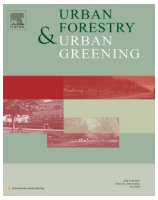
Urban Forestry & Urban Greening 75 (2022) 127693

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug



A tale of urban forest patch governance in four eastern US cities

Anita T. Morzillo [a,*], Lindsay K. Campbell [b], Kristen L. King [c], Katherine J. Lautar [d], Lydia Scott [e], Michelle L. Johnson [b], Mysha Clarke [f], Luke Rhodes [g], Stephanie Pincetl [h], Nancy F. Sonti [i], Dexter H. Locke [i], John Paul Schmit [j], Robert T. Fahey [a,k], Matthew E. Baker [l], Lindsay Darling [e,m], Lea R. Johnson [n,o]

[a] Department of Natural Resources and the Environment, University of Connecticut, United States
[b] USDA Forest Service, Northern Research Station, NYC Urban Field Station, United States
[c] Forestry, Horticulture, and Natural Resources, New York City Department of Parks and Recreation, United States
[d] Baltimore Green Space, United States
[e] Morton Arboretum, United States
[f] School of Forest Resources and Conservation, University of Florida, United States
[g] Project Manager, Fairmount Park Conservancy, United States
[h] Institute for the Environment and Sustainability, University of California, Los Angeles, United States
[i] USDA Forest Service, Northern Research Station, Baltimore Field Station, United States
[j] US National Park Service, National Capital Region Inventory & Monitoring Network, United States
[k] Center for Environmental Sciences and Engineering, University of Connecticut, United States
[l] Department of Geography & Environmental Systems, University of Maryland Baltimore County, United States
[m] Department of Forestry and Natural Resources, Purdue University, United States
[n] Division of Research and Conservation, Longwood Gardens, United States
[o] Department of Plant Science and Landscape Architecture, University of Maryland, College Park, United States

ARTICLE INFO

Keywords:
Forest patch
Urban ecosystems
Urban forest
Urban forest governance
Urban forest management, urban forest patch

ABSTRACT

Urban forests are important components of societal interactions with nature. We focused on urban forest patches, a distinct and underexplored subset of the urban forest that spans land uses and ownerships, and requires silvicultural practices to address their unique biophysical characteristics and management regimes. Our goal was to elucidate multi-scalar urban forest patch governance arrangements as they translated to on-the-ground management in four urban areas (Chicago, New York City, Philadelphia, and Baltimore) within the eastern United States. A transdisciplinary knowledge co-production framework was used to guide identification of the prominent management challenge or dilemma motivating change to forest patch management in each location, and to describe the dynamic interplay of decision-making and governance processes across locations as they advanced toward desired forest conditions. A common management goal existed across all four locations: multi-age, structurally complex forests dominated by regionally native species. Ecological and social concerns affected by local context and city capacity served as starting points prompting management action and new collaborations. Disparate governance arrangements including top-down municipal resources, regional conservation facilitated by landowners, and grass-roots community-driven stewardship led to diverse support-building processes and innovative strategies that served as forces initiating and shaping new management actions. Science and iterative learning and adaptation influenced change in all locations, reinforcing new management arrangements and practices. Among the four study areas, the earliest management of urban forest patches started in the 1980 s, historically lacking embeddedness in urban forest management more broadly, and experiencing challenges with integration into existing governance infrastructure. Ultimately, new management and governance approaches to urban forest patches in all four study areas have evolved uniquely and organically, driven by place-based historical legacies and ongoing socio-ecological feedbacks. The generalization of findings for broader urban forest management guidelines, such as for trees and park, would lead to misguided outcomes.

* Correspondence to: Department of Natural Resources and the Environment, University of Connecticut, 1376 Storrs Rd., Rm 227, Unit 4087, Storrs, CT 06269-4087, United States.
E-mail address: anita.morzillo@uconn.edu (A.T. Morzillo).

https://doi.org/10.1016/j.ufug.2022.127693
Received 4 October 2021; Received in revised form 30 June 2022; Accepted 29 July 2022
Available online 1 August 2022

1. Introduction

Urban forest management is conceptualized as a set of strategic, tactical, and/or operational practices (Gustavsson et al., 2005). Power differences (Campbell and Gabriel, 2016) and rules and norms affect where, when, and which practices are implemented (e.g., Mincey et al., 2013; Ordóñez and Duinker, 2013). Municipal sustainability and resilience plans aimed to enhance ecosystem services, support natural features, and provide equitable access (see, e.g., Campbell, 2017) also play a role. Collaboration, science, and learning create feedback loops (e.g., Silva and Ramirez, 2018), which lead to adjustments to management over time (Williams, 2011). Values and perceptions provoke and enhance public reactions, community involvement, and comprehensive planning (Gibbons and Ryan, 2015; Tozer et al., 2020). Together, these complex ecological and social processes (e.g., Avolio et al., 2015), approaches (van der Jagt and Lawrence, 2019), and place-based participation (Gulsrud et al., 2018) shape governance of urban trees (e.g., Ostoić and Konijnendijk van den Bosch, 2015) as an important component of nature-based urban planning (e.g., Albert et al., 2019).

Most urban forest management research to-date has focused broadly and inclusively on *all* city trees (e.g., Konijnendijk et al., 2006, Pincetl, 2010), or prioritized street trees and parks (e.g., Ordóñez and Duinker, 2013). When inclusively considering *all vegetation* in urban areas, governance approaches vary widely given diverse circumstances such as funding, stakeholder interactions, and institutional arrangements. (e.g., Wilkes-Allemann et al., 2015; Ordóñez et al., 2019). Associated frameworks consider diverse actors (Svendsen and Campbell, 2008; Rines et al., 2011; Tacconi, 2011), various organizational structures and networks (e.g., Pincetl, 2010; Bixler, 2013), and regulations, strategies, and desired outcomes (e.g., Konijnendijk van den Bosch, 2014; Ordóñez et al., 2019; Butt et al., 2021). Legacies, such as socioeconomic change and neighborhood form, affect governance processes and outcomes (Morzillo et al., 2016; Roman et al., 2018). Therefore, research underpinning public management and civic stewardship highlights important interfaces within urban systems, such as governance arrangements and relationships between decision-making and outcomes (McPhearson et al., 2016; Johnson et al., 2019).

1.1. Conceptual background - urban forest patches

This study makes a significant contribution to the existing literature in two main ways: 1) by addressing an underexplored subset of the urban forest for which formal management guidance is largely nonexistent, and 2) through descriptive and comparative analysis across multiple locations. First, in this study, we focused on urban forest patches, a distinct component of the urban forest, which contains spontaneously regenerating and self-organizing forest vegetation, and excludes street trees (Johnson et al., 2021). In this context, patch definition is biophysical and not restricted to formal parkland. Each urban forest patch requires silviculture to address unique biophysical characteristics, land use, ownership, and management (Piana et al., 2021). Despite nascent efforts (e.g., Forests in Cities; Natural Areas Conservancy (NAC), 2019), no national guidance or programs exist for urban forest patch management as exists for street trees (e.g., Tree City USA). Urban forest patches also reflect less formal institutionalization than other urban infrastructure including parks (Cranz, 1982). Each urban forest patch is associated with a unique historical legacy, potential management priorities, and diverse socioeconomic conditions and social values, even within a metropolitan area (e.g., Payne et al., 2002; Roman et al., 2018; Sonti, 2020). Thus, their existence is an artifact of conditions related to historical urbanization trends (Dow, 2000; Ogden et al., 2019). Such diversity creates a complex situation with no "one size fits all" approach to achieve desired forest conditions, such that generalization of broader urban forest management guidelines (e.g., those for street trees or parks) may lead to misguided outcomes.

Second, efforts addressing social components of urban forest management more broadly (e.g., McPhearson et al., 2016) also largely have focused on individual cities and metro areas (e.g., Pincetl, 2010; Campbell, 2014), with few inter-city or -metropolitan assessments (e.g., Lawrence et al., 2013; Ordóñez et al., 2020). For urban forest patches as defined here (above), to our knowledge only three studies of governance structures exist, the first two of which, as follows, applied the same framework (Ostrom, 2011). First, Wilkes-Allemann et al. (2015) revealed numerous stakeholders involved in planning, implementation, operation, finance, conflict resolution, and monitoring when managing Swiss urban forests for recreation. Second, Heneghan et al. (2019) observed similar outcomes despite differences in organizational structures and approaches to oak woodland governance in Chicago. Most recently, Johnson et al. (2021) presented a conceptual model for urban forest patches within a broader regional context, and identified how multi-scalar socio-ecological drivers interact spatially and temporally with forest patch conditions. Despite collective limited understanding of the governance and management practices that support them, urban forest patches serve an important contribution to ecosystem services (Livesley et al., 2016; Vieira et al., 2018) and critical infrastructure as part of the broader urban forest (e.g., Minor et al., 2015).

