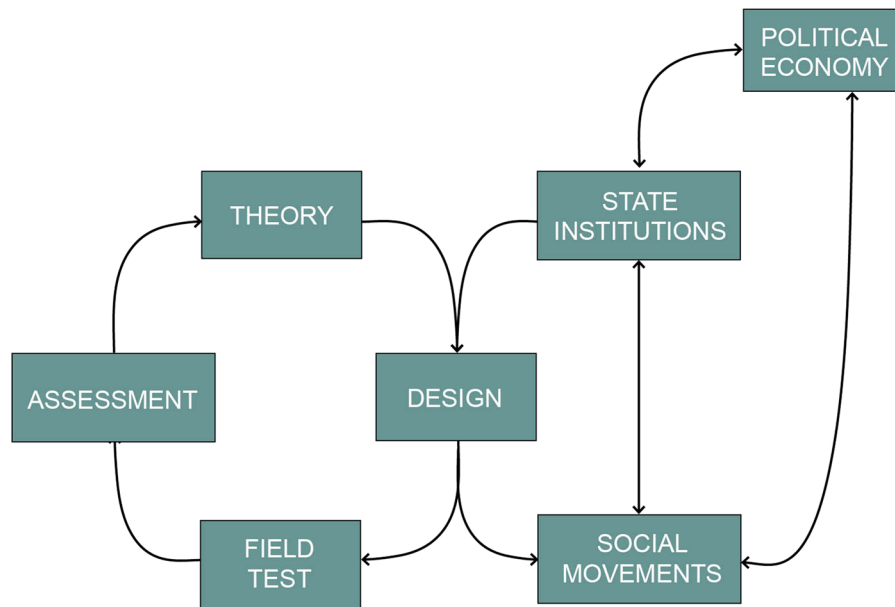


Fig. 2 Governance framework for Design-in-Science (Foo 2018)

Keynesianism and Neoliberalism, and a major institutional difference between these two models relates to the size of government. In Keynesianism, which predominated in the postwar era, government agencies tend to initiate, fund, develop, implement, and monitor their own programs (Peet and Hartwick 2015). In contrast Neoliberalism, which has prevailed since the late 1970s, is based on the concept of a “self-regulating market” (Polanyi 1944), in which markets become “comprehensive as the governing mechanism for allocating all goods and services” (McCarthy and Prudham 2004, p. 276). Keynesianism emphasizes the redistributive powers of the state, whereas neoliberal modes of management emphasize security and property law, with diminished investments in public services. While Keynesianism has the capacity for participatory planning, in many cases neoliberalism places greater emphasis on local action by a diverse set of civic actors (Lemos and Agrawal 2006; Seto et al. 2010).

The state institutions associated with neoliberalism are the rules and norms that prevail under neoliberal political economic relations. Neoliberal institutions have limited the size, role, and influence of public agencies in decision-making. In the West slashes to government resources progressively “hollow out” the regulatory and social provisioning functions of governments (Jessop 2008), whereas in developing

countries, neoliberal governance constrains the size and power of government agencies. Neoliberal governance has also involved the greater integration of scientific, technical, and lay knowledge, and also the involvement of many actors, including informal resource users and managers (Lemos and Agrawal 2006). As a result, they must partner with non-state entities in order to deliver government services, and this significantly increases their risk. Finally, neoliberal state institutions are associated with a focus on private land and private finance mechanisms, at the expense of public space (Brenner and Theodore 2002; Peck et al. 2009).

Research design

This study employs an institutional ethnography of the public policy processes around urban tree planting in the three American cities of Boston, Philadelphia, and Baltimore. Institutional Ethnography is a variety of ethnography that attempts “to uncover the macro foundations of a microsociology” (Smith 2005, p. 32). Institutional ethnography asks “macrosocial questions about the causes of events or the constitution of major systems and processes” (Marcus 1986, p. 168). It makes visible the ways in which individuals are “connected into the extended social relations of ruling

and economy and their intersections” (Smith 2005, p. 29). In this way, its empirical method may approximate the cross-case method, which compares and contrasts analyses across individual cases. This multisite method prompts “more robust conclusions about the factors that appear to influence patterns” in diverse localities (Bebbington and Batterbury 2001, p. 373).

Our target population consisted of the key policy stakeholders associated with each city’s tree initiative. All initiatives incorporated the participation of actors and organizations within multiple departments of the municipal government, place-based civic organizations, and private firms of varying sizes. The target population in each city reflected the organizational composition and structure of that city’s tree initiative. The demographic profile of the target population largely consisted of Caucasian men and women above the age of 30, with higher education and from the northeastern US. Key policy stakeholders in Philadelphia featured notably more women than Boston and Baltimore, as well as a high proportion of individuals born and raised in Philadelphia.

