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Climate Adaptive Silviculture for the City: Practitioners and Researchers Co-create a Framework for Studying Urban Oak-Dominated Mixed Hardwood Forests

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Urban forested natural areas are an important component of the forest and tree canopy in northeastern United States urban areas. Although similar to native forests in surrounding regions in structure, composition, and function, these natural areas are threatened by multiple, co-occurring biological and climate stressors that are exacerbated by the urban environment. Furthermore, forests in cities often lack application of formal silvicultural approaches reliant upon evidence-based applied ecological sciences. These include both urban- and climate-adapted silvicultural techniques to increase the resilience and sustainability of native forests in cities. With this in mind, we convened a group of urban forest practitioners and researchers from along a latitudinal gradient in the northeastern United States to participate in a workshop focused on co-developing long-term, replicated ecological studies that will underlie the basis for potential silvicultural applications to urban forests. In this article we review the process and outcomes of the workshop, including an assessment of forest vulnerability, and adaptive capacity across the region, as well as shared management goals and

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objectives. We discuss the social and ecological challenges of managing urban oak-dominated mixed hardwood forests relative to non-urban forests and identify potential examples of urban- and climate-adapted silviculture strategies created by practitioners and researchers. In doing so, we highlight the challenges and need for basic and long-term applied ecological research relevant to silvicultural applications in cities.

Keywords: urban forests, urban forestry, silviculture, forest restoration, climate adaptation, climate vulnerability, resilience

INTRODUCTION

Creating, restoring, and maintaining urban greenspace is a critical component for promoting human equity and infrastructure resilience in cities worldwide. Specifically, Urban Forested Natural Areas (UFNA's) are of particular importance for cities in forested biomes. The socio-ecological contexts of these urban greenspace types have only recently been defined (e.g., Pregitzer et al., 2019a; Johnson et al., 2020; Piana et al., 2021a) and can be similar to non-urban native forests in composition, structure, and function (e.g., Pregitzer et al., 2019b; Piana et al., 2021b).

Natural areas (includes forests, wetlands, grasslands, and deserts) occupy 84% of municipal parkland in the United States (Trust for Public Land [TPL], 2017) and UFNA's, in particular, are common across some of the world's largest and densest cities (Lawrence et al., 2013). For such cities, UFNA's provide a disproportionate amount of the total ecosystem services (Mexia et al., 2018; Pregitzer et al., 2021). Urban Forested Natural Areas help mitigate the urban heat island effect, stormwater and coastal flooding, and provide opportunities for people to interact with nature—leading to improved physical and mental health (e.g., Frumkin et al., 2017; Mexia et al., 2018; Bratman et al., 2019). Therefore, it is imperative that these forests are resilient to current and expected effects of biological and climate stressors that are exacerbated by urban environment.

