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Making Meaning of Urban Greening in the Anthropocene

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Abstract

Municipalities worldwide are showing substantial interest in urban greening, defined here as the introduction or conservation of flora in cities. Encompassing innovative policies, designs, and initiatives that are vegetating the urban landscape, this bloom of activity may be unlike anything since street trees and large parks transformed the fabric of cities in the 19th century. Yet, there has been little scholarship on the historical and contemporary contours of these practices, which are emerging amidst two important phenomena: global urbanization; and increasing awareness of human-induced alteration of the biosphere, described here as the Anthropocene Awakening. This dissertation strives to make meaning of urban greening at this significant inflection point through a chronicle of trees in U.S. cities, assessment of city planning scholarship, review of scientific literature addressing human health benefits of urban vegetation, and a survey of municipal tree planting practitioners. Longitudinal study reveals that the rationale for urban trees has recently shifted from civic improvement and beautification to ecosystem services. Research on urban ecosystem services is an open frontier; and there is a pressing need for a definition and conceptual framework that reflects municipal greening practice. Human health is a central aspect of ecosystem services, and scientific literature reveals a psychosocial orientation to the human health benefits of urban flora. This suggests that cultural ecosystem services are especially important in urban settings; and that research and practice should address the socioecological dimensions of flora in cities. This represents an opportunity for urban planners and designers, despite a lack of attention to greenery in city planning scholarship. Literature also suggests that urban trees may, depending on many factors, be a minor component in mitigating local and global air pollution; and arguments based on this rationale may divert attention from the problem – fossil fuel emissions. A survey of municipal tree planting programs and practitioners supports this reasoning. Findings also suggest a planning and design norm described as proximal greening for multifunctional urban landscapes. Finally, as municipal leaders and residents grapple with the profound implications of the Anthropocene and seek to enhance the livability and sustainability of cities, urban greening may contribute more to the former than the latter.

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Theodore Stephen Eisenman

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ABSTRACT

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suggests that cultural ecosystem services are especially important in urban settings; and that research and practice should address the socioecological dimensions of flora in cities. This represents an opportunity for urban planners and designers, despite a lack of attention to greenery in city planning scholarship. Literature also suggests that urban trees may, depending on many factors, be a minor component in mitigating local and global air pollution; and arguments based on this rationale may divert attention from the problem – fossil fuel emissions. A survey of municipal tree planting programs and practitioners supports this reasoning. Findings also suggest a planning and design norm described as proximal greening for multifunctional urban landscapes. Finally, as municipal leaders and residents grapple with the profound implications of the Anthropocene and seek to enhance the livability and sustainability of cities, urban greening may contribute more to the former than the latter.

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PREFACE

Having spent most of my career in environmental protection, planning, and design, I came into this PhD research to deepen my capacity to advance that work in an urban context. I did not have a particular question in mind, and thus pursued a path of inductive inquiry – immersing myself in the scholarly literature, paying attention to developments in urban greening practice, and allowing questions to emerge based on the findings and phenomena observed.[1]

This forced me time and again to reconcile my predispositions. While some question the notion of absolute objectivity,[2] impartial analysis is clearly foundational to the academic enterprise. Yet, we are all shaped by culture, and in the interest of explicating my own positionality:[3] if I held any subjective orientation entering this research, it was that urban greening is 'good' – in the fullest sense of the term. This may still largely be true.

I understand that certain findings of this dissertation may be unsettling to some. That is a challenge I have confronted myself; and when sharing this work with friends and colleagues, many whom have dedicated their personal and professional lives to protecting the environment. I share this passion and conviction, as the scale and implications of human induced ecological decline are staggering.

It is that same spirit of concern that underpins this work. And it is my heartfelt hope that this dissertation can contribute a small step towards a more sustainable, livable future.

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[1] Sharon M. Ravitch and Matthew Riggan, *Reason & Rigor: How Conceptual Frameworks Guide Research* (Los Angeles, CA: Sage Publications, Inc., 2011).

[2] Thomas Nagel, *The View From Nowhere* (New York: Oxford University Press, 1986).

[3] Positionality refers to the researcher's role and identity in relationship to the context and setting of the research. See Sharon M. Ravitch and Nicole Mittenfelner Carl, *Qualitative Research: Bridging the Conceptual, Theoretical, and Methodological* (In Press, 2015). Sandra Harding also argues that recognizing the cultural frames in which we are positioned can lead to greater objectivity. See "After the Neutrality Idea: Science, Politics, and 'Strong Objectivity,'" *59* 3 (1992): 567–87.

CHAPTER I

Introduction

"Trees satisfy our longing 'to find in nature a consolation for our own mortality.' It is hardly surprising, then, that few of the world's cultures lack an arboreal component; in many, trees play a central role."

- Thomas J. Campanella, in *Republic of Shade: New England and the American Elm* (2003, 5)

"It seems appropriate to assign the term 'Anthropocene' to the present, in many ways human-dominated, geological epoch . . . This will require appropriate human behaviour at all scales . . . At this stage, however, we are still largely treading on *terra incognita.*"

- Paul J. Crutzen, in *Geology of Mankind* (2002, 23)

Context

Municipalities around the world are showing substantial interest in urban greening (Birch and Wachter 2008; Daniels 2008), defined here as the introduction or conservation of vegetation in cities. Singapore has devoted roughly half of its ground area to greenspace (Beatley 2011) and established a goal of "pervasive greenery . . . wherever the eye could see" (ULI 2013, 26). Berlin, Malmö, Seattle, and Washington, D.C. have adopted Green Area Ratios, innovative planning policies that require the minimum surface of a site to contain flora (Keeley 2011; Kruuse 2011; District of Columbia 2014). Over 30 North American cities have green roof and/or wall policies, incentives or guidelines (GRHC 2014), and some 100 living walls have been installed in Paris.[1] New York City (2013) has committed $8.5 million to create 480 new green street sites by 2017, while U.S. municipalities are establishing ambitious canopy cover goals and pursuing major tree