Interviews

An interview instrument approved by the Institutional Review Board (IRB) guided the topics and flow of each interview. The topics covered included: (1) the range of administrative practices: (a) associated with the tree initiative, (b) linking the initiative with other programs within municipal, state, and federal government, and (c) linking the initiative with the work practices of civic organizations, private firms, and research entities; (2) roles of different parties in carrying out these practices; (3) rules and norms coordinating these practices, (4) the degree to which these rules and norms are commonly held or contested, and (5) the direction of influence among the parties.

Because the method links bureaucratic practices in disparate locations and positions within broader social relations, the content of the interviews varied widely. Specific questions were developed based on the specific position, experience, and expertise of the interviewee. The number of interviews per person also depended on his or her knowledge and experience, and they averaged one to two interviews per interviewee. A total of ninety-four (94) interviews were conducted, of which eleven (11) interviews were a second

interview. The interviews averaged sixty minutes and were mostly conducted in person. The interviews were audio recorded, transcribed, and analyzed manually.

Participant-observation

Sites of participant-observation were selected based on two sets of criteria. For each city, there were analytical and logistical questions: what was the centrality of a given organization to the tree initiative, and its position relative to other organizations, and what opportunities of access to a target organization were available? Additionally, another consideration was the exposure to different partners in the urban tree initiatives in order to understand the work flow from different organizational perspectives.

In Boston, participant-observation was based in the Mayor’s Office of Boston City Hall; in Philadelphia, the USDA Forest Service Philadelphia Field Station; and in Baltimore, the Baltimore Recreation and Parks department. The Mayor’s Office in Boston was chosen because it granted the best access to institutional partners, and also because access was granted through an external fellowship. The Philadelphia Field Station was chosen because it granted access to a federal agency that has been key in advancing urban forest scholarship and governance, and also because access was granted through an external fellowship. The Baltimore Recreation and Parks department was chosen because it was central to that city’s tree planting initiative, it granted access to other partners, and it also gave insight into the inner workings of a municipal parks department.

Participant-observation was oriented toward these organizations in each city, but it also spanned different activities and sites. Activities in which the lead author participated included: tree care trainings, community-based trainings, publicity events, neighborhood-based tree plantings, city-wide community meetings, and neighborhood-based community meetings. Detailed notes were taken immediately following the observation event, and these notes were manually analyzed together with the interview transcripts.

Cases

In this study, we focus on the cities of Boston, MA; Philadelphia, PA; and Baltimore, MD. These cities

developed their tree initiatives in 2006–2008, when many other cities were deploying similar programs. Each city's tree canopy goals and timeline are depicted in Table 1. These are historical cities in the forested northeastern region of the United States. The cities are similarly dense, racially/ethnically diverse, and segregated urban areas, and they also possess numerous active civic and neighborhood-based organizations. Their tree initiatives are differently situated in city government, with different relationships with higher-level public administrators, local and extra-local private firms, and local civic actors.

Tree planting programs as codified design

The initiatives display a high level of similarity in their programming. The tree giveaway was the signature program associated with the initiatives. This program offered 2- or 5-gallon pot trees for individuals to plant and establish on private parcels of land. Each initiative identified pick-up locations at either the city's nursery (Baltimore) or a non-profit organization's nursery (Boston and Philadelphia) on certain dates during the spring and fall windows for tree planting.

The marketing firms working with Philadelphia and Baltimore's initiatives developed similar concepts for marketing the tree giveaway to a broader swath of the general public. In this concept, the tree initiatives co-hosted events with other organizations or companies on their property. TreePhilly celebrated 2014 Arbor Day with "ArBrew" Day events, which involved a tree giveaway, a photo booth, and other publicity at a handful of breweries around the city. In Baltimore, this was established in 2014 as a periodic event, called a TreeUp, in which TreeBaltimore hosted an event on the property of a partnering organization. TreeBaltimore provided food and funds for the organization to make t-shirts, everyone planted 2"–3" ca. trees

together, and TreeBaltimore hosted a tree giveaway. The purchase of a tree truck by Philadelphia in 2013 and Baltimore in 2014 aided in the distribution of trees while publicizing the tree planting initiative.