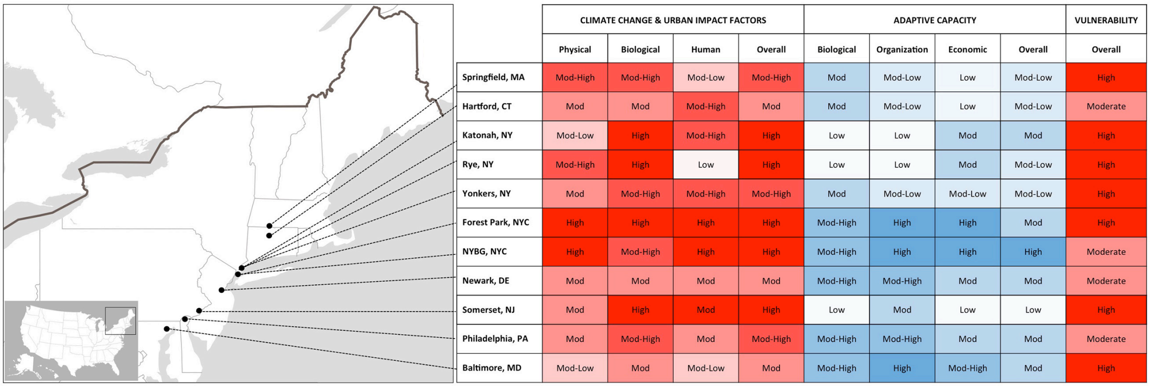
Despite their importance there is a lack of well-defined silvicultural options for practices that address current and future challenges associated with climate change and urban pressures (Pregitzer et al., 2019c; Piana et al., 2021a). Climate adaptive frameworks for urban forestry are emerging (e.g., Ordóñez and Duinker, 2014) but need to be developed for specific urban forest types including UFNA's. The similarity between UFNA's and surrounding native forests presents an opportunity to draw upon the techniques of silviculture. Defined as the "art and science of controlling establishment, growth, composition, health, and quality of forests … to meet the diverse needs and values of landowners and society," silviculture is informed by more than 100 years of study and practice in the United States, mostly in non-urban forested areas (Ashton and Kelty, 2018). However, there are several factors that complicate the application of silviculture in urban areas. For example, not all traditional silvicultural practices may be practical or possible in UFNA's (e.g., prescribed burn, harvesting, use of herbicides, limited deer control options) given the social-ecological context, including policy, law, and/or public perception of these greenspaces. However, the primary issue is that though many of the same problems in urban natural areas are faced in non-urban areas (e.g., climate change, invasive pests and plants, deer herbivory, aging canopy, and pollutants), they are under greater interacting extremes from these stressors because of much greater fragmentation, higher chronic levels of disturbance, and the ever-present urban heat island effect (e.g., Hellmann et al., 2010; IPCC, 2019; Johnson et al., 2020; Trammell et al., 2020; Piana et al., 2021b). Urban Forested Natural Areas currently face more extreme conditions (Gill et al., 2007; Kirshen et al., 2008) that our more rural forests might experience in the future (Carreiro and Tripler, 2005).

Cities can contribute to emerging research efforts focused on adapting current silvicultural techniques to more extreme conditions and circumstances (e.g., Kern et al., 2017; Nagel et al., 2017; D'Amato and Palik, 2021). Lastly, given that UFNA's are part of a social-ecological system (Vogt, 2020), the development of silvicultural applications in an urban world will necessarily need to develop a community-based management strategy (Campbell et al., 2016). There is a need and opportunity for UFNA research and practice to apply both existing and emerging adaptive silviculture techniques for urban forest management circumstances.

It is our perspective that urban silviculture strategies are required to address the urban and climate vulnerabilities of natural areas in cities. This can be best achieved by convening practitioners and scientists to co-create novel strategies focused on specific forest types and conditions within cities. Collectively this approach supports the implementation of evidence-based practices and the establishment of long-term studies necessary to support this emerging field of practice.

THE NORTHEAST URBAN SILVICULTURE WORKSHOP

To address these needs, we organized the Northeast Urban Silviculture workshop, which met virtually during a series of five meetings (December 2020 – January 2021). The participants included municipal and private forest practitioners from Baltimore, MD; Philadelphia, PA; Somerset, NJ; Westchester County, NY; New York City, NY; Hartford, CT; and Springfield, MA. In addition, researchers from the United States Forest Service, University of Massachusetts, University of Connecticut, Yale University, Rutgers University, and the University of Delaware participated. The overarching question for the workshop was: How does the urban social-ecological system interact with our potential to sustainably manage oak dominated