Our goal was to elucidate multi-scalar urban forest patch governance arrangements as they translate to on-the-ground management in four urban areas (Chicago, New York City, Philadelphia, and Baltimore) within the eastern United States. Our objectives were: 1) to identify the prominent management challenge or dilemma that motivated change in forest patch management for each location, and 2) to describe similarities and differences in the processes of decision-making and governance that have contributed to progress toward and/or achievement of desired forest conditions in each location. Our working definition of governance was the organizations, mechanisms, rules and regulations, and processes through which actors enable and influence decisions to reach desired outcomes (from Lemos and Agrawal, 2006; p. 298).

2. Methods

This analysis is a result of the "Socio-ecological drivers of change over time in urban woodlands" Pursuit working group at the US-based National Socio-Environmental Synthesis Center (Palmer, 2016). Commenced in 2018, the group consisted of 20 social science and ecological researchers and land management practitioners who lead urban forest patch management within the four study areas (human population in parentheses): the Chicago metropolitan region (8.4 million), and cities of New York (NYC; 8.3 million), Philadelphia (1.6 million), and Baltimore (600,000; US Census Bureau data). In these study areas, researchers and practitioners systematically have been collecting fine-scale biophysical data for urban forest patches, landscape level data about stewardship organizations and governance (e.g., Svendsen et al., 2016), and assembling a new database of tree ordinances. Our scope focused on existing data for the study areas, which contained limited information on social perspectives and uses of urban forest patches (e.g., Campbell et al., 2016a; Sonti et al., 2020; Johnson et al., 2021).

A 'governance and management subgroup' was formed in May 2019 to describe the diverse governance and management arrangements repeatedly alluded to during ongoing research (Johnson et al., 2021; see above). This subgroup included social scientists, and land management practitioners, and ecologists, who are among the author team of this paper. A knowledge co-production approach (Campbell et al., 2016b; Norström et al., 2020) guided discussion with a defined research goal (see above). The subgroup convened concurrently with the full working group for interactive engagement and learning in-person once and virtually three times, and then the subgroup virtually met monthly for approximately two years until manuscript submission. Rooted in the context of urban forest patch management in the four study areas, the group first identified the most significant management challenge or dilemma that initiated urban forest patch management action, and then

used an inductive, iterative, multi-disciplinary, and comparative dialogue and illustration (on a whiteboard) to describe, diagram, and compare the unique governance arrangements and processes as they have evolved in each study area in pursuit of desired forest conditions. The subgroup drafted initial results and then, to enhance inclusiveness and diversity of perspectives, provided the full working group opportunity to review and comment on the results and participate as part of the author team. Therefore, researcher and practitioner knowledge and expertise were produced, embedded, and verified throughout the analysis by key representatives of the research and practice communities (Wenger, 1998; Campbell et al., 2016b) in each study area.

3. Results and discussion

Comparative assessment and synthesis of results across the four study areas are described in narrative vignettes, and anchored in a basic conceptual model (Fig. 1) and table (Table 1). Detailed individual conceptual models for and a representative example of an urban forest patch in each study area are provided in the same format in the Appendix.

3.1. Chicago Region Trees Initiative and the oak ecosystem recovery plan

Oak-dominated forest, woodlands, and savannas were the predominant pre-urban forest types across much of the Chicago metropolitan region (Fahey et al., 2012). Increased dominance by mesophytic tree species, non-native invasive plants, and fragmentation from urban development brought about small, disconnected, and diversely owned forest patches, within which native oak species were not regenerating (Fahey and Casali, 2017), and largely (~70 %) existed under private ownership (Fig. 1a,b and Table 1a,b; see also Appendix A1).

Given those findings (Fig. 1c and Table 1c), the Chicago Wilderness Oak Ecosystem Recovery Plan (OERP; Fahey et al., 2015) was developed, and introduced regionally in 2016, to promote ecological integrity and function within existing forest patches, mitigate fragmentation, and improve collaboration and implementation of best management practices across land ownerships (Fig. 1d and Table 1d). In 2017, while Chicago Wilderness experienced reorganization, The Morton Arboretum founded the Chicago Region Trees Initiative (CRTI) and began coordinating the OERP effort. CRTI stakeholders aimed to improve urban forest health and enhance oak ecosystems (Chicago Region Trees Initiative (CRTI), 2019) by engaging with regional partner organizations within seven counties, 284 municipalities, and 174 park districts, with leadership by a 14-member Executive Advisory Council composed of federal, state, non-profit, regional, and local stakeholders (Fig. 1e and Table 1e).

The CRTI facilitates innovative approaches to regional collaborative forest patch management and OERP implementation with public and private landowners (Fig. 1f and Table 1f). Among those approaches, the CRTI has encouraged public county forest preserves and conservation districts to select at least one priority oak ecosystem "core complex" within their county for cross-boundary engagement, learning, and outreach (Fig. 1g and Table 1g). Core complexes have been identified based on size, area-to-perimeter ratio, percentage of publicly owned oak forest, proximity to other oak remnants, and ecosystem quality (ranked by the Illinois Natural Areas Inventory; Illinois Department of Natural Resources (IDNR), 2020). To date, six of seven Chicago region counties have committed one core complex toward supporting OERP goals.

The OERP also has provided landowner engagement opportunities to identify management actions (e.g., invasive species control; Fig. 1h and Table 1h). Staff from multiple public lands agencies, nurseries, and land trusts develop these resources, enhancing regional cross-boundary management (Fig. 1i and Table 1i). The CRTI holds regular meetings focused on knowledge sharing, management strategies, funding, and private landowner engagement through programs that provide resources including professional expertise (Fig. 1j and Table 1j). Outcomes to-date have included federal funding for cross boundary restoration, and state designation of October as OAKtober for oak ecosystem-related outreach and educational events.

3.2. New York City forest health and civic investment

From 2007–2015, MillionTreesNYC planted one million trees throughout the city, focusing on both street trees and natural area forest patches with little-to-no intact tree canopy. This public-private partnership between the New York City Department of Parks and Recreation (NYC Parks) and non-profit New York Restoration Project was launched as part of a mayor-led sustainability plan (Campbell, 2017). More than half of those trees were planted across more than 300 acres of parkland consisting of existing or new forest patches, many managed by civic stewards during curated community engagement events. When funding for MillionTreesNYC ended, it had improved the condition of less than 10 % of NYC's forests, revealing a need to communicate and address forest conditions across the City (author unpublished data; Fig. 1a and Table 1a; see also Appendix A2).

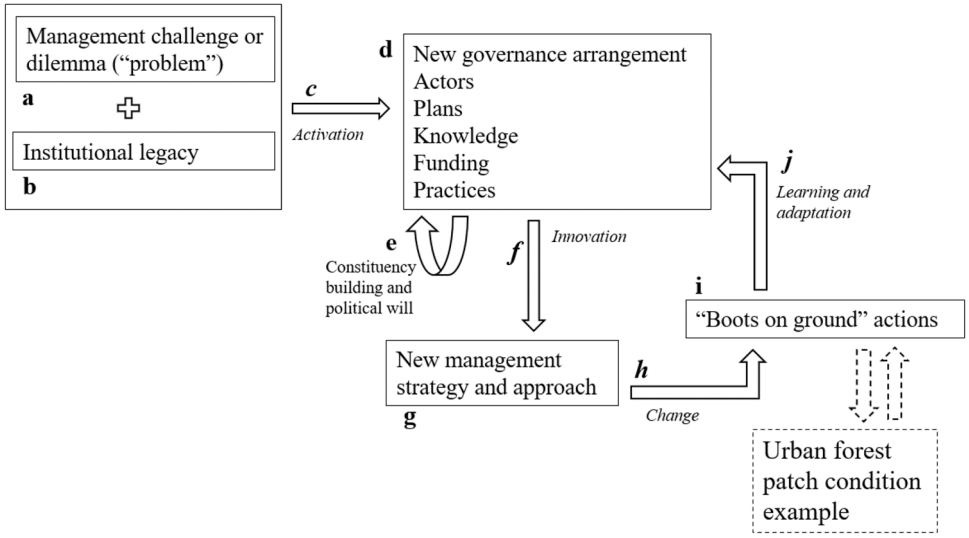


Fig. 1. General conceptual model of urban forest patch management applied to four study areas. Governance components included stocks (boxes; normal font) and flows and feedbacks (arrows; *italic font*), respectively, that shape decision-making and management. Letters align with each item as described in the text, corresponding rows in Table 1, and with detailed individual conceptual models for each study area in the Appendix.