In addition to the tree giveaway program, non-profit organizations in Philadelphia and Baltimore also leverage the civic volunteers for tree planting initiatives on vacant land as well. These organizations develop, manage, implement, and monitor programs to organize tree plantings with community organizations on vacant land. In the case of Philadelphia, the non-profit organization receives a line in the city's permanent budget to green the city's vacant lots (Foo 2017).

The tree initiatives overlap with parks departments' longstanding oversight of street trees and trees on park land. The parks departments are legally charged with planting, stewarding, and monitoring its street trees. All departments have a perpetual backlog of requests for individual street trees scattered across their city. To address this backlog, Philadelphia streamlined the several request forms for a single tree planting, but it remains a problem because the small number of inspectors heavily restricts the speed at which arborists can proceed with tree planting. Because it could not increase staffing for the inspection position, the city experimented by giving its non-profit organization permission to handle 100 of the 500 requests that were located in that organization's informal neighborhood territories (Interview 61 on 5/29/14). Philadelphia tried to increase efficiency by converting it from a point-based program to a block-based program, although this program's life span was brief.

Parks have not been a programmatic focus of the tree canopy expansion efforts in Boston and Philadelphia. In Boston, tree planting initiatives largely do not occur on park land, whereas in Philadelphia and Baltimore, external entities plant trees on municipal park land. Boston's parks leadership explicitly prefers

Table 1 Tree canopy goals for Boston, Philadelphia, and Baltimore

| | Date of initial announcement | Projected date of completion | Tree goals (# trees) | Tree goals (% cover) |
|--------------|------------------------------|------------------------------|----------------------|----------------------|
| Boston | 2007 | 2030 | 100,000 trees | 35 city-wide |
| Philadelphia | 2008 | 2015 | 300,000 trees | 30 by neighborhood |
| Baltimore | 2007 | 2040 | 750,000 trees | 40 city-wide |

tree planting opportunities for which its staff does not hold stewardship responsibilities. The Department repeatedly expressed reluctance to increase its administrative responsibilities in any capacity, despite the fact that the departmental staffing and budgetary situation has improved during the preceding few years. Tree planting on public park land in Philadelphia and Baltimore tends to be financed from entities outside the municipal parks department. In the Philadelphia Parks & Recreation Department, the Natural Lands Division, which was created and funded by a private foundation in the late 1990s, handles tree planting and management on the city's natural lands. Baltimore's Recreation & Parks Department is the only department to provide a steady stream of funds for tree planting on the city's parkland, thanks to an unusual regulatory context. Due to strict tree conservation laws in the state of Maryland, developers must pay for trees that are cut down in the development process. This law contributes significantly to the trees planted in Baltimore City, although the MD Department of Natural Resources presently funds tree plantings on the city's natural lands. In addition to this law, Baltimore City further stipulates that developers must replace trees that they cut down at a 3:1 ratio. To convey the scale of trees planted through mitigation funds, one policy stakeholder explained, "Right now we are looking at 2600 trees, and we are looking at where those trees can be planted." Outlets tend to be the City's park lands as well as public properties owned by the Recreation & Parks Department.

In sum, the tree initiatives primarily focus on tree planting by private entities on private land, although they expand efforts to include urban vacant land where available. Public agencies provide the trees, and civic volunteers are recruited to plant, establish, and steward the trees. The background context of tree planting on streets and in parkland is highly variable across the cities. All three cities struggle to manage residents' requests for new trees, even the best funded among them, and they rely heavily on external entities for long-term management and expansion of tree canopy efforts on parkland.

State institutions and the prominent role of NGOs in urban tree planting

The signature tree giveaway program is closely related to the particular state institutions associated with the urban tree initiatives. The rules and norms of tree planting indicate strong roles for public, private, and civic entities, as indicated in Figs. 3, 4 and 5. In Philadelphia and Baltimore, the Mayor entrusted management of the tree initiatives to the municipal parks departments. In contrast, Boston's Mayor entrusted the non-profit organization with the responsibility for managing the initiative—much to its surprise—rather than its municipal parks department. A mayoral cabinet and the Parks & Recreation Department would oversee the non-profit organization. But while the leadership varied among the cities, the management of each of the initiatives depended on a delicate interplay among research, marketing, and funding or fund-raising entities across sectors.

Boston's initiative contained the fewest types of participants compared with Philadelphia and Baltimore's initiatives. Its spatial analysis immediately preceded the development of the method that would predominate across many cities in the United States, so its method was rudimentary and also contained numerous errors. Boston's initiative did not incorporate a marketing focus, nor did it carry out a targeted fund-raising effort to secure major donors. The City of Boston's average per capita income exceeded the other two cities by a wide margin, but much to the chagrin of its non-profit partners, the city refused to provide funding for program development, implementation, and monitoring. As a result, that city's initiative lacked a clear and mutually agreed upon organizational structure, and it remained resource poor until it finally collapsed in 2013.