	CLIMATE CHANGE & URBAN IMPACT FACTORS				ADAPTIVE CAPACITY				VULNERABILITY
	Physical	Biological	Human	Overall	Biological	Organization	Economic	Overall	Overall
Springfield, MA	Mod-High	Mod-High	Mod-Low	Mod-High	Mod	Mod-Low	Low	Mod-Low	High
Hartford, CT	Mod	Mod	Mod-High	Mod	Mod	Mod-Low	Low	Mod-Low	Moderate
Katonah, NY	Mod-Low	High	Mod-High	High	Low	Low	Mod	Mod	High
Rye, NY	Mod-High	High	Low	High	Low	Low	Mod	Mod-Low	High
Yonkers, NY	Mod	Mod-High	Mod-High	Mod-High	Mod	Mod-Low	Mod-Low	Mod-Low	High
Forest Park, NYC	High	High	High	High	Mod-High	High	High	Mod	High
NYBG, NYC	High	Mod-High	High	High	Mod-High	High	High	High	Moderate
Newark, DE	Mod	Mod	Mod	Mod	Mod-High	Mod-High	Mod	Mod	Moderate
Somerset, NJ	Mod	High	Mod	High	Low	Mod	Low	Low	High
Philadelphia, PA	Mod	Mod-High	Mod	Mod-High	Mod-High	Mod-High	Mod	Mod	Moderate
Baltimore, MD	Mod-Low	Mod	Mod-Low	Mod	Mod-High	High	Mod-High	Mod	High

FIGURE 1 | Participating cities and forest sites and summary of overall impacts, adaptive capacity, and vulnerability for selected sites in each city. The Northeast Urban Silviculture workshop focused on oak forests in cities along a north-south gradient in the eastern United States and involved scientists and land managers in a facilitated workshop with the goal of developing a replicated long-term ecological study. Impacts were defined as the direct and indirect consequences of climate change and urbanization on forests. Impacts could be beneficial or harmful to a particular forest or ecosystem type and the magnitude of those impacts depend on the sensitivity of the forest to change. Rankings were identified on a scale from "Low" to "High" (**Supplementary Material**). Vulnerability, which we define as a function of a forest's potential impacts and adaptive capacity, is the susceptibility of a system to the adverse effects of urbanization and/or climate change.

mixed hardwood forests in cities? The overall goal was to develop a network of long-term, replicated studies across these sites to test this question.

We used an existing field-tested framework focused on adapting UFNA's to climate change (Brandt et al., 2016) to: (1) engage participants in the co-creation of urban and climate change adaptation strategies and (2) use an adaptive planning process to design specific silvicultural treatments. This framework also provided an opportunity to examine social learning through knowledge exchange during the workshop and the potential to enhance development of treatments to increase urban forest resilience through resulting outcomes.

Oak dominated mixed hardwood forests are the most dominant forest type group across the eastern United States (Ruefenacht et al., 2008; Oswalt et al., 2014) and are common in regional cities represented within the workshop. As an important genus of the eastern United States, conserving the oak resource is also a priority for foresters and ecologists (Dey, 2014; Hanberry and Nowacki, 2016). In general, sustaining native oak forest communities (both urban and rural) is particularly important because they provide critical habitats for migratory birds and other wildlife species. Given that one of our goals was to create a replicated experimental design across multiple cities, practitioners identified closed-canopy, oak-dominant forested areas in each city that can accommodate long-term study plots.

Managers were also tasked with selecting "good woods," meaning intact relatively large tracts of closed-canopy forests with minimal invasive plant and site disturbance, dominated by native trees in the canopy and midstory. Such areas are especially valuable in cities because of the local ecosystem services they provide, such as access to high quality recreational greenspace for residents. However, even "good woods" in urban areas typically have limited natural regeneration of native tree species, high pressures of herbivory from deer, and high pollutant loading all resulting in a dissimilarity between the mature canopy and seedling composition (e.g., Pregitzer et al., 2019b; Piana et al., 2021b). As a result, today's "good woods" are vulnerable to future disturbance, such as windthrow and pests, and may become tomorrow's invaded forest gaps. We opened the workshop series with managers' providing a virtual field tour of their selected sites, including their social and ecological context and potential constraints, creating a shared knowledge about the potential network of study sites.