Table 1
Governance and management processes for four study areas[a] driving pursuit of a common forest patch management goal.

Component		Chicago	New York City	Philadelphia	Baltimore
a	Management challenge or dilemma	Oak ecosystems decline + Lack of regeneration	Need to understand and communicate about forest conditions and value of natural areas	Poor condition of forest and forested streams + Preservation and protection of high-quality forests and streams	Loss of and threats to community forests; lack of knowledge about forest condition
b	Institutional legacy	Fragmented ownership by counties, townships, preserve districts, municipalities, park districts, and private landowners	NYC Parks - Natural Resources Group	Philadelphia Parks and Recreation + Philadelphia Water Department + Fairmount Park Conservancy	Community associations and neighbors + City of Baltimore + Baltimore Green Space
c	*Activation*	Observable, quantified loss of native ecosystem	Inconsistent funding for and focus on natural areas	Stakeholder concerns about protection of green space and water quality	Advocacy for community forests; rapid field assessment
d	New governance arrangement	Oak Ecosystem Recovery Plan introduced by Chicago Wilderness + Reorganized into Chicago Region Trees Initiative	New York City Parks + Natural Areas Conservancy	Fairmount Park System Natural Lands Restoration Master Plan + Green City, Clean Water + Philadelphia Forest Framework + Urban Forest Strategic Plan	Forest Stewardship Program
e	Constituency building and political will	Coalition building across multiple ownerships	Investigating and building a network focused on natural areas management	Building stakeholder coalition	Convening and brokering leadership, interest, and need as driven by stewardship
f	*Innovation*	Implementation of Oak Ecosystem Recovery Plan, facilitated by regional coalition-based collaboration	Expansion from management for individual parks to systematic citywide focus on natural areas	Implementation of a city-wide science-based approach	Modeling and co-leading of community strategies, outreach, and training
g	New management strategy and approach	"Core complex" establishment + Landowner support and resources	Forest Management Framework + Rapid Site Assessment Protocol	Agency and partner-led research projects	Neighborhood forest stewardship, outreach, and leadership training
h	*Change*	Landowner engagement + Public and private collaboration	Data-driven prioritization of management efforts	Advance management plans and facilitate community involvement	Leadership development, expert assistance, community engagement, research, and advocacy
i	Boots on the ground actions	Cross-boundary implementation of best management practices and collaboration	New management approaches based on forest structure and composition	Tree planting + Invasive species removal + Stream restoration	Community forest management and stewardship plans
j	*Learning and adaptation*	Ongoing outreach and recruitment	Engagement and training expanded to new partners	Formal and informal agreements + Workforce development	Identify programming goals and knowledge gaps

[a] Letters in first column and components in second column align with stocks (boxes; regular font) and flows and feedbacks (arrows; *italic font*), respectively, in Fig. 1, and detailed individual conceptual models for each study area in the Appendix.

Founded in 1984, NYC Parks Natural Resources Group (NRG; Fig. 1b and Table 1b) operates within NYC Parks' Forestry, Horticulture, and Natural Resources Division, which oversees care and management of natural areas of parkland. NRG initially was tasked with inventorying all park property parcels recorded as "undeveloped" (Bounds et al., 2015), and since has worked with nonprofit managers that supplement NYC Parks efforts focused both city-wide (e.g., Trees New York, NY Tree Trust) and on individual parks (e.g., Central Park Conservancy; Taylor, 2009). An outcome from these efforts has been the first NYC collaborative program for ecological restoration within urban forest patches. Since then, NRG has developed practices for planting native species in urban conditions, and maintained an ecological restoration monitoring program informing adaptive management.

To establish a consistent funding stream for natural areas management (Fig. 1c and Table 1c), in 2012, the Natural Areas Conservancy (NAC) was incubated by NYC Parks as a non-profit conservancy partner to NRG (Fig. 1d and Table 1d). This effort involved building political will and recognition of the importance of ongoing funding to conserve and protect natural areas city-wide (Fig. 1e and Table 1e). With a systematic citywide focus in place (Fig. 1f and Table 1f), the partnership's first task was an ecological and social assessment of all 10,000 acres of NYC parkland natural areas, which revealed a largely native tree canopy with widespread invasive species among the mid- and understory (Pregitzer et al., 2019a). Those results, combined with a shift in emphasis from MillionTreesNYC's focus on tree planting towards collaborative long-term ecological health of natural areas by forest managers, conservancies, and stewards, formed the basis of a new Forest Management Framework (FMF; Pregitzer et al., 2018).

The FMF and its companion Rapid Site Assessment Protocol, a streamlined version of the systematic ecological assessment (Fig. 1g and Table 1g), outlined a new approach to strategically prioritize locations with intact native forest canopy ("high health") and a large proportion of invasive understory species cover ("high threat"), and cost assessments for restoration, management, and conservation work citywide (Fig. 1h and Table 1h). This marked a shift toward multiple-approach management of all urban forest patches based on forest structure and composition, native groundcover establishment, trail formalization and improvement, and deer impact management (Fig. 1i and Table 1i). The FMF also established alignment between NYC Parks (as the central land manager) and associated non-profit land management groups via a NAC-led engagement and training program, which has allowed for expansion of partnerships representing areas without historic investment by NRG (Fig. 1j and Table 1j). FMF's first year (2019) was funded as part of the New Yorkers for Parks' "Play Fair" initiative, which increased baseline funding for park management, and designated the first time that forests were funded as assets equitable to park amenities such as ballfields and benches. The funding also allowed NRG to expand acres managed, pilot FMF guidelines, and hire new staff – all efforts that will inform future planning and practices (New Yorkers for Parks, 2021).

3.3. Philadelphia healthy forests and clean water

Management of Philadelphia's parks has been driven by the condition and presence of urban forest patches and adjacent streams (Fig. 1a and Table 1a; see also Appendix A3). Historically, forested parklands were isolated, overbrowsed by deer (Goldenberg, 1999), and often contained mature trees with limited understory and recruitment (Trammell et al., 2020).

Three organizations lead urban forest patch management in Philadelphia: Philadelphia Parks and Recreation (PPR), Philadelphia Water Department (PWD), and the non-profit Fairmount Park Conservancy (FPC; Fig. 1b and Table 1b). PWD is federally mandated by the Clean Water Act to mitigate pollution in city waterways, and monitor water, stormwater, and sanitation lines. PPR and PWD share governance of upland forests and coordinate with other city agencies to prioritize stormwater management and conveyance systems. Through shared governance, ecological goals including forest restoration within parks are balanced with protection and maintenance of critical infrastructure. FPC champions the Philadelphia park system by leading capital projects, fostering neighborhood-park stewardship, developing innovative programs, acting as an umbrella stewardship organization to support activities for more than 115 community-based "friends of" groups, and redistributing park improvement funding through mini-grants.

In 1996, forest patch management efforts were improved following concerns from environmental stakeholders about soil erosion, invasive species, and lack of regeneration, compounded by stormwater management and related flooding issues (Goldenberg, 1999; Fig. 1c and Table 1c). Since then, management efforts have evolved into an extensive green stormwater infrastructure program with sequential governance and management plans (Fig. 1d and Table 1d). First, the Fairmount Park System Natural Lands Restoration Master Plan (1999) established long-term stewardship policies and identified type and significance of natural lands and disturbances to vegetation (Fairmount Park Commission, 1999). In 2009, the Office of Sustainability's Greenworks established the Urban Forestry and Natural Lands Division to increase city tree canopy to 30 % within each neighborhood, and to restore and maintain as much park natural area as possible. Green City, Clean Water, adopted by PWD in 2011, established priorities for capturing stormwater before it enters sewers (Philadelphia Water Department (PWD), 2011).

In 2013, the Philadelphia Forest Framework, created for PPR by the private firm Bio-Habitats, identified specific forest management projects and implemented a science-based approach focused on adaptive management of novel ecosystems (Philadelphia Parks and Recreation (PPR), 2013).