Philadelphia and Baltimore both incorporated research and marketing into their initiatives in an ongoing way. Both had access to urban field stations of the federal agency USDA-Forest Service, which connected the initiatives to the University of Vermont Spatial Analysis Lab through LiDAR-based assessments. While the approach is not as useful for direct tree management, its visualizations provided a common benchmark to guide tree initiatives, and one that communicated well to broad audiences. Moreover, both initiatives secured partnerships with marketing firms either on a paid contract (Baltimore) or as a pro

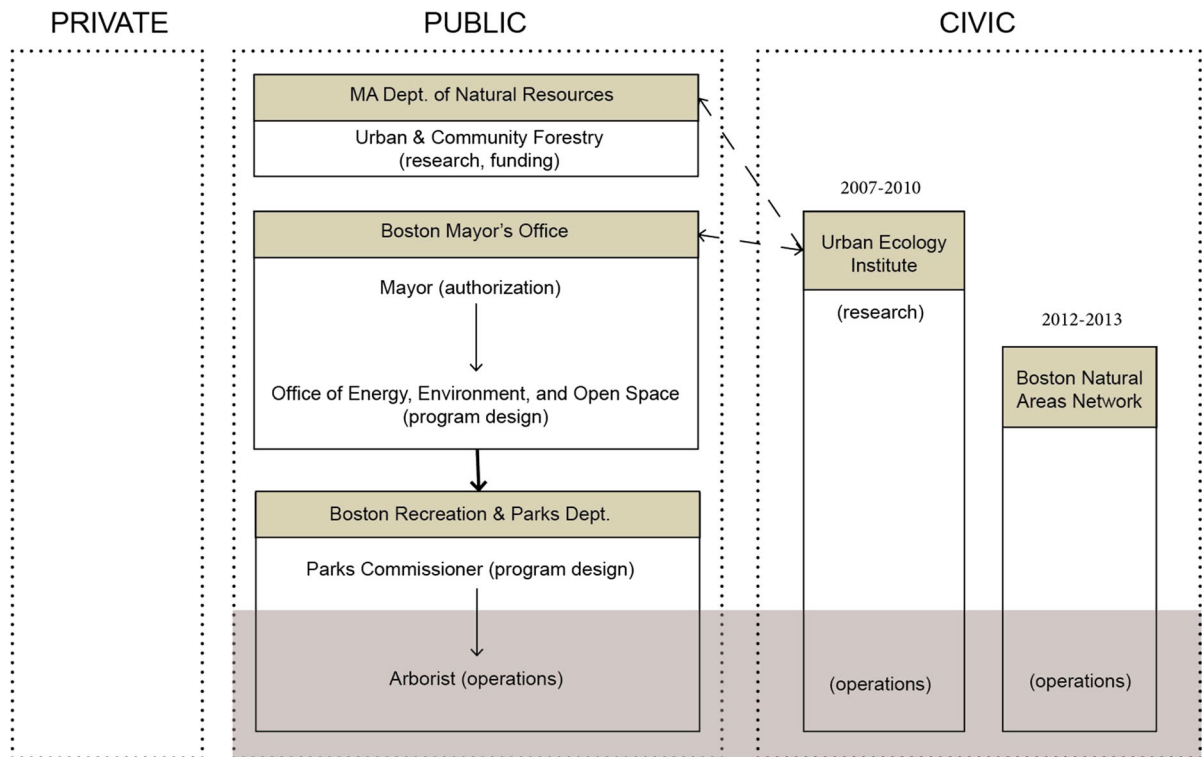


Fig. 3 Organizational structure of Boston's tree initiative

bono project (Philadelphia). These firms transformed the public face of urban tree planting, revamping the city's website—sometimes hosting it on a “.org” rather than “.gov” domain—creating a logo for the initiative, developing innovative programming, and even devising a tree truck idea (see Fig. 6).

Likewise Boston did not conduct a targeted fundraising campaign due to management conflicts. Baltimore non-profit organizations pursued rigorous campaigns to secure funding for its tree initiative, often competing with each other for foundation monies. Philadelphia was the most successful among the three initiatives in its fundraising effort, obtaining a large multi-year donor within its 1st year of operation.