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[1] Jacques-Olivier Bled, pers. comm., 2013. Agence d'écologie urbaine, Direction des espaces verts et de l'environnement, Mairie de Paris, France.

planting programs, many of which aspire to a million new trees within the decade (R. F. Young 2011).[2]

This bloom of activity – described by some as a "frantic greening process" (Cariñanos and Casares-Porcel 2011, 206) – may be unlike anything since street trees and large parks transformed the fabric of cities in the 19th century (Schuyler 1986; Lawrence 2006). These urban practices are arising amidst two major historical events. First, cities are now the dominant form of human settlement and nearly 70% of people will live in urban areas by 2050 (UN 2012). Second, humanity's cumulative impact upon the biosphere suggests that the Earth has entered a new geological era described as the Anthropocene (Crutzen and Stoermer 2000; Crutzen 2002; Steffen, Crutzen, and McNeill 2007; Rockström et al. 2009; Zalasiewicz et al. 2010; Kolbert 2011; Revkin 2011; Robin, Sörlin, and Warde 2013; Kolbert 2014).[3] As world historian David Christian (2012, n.p.) observes:

> "Climate change, acidification of oceans, high rates of extinction, and deforestation are all linked and have to be seen as expressions of a single phenomenon: the astonishing technological creativity of our species that has culminated in the Anthropocene epoch."

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[2] Current interest in street tree planting may extend beyond the U.S. In Paris, the number of street trees has surged since the late 1990s by more than 12%, to over 100,000 today (Laurian 2012). London has set a target to increase tree cover from 20% to 25% by 2025, which equates to roughly 2 million additional trees (Ween 2012).

[3] The Anthropocene has been described as supplementing the Holocene, the unusually warm post-glacial period of the past 10 to 12 thousand years (Crutzen and Stoermer 2000; Crutzen 2002) during which major advances in human technology – including the Agricultural Revolution, the Industrial Revolution, and the Information Age – have occurred. The Geological Society of London is now looking at the Anthropocene as a formal problem in geology (Kolbert 2011). Crutzen and Stoermer (2000) acknowledge that assigning a date to the onset of the Anthropocene can seem arbitrary, and some proposals may include the entire Holocene. Yet, they have proposed the latter 18th century emergence of the Industrial Revolution as an epochal transition point, after which the concentration of greenhouse gases from fossil fuel emissions and large changes in biotic assemblages in lakes suggest a systemic human influence.

We have just begun to internalize this new understanding, and as we grapple with the implications, Crutzen notes that "we are still largely treading on *terra incognita*" (2002, 23). This dissertation seeks to make meaning of urban greening at this unprecedented inflection point. It does so through: a longitudinal chronicle of trees in U.S. cities; assessment of city planning and urban ecosystem services scholarship; review of scientific literature on the human health benefits of urban vegetation; a survey and interview of municipal tree planting practitioners; and exploring potential planning and design norms for greening 21st century cities.

Research Questions, Methods, and Conceptual Framework

Perhaps the largest and most symbolic type of plant material in the urban greening toolkit is trees; and in the United States, large-scale tree planting initiatives have cropped up in major cities. Young (2011) identified such programs in eight municipalities and one metropolitan county (see Figure 1.1). The greater Philadelphia region is planting one million trees (PHS 2014), and many other cities are pursuing ambitious canopy cover and tree planting goals (City of Boston 2007; City of San Antonio 2014; District of Columbia 2013). Yet, that there has been little research on the historical, cultural, political or institutional origins of such programs (Pincetl et al. 2013). This gap underlies Question 1 of this dissertation: *What is the historical basis for trees in U.S. cities?*

City	Launch date	Planting goal (# of trees)	Planting goal (# of years)	Total trees planted (11/30/2010)
New York City	2008	1 million	10	379,170
Los Angeles	2008	1 million	"several"	250,000
Houston	2008	1 million	5	400,000
Salt Lake County	2007	1 million	10	150,538
Sacramento	2005	5 million	20	40,882
Denver	2006	1 million	19	191,366
Seattle	2007	650,000	30	125,000
Baltimore	2006	a	30	28,000
Albuquerque	2004	75,000	2	30,000
Totals		11 million		1,594,956

Note: a. The City of Baltimore set doubling the city's canopy cover (from 20% to 40%) as their goal, rather than the planting of a specified number of trees.

Figure 1.1: City tree planting initiative launch dates, targets and performance (Young 2011).

Chapters II and III address this question by providing a history of urban trees in the United States. This research uses secondary source material as a foundation,[4] drawing upon works by Campanella (2003), Cohen (2004), Cranz (1982), Forrest and Konijnendijk (2005), and Lawrence (2006). These substantial historical works are augmented by literature on the history of gardens, which informed early urban greening interventions, as well as book chapters, peer-reviewed journal articles, organizational reports and original research, resulting in a chronological account in five parts: Colonial Settlements; the Early Republic; the Industrial Era; the Modern Metropolis (Chapter II); and the contemporary era, described as the Anthropocene Awakening (Chapter III).[5]

Within each of these periods, three crosscutting themes are consistently addressed: the dominant tree planting outputs of the era; followed by subsections addressing prominent

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[4] Secondary source material describes, interprets, analyzes and evaluates primary sources (Benjamin 2007; Ithaca College Library 2014), and serves as a departure point in historical research (Princton University Library 2014).