Under PPR's leadership, partnering organizations engaged in adaptive management, stewardship, and community involvement to work toward forest management goals city-wide (Fig. 1e-f and Table 1e-f). Annual "Tree Summits" serve as a forum to guide approval and consensus among land managers. Research projects, which may be initiated by PPR or proposed by civic organizations, are reviewed and implemented by PPR through resource identification (Fig. 1g and Table 1g). These projects advance city-wide forest management and facilitate community involvement that often focuses on neighborhood parks, and raise capital funds for forest restoration, tree and invasive species removal, and stream restoration (Fig. 1h-i and Table 1h-i). FPC and other non-profit organizations, operating similarly to community development corporations, adopt stretches of parkland to engage in direct management, capital improvements, and stewardship. Science-based workshops facilitate neighborhood participation, feedback, and support for management practices (e.g., tree inventory data on climate-adaptable species; planting density experiments; Philadelphia Parks and Recreation (PPR), 2020). Although most non-profit relationships and workforce development programs with PPR are informal, some organizations are pursuing formal agreements (Fig. 1j and Table 1j). Slated for completion in 2022, the Urban Forest Strategic Plan (Philly Tree Plan) will complement the Philadelphia Forest Framework, integrate neighborhood ambassadors and a community steering committee into its development, and encompass management of the entire urban forest (City of Philadelphia, 2020).

3.4. Baltimore green space forest stewardship program

Given limited resources, historical greening efforts by the City of Baltimore have focused primarily on planting street trees, with inequitable care and maintenance across neighborhoods (Shcheglovitova, 2020). In 2010, a City of Baltimore municipal side yard program led to the loss of several neighborhood forest patches (Fig. 1a and Table 1a; see also Appendix A4). This outcome triggered Baltimore Green Space (BGS; Fig. 1b and Table 1b), Baltimore's environmental land trust, to investigate forest patch protections. Concurrent to that investigation, neighborhood leaders had begun approaching BGS out of concern for, and seeking assistance with, care and protection of their community forests. Together, these events initiated advocacy by BGS and neighborhood leaders for policy improvements for managing community forests (Fig. 1c and Table 1c).

Other than sporadic inventory efforts, no management goals historically existed for many wooded properties in Baltimore, although some were cared for by neighborhood leaders or managed by BGS collaborators (Lautar, 2020). In 2011, BGS partnered with University of Maryland Baltimore County and the Baltimore City Office of Sustainability to map all Baltimore City forested lands with an understory of at least 0.093 ha (10,000 square feet). Results suggested that urban forest patches comprised 29 % of Baltimore's tree canopy (author unpublished data). Those found within municipal parks were managed by Baltimore City Recreation and Parks; however, 21 % percent of Baltimore's forest patches were outside of parks on properties that could be bought and sold and, therefore, subject to development pressure (Avins, 2013). BGS subsequently launched a Forest Stewardship Program to engage local community members, and began rapid field assessment of privately-held or unmanaged city-owned patches in 2012 (Fig. 1c and Table 1c).

Today, the BGS Forest Stewardship Program (Fig. 1d and Table 1d) includes 10–15 self-selected, community-maintained forest patches managed by dozens of neighborhood forest stewards and distributed across a diversity of neighborhoods and socioeconomic conditions. Given the crucial roles of community engagement and advocacy, forest patch management organized by BGS is stewardship-driven, with partnership support from non-profit, academic, and government agencies. Therefore, BGS's approach to each forest patch is focused on brokering and convening based on community leadership, interest, and need (Fig. 1e and Table 1e). Stewards often live near the forest patch that they care for, and may have personal attachment to or a history of forest care for that forest patch prior to collaboration with BGS.

Initially, BGS's staff models community outreach strategies for and with community leaders, which includes training in skills such as species identification and forest management (Fig. 1f and Table 1f). BGS then co-leads community outreach until stewards are empowered to lead events themselves, facilitating a process to ensure that partners and attendees perceive forest stewards as authority and leadership (Fig. 1g and Table 1g) when BGS personnel are either not present or are assisting behind the scenes. Part of the process is informing forest stewards that their continued leadership is expected after training is completed.

Community forest management goals are developed and achieved through combined strategies (Fig. 1h and Table 1h). Motivated by steward interest and need, BGS amplifies neighborhood leaders as decision-makers and primary informants about stated goals, which may relate to various motivations (e.g., access, trash, native and invasive species, biodiversity, education), and facilitates organization of an iterative research process to increase understanding and support for forest patch management. Meetings provide forums for forest stewards to discuss community forest interests and goals with natural resource management experts, share information, and identify desired

stewardship outcomes. From 2015–2019, 47 patches, both with and without formal protections, were selected for detailed forest condition assessments. Results facilitated steward understanding of forest patch conditions, and informed development of "do-it-yourself" community forest management plans that serve as outreach and learning tools for further stewardship engagement (Fig. 1i and Table 1i). Programming goals and gaps in ecological understanding also were identified to guide future workshops, research support, and training by expert partners, which include several universities, federal and state agencies, and local non-profits (Fig. 1j and Table 1j). Assessment results also informed BGS's work with city government, including advocacy for municipal positions to manage city forested easements, and partnership with the Office of Sustainability to develop a tree ordinance approved by City Council in 2020 (City of Baltimore, 2020).

3.5. Cross-location analysis

Governance arrangements and collaborations have led to diverse support-building processes and innovative strategies (Table 1e,f), which have functioned as driving forces initiating and shaping new management actions in urban forest patches (Table 1g-i) – all of which have been pursuing a common goal. NYC and Philadelphia have relied on political will and top-down municipal and land management organizational resources on public lands (Table 1d,e), innovating within those structures. In NYC, focus evolved from increasing tree canopy to improving overall ecological condition of forests (Table 1f), whereas multiple management plans and federal water quality ordinance in Philadelphia expanded into a citywide management plan developed by experts and managers who seek support from community partners (Table 1d-g). In contrast, in Baltimore, BGS's initial focus on "pocket" parks and community gardens combined with grass-roots community-driven organizing and stewardship have led to multiple pathways emphasizing community-managed forests among different ownerships accompanied by public leadership (Table 1, c-i). Chicago's historically regional conservation and landowner-driven governance has relied on decisions by myriad county, public, and private actors, supported by forestry experts and researchers (Table 1,b-f).

Iterative learning and adaptation have reinforced new management arrangements (Table 1g) and practices (Table 1i-j) as influenced by historical legacies (Table 1b), location-specific outcomes and contexts, stakeholder values, programming success, and long-term land use planning. The CRTI in Chicago seeks to improve social perceptions of oak-related benefits (Table 1j), historically valued by managers yet inconsistently valued among other actors even after restoration efforts, demonstrating how differences in and prioritization among actors affects progress. In NYC and Baltimore, social engagement in stewardship is among many outcomes achieved within a forest health and management context. In Chicago, NYC, and Philadelphia, forest health serves as a goal activating the management process (Table 1c) and focus of outreach and engagement (Table 1j). Socio-ecological concerns in Baltimore (preserving community forests), Chicago (reduced oak regeneration), and Philadelphia (water quality) prompted action and new collaborations to address the problem (Table 1a). In all four locations, science triggered management action with varying degrees and timelines for political engagement and support (Table 1g-h). In Chicago, NYC, and Philadelphia, expert-led ecological assessments preceded excogitation of public support; conversely, scientific investigation in Baltimore was initiated by community inquiry. Therefore, science is both a hook and a driver for forest patch management, and 'learning by doing' has propelled change in all four locations despite differences in historical timing, starting point for change, and development stage. Ultimately, all four approaches have demonstrated success in city-wide constituency building and engagement, research and outreach programming, and management plan development.

Echoing previous literature for both urban forests more broadly (e.g., Lawrence et al., 2013; Campbell, 2017), hybrid spaces (Trentanovi et al., 2021) and urban forest patches (Wilkes-Allemann et al., 2015; Heneghan et al., 2019), our analysis illustrated an interplay of actors, institutional and resource-based factors, historical legacies, and activating events unique to each location. Each governance arrangement contained a unique set of actors that have led to diverse ways to build, support, and innovate (e.g., Svendsen and Campbell, 2008; Tacconi, 2011; Ordóñez et al., 2019). Relationships among science and engagement, education, and advocacy were consistent with findings from elsewhere that have demonstrated knowledge as a motivator for involvement in the governance process (e.g., Bixler, 2013; Campbell et al., 2016b; Butt et al., 2021). Although less studied, challenges observed for urban forest patches were similar to those noted for broader urban forest management, including inconsistent funding and funding cycles and uncertainties, inclusiveness in participation and decision-making, and scalar mismatches between ecological and social system components (e.g., Lawrence et al., 2013; Ordóñez et al., 2019; Ordóñez et al., 2020; Tozer et al., 2020). For example, regional ecosystems, fragmented jurisdictions, and lack of a formal regional governing body led to a regional collaborative approach in Chicago (see also Heneghan et al., 2019), whereas formal and powerful municipal boundaries have enabled top-down approaches in NYC and Philadelphia, while also inhibiting regional planning in NYC, Philadelphia, and Baltimore. Relative success in acquisition of capital funding for certain activities (e.g., "to build or plant forest") often does not encompass personnel and ongoing maintenance costs (e.g., Young and McPherson, 2013). Similar to Lawrence et al. (2013), our results described a shared combination of paid staff and volunteers to implement maintenance and fill funding gaps. Volunteering in urban forest stewardship also results in co-occurring social benefits, such as strengthening social ties and creating opportunity for other civic engagement (Fisher et al., 2015). Additionally, grant funding available to non-profit organizations often focuses on "building" activities such as planting, rather than long-term care (e.g., Young, 2011; Foo et al., 2018; Campbell et al., 2022).