URBAN OAK-DOMINATED HARDWOOD FOREST VULNERABILITY ASSESSMENT

During the workshop, practitioners completed a vulnerability assessment for their potential study sites (**Supplementary Material**), using a self-assessment worksheet that was modified from previously developed concepts (Brandt et al., 2016). For each of their selected potential forest sites, practitioners were asked to identify physical impact factors associated with climate change (e.g., susceptibility to increased drought, or precipitation from storm events); biological impact factors associated with climate change (e.g., species-specific responses to increasing temperatures); impact factors from human activity (e.g., trampling, adjacent land use and edge effect); and local urban ecosystem stressors (e.g., land use history, urban heat island, localized pollution or contamination). We asked participants to evaluate adaptive capacity, which was defined as the ability of the proposed study area to accommodate or cope with potential climate change and urbanization impacts with minimal disruption, in three sub-categories: biological, organizational-technical, and economic-social. The top five overall impact and adaptive capacity factors were highlighted by participants and an "overall" impact and adaptive capacity score assigned (**Figure 1** and **Table 1**). Lastly, the impact and adaptive capacity scores were used by the practitioners to determine the overall vulnerability for their potential study sites.

The vulnerability assessment revealed many shared impact factors across the region. Across all cities, the potential study areas are particularly susceptible to canopy loss and characterized by limited advance regeneration of oak or any other tree species to sustain current forest communities. Impact factors of particular concern were intense herbivory pressure and threat from invasive plants, pests, and pathogens, as well as increased or more intense storm events. Public perception and ordinances are potential barriers to effective management. The vulnerability assessment not only identified individual factors of concern with respect to the sustainability of these forests but suggested that despite being characterized as "good woods," even the healthiest urban oak-dominated hardwood forests are vulnerable to current and future urban and climate impacts. The vulnerability of these forests means that both proactive and reactive long-term management strategies need to be developed to ensure their sustainability as an important ecological component of urban greenspace.

Climate change vulnerability assessments of non-urban oak-dominated hardwood forests for the Mid-Atlantic and New England regions suggest these forests to be less vulnerable than other forest types in the region, primarily because of their likely ability to persist in hotter more extreme climates of higher rainfall with stronger episodic droughts (Butler-Leopold et al., 2018; Janowiak et al., 2018). However, urban oak forests tend to be more fragmented, disturbed, and dominated by more invasive species than their non-urban counterparts, potentially reducing their adaptive capacity. In addition, impacts from increased extremes of high temperature and high levels of air-borne pollutants create the urban heat island effect (Cregg and Dix, 2001). These, and other factors, such as increased herbivory, may conspire to create early establishment barriers (Piana et al., 2021a). Though the causative factors may be amplified and/or different in cities, failure to regenerate oak-dominated hardwood forests is a regional phenomenon (Dey, 2014).

ADAPTIVE MANAGEMENT STRATEGIES

The vulnerability assessment described above was used to facilitate a dialog focused on management challenges, opportunities, and adaptation planning. Focusing on the selected sites in each city, our group participated in a semi-structured process to define management goals and objectives, incorporate vulnerability assessment information, identify challenges and opportunities associated with current or projected climate change and urban forest conditions, select potential adaptation strategies from a menu of peer-reviewed options, and develop potential on-the-ground tactics (e.g., thinning or planting technique). For this exercise, we piloted the newly developed "Urban Forest Climate and Health Menu" (Janowiak et al., 2021), developed for use with the Adaptation Workbook (Swanston et al., 2016). Subsequent exercises focused on identifying specific tactics that could be implemented to achieve these management goals.