Non-profit organizations played a prominent role in all organizational structures in roles ranging from program development to implementation. While Boston's initiative was the only that entrusted leadership formally to the non-profit organization, the lead non-profit organizations in the other two initiatives were absolutely instrumental to their implementation. Both

organizations had several decades of experience, many and powerful connections with public agencies, and a varied and well-funded portfolio of programming, and both were perceived to pose a threat to the authority of city agencies. The state agencies used contrasting tactics to maintain their authority: Philadelphia formally excluded the lead non-profit organization from the initiative's planning meetings, whereas Baltimore brought all of its (multiple) non-profit partners to the table in planning that city's initiative's activities.

Political economic relations, decentralization, and urban tree initiatives

These initiatives demonstrate the impact of political and economic decentralization on urban landscape patterns, with some variation depending on the historical legacies of state agencies. The U.S. federal government has decreased its financial redistributions to localities over the last four decades. Diminished city

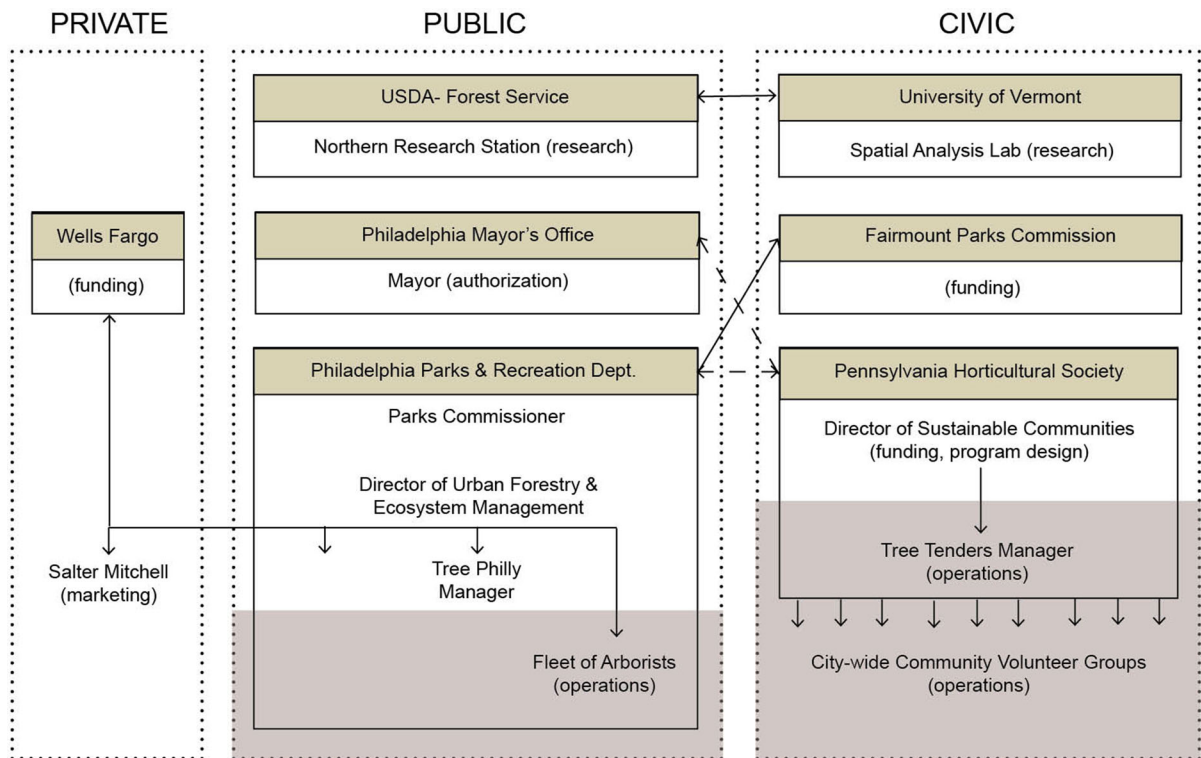


Fig. 4 Organizational structure of Philadelphia's tree initiative

budgets have strained municipal operations, and city managers have disproportionately stripped parks departments of their funding compared with revenue-generating departments. As a result, parks departments in U.S. cities have suffered disproportionately from decades of budget cuts to city governments, which have resulted from dwindling redistributions from the federal government.

Concurrently, the broader economic trajectory of U.S. cities since the 1970s has exhibited a marked increase in economic inequality and social exclusion. This trend has increased the heterogeneity of the socio-economic conditions on the ground in urban areas, leading to relatively wealthy metropolitan regions like Boston, severely impoverished regions like Baltimore, and rebounding cities like Philadelphia. In the context of political economic decentralization, then, many of these tree initiatives are expected to raise the funds needed for development, implementation, and monitoring. All three cities attempted to shift this responsibility to the private and civic sector in different ways and with varying success.