How urban forest patches differ from the broader urban forest has implications for governance. First, as revealed, urban forest patches remain less managed and resourced, historically treated as remnant properties or "undeveloped" parkland, as compared to street trees that are managed as public rights-of-way and streetscape by departments of parks and public works. Second, management of urban forest patches has occurred only since the 1980 s (NYC) or later – much more recently than other preexisting urban infrastructures (e.g., parks, roads, water, power). Thus, a previously lacking embedment of urban forest patch management in city infrastructure has resulted in the indoctrination of focus and resources for management of these spaces from diverse starting points, with each location en route on its own path-dependent trajectory (Bennett and Elman, 2006), and with unique circumstances affected by local context and city capacity. Finally, in the US, street and other landscaped trees and parks share common arboricultural organizations and guidance, enabling knowledge sharing across locales; such mechanisms are only just emerging for forest patch management through growing networks such as Forests in Cities (Pregitzer et al., 2019b). Integrating new land management concerns and associated practices into existing governance structures is challenging and takes time, as shown by our examples.

Our results offer insight for refining Johnson et al. (2021) and other conceptual frameworks, and provides a foundation for empirical evaluation, as also noted by Lawrence et al. (2013). For example, Johnson et al. (2021) illustrated "management problems" as a one-way "perceptions" arrow from forest patch conditions to people, and depicted management and stewardship actions together on the same arrow. However, as observed elsewhere (Frantzeskaki and Bush, 2021), our analysis here of new management practices highlighted more complexity, such as one-way top-down flow in NYC but a two-way flow in Baltimore, where community organizing meets stakeholders 'where they are' in terms of engagement, agenda-setting, and taking action. Our analysis also focused on research and practice leadership, leaving

opportunity to integrate perspectives of other stakeholders about topics such as avenues of conflict and collaboration, interrelationships between management strateies and actions as components of both governance and as processes that lead to desired outcomes, equity and inclusion, and emerging threats such as climate change and urbanization (e.g., Ordóñez et al., 2020; Tozer et al., 2020).

In conclusion, while in pursuit of a common management goal, management and governance approaches evolved organically in our four study areas, all driven by place-based historical legacies, individual contexts, and socio-ecological feedbacks. Compared to the broader urban forest governance, urban forest patch governance was distinguished by recency of management efforts focused on these wooded sites, governance arrangements and processes, and desired forest conditions focused on intact canopy and native species. Historically, fewer opportunities for knowledge sharing across cities had been realized than those that exist for other parts of the broader urban forest (e.g., street trees), yet science was prominent in verifying outcomes of management decisions. However, counterintuitive findings, miscommunication, and inaccurate interpretation of results can be influenced politically and lead to targets inconsistent with desired forest conditions (e.g., NYC - planting more trees does not always equal healthy forests). The net result is an ongoing dilemma for managers who must select management approaches (i.e., what to "manage for") that balance short-term political objectives and long-term social and ecological goals, while adapting to dynamic socioeconomic priorities and biophysical conditions, with limited opportunities for learning from others outside of their specific urban location.

Declaration of Competing Interest

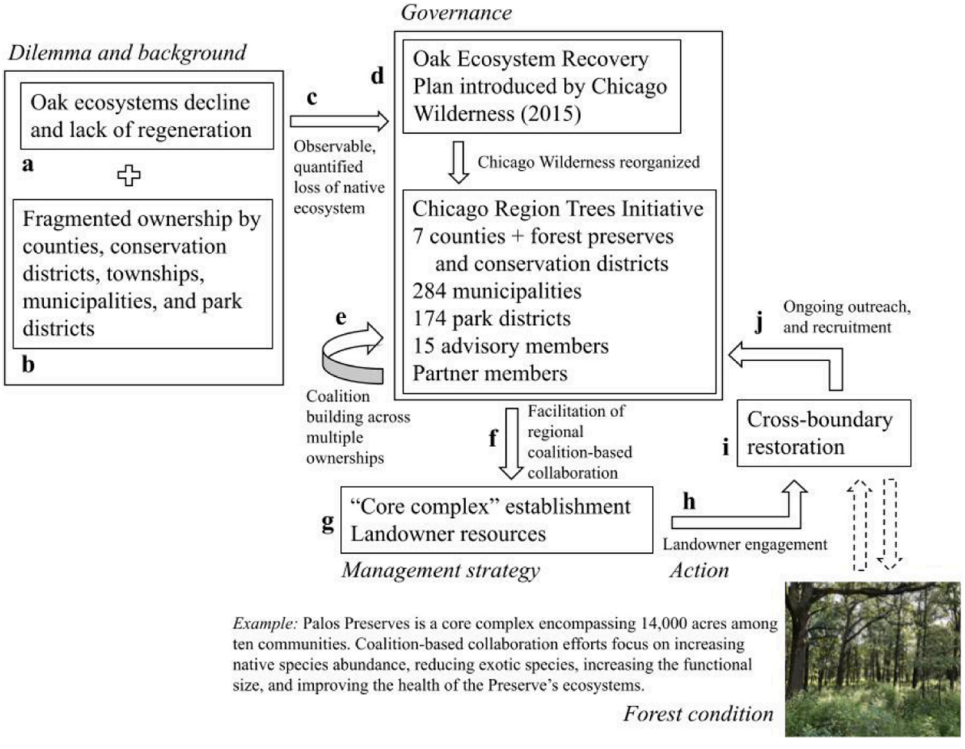
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

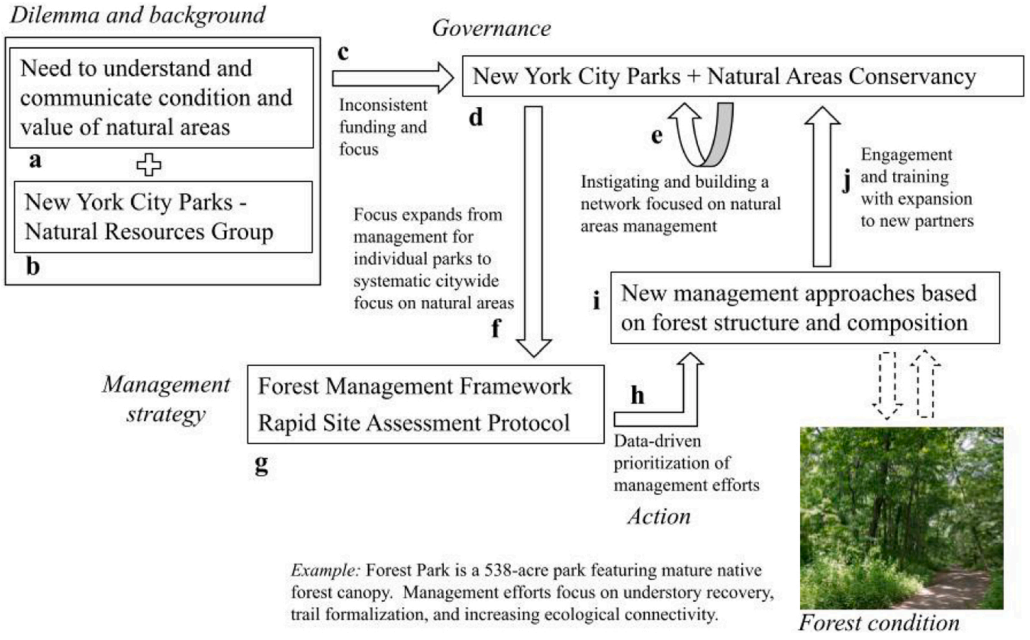
This work was supported by the National Socio-Environmental Synthesis Center (SESYNC; National Science Foundation DBI-1639145), and in part by the US Department of Agriculture, Forest Service. The findings and conclusions in this paper are those of the author(s) and should not be construed to represent any official USDA or U.S. Government determination or policy. Thank you SESYNC for facilities and institutional support, M. Aronson, A. Bowers, V. D'Amico, J. Kramer, T. Martello, M. Poppick, C. Pregitzer, and E. Svendsen. Photo credits: Forest Preserves of Cook County, NYC Parks, T. Witmer, and Baltimore Green Space.