For our group, we reached consensus around a management goal for healthy oak forests focused on creating a native tree canopy that is resilient to future disturbance; not necessarily to maintain these forests as oak dominant. Discussion highlighted several issues and perspectives regarding forest management, which drew upon silvicultural expertise and local knowledge of participants, including regeneration options, deer herbivory, vulnerability to gap events, and pest and plant invasion risk. Social factors, including public perception of tree removal and other management activities, along with rules and regulations of governance organizations that prevent specific actions, were viewed as very important social and political factors affecting effective management of these sites. Participants reached consensus on management strategies and approaches that retain existing trees, sustaining or enhancing functional diversity (i.e., oaks and other masting tree species, e.g., hickory, beech), and increased structural and species diversity through the establishment of multiple age classes (**Table 1**). According to climate adaptation models, many of the masting tree species of the region (oak, hickory) are predicted to be better suited to future conditions of a changing climate (e.g., drought tolerance) (Janowiak et al., 2018). Furthermore, oak trees are ecologically important in these systems and represent a key functional group in the forest community (Hanberry and Nowacki, 2016). Oaks can form monodominant stands like some other native species (e.g., *Fagus grandifolia*) on poorer, drier soils but usually, because of land use history and other factors, are found as canopy trees in mixture with other more mesophytic species on better soils; promoting greater native tree diversity. Such soils and sites support higher native species mixtures across a greater diversity of trophic levels and habitat heterogeneity (e.g., Hansen, 2000; Tallamy and Shropshire, 2009; Stoler and Relyea, 2011).

There are several barriers and challenges to implementing silviculture commonly used to sustain oak forests (Dey, 2014; Iverson et al., 2019). For instance, oak often relies on treatments that simulate episodic disturbances whereby there is significant canopy tree removal and increased light that coincides with masting and soil surface perturbations (e.g., Loftis and McGee, 1992; Dey et al., 2010). In cities, canopy removal is usually not viable because of public resistance to cutting trees, but also because of ecological concern of an already high rate of canopy loss from drought, exotic insects and disease, limited forest area, and high public visibility. Silvicultural techniques need to be tested that include this context and then evaluated for efficacy and acceptability (Pastick et al., 2021). Furthermore, deer, altered site conditions, and invasive plants may also limit oak regeneration and recruitment even when light and site treatment is no longer a limiting factor.

Similar challenges, "not enough light and too many deer," exist in non-urban oak forests (e.g., Dey, 2014) and are a challenge for selecting regeneration methods focused on creating canopy openings of sufficient size to establish new age-classes (e.g., Kern et al., 2017). We reached broad consensus on alternative management tactics which included: (1) leveraging existing and/or newly formed canopy gaps instead of creating them; (2) using temporary fencing around such openings along with potential methods for accelerating tree establishment (e.g., a nurse tree strategy); (3) testing the success of improved oak planting stock and the adaptive capacity of native oak to both local site conditions and projected climate change (e.g., assisted

TABLE 1 | Top selected impact factors, adaptive capacity factors and adaptive management approaches.

Impact factors	Adaptive capacity factors	Adaptive management strategies and approaches
• *Biological*: As temperatures increase, suitable habitat for many invasive plant species could increase (9/11) • *Biological*: Many pests and pathogens are expected to benefit from longer growing seasons, wetter spring conditions, and warmer temperatures (9/11) • *Human Activity:* Adjacent land use and human activity may cause the area to be more susceptible to future plant invasions (8/11) • *Biological*: Warmer winters could be beneficial to some herbivores (7/11) • *Biological:* A large percentage of trees in the area susceptible to wind damage (7/11)	• *Organizational*: Trained forestry professionals may be more likely to recognize potential problems and identify appropriate solutions (6/11) • *Organizational*: Knowing the mix of species, age classes, and conditions of trees can help determine how many trees could be vulnerable (5/11) • *Biological*: Structural and age diversity can increase forest resilience and recovery from disturbance (e.g., storm events) (4/11) • *Biological*: Species-rich communities have exhibited greater resilience to extreme environmental conditions and greater potential to recover from disturbance (4/11) • *Social*: Attitudes and public perception of management activities (4/11)	• *Maintain or increase extent of UFNA's and vegetative cover (Strategy 3)* ◦ 3.1 Maintain existing trees through proper care and maintenance ◦ 3.2 Minimize forest loss and degradation • *Reduce the impact of physical and biological stressors on urban forests (Strategy 5)* ◦ 5.4 Maintain or improve the ability of forests to resist pests and pathogens ◦ 5.5 Prevent invasive plant establishment and remove existing invasive species ◦ 5.6 Manage herbivory to promote regeneration, growth, and form of • *Enhance taxonomic, functional, and structural diversity (Strategy 6)* ◦ 6.1 Enhance age class and structural diversity in forests ◦ 6.2 Maintain or enhance diversity of native species • *Alter urban ecosystems toward new and expected conditions (Strategy 7)* ◦ 7.1 Favor or restore non-invasive species that are expected to be adapted to future conditions. ◦ 7.3 Introduce species, genotypes, and cultivars that are expected to be adapted to future conditions ◦ 7.6 Promptly revegetate and remediate sites after disturbance