Boston's initiative transferred the full leadership of its tree initiative to a non-profit organization with limited staff and funding. This organization, the Urban Ecology Institute, had prepared the urban tree canopy assessment that motivated the city to set tree canopy goals, but it did not expect or want to direct the initiative itself. Additionally, Boston's Parks & Recreation Department has relatively few resources focused on urban forestry, at times employing one only one arborist to cover the entire city. Disagreements about funding responsibility led to shifting leadership, a very small number of trees planted in the city, and ultimately a short lifespan for the initiative.

Philadelphia adapted to this fiscal decentralization by creating a non-profit parks conservancy designed to raise funds for the park system. The conservancy ensured a steady stream of funding flowing into the tree initiative, and the Mayor gave the nascent tree initiative funding to plan, implement, and manage the initiative. The city also had other resources benefitting the program, including an urban forestry & ecosystem ecology unit of the Parks & Recreation Department and a full fleet of arborists dedicated to tree care on the

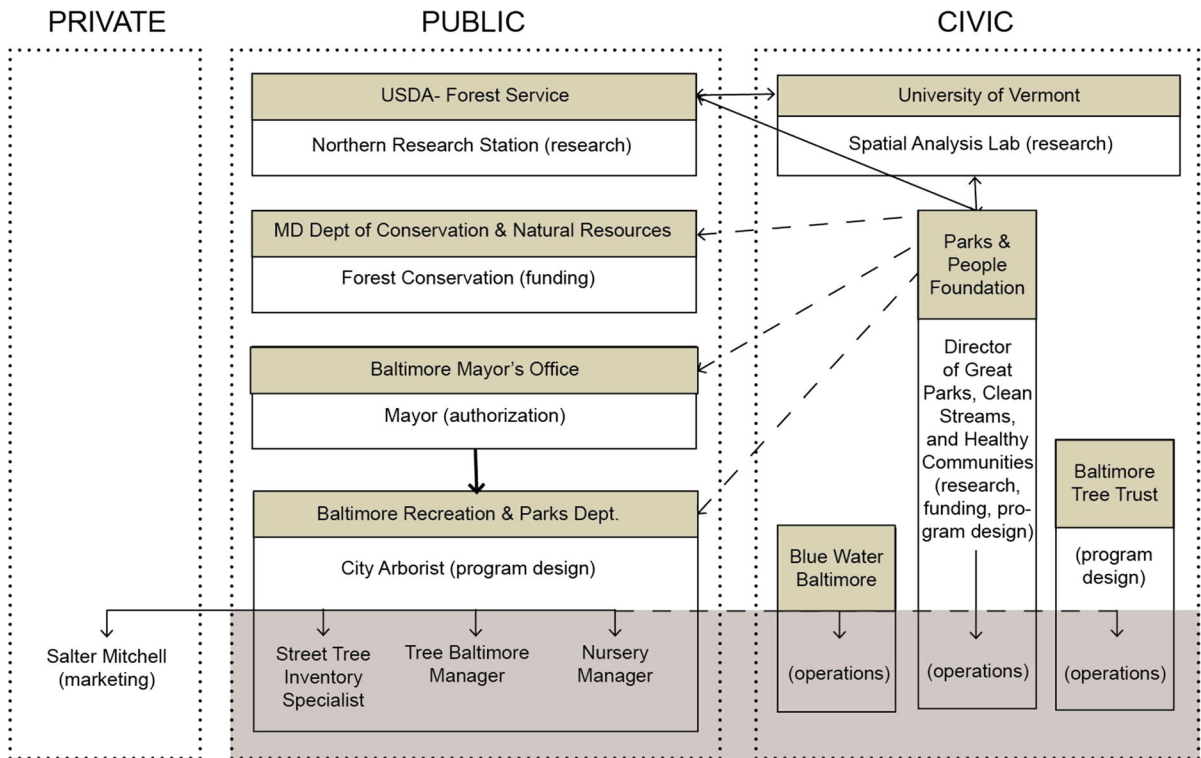


Fig. 5 Organizational structure of Baltimore’s tree initiative



Fig. 6 TreePhilly Tree Truck. <https://treephilly.files.wordpress.com/2014/02/truck.jpg>

city’s extensive public lands. Further, the Mayor accepted the Department’s request for the city to categorize trees as infrastructure in its capital budget,

which would increase its funding for trees and provide long-term security for tree care in the city.