Appendix

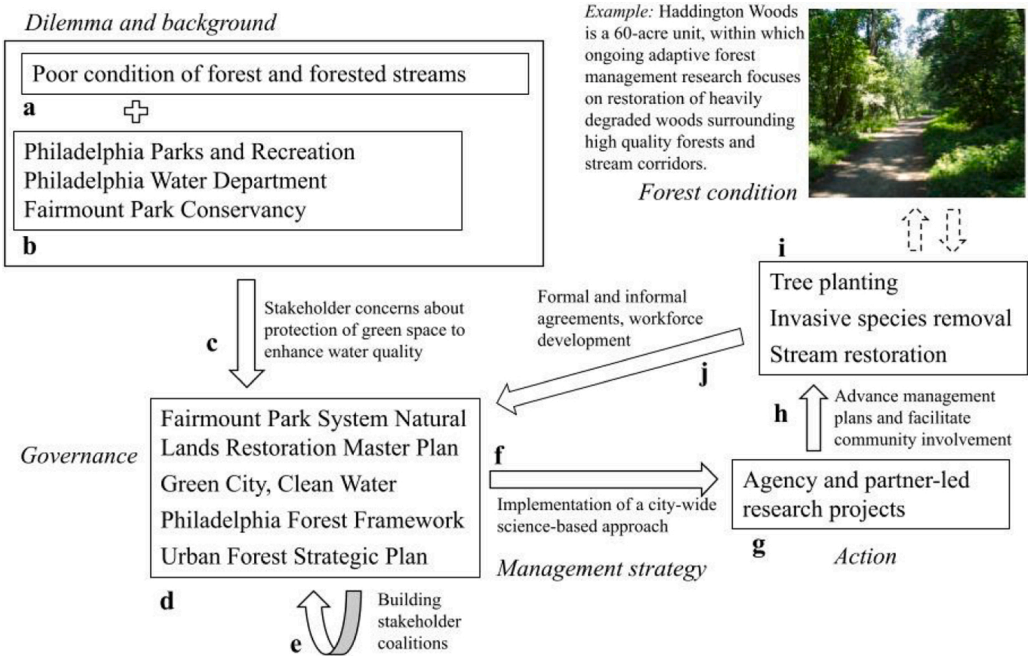
Conceptual models for each of the four individual study areas. A1: For the Chicago region, the governance process for restoration of native oak ecosystems takes place at the regional scale as guided by the Oak Ecosystem Recovery Plan. A2: For New York City, the governance process for identifying areas of management need and native ecosystem restoration takes place at the city scale as guided by the Forest Management Framework. A3: For Philadelphia, the governance process began as greenspace protection to enhance water quality has developed into an extensive green stormwater infrastructure program at the city scale. A4: For Baltimore, Baltimore Green Space serves as an organizer for a governance process at the city scale that was motivated by community stewardship actions to protect neighborhood forests.



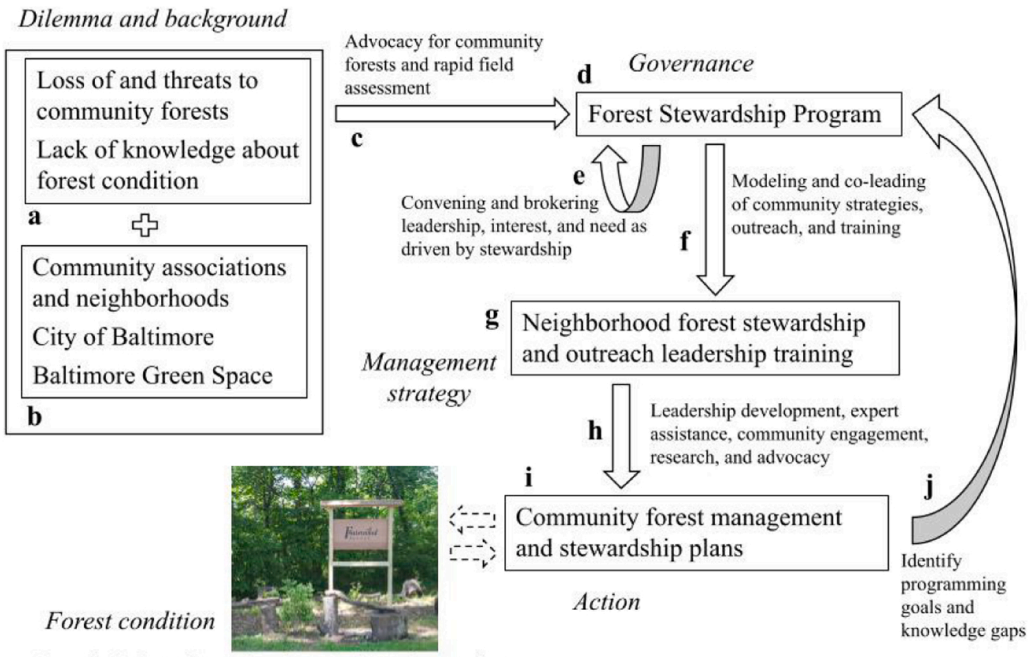
.


Dilemma and background
Need to understand and communicate condition and value of natural areas
a
New York City Parks - Natural Resources Group
b
Governance
c
Inconsistent funding and focus
New York City Parks + Natural Areas Conservancy
d
e
Instigating and building a network focused on natural areas management
j
Engagement and training with expansion to new partners
Focus expands from management for individual parks to systematic citywide focus on natural areas
f
i
New management approaches based on forest structure and composition
Management strategy
Forest Management Framework
Rapid Site Assessment Protocol
g
h
Data-driven prioritization of management efforts
Action
Example: Forest Park is a 538-acre park featuring mature native forest canopy. Management efforts focus on understory recovery, trail formalization, and increasing ecological connectivity.
Forest condition

.


Dilemma and background
Poor condition of forest and forested streams
a
Philadelphia Parks and Recreation
Philadelphia Water Department
Fairmount Park Conservancy
b
Example: Haddington Woods is a 60-acre unit, within which ongoing adaptive forest management research focuses on restoration of heavily degraded woods surrounding high quality forests and stream corridors.
Forest condition
i
Tree planting
Invasive species removal
Stream restoration
c
Stakeholder concerns about protection of green space to enhance water quality
Formal and informal agreements, workforce development
j
h
Advance management plans and facilitate community involvement
Governance
Fairmount Park System Natural Lands Restoration Master Plan
Green City, Clean Water
Philadelphia Forest Framework
Urban Forest Strategic Plan
d
f
Implementation of a city-wide science-based approach
Agency and partner-led research projects
g
Action
Management strategy
e
Building stakeholder coalitions

.



.

References

Albert, C., Schröter, B., Haase, D., Brillinger, M., Henze, J., Herrmann, S., Gottwald, S., Guerrero, P., Nicolas, C., Matzdorf, B., 2019. Addressing societal challenges through nature-based solutions: How can landscape planning and governance research contribute? Landsc. Urban Plan. 182, 12–21.

Avins, M., 2013. Baltimore's Forest Patches: emerald assets for ecosystem services. Baltim. Green. Space Baltim. MD 2021. Accessed February 16. ⟨https://baltimoregreenspace.org/wp-content/uploads/2014/08/ForestPatchesWeb.pdf⟩.

Avolio, M.L., Pataki, D.E., Gillespie, T.W., Jenerette, G.D., McCarthy, H.R., Pincetl, S., Weller Clarke, L., 2015. Tree diversity in southern California's urban forest: the interacting roles of social and environmental variables. Front. Ecol. Evol. 3 article 73.

Bennett, A., Elman, C., 2006. Complex causal relations and case study methods: the example of path dependence. Political Anal. 14, 250–267.

Bixler, R.P., 2013. From community forest management to polycentric governance: assessing evidence from the bottom up. Soc. Nat. Resour. 27, 155–169.

Bounds, K., Feller, M.J., Greenfeld, J., Heaviland, M., Pregitzer, C., Wenskus, T., Gunther, B., Johnson, L.R., King, K., Lu, J., et al., 2015. Guidelines for urban forest restoration. New York City Department of Parks and Recreation Natural Resources Group, New York. NY. Accessed February 1, 2021. http://www.nycgovparks.org/pagefiles/84/guidelines-to-urban-forest-restoration.pdf.