[5] In this periodization, the Anthropocene is framed as the culmination of a half-century awakening in ecological consciousness that began with the environmental movement of the 1960s-1970s and evolved to systemic concerns about sustainability in the 1980s-1990s. Today, the Anthropocene construct is penetrating scholarly and popular discourse, including such mainstream outlets as *Forbes* (2014a; 2014b), *National Geographic* (2011), *National Public Radio* (2008; 2013), and *The Economist* (2011).

actors and drivers. While the primary focus of the chapter is on public trees in U.S. cities, it behooves the narrative to provide historical context, especially as early American tree planting was influenced by European precedent (Lawrence 2006). Thus, initial sections in Chapter II address the introduction of urban trees in the public landscape of European cities during the Medieval, Renaissance, and Enlightenment periods.

An important finding of this historical research is that the rationale for urban trees has undergone a significant shift, from civic improvement and beautification to ecosystem service provision (e.g. Campanella 2003; Lawrence 2006; Young 2010; Silvera Seamans 2013; Young 2013). In public policy discourse, urban ecosystems are often portrayed as green infrastructure (EEA 2011; DG Environment 2012); and green infrastructure can be understood as the biophysical artifact that generates urban ecosystem services. These related constructs are informing much of current research on urban greening (Wolf 2008). Both ecosystem services and green infrastructure share an anthropocentric orientation, where human health is framed as a principal benefit (MEA 2005; APA 2013).[6] This is elaborated upon further in Chapters IV and V, which revealed that green infrastructure and urban ecosystem services discourse make little reference to public health scholarship. This suggests that there may be an *a priori* presumption of human health benefits undergirding contemporary urban greening research and practice.[7] Figure 1.2 illustrates this in visual terms and serves as a conceptual framework for the dissertation.

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[6] Early conceptualization of green infrastructure had a strong wildlife conservation orientation that drew upon norms in landscape ecology, such as the protection and restoration of "hubs and links" (Benedict and McMahon 2002). However, green infrastructure soon became synonymous with "low impact development" and alternative stormwater management techniques, where the primary goal is to hold or infiltrate stormwater directly into the ground – often but not always through vegetated systems – instead of channeling runoff into traditional grey infrastructure culverts and pipes that discharge into nearby surface waters (Prince George's County, MD 1999; Eisenman 2004; Eisenman 2005; City of New York 2012; LIDC 2014).

[7] *Dictionary.com* defines "a priori" as: 1) From a general law to a particular instance; valid independent of observation; 2) Existing in the mind prior to and independent of experience, as a faculty or character trait; 3) Not based on prior study or examination; non-analytic: an a priori judgment.
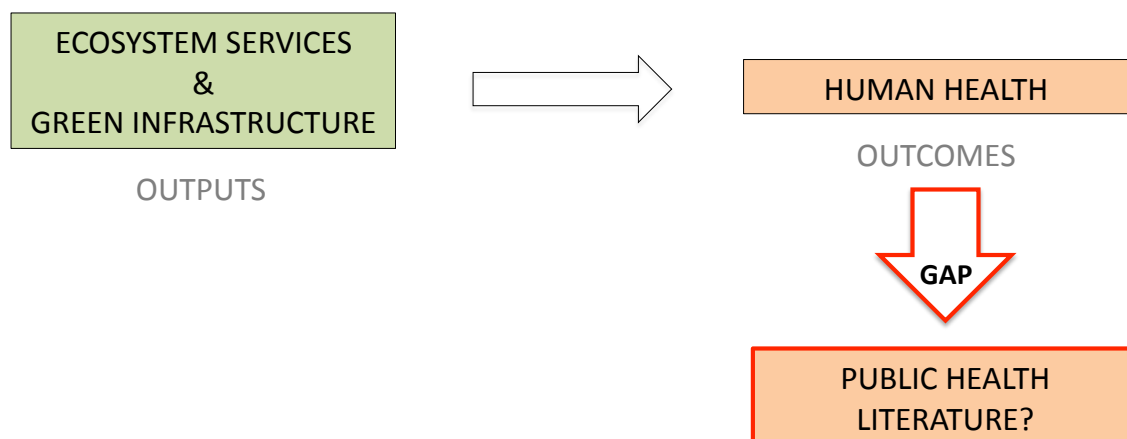
Figure 1.2: Conceptual framework linking public health literature to ecosystem services and green infrastructure. Source: author.

Some scholars contend that scientific claims underlying ecosystem service arguments for urban sylva may be flawed (Pataki et al. 2011; Pugh et al. 2012; Pataki et al. 2013; Pincetl et al. 2013; Vos et al. 2013; Whitlow et al. 2014b), and that tree planting may divert attention from the underlying causes of environmental decline while inhibiting more substantive solutions (Cohen 1999; Cohen 2004; Silvera Seamans 2013). This raises important questions about the relationship between urban greening science and practice, and it highlights a noteworthy gap in the literature: "exploring the attitudes of municipal managers . . . towards trees within urban environments (Roy, Byrne, and Pickering 2012, 360).

These lacunae underpin Question 2: *How do urban greening practitioner perceptions of benefits compare to scientific literature?* To address this question, two studies were undertaken. First, a literature review on the human health benefits of urban vegetation was conducted (see Chapter V). Drawing upon peer-reviewed literature identified in common search engines (Avery Index to Architectural Periodicals; GreenFILE; ISI Web

of Science, MEDLINE) through August 30, 2013, plus indices in relevant books, reports, and articles, this study assessed links between urban vegetation and five categories of human health outcomes: 1) air quality and asthma; 2) cooling and heat related morbidity and mortality; 3) physical activity and obesity; 4) mental health; and 5) social cohesion. When available, peer-reviewed reviews in scholarly journals served as a foundational data source. Twenty such reviews were identified, the findings of which were classified and aggregated by: method (qualitative or quantitative); whether the review was systematic or not; and by the direction of evidence (i.e. "+" = beneficial effects cited; "+/-" = mixed effects or weak evidence cited; and "-" = no effects or disservices cited).