Each management team (n = 11) identified the top five impact and adaptive capacity factors for their selected site(s). Adaptive management strategies and approaches were selected by managers and scientists and used to develop urban-adapted tactics (see ***Supplementary Material*** *for full results). Numbers in parentheses represent the number of teams that selected each factor. Adaptive management strategies and approaches were selected from the "Urban Forest Climate and Health Menu" (Janowiak et al., 2021), developed for use with the Adaptation Workbook (Swanston et al., 2016).*

migration strategies); and (4) sustaining functional diversity through alternative mast species, including disease resistant American chestnut (*Castanea dentata*) and butternut (*Juglans cinerea*) and future climate adapted species such as Chestnut oak (*Quercus prinus*).

DISCUSSION

Silvicultural practice in the United States is guided by prescriptions and management decisions that are based on long-term research (Oliver and Larson, 1996; Ashton and Kelty, 2018). Although silvicultural practices are noted as early as the 18th century (Von Carlowitz, Sylvicultura Oeconomica 1713), implementation and study of forest management practices in the United States began almost 150 years ago with Gifford Pinchot, among others. Pinchot was focused on preserving the services forests provide to communities through science-based forest management techniques. These services were so important in Pinchot's view that he deemed them "indispensable to the progress of civilization" (Pinchot, 1895). One of these services was the production of timber and the other was the "indirect influences of the forest as they regard water and climate." Landscape architect Fredrick Law Olmsted recognized the importance of science-based management within designed urban forest spaces (Thoren, 2014) and, in 1889, made an impassioned plea for allowing traditional forestry practices in large urban forest parks, including Central Park (Olmsted and Harrison, 1928). In 1895, Gifford Pinchot outlined a need for forest schools in America to create a workforce that could implement applied forest management practices based on science (Pinchot, 1895). Today, we face a similar need to train professionals in urban silvicultural practice and establish degrees or certification programs focused on urban-adapted and climate-adapted silvicultural practices. We continue these discussions today, focusing on management practices for UFNA's.

Silviculture Practice and Research in the City

Oak forests are an important part of each urban landscape, and the sustainability and resilience of this forest type is of concern throughout the region (Long et al., 2012; Dey, 2014; Sonti et al., 2021). In rural forests, documented declines in oak trees in maturing forests and the lack of oak regeneration has stimulated research on the development of additional silvicultural techniques to promote oak regeneration (Abrams, 2003; Dey, 2014). This, together with interest in creating greater structural and age-class diversity in relatively even-aged forests, often originating from a common land-use history, is leading to the testing and development of silvicultural techniques that are designed to create greater heterogeneity in this forest type (e.g., Raymond et al., 2009; Wikle et al., 2019; Hanle et al., 2020). Such techniques, conceptually at least, are further advancing notions of climate resiliency through ecological complexity (D'Amato and Palik, 2021).