Butt, S., Smith, S.M., Moola, F., Conway, T.M., 2021. The relationship between knowledge and community engagement in local urban forest governance: a case study examining the role of resident association members in Mississauga, Canada. Urban For. Urban Green., 127054

Campbell, L.K., 2014. Constructing New York City's urban forest: The politics and governance of the MillionTreesNYC campaign. In: Sandberg, L.A., Bardekjian, A., Butt, S. (Eds.), Urban forests, trees and greenspace. A policy perspective. Routledge, New York, pp. 242–260.

Campbell, L.K., 2017. City of Forests, City of Farms: Sustainability Planning for New York City's Nature. Cornell University Press, Ithaca.

Campbell, L.K., Gabriel, N., 2016. Power in urban social-ecological systems: processes and practices of governance and marginalization. Urban For. Urban Green. 19, 253–254.

Campbell, L.K., Svendsen, E.S., Sonti, N.F., Johnson, M.L., 2016a. A social assessment of urban parkland: analyzing park use and meaning to inform management and resilience planning. Environ. Sci. Policy 62, 34–44.

Campbell, L.K., Svendsen, E.S., Roman, L.A., 2016b. Knowledge co-production at the research-practice interface: embedded case studies from urban forestry. Environ. Manag. 57, 1262–1280.

Campbell, L.K., Svendsen, E.S., Johnson, M.L., Plitt, S., 2022. Not by trees alone: centering community in urban forestry. Landsc. Urban Plan. 2224, 104445.

Chicago Region Trees Initiative (CRTI) (2019). Chicago Region Trees Initiative Master Plan. Chicago Wilderness, Chicago, IL. Accessed February 3, 2021. http://chicagorti.org/MasterPlan.

City of Baltimore. 2020. An ordinance concerning natural resources – forest and tree conservation (Council Bill 20–0546), Baltimore, MD. Accessed February 16, 2021. https://baltimore.legistar.com/LegislationDetail.aspx?ID=4577601&GUID=4AABBBE8-EBED-4^{48}E–^{81}F4–6D3B141F6913&Options=ID%7CText%7C&Search=forest.

City of Philadelphia. 2020. Philly Tree Pan. Accessed June 15, 2022. https://sites.google.com/hinge-collective.com/philly-tree-plan.

Cranz, G., 1982. The politics of park design. A history of urban parks in America. Massachusetts Institute of Technology Press, London, UK.

Dow, K., 2000. Social dimensions of gradients in urban ecosystems. Urban Ecosyst. 4, 255–275.

Fahey, R.T., Bowles, M.L., McBride, J.L., 2012. Origins of the Chicago urban forest: composition and structure in relation to presettlement vegetation and modern land use. Aboricult. Urban For. 38, 181–193.

Fahey, R.T., Casali, M., 2017. Distribution of forest ecosystems over two centuries in a highly urbanized landscape. Landsc. Urban Plan. 164, 13–24.

Fahey, R.T., Darling, L., Anderson, J., 2015. Sustaining our oaks: a vision for the future of oak ecosystems in the Chicago Wilderness Region. Chic. Wilderness 40. Accessed February 1, 2021. http://chicagorti.org/sites/chicagorti/files/OERP-Full-Report-lowres.pdf.

Fairmount Park Commission. 1999. Fairmount Park System Natural Lands Restoration Master Plans. Accessed February 1, 2021. https://ansp.org/research/environmental-research/projects/fairmount-park/.

Fisher, D., Svendsen, E., Connolly, J., 2015. Urban Environmental Stewardship and Civic Engagement: How Planting Trees Strengthens the Roots of Democracy. Abingdon-on-Thames, Oxfordshire, England, UK. Routledge.

Foo, K., McCarthy, J., Bebbington, A., 2018. Activating landscape ecology: a governance framework for design-in-science. Landsc. Ecol. 33, 675–689.

Frantzeskaki, N., Bush, J., 2021. Governance of nature-based solutions through intermediaries for urban transitions-A case study from Melbourne. Aust. Urban For. Urban Green. 64, 127262.

Gibbons, K.H., Ryan, C.M., 2015. Characterizing comprehensiveness of urban forest management plans in Washington State. Urban For. Urban Green. 14, 615–624.

Goldenberg, N., 1999. Philadelphia launches major restoration initiative in park system. Ecol. Restor. 17, 8–14.

Gulsrud, N.M., Hertzog, K., Shears, I., 2018. Innovative urban forestry governance in Melbourne?: investigating "green placemaking" as a nature-based solution. Environ. Res. 161, 158–167.

Gustavsson, R., Hermy, M., Konijnendijk, C., Steidle-Schwahn, A., 2005. In: Konijnendijk, C., Nilsson, K., Randrup, T., Schipperijn, J. (Eds.), Management of urban woodland and parks—searching for creative and sustainable concepts. In Urban forests and trees. Springer, Berlin, Heidelberg, pp. 369–397.

Heneghan, L., Westphal, L.M., Ross, K.A., Watkins, C., Gobster, P.H., Iannone, B.V., Tutor, M., Vining, J., Wali, A., Zellner, M., et al., 2019. Institutional diversity in the planning process yields similar outcomes for vegetation in ecological restoration. Soc. Nat. Resour. 33, 949–967.

Illinois Department of Natural Resources (IDNR). 2020. Natural Heritage Database. Accessed August 19, 2020. https://www2.illinois.gov/dnr/conservation/NaturalHeritage/Pages/NaturalHeritageDatabase.aspx.

Johnson, L.R., Johnson, M.L., Aronson, M.F.J., Campbell, L.K., Carr, M.E., Clarke, M., D'Amico, V., Darling, L., Erker, T., Fahey, R.T., et al., 2021. Conceptualizing social-ecological drivers of change in urban forest patches. Urban Ecosyst. 24, 633–648.

Johnson, M.L.D.H.Locke, Svendsen, E., Campbell, L.K., Westphal, L.M., Romolini, M., Grove, J.M., 2019. Context matters: influence of organizational, environmental, and social factors on civic environmental stewardship group intensity. Ecol. Soc. 24, 1.

Konijnendijk, C.C., Ricard, R.M., Kenney, A., Randrup, T.B., 2006. Defining urban forestry–A comparative perspective of North America and Europe. Urban For. Urban Green. 4, 93–103.

Konijnendijk C., van den Bosch, 2014. From Government to Governance: Contribution to the Political Ecology of Urban Forestry. In: Sandberg, L.A., Bardekjian, A., Butt, S. (Eds.), Urban forests, trees and greenspace: a political ecology perspective. Routledge, New York, USA, pp. 35–46.

Lautar, K.J., 2020. Leadership learning communities, scientific sustenance, and adventures in inspiration feedback loops in Baltimore. Md. Cities Environ. CATE 13, 1–7.

Lawrence, A., De Vreese, R., Johnston, M., C.C.K. van den Bosch, M., Sanesi, G., 2013. Urban forest governance: towards a framework for comparing approaches. Urban For. Urban Green. 12, 464–473.

Lemos, M.C., Agrawal, A., 2006. Environmental governance. Annu. Rev. Environ. Resour. 31, 297–325.

Livesley, S.J., McPherson, E.G., Calfapietra, C., 2016. The urban forest and ecosystem services: impacts on urban water, heat, and pollution cycles at the tree, street, and city state. J. Environ. Qual. 45, 119–124.

McPhearson, T., Pickett, S.T.A., Grimm, N.B., Niemelä, J., Alberti, Marina, Elmqvist, T., Weber, C., Haase, D., Breuste, J., Qureshi, S., 2016. Advancing urban ecology toward a science of cities. Bioscience 66, 198–212.

Mincey, S.K., Hutten, M., Fischer, B.C., Evans, T.P., Stewart, S.I., Vogt, J.M., 2013. Structuring institutional analysis for urban ecosystems: a key to sustainable urban forest management. Urban Ecosyst. 16, 553–571.

Minor, E.S., Park, C.R., Lee, D., 2015. Effects of habitat structure, human disturbance, and habitat connectivity on urban forest bird communities. Urban Ecosyst. 18, 857–870.

Morzillo, A.T., Kreakie, B.J., Netusil, N.R., Yeakley, J.A., Ozawa, C.P., Duncan, S., 2016. Resident perceptions of natural resources between cities and across scales in the Pacific Northwest. Ecol. Soc. 14.

Natural Areas Conservancy (NAC). 2019. Forests in Cities. Accessed June 27, 2022. https://fic.naturalareasnyc.org/.

New Yorkers for Parks (NY4P). 2021. Play fair. Accessed September 30, 2021. http://www.ny4p.org/what-we-do/play-fair.