Findings from this review were then compared with the perception of benefits amongst municipal tree planting organizations and leaders, using qualitative and quantitative methods. Summarized in Chapter VI, this study first tabulated the benefit claims of urban trees in the web-based documentation – one of three forms of qualitative data (Patton 2002) – of 27 municipal, national, and nonprofit organizations engaged in or advocating for urban tree planting and cities identified as having exceptional urban forests. These organizations were identified in literature and through Internet search. Following up on this document review, I surveyed and interviewed by telephone 33 local managers of municipal tree planting in cities identified in literature as having large scale tree planting initiatives or exceptional urban forests.[8]

Survey/interviews were conducted between February 13, 2014 and June 9, 2014. Participants represented 25 organizations in 13 cities and included the following professional titles: Arborist; Chair of City Forest Conservancy District Board; Chief Forester; City Arborist; Community Engagement Manager; Community Forest Manager; Community Forester; Community Partnerships Director; Director of Technical Services

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[8] In keeping with guidelines at the University of Pennsylvania Institutional Review Board, the personal and institutional identity of research subjects must remain anonymous.

and Research; Environmental Sustainability Manager; Environmental Sustainability Policy Advisor; Executive Director; Forestry Inspections Supervisor; Greening Coordinator; Horticulturist; Neighborhood Trees Manager; Neighborhood Trees Senior Specialist; Operations Director; Program Manager; Project Manager; Senior Planner; Urban Forester; Urban Forestry Manager; and Urban Forestry Supervisor. Following the survey/interview, participants were provided an opportunity to review their responses to ensure accuracy.

The survey was structured as listing questions, ranking questions, and Likert scale questions (a.k.a. summated rating). Listing questions allowed respondents to narrow the field of potential benefits so that they could subsequently rank these benefits in a meaningful way (Iarossi 2006). The purpose of ranking is to depict the position of certain items or categories, usually on the basis of magnitude or frequency (P. V. Young [1939] 1966). Here, respondents were asked to list the top five benefits of urban trees across different categories; then they were asked to rank these benefits on a scale of one to five, where one is the most important and five is the least important. Likert scale questions are a common tool for measuring people's attitudes, beliefs, emotions, feelings, perceptions, personality characteristics, and other psychological constructs. This survey technique also allows people to indicate their position on items along a quantitative continuum (ibid.; Spector 2004).

Survey questions were structured around three themes. The first set of questions sought to identify respondents' perception of the most important human health and well being benefits and quality of life benefits of urban trees. Here, one question focused specifically on the perception of urban trees to significantly reduce air pollution, as this is currently a subject of debate in scientific literature (Pataki et al. 2011; Nowak et al. 2013; Pataki et al. 2013; Whitlow et al. 2014a; Nowak et al. 2014; Whitlow et al. 2014b). Several studies suggest that urban trees may concentrate street level air pollution by reducing air

circulation (Gromke and Ruck 2007; Gromke and Ruck 2009; Gromke and Ruck 2012; Wania et al. 2012; Vos et al. 2013), contribute to air pollution through release of volatile organic compounds (VOCs) (Chameides et al. 1988; Domm et al. 2008); and increase pollen allergy and/or asthma (Dales et al. 2008; Jariwala et al. 2011; Cariñanos and Casares-Porcel 2011; Lovasi et al. 2013; Jariwala et al. 2014).

A second set of questions sought to identify participants' perception of the value of urban trees to address global environmental decline, in particular climate change. Here, there are also conflicting messages circulating in the literature. Some argue that urban tree planting is a meaningful strategy to mitigate global climate change (Akbari et al. 1992; McPherson 1992; Nowak and Crane 2002; Simpson 2002; Nowak et al. 2007); others question this strategy (Pataki et al. 2009; Pataki et al. 2011; Pincetl et al. 2013).
A final set of questions explores how practitioners perceive residents' appreciation of urban tree benefits. This is predicated on arguments that professionals often hold a different set of values from laypeople (Corburn 2005), and that urban environmental policy is strengthened by incorporating community-based knowledge (Irwin 2001; Corburn 2007).

Findings for listing questions were summarized as a percentage of total respondents. Findings for ranking questions were summarized in rank order, where "1" is the most important benefit and "5" is the least important. Likert scale questions were summarized as a percentage of total respondents. This quantitative survey was followed by open-ended questions, a second form of qualitative data that adds richness to closed-ended data and provides interviewees the opportunity to explain the nuances of their choices (Patton 2002). Open-ended questions also add meaning to what may otherwise be abstract quantitative results (Hyman 1955).

To translate these findings – as well as those from the history of trees in U.S. cities – into meaningful guidance for urban greening research, policy, and practice, <u>Question 3</u> in Chapter VII asks the following: *What are the gaps, opportunities, and potential norms for urban greening research, policy, and design?* In addition to exploring recommendations for urban ecosystems services, and urban planning and design, this final chapter concludes with a section that situates the findings of this dissertation in the context of the Anthropocene.

Relevance for Urban Planning & Design

The presence of vegetation in urban settings dates to antiquity (Gleason 2013). Roman poet, Martial (1897), coined the phrase *rus in urbe* to denote the virtues of urban greenery, suggesting that the ideal town environment would offer the benefits of countryside within its walls. Some two millennia thereon, this greening impulse was evident in the very roots of the urban planning profession, when parks and park systems emerged in response to the ills of 19th century urbanization, setting an early precedent for comprehensive thinking about urban design and planning (Schuyler 1986). Indeed, the aspiration to integrate nature and city has been "one of the few unchanging themes and goals of urban planning" (Hirt 2011, 19).