Our workshop demonstrated the value of connecting foresters and researchers focused on studying upland oak forests in urban areas. This reveals an opportunity for connecting foresters and researchers focused on managing or studying different areas of urban, peri-urban and wildland continuum around common prospective silvicultural approaches to create more healthy, resilient, and sustainable UFNA's. The previously stated overarching question for our workshop focused on managing and maintaining oak dominated forests in cities. We quickly realized that there are significant challenges specific to managing forests in cities that make maintaining oak dominated forests impractical. Consequently, our group reached consensus around managing and maintaining forests dominated by native tree species with an oak component. The workshop resulted in the formation of the northeast urban silviculture network which includes a latitudinal gradient of permanent study sites in areas where temperatures are already warmer than surrounding exurban forests (Trust for Public Land, 2021) presenting a unique opportunity to test the climate and urban adaptability of two oak species (*Quercus montana* and *Quercus alba*), both of which have a broad native range in the U.S. and are of particular interest to rural forest managers. New or adaptive approaches may be needed to sustain oak forests and forests in cities and may help provide a window into the future of our rural forests.

In 1908, the United States Forest Service established a system of experimental forests to provide research necessary to manage the land (Lugo et al., 2006). These long-term experiments have informed forest management practice and environmental policy for decades. Inspired in part by the experimental forests, a growing body of work examining specific dynamics of forests in urban settings provides the basis for urban silviculture (Schuler and Forrest, 2008; Pregitzer et al., 2019a; Sonti et al., 2019; Piana et al., 2021b; Zukswert et al., 2021). Also, at a broader scale, frameworks are being developed for adapting urban forests to climate change (e.g., Brandt et al., 2016) and efforts are emerging in other cities that test silvicultural strategies to adapt to a changing climate (e.g., Hammes et al., 2020; Pastick et al., 2021). Even so, there are few urban forestry studies covering a time span necessary to understand forest stand dynamics (Oldfield et al., 2013) and no applied forest management studies replicated across multiple cities. The reasons for this could include:

- unique social-ecological context of each city
- concerns about possible human interference with permanent study plots
- limited area for setting up permanent plots
- mismatch between operational and biological time scales
- varied ecological conditions and disturbance regimes.

The benefits of overcoming these challenges and establishing a long-term multi-city replicated experiment include the ability to compare results within and between social-ecological systems, test species-specific responses and ecological thresholds within the urban context, and gain a better understanding of the long-term impacts of management actions.

Co-producing Resilient Urban Natural Areas

Resilience concepts in urban forestry are nascent, with the climate-related vulnerability assessment applied here being the most common resilience framework (Huff et al., 2020). By broadening our urban adaptive silviculture approach to include resilience thinking (Rist and Moen, 2013), we also consider the larger social-ecological system, including: (1) social processes of decision-making, such as identifying shared goals (Gerlak and Heikkila, 2011) and engaging in social learning (Reed et al., 2010), and (2) social-ecological dynamics surrounding the forest sites, including city- and neighborhood-level factors and organizational culture of practitioner organizations, to improve social-ecological resilience. Acceptance and support for adaptive management strategies by practitioners was mixed during the workshops, highlighting the possibilities, but also constraints, of urban silviculture experiments. Practitioners identified social acceptance by the broader public as a critical factor in their decision-making, pointing to a need to consider and include public voices in planning urban forest futures (Janse and Konijnendijk, 2007).

By gathering practitioners and researchers with a breadth of expertise around urban forests and silviculture, our workshop not only contributed to social learning for practitioners and researchers but incorporated social-ecological context when identifying adaptive management strategies. With a tangible problem to be solved and open communication and respect, our group's process of developing an urban, adaptive silviculture has several supportive elements for successful collaboration (Johnson et al., 2019). We used ideas generated during the workshop to design replicated experiments aligned with the management priorities of participating cities and implement a common garden study that tests the climate adaptability of two oak species. Funding has been secured (2021 USDA Forest Service Urban and Community Forestry Cost Share Grant Program) and continued collaboration and results from the long-term study also hold the seeds for transformation in how individuals and the collective network may think about urban oak forests, their social-ecological settings, and the larger questions of resilience: to what and for whom.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

MP, RH, LB, and NS conceived of and planned the Northeast Urban Silviculture Workshop. MP, RH, MJ, NS, and LB led in writing the manuscript and all workshop participants contributed to early drafts of the manuscript. All authors participated in the workshop and conceived of the ideas presented in the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2021.750495/full#supplementary-material

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