Baltimore’s governance has been from the standpoint of long-term, unabated fiscal crisis. One of its staff likened working conditions in Baltimore City to previous time spent in the Peace Corps in West Africa. The city’s depopulation has increased the land holdings of the department, which has been strapped for resources to manage the land. Meanwhile, the Department was forced to lay off its arborists and privatize direct tree care in order to stay afloat. It received a new staff position dedicated to the tree initiative, but its funds from the city have remained extremely limited. Multiple civic organizations have stepped up into this vacuum, but they widely report the lack of private underwriters and/or foundation funding in the greater Baltimore region. The saving grace of urban tree planting efforts has been the State of Maryland’s legacy of strong forest conservation, and its regulations have provided essential funding for the tree initiative.

In the face of fiscal decentralization, all three departments have sought external funding, resources,

and support to maintain their programming. Boston did not display the initiative and incentives needed to draw in such resources in an effective and sustained way. Its parks leadership took a very passive approach to its problems, and it was known for holding steady in its existing programming, while refusing new ideas proposed by other departments in the city. Its leadership lamented the poor fiscal situation of parks funding, and attributed the weakness of urban greening in Boston to the city's lack of a celebrity underwriter and marketer, pointing to the role that Bette Midler has played in New York City's community gardening and tree planting movement. The weak leadership in the city and *nonfunctional* institutional relationship with non-profit organizations caused even the partnering organizations to withdraw their support from the initiative over time.

Baltimore's department, while it has weathered variable (and sometimes no) leadership of its forestry division in recent decades, currently enjoys strong activist leadership, which has done much to secure resources needed for core programming. In particular, it made the decision to manage its tree initiative as a coalition, and it has brought its several civic partnering organizations to the table in managing the initiative. These partners include one especially strong non-profit organization, which has either competed with the city in managing the city's park and recreational land. By bringing the partners within the scope of the initiative, the public agency abated competition among the multiple non-profit partners, while coordinating activities among them. However, its power was limited because the coalition consisted of financially independent entities. Thus, when one partner refused to cooperate according to the terms set by the other members of the coalition, the lead agency could not change that partner's behavior but only exclude that partner from the formal coalition.

Philadelphia's department is similar to Baltimore in its strong, long-term, continuous leadership. Its Parks & Recreation Department also has a strong organizational focus on urban forestry, but unlike Baltimore, it has retained a fleet of arborists in house, and it is further bolstered by the funding secured by Fairmount Parks Conservancy, especially through the major contract it landed with Wells Fargo. Additionally, Tree Philly benefits from a strong lead non-profit organization, which has extended its programming and has also provided direct competition to the city,

leading the Parks & Recreation Department to exclude it from the formal coalition governing Tree Philly. Despite behind-the-scenes dispute about the terms of their collaboration, the partnership works smoothly overall.

These organizational structures reflect both the diverse economic conditions of localities as well as the increased fund-raising pressure they bear under neoliberal governance. Activist management mitigates some of this economic differentiation, as Boston's passive leadership results in the relatively wealthy city performing quite poorly in expanding its tree canopy, whereas Baltimore and Philadelphia's strong leadership has funneled resources into public services that otherwise would not exist. This orientation led Philadelphia to adapt more effectively to neoliberal governance conditions compared with Boston, as it created a conservancy dedicated to park fundraising in the 1990s, while Boston laments the absence of celebrity underwriters. Leadership style aside, however, it is apparent that the economic context of the cities ultimately determines the financial resources available for service delivery. This point is evidenced by the fact that Baltimore has not yet convinced the city to manage trees as critical infrastructure, as Philadelphia was able. Neither has the resource poor state of Baltimore city government been able to secure corporate donations nor environmental foundations, which largely focus on the Chesapeake Bay.

The organizational structures also reveal gaps and overlaps in the functions provided by the initiatives, which constrain their programming and funding (Foo 2018). As evidenced by Fig. 3, Boston's initiative was characterized by few players, shifting leadership, and weak hierarchy. The non-profit organizations disagreed with the terms of agreement set by the city. Meanwhile the city could not enforce its rules across sectors, especially without providing full programmatic funding for its initiative. It lacked multiple functions of fund-raising/funding, marketing, and high quality research by the UVM Spatial Analysis Lab, which has become the dominant academic consultant for U.S. urban forestry. Moreover, the lead non-profit organization lacked informal or formal ties with city agencies, as it had no history of working closely with the city (unlike the lead non-profit organizations in Philadelphia and Baltimore). As seen in Fig. 5, Baltimore's management structure includes a dearth