Over the past few decades, however, peer-reviewed urban planning journals have not devoted much attention to vegetation in cities (see Chapter IV). This is surprising given that flora is a substantial component in the physical, ecological, political, social and aesthetic life of cities. As early as 1852, the first U.S. municipal organization dedicated to "village improvement" named itself the Elm Tree Association, reflecting the priority placed on urban sylva. In the late nineteenth century, tree planting emerged as a formal municipal enterprise, and in the 1930s city planning journals published articles on Dutch elm disease (Campanella 2003).

Set in this historical context, the lack of attention to vegetation in contemporary urban planning literature raises questions about the evolution of the field, as well as issues directly germane to contemporary greening: Why haven't urban planners published more on this topic? Do urban planners not conceive of vegetation as legitimate infrastructure worthy of the same institutional, financial, and intellectual support as other capital investments and traditional grey infrastructure? If so, what hurdles does this present to institutionalizing green infrastructure today?

Another related issue is how potential urban greening benefits are framed within the larger suite of solutions to pressing environmental and public health problems. As illustrated in Chapter VI, prominent claims of urban tree planting practitioners include air and water quality improvement, urban heat island mitigation, and climate change mitigation, in addition to other benefits. Yet, scholars now question some of the purported ecosystem services of urban vegetation and also highlight disservices.

This dissertation situates contemporary municipal greening within the context of the Anthropocene, a phenomenon that is planetary in spatial scope and geologic in temporal span. This opens up important questions about the role of cities – and the greening of urban landscapes – in addressing the pervasive influence of humans upon the biosphere. By extension, what role might urban planning play in exploring the relationship between cities and ecosystem services? Scholars that study related issues have explicitly called for greater involvement of urban planners in this conversation (Wania et al. 2012; Keune et al. 2013).

This dissertation may also cultivate stronger links among city planners, public health scholars, and natural scientists. Urban planning and public health, for example, are fields that informed one another and co-emerged in the late 19th and early 20th centuries – an association that weakened over time (Corburn 2004). And while the influence of the built

environment upon human health and well-being has emerged as a topic of substantial interest over the past decade, public health journals have published most of the research in this arena (Botchwey 2012). This represents an untapped opportunity for urban planners.

Lastly, the bloom of greening witnessed in municipalities around the world today is likely to have a substantial impact on the urban fabric and people's experience in cities. This is not a minor consideration, as the vast majority of humans will, by the middle of the 21st century, be living in cities. In these "socio-ecological systems . . . built by and for humans" (Groffman et al. 2014, 74), sustainable and livable urbanism is likely to become an increasing concern. Set in this context, it behooves planners and other disciplines engaged in the design and management of urban landscapes to gain greater clarity about the historical underpinnings, scientific literature, and practitioner perceptions of contemporary greening, in order to improve research and decision-making on the introduction and conservation of vegetation in cities.

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CHAPTER II

Urban Trees in the United States: Historic Context

"Everything humans do, and our ideas of the natural world, exist in a context that is historically, geographically, and culturally particular, and cannot be understood apart from that context."
  - Cecil C. Konijnendijk (2008, 2), in *The Forest and the City: The Cultural Landscape of Urban Woodland*

Introduction

Today, tree canopy covers roughly 35% of urban areas in the United States (Nowak and Greenfield 2012a), and it is hard to imagine an American city without verdant parks and tree-lined streets. Yet, the introduction of trees in the public realm of urban landscapes is a relatively recent phenomenon. For a medieval city dweller it would have seemed quite odd to plant a tree along a street instead of in a garden behind the house, and as late as the 1770s one British critic wrote: "a garden in a street is not less absurd than a street in a garden; and he that wishes to have a row of trees before his door in town, betrays almost as false a taste as he that would build a row of houses for an avenue to his seat in the country" (in Lawrence 2006, 3).[1]

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[1] Lawrence (2006) attributes this anonymously published statement to John Smith in *Critical Observations on the Building and Improvements of London* in 1771.

Few objects in human culture are infused with as much symbolic meaning as trees
(Davies 1998; Rival 1998; Cohen 1999); and as the largest and most iconic type of plant
material in the urban greening toolkit, their emergence in the public realm of cities
deserves special attention. This is especially true in the U.S., where trees hold a powerful
grip on the collective psyche. So deep is this taproot, that Rutkow describes the
"relationship with trees as one of the great drivers of national development;" one that
"belongs in a conversation with other forces that helped to forge American identity"
(2012, Kindle location 314).

To treat this subject comprehensively would require a book-length manuscript. That is
beyond the scope of this chapter and the following chapter, which are intended to frame
current-day urban greening by placing city trees in historic and contemporary contexts.
Fortunately, other scholars have engaged this topic from various angles. In *City Trees: A
Historical Geography from the Renaissance through the Nineteenth Century* (2006),
Henry W. Lawrence analyzes historic documents including reproductions of maps to
distill urban tree planting practice in Western civilization across three centuries, and he
identifies three dimensions that have informed the introduction of public city trees:
aesthetics, power and control, and national identity. *Urban Forests and Trees* (2005) is an
edited volume focusing primarily on Europe, where Mary Forrest and Cecil C.
Konijnendijk outline the history of urban forestry and trees on the continent. In *The
Forest and the City: The Cultural Landscape of Urban Woodland* (2008), Konijnendijk

extends this European inquiry by offering an in-depth analysis of city forests as cultural landscapes.

Across the Atlantic, Thomas J. Campanella's *Republic of Shade: New England and the American Elm* (2003) describes how this elegant and adaptable tree was an essential feature of U.S. cities for more than 100 years before succumbing to Dutch elm disease in the mid-20th century. In *Planting Nature: Trees and the Manipulation of Environmental Stewardship in America* (2004, 1)*,* Shaul E. Cohen situates U.S. forestry and urban tree planting in a mostly 20th century sociopolitical context, and he offers a provocative examination of "deputizing trees to do our environmental bidding."[2] *Politics of Park Design: A History of Urban Parks in America* by Galen Cranz (1982), supports the aforementioned urban tree histories by classifying and characterizing U.S. city parks in four periods.