Norström, A.V., Cvitanovic, C., Löf, M.F., West, S., Wyborn, C., Balvenera, P., Bednarek, A.T., Bennett, E.M., Briggs, R., De Bremond, A., et al., 2020. Principles for knowledge co-production in sustainability research. Nat. Sustain. 3, 182–190.

Ogden, L.A., Aoki, C., Grove, J.M., Sonti, N.F., Hall, W., Locke, D., Pickett, S.T.A., Avins, M., Lautar, K., Lagrosa, J., 2019. Forest Ethnography: an approach to study the environmental history and political ecology of urban forests. Urban Ecosyst. 22, 49–63.

Ordóñez, C., Duinker, P.N., 2013. An analysis of urban forest management plans in Canada: Implications for urban forest management. Landsc. Urban Plan. 116, 36–47.

Ordóñez, C., Threlfall, C.G., Kendal, D., Hochuli, D.F., Davern, M., Fuller, R.A., van der Ree, R., Livesley, S.J., 2019. Urban forest governance and decision-making: a systematic review and synthesis of the perspectives of municipal managers. Landsc. Urban Plan. 189, 166–180.

Ordóñez, C., Threlfall, C.G., Livesley, S.J., Kendal, D., Fuller, R.A., Davern, M., van der Ree, R., Hochuli, D.F., 2020. Decision-making of municipal urban forest managers through the lens of governance. Environ. Sci. Policy 104, 136–147.

Ostrom, E., 2011. Background on the institutional analysis and development framework. Policy Stud. J. 39, 7–27.

Ostoić, S.K., Konijnendijk van den Bosch, C.C., 2015. Exploring global scientific discourses on urban forestry. Urban For. Urban Green. 14, 129–138.

Palmer, M.A., Kramer, J.G., Boyd, J., Hawthorne, D., 2016. Practices for facilitating interdisciplinary synthetic research: the national socio-environmental synthesis center (SESYNC). Curr. Opin. Environ. Sustain. 19, 111–122.

Payne, L.L., Mowen, A.J., Orsega-Smith, E., 2002. An examination of park preferences and behaviors among urban residents: the role of residential location, race, and age. Leis. Sci. 24, 181–198.

Philadelphia Parks and Recreation (PPR). 2013. Philadelphia Parks & Recreation - Parkland Forest Management Framework. Accessed February 1, 2021. https://www.phila.gov/media/20171220162100/Parkland-Forest-Management.pdf.

Philadelphia Parks and Recreation (PPR). 2020. Philly Forest Science. Accessed February 1, 2021. https://phillyforestscience.org/.

Philadelphia Water Department (PWD). 2011. Green city, clean waters. The City of Philadelphia's Program for combined sewer overflow control program summary. Accessed February 1, 2021. http://archive.phillywatersheds.org/doc/GCCW_AmendedJune2011_LOWRES-web.pdf.

Piana, M.R., Pregitzer, C.C., Hallett, R.A., 2021. Advancing management of urban forested natural areas: toward an urban silviculture? Front. Ecol. Environ. 19, 526–535.

Pincetl, S., 2010. Implementing municipal tree planting: Los Angeles million-tree initiative. Environ. Manag. 45, 227–238.

Pregitzer, C.C., H.M. Forgione, K.L. King, S. Charlop-Powers, and J. Greenfeld. 2018. Forest Management Framework for New York City. Natural Areas Conservancy, New York, NY. https://naturalareasnyc.org/forests.

Pregitzer, C.C., Charlop-Powers, S., Bibbo, S., Forgione, H.M., Gunther, B., Hallett, R.A., Bradford, M.A., 2019a. A city-scale assessment reveals that native forest types and overstory species dominate New York City forests. Ecol. Appl. 29, e01819.

Pregitzer, C.C., Charlop-Powers, S., McCabe, C., Hiple, A., Gunther, B., Bradford, B.A., 2019b. Untapped Common Ground: the Care of Forested Natural Areas in American Cities. Natural Areas Conservancy, New York, NY, p. 2021. Accessed June 7. ⟨https://naturalareasnyc.org/content/national/nac_careofurbannature_lores-singles.pdf?1553522646⟩. Accessed June 7.

Rines, D., Kane, B., Kittredge, D.B., Ryan, H.D.P., Butler, B., 2011. Measuring urban forestry performance and demographic associations in Massachusetts. Usa. Urban For. Urban Green. 10, 113–118.

Roman, L.A., Pearsall, H., Eisenman, T.S., Conway, T.M., Fahey, R.T., Landry, S., Vogt, J., van Doorn, N.S., Grove, J.M., Locke, D.H., et al., 2018. Human and biophysical legacies shape contemporary urban forests: a literature synthesis. Urban For. Urban Green. 31, 157–168.

Shcheglovitova, M., 2020. Valuing plants in devalued spaces: caring for Baltimore's street trees. Environ. Plan. E Nat. Space 3, 228–245.

Silva, P., Ramirez, R.L., 2018. In: Krasny, M.E., Tidball, K.G. (Eds.), Making knowledge in civic ecology practices. In Grassroots to global: Broader impacts of civic ecology. Cornell University Press, Ithaca, pp. 124–154.

Sonti, N.F., 2020. Ambivalence in the woods: Baltimore Resident Perceptions of Local Forest patches. Soc. Nat. Resour. 33, 823–841.

Sonti, N.F., Campbell, L.K., Svendsen, E.S., Johnson, M.L., Novem Auyeung, D.S., 2020. Fear and fascination: use and perceptions of New York City's forests, wetlands, and landscaped park areas. Urban For. Urban Green. 49, 126601.

Svendsen, E., Campbell, L., 2008. Urban ecological stewardship: Understanding the structure, function and network of community-based urban land management. Cities Environ. CATE 1, 1–32.

Svendsen, Erika S., Campbell, Lindsay, K., Fisher, Dana, R., Connolly, James, J.T., Johnson, Michelle, L., Sonti, Nancy, F., Locke, Dexter, H., Westphal, Lynne, M., LeBlanc, Fisher, Cherie, Grove, Morgan, J., Romolini, Michele, Blahna, Dale, J., Wolf, Kathleen, L., 2016. Stewardship mapping and assessment project: a framework for understanding community-based environmental stewardship. Gen. Tech. Rep. 156. Newtown Square, PA: U.S. Department of Agriculture. For. Serv. North. Res. Station 134.

Tacconi, L., 2011. Developing environmental governance research: the example of forest cover change studies. Environ. Conserv. 38, 234–246.

Taylor, D., 2009. The Environment and the People in American Cities. 1600s-1900s: Disorder, inequality, and social change. Duke University Press, Durham.

Tozer, L., Hörschelmann, K., Anguelovski, I., Bulkeley, H., Lazova, Y., 2020. Whose city? Whose nature? Towards inclusive nature-based solution governance. Cities 107, 102892.

Trammell, T.L.E., D'Amico III, V., Avolio, M.L., Mitchell, J.C., Moore, E., 2020. Temperate deciduous forests embedded across developed landscapes: younger forests harbor invasive plants and urban forests maintain native species. J. Ecol. 108, 2366–2375.

Trentanovi, G., Zinzani, A., Bartoletti, R., Montanari, F., 2021. Contested novel ecosystems: socio-ecological processes and evidences from Italy. Environ. Dev. 40, 100658 https://doi.org/10.1016/j.envdev.2021.100658.

van der Jagt, A.P.N., Lawrence, A., 2019. Local government and urban forest governance: insights from Scotland. Scand. J. For. Res. 34, 53–66.

Vieira, J., Matos, P., Mexia, T., Silva, P., Lopes, N., Freitas, C., Correia, O., Santos-Reis, M., Branquinho, C., Pinho, P., 2018. Green spaces are not all the same for the provision of air purification and climate regulation services: the case of urban parks. Environ. Res. 160, 306–313.

Wenger, E., 1998. Communities of Practice: Learning, Meaning, and Identity. Cambridge University Press, Cambridge.

Wilkes-Allemann, J., Pütz, M., Hirchi, C., 2015. Governance of forest recreation in urban areas: analyzing the role of stakeholders and institutions using the institutional analysis and development framework. Environ. Policy Gov. 25, 139–156.

Williams, B.K., 2011. Adaptive management of natural resources - framework and issues. J. Environ. Manag. 92, 1346–1353.

Young, R.F., 2011. Planting the living city. J. Am. Plan. Assoc. 77, 368–381.

Young, R.F., McPherson, E.G., 2013. Governing metropolitan green infrastructure in the United States. Landsc. Urban Plan. 109, 67–75.