of funders/fund-raising organizations and an abundance of civic players that fulfill similar operational functions in the initiative. The initiative's manager attempted to mitigate the implicit and potential competition by arranging for the well-behaving partners to share governance of the initiative. However, the city's lack of political and financial leverage left it unable to regulate its behavior and modify undesired behaviors to improve efficacy of the initiative. Philadelphia's organizational structure covered many functions with little redundancy among the entities. The distinct niche of each participant was more clearly defined than the other cities. A distinct hierarchy driven by the municipal parks department ensured cohesion and momentum, and a robust NGO worked closely with numerous small community groups across the city to plant and steward trees.

Conclusion: how the tree initiatives are shaping urban landscape patterns

This paper created an approach for examining hierarchical constraints on landscape design in order to investigate linkages among urban greening initiatives, patterns of landscape change, and the broader societal values driving those changes. Its premise is that durable connections between societal values and landscape design processes exist, and that these connections may be assessed through a close evaluation of the programs deployed to meet urban sustainability goals. These programs connect to particular patterns of landscape change with different governance frameworks, thus providing an integrative and actionable approach for landscape sustainability science.

Urban tree initiatives create parameters for changes to existing urban tree patterns. The tree giveaway program is the predominant way in which they are doing so, and this program plants (mostly) individual trees on private residential land parcels within the administrative boundaries of the cities. Landowners determine the exact placement of the trees on their property and in the geography of the city. Other tree planting activities do occur outside of the tree planting initiatives within municipal parks departments on public parkland. But the number of trees being added to these parks varies widely by city. While minimal new trees are being planted on Boston park land,

numerous trees are being planted on Philadelphia and Baltimore park land due to special circumstances in both cities. In Philadelphia, an area foundation established the Natural Lands division of the Parks & Recreation Department, while in Baltimore, exceptionally strong state and city conservation laws provides a continuous supply of trees for planting on city parks and vacant lands. Based on these cases, the limited budgets of public parks departments translate into minimal additional plantings on public park land in the absence of external interventions or special regulations.

Therefore tree giveaways are the predominant program driving tree canopy expansion in U.S. cities. Its design parameters indicate that trees will be planted as individual trees in a scattered nature around the city. Many policy stakeholders identified equity as an important principle of their city's tree initiative, yet they also described the difficulty of actually planting trees across the city with an even spatial distribution. Multiple stakeholders in Philadelphia and Baltimore characterized the problem as stemming from the fact that civic organizations were unevenly distributed through their city. Neighborhoods with generous tree cover tended to possess more and better established neighborhood groups, whereas neighborhoods with low tree cover tended to have few neighborhood groups. However, the tree giveaway program depends on civic activism, outreach, and initiative. Therefore, spatial fragmentation of urban tree cover is happening with some clustering by land value.

Apart from this spatial decentralization, the initiatives are also indicative of a temporal fragmentation in the way that the urban forest is changing. Political and economic decentralization has generated divergent trajectories for different cities, with the effect of changing the organizational landscapes of those cities (Foo 2017). As a wealthy city, Boston possesses a number of potential but untapped investors, while it lacked strong environmental NGOs. In contrast, Baltimore has an abundance of NGOs, but it lacks investors. Philadelphia, a city on the cusp of economic comeback, manages to possess both strong NGOs and investors willing to commit to tree planting. In this sense, institutional decentralization unhinges individual cities from a common narrative around urban tree canopies, instead leaving them subject to a number of contingencies.

Spatial and temporal fragmentation undermines the long-term security of urban tree planting programs from a national perspective, and it suggests reconsideration of the role of state regimes in driving broad scale spatial planning. In a perspective essay for *Conservation Biology* Joan Nassauer commends the multiscale systems thinking expressed by the ecological landscape planners of the 1960s: Carl Steinitz, Ian McHarg, and Phil Lewis. Reflecting on the intervening time period, she notes that

The contemporary zeitgeist has warmed to local and private approaches to landscape planning... Perhaps as a consequence, [scholars] recently have exhibited a propensity for framing relationships between landscape and biodiversity within more narrow conceptual, temporal, and spatial bounds (Nassauer 2006).

This paper makes a similar call: in response to largely “local and private” approaches to landscape change, landscape ecologists should critically assess the multiscale influences on landscape design. Environmental planning must be considered within the larger trajectory of economic and urban development (e.g. Leichenko 2011; Agrawal 2010).

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