These substantial historical works are augmented by literature on the history of gardens, which informed many early urban greening interventions, as well as book chapters, peer-reviewed journal articles, organizational reports, personal communications, and original research, generating a chronological account in three parts. While the primary focus of this and the following chapter are on public trees in U.S. cities, the narrative provides

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[2] In *American Canopy: Trees, Forests, and the Making of a Nation* (2012), Eric Rutkow situates trees and forests at the center of an historical account of U.S. nation building. While compelling, this narrative does not focus much on urban trees.

historical context as early American examples were heavily influenced by European

precedent (Lawrence 2006). Thus, Part 1 of this chapter briefly addresses the introduction

of trees in the public landscape of European cities during the Medieval, Renaissance, and

Enlightenment periods. Part 2 addresses trees in the historical U.S. city covering four

periods: Colonial Settlements; the Early Republic; the Industrial Era; and the Modern

Metropolis. The ensuing chapter (Part 3) covers U.S. urban trees in the contemporary

period, described as the Anthropocene Awakening.

Within each of these eras, three crosscutting themes are consistently addressed: the

dominant tree planting *outputs* of the period; followed by sections addressing prominent

actors and *drivers*. This chapter on trees in the historical U.S. city and the following

chapter on trees in the contemporary U.S. city are structured as one coherent narrative.

Thus, a historical summary is provided at the end of Chapter III.

<div align="center">PART 1</div>

<div align="center">**Trees in European Cities**</div>

The Medieval City (<1400s)

As early as 2800-2100 B.C. in Egypt, trees were used in private gardens to provide a

more salubrious setting for the wealthy or ruling class, but no evidence has been

uncovered regarding the use of trees in the public landscape of cities (Zube 1973). During

the Greek and Roman era, trees were present in public places, and it is to these classical

civilizations that we owe the concept of public parks and gardens (Gleason 2013).

Drawing upon historical literature, Gleason describes how: the victorious Greek general

Cimon returns rich from campaigns in Persia and makes a public gift of shade and water

to the agora (central gathering space) and the gymnasium (athletic training grounds);

Pompey gave his horti (garden) over to the populace during his lifetime, while Julius

Caesar and Marcus Agrippa did so upon their deaths; and Augustus, as emperor, built

Campus Martius as a vast public park. Yet over time, the nature of these gifts faded, so

that the tradition of the Roman public park was lost until the texts were explored again by

Rudolfo Lanciani and Pierre Grimal in the 20th century.

By the middle of the first millennium C.E., cities in Europe – including those still within

the Eastern Roman (Byzantine) Empire – had done away with pagan temples, and

apparently, with most trees in the public realm (Lawrence 2006). Analyzing

reproductions of old maps, Lawrence treats the idea of public open spaces primarily as

those which can be visibly encountered from the street, and he concludes that there could

hardly be a clearer contrast than that between the street and the garden in medieval

European cities. Trees in public spaces during this period were by and large limited to

churches or near the city wall, where the latter provided shade for periodic gatherings

such as livestock markets. Beyond the public realm, medieval European cities did of

course contain trees, but most were in small farm plots around the outer edge of the city, or in private gardens behind walls.[3]

It is noteworthy that within the era described as "the Middle Ages" – running from roughly 500 to 1500 – the notion of the garden itself underwent a substantial transformation. Based on an examination of illustrations depicting the biblical Garden of Eden, Leslie (2013) argues that prior to year 1000 (and for some time thereafter) most people perceived the garden primarily as an idea rather than a reality. For example, in illustrated Bible texts from this period, features that we would consider essential to an actual garden are largely absent. These post-lapsarian depictions of the Garden of Eden feature stylized trees that punctuate a simplistic two-dimensional narrative, "akin to a code rather than attempting realistic representation" (ibid 17). This all changed, however, in the High Middle Ages, when illustrations depicting the Garden of Eden used

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[3] An archetypal garden of the early Renaissance is that associated with monasteries. Here, men and women without great personal wealth—though the institutions were often wealthy, particularly after the year 1000 —created gardens and other garden-like spaces in orchards, meadows, and woodlands. These ecclesiastic green spaces were prized not so much for their aesthetic quality, but rather, because they contributed to a sense of purposefulness and productivity, working with and fulfilling God's creation, e.g. the physic garden, the herb garden, the orchard, and the cemetery garden. Yet, Leslie (2013, 13) points out that both religious and nonreligious gardens in this period were characterized by a walled boundary, creating "a private, contained, controlled exclusive world" that was physically separated from the physically accessible public landscape of streets, plazas, and marketplaces. In addition, Konijnendijk (2008, 3) describes royal hunting grounds and deer parks along the urban periphery as part of the peri-urban woodland, and he cites evidence that the German term – *Forst* – originally referred to royal hunting areas. Access to these feudal woodlands was limited to royalty and nobility (Forrest and Konijnendijk 2005).

architectural detail contemporary with the images and included trees strategically placed at the garden edge and/or center. Leslie points out these differences to reinforce that the idea of the garden has changed as a result of social, political, economic, and cultural developments. The same holds true for urban trees.

The Renaissance City (1400s–1700s)

Abetted by the unprecedented exchange of ideas thanks to the invention of the printing press and increased travel, Renaissance Europe[4] emerged from centuries of church orthodoxy to find a world that was changing rapidly in scale and scope. Amidst such upheaval, the "garden provided an earthen palette on which to address these changes," (Hyde 2013, 4) and "the cultivation of plants and the landscape became entwined with the cultivation of the self" (ibid 2). Of note, large spaces were designed – for the first time – with the same skill as individual buildings, and gardens created precedents for urban design and the introduction of trees in cities (Lawrence 2006).

Early Renaissance Italy departed from medieval traditions by using almost exclusively ornamental plants, and brought forth spectacular gardens characterized by classical geometries, fountains, flowerbeds, trees, ornate topiary, grottos, multi-level parterres, and a range of vistas to enhance the aesthetic experience. Emphasizing views to the

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[4] Lawrence (2006) treats the seventeenth century as a discrete Baroque period; yet, Hyde (2013) describes the numerous and competing definitions of the Renaissance and settles on the period between 1400 and 1700, thereby situating the Baroque as a sub-period within the Renaissance.

surrounding countryside, these gardens "jumped the wall" and became of interest to others. By the early 16th century, some garden owners built gates for public access and posted inscriptions of what was to be called the *Lex Hortum*, the law gardens, stipulating that the public be admitted as long they behave themselves (ibid).

During this period, an important influence of upon urban tree planting emerged in the late Renaissance (or Baroque) in France, whose autocratic monarchs saw the landscapes of gardens, palaces, and capital cities as a canvas upon which to demonstrate their power. Here, garden design extended directly into urban design, and the first systematic planting of trees in the public landscape of Western cities would borrow a prominent element from the Baroque garden: the double row of trees known as an *allée* (ibid). A notable example is the Tuileries gardens adjacent to The Louvre in Paris, designed in 1570 by Philibert de l'Orme for Catherine de Médicis, then Queen Mother. Originally inspired by the Italian Renaissance landscape tradition, the garden's main axis was later extruded into a largely unbuilt rural landscape by order of Marie de Medici. In the ensuing decades, this was extended 1.9 km and lined with trees, establishing a spatial ordering mechanism for the capital city and creating one of the world's most recognized boulevards, the Champs Élysées (Steenbergen and Reh 2003).

The allure of the allée might also be seen as an artifact of the Renaissance mind's new understanding of linear perspective. Prior to this revelation, paintings and drawings

typically sized objects and characters hierarchically according to their spiritual or thematic importance, not their distance from the viewer. Yet, as Lawrence (2006) describes, influential 17th century garden designers, Claude Mollet and Jacques Boyceau, worked out the mathematical relationships for the most harmonious dimensions of an allée. The latter cautioned that these long pathways need to be sufficiently wide to avoid a visual tunnel effect.

The translation of garden design to urban design also reflected changing recreational and cultural habits. With increasing prosperity and wealth, there developed a growing number of people with leisure time, and outdoor recreation moved beyond the garden wall to become an important urban land use. The double allée, for example, provided shade and marked the course of *palemail*, an increasingly popular game originating in Italy and moving north through France, Holland, and England, where it became known as *pall mall.* In the 1660s, Charles II ordered the construction of Pall Mall in London's St. James Park, which was open to the public "as long as they behaved themselves" (Lawrence 2006, 33). After the game fell out of favor in the 17th century, these long allées of trees were adapted for use as promenades, and by the 18th century the terms *mail* and *mall* were increasingly used for promenades without grass or lawn games of any kind – a precedent that would be replicated throughout U.S. cities and university campuses in the 20th century.

Recreational carriage promenades also gained popularity. In Paris, 1610, a 1 km quadruple row of elm trees along the right bank of the Seine demarked the *cours la Reine,* accessible only via the queen's gatekeeper and perhaps the most exclusive outdoor social venue in Europe. In uniting trees and wheeled vehicles for the first time in a European city, this set a precedent that would soon by emulated in urban landscapes across the continent. In 1647, Berlin constructed the *Unter den Linden*, a 1 km long and 60 m wide allée of Linden trees with a central lane enclosed by a wooden railing reserved for pedestrians, and two outer lanes for horses and carriages. This adaptation to vehicular travel would see the tree-lined allée evolve into the urban boulevard and avenue, described by Mumford (1961) as the most important artifact and symbol of the Baroque city, expressing the hegemony of the monarchy and establishing a monumental scale and urban design language that would be replicated worldwide.

The Netherlands was another important innovator in urban tree planting during this period. In order to stabilize soil, planting trees along canals and moats became an increasingly common practice. In a 1597 plan of Amsterdam, trees are shown along some canals and even in front of a few buildings. By 1625, almost all of the city's canals were lined with trees: first lindens that were gradually replaced by elms in the 1700s. The streets adjacent to these canals were so narrow that tree leaves often touched the buildings, whose lot widths (generally 20-, 26-, or 30-feet) dictated the spacing of plantings: one per lot. So cherished were these trees that the city established ordinances

and encased the trunks in wooden boxes to protect them. This resulted in an unprecedented – and for the time astounding – introduction of trees throughout the urban fabric. To visitors witnessing this for the first time, it was unclear "if they were seeing a city in a forest or a forest in a city" (Lawrence 2006, 44), and pedestrians experienced the urban fabric as a network of promenades – albeit less ostentatious and more accessible to lay citizens than the aristocratic precedents of France.

Seventeenth century England also contributed two innovative urban landscape forms that advanced the introduction of city trees: the residential square and the tree-lined walkway. Based on continental models from royal gardens, the residential square became a significant new feature of elite residential areas for 200 years, especially in London. The Covenant Garden Piazza, begun in 1630 between Westminster and the City of London, was the first; and by the 1690s, provincial towns were imitating precedents of the capital city, most of which contained trees. These residential squares were intended for passive enjoyment, as settings for the relatively modest townhouses of the wealthy class. The first and most influential of English tree-lined walkways – essentially garden allées outside of the garden – were those on the Moorfields of London, which connected a series of fields just beyond the old city walls (ibid).

A few noteworthy advances emerged elsewhere in Europe. In addition to the *Unter den Linden* described above, Berlin's *Lindenstrasse* was lined with trees by the late 17th

century, several German towns planted trees along portions of their fortifications and Lindens were commonly planted in malls. In Madrid, the *Paseo del Prado* along the lines of the old city walls in front of the royal gardens echoed the French *cours* for carriages, and was the only important tree-lined promenade in the Iberian peninsula. In Rome, Pope Alexander VII also drew upon French precedent when laying out a tree-lined avenue running from the Arch of Septimius Severus to the Arch of Titus. Yet, France, the Netherlands, and Britain largely pioneered the introduction of trees in the public urban landscape in Europe during the Renaissance era, reflected in the formal allée, tree-lined canal, and residential square and semi-rural park, respectively (ibid). Lawrence notes that most tree planting during this era occurred at locations along the urban edge, due in part to greater availability of land but also to the belief that trees belonged in nature outside of the city. A noteworthy exception is The Netherlands, where tree-lined canals were internal, not external, to the city proper.

Actors & Drivers

The 17th century was a time of increasing material prosperity, leading to a growing leisure class and emphasis on recreation as an important urban land use. Accompanied by a system of social rituals that included displays of wealth, sense of taste, and fashion, many of these public places were outdoor promenades lined with trees. The outdoor promenade offered freedom from the confining social codes of indoor space, the possibility of private conversation and chance encounters, and the trees that characterized

these public spaces connoted the sense of joy and pleasure associated with gardens. Yet,

behavior in these outdoor settings came with a code – gentle, passive recreation –

developed first by the aristocracy then modified by the emerging bourgeoisie

(Konijnendijk 2008).

Reflecting the power structure of the period, most urban tree planting initiatives were

sanctioned by a small cadre of individuals, oftentimes a single leader such as Loius XIV

in France, Friedrich-Wilhelm in Germany, or Pope Alexander VII in Italy. These actors

saw urban tree planting as public expressions of power, inspired by a similar impulse that

undergirded the royal gardens of Versailles: "the most splendid expression of absolute

monarchy in history" (Jellicoe and Jellicoe 1995, 188). But the autocrats who planted

tree-lined public allées were also expressing another kind of power: the ability to provide

their leisure-class subjects an amenity that they could not provide for themselves. In so

doing, these early urban greening interventions accrued to their agents the mark of

beneficence.

In the Netherlands, by contrast, local leadership responded to a more utilitarian impulse

that benefitted the population at large by stabilizing canal banks. It is also significant that

formal planning in Dutch cities included trees, as this was noticeably absent elsewhere in

Europe (Lawrence 2006).

The Enlightenment (1650–1800)

The Renaissance period's liberation of creative agency gave rise to the Enlightenment, a

cultural movement beginning in late 17th-century Europe that sought to reform society

using reason, challenging ideas grounded in tradition and faith, and advancing knowledge

through the scientific method (Kors 2005). In cities, this expressed itself through

embellissement, "not just visual niceties, but serious change in the quality of the urban

environment" (Lawrence 2006, 66). Indeed, the vast majority of people during this period

lived and traveled on streets that not only lacked trees, but also sidewalks, drains, and

lighting: a condition that had not improved much since the Middle Ages, resulting in

pedestrians routinely being injured or killed under the wheels of vehicles.

Lawrence contends that the Enlightenment contributed two ideas relevant to the use of

trees in cities; namely, an emerging emphasis on order and nature. The aspiration for

order expressed itself through an appreciation of aesthetic values such as visual clarity,

symmetry, and harmony – leading to a desire for urban beauty. In nature, the human mind

now perceived an impartial reference to guide conduct, and there existed a reciprocal

relationship wherein man could both improve nature through reason and design, and

nature contact could improve man by making him less artificial.

In *Symbolic Space: French Enlightenment Architecture and its Legacy,* Etlin (1994)

identifies four characteristics of an enlightened view of the ideal city that emerged in the

middle of the 18th century: the space of *magnificence* expressed through long views and monumental scale; the space of *hygiene* expressed through openness, free circulation of air, and provision of clean water; the space of *clarity* illustrated through recognizable order, such as appropriate architectural treatments for a building's purpose; and the space of *emulation* manifest through associational statuary. Lawrence (2006, 62) argues that trees were integral to each of these constructs:

> "The space of magnificence often relied on trees to frame long vistas; the space of hygiene included the planting of trees both for healthy recreation in promenades and for the shade they afforded in the summer; the space of clarity used green spaces and peripherals allées to establish a relationship between city and country; and the space of emulation included the inspiration to moral improvement supplied to the lower classes by observing the behavior of the upper middle classes in public green places"

As evidence, he draws upon examples from France and Britain, whose urban landscape traditions were the dominant influences of the period.[5] Throughout the 18th century, the French style of formal gardens and taste in recreation dominated continental Europe, and by the 1780s there was hardly a town that did not have some sort of green promenade. The Province of Brittany, for example, was said to have 54 new promenades in 28 towns.

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[5] See Lawrence (2006, 70–75) for a description of trees in European cities beyond France and England during the period.

With the increasing decommissioning of fortifications, a great number of promenades were laid out atop or along city walls, while several cities (Nantes, Orléans, Caen, and Bordeux) completely razed their walls and replaced them with tree-lined boulevards.

While the number of peripheral promenades multiplied, a new urban landscape element emerged: formal squares planted with trees in the interior of towns. The large *Place Bellecour* in Lyon in the 1720s was the earliest, with allées of trees running along three of its sides. Nancy, La Rochelle, and Rochefort followed suit, yet the vast majority of *places* (French urban squares) did not contain trees (ibid).

While no new towns were built in France during the 18th century, cities such as Lyons and Nantes did attempt expansions that included trees in the plan. But the more important way that urban expansion influenced the use of trees was when it enveloped previously peripheral promenades and transformed them into internal tree-lined streets. As Paris expanded outward, trees originally intended for foot and carriage promenades became ornamental frames for new pleasure zones. But these swaths of green were still far from the urban center, and they functioned primarily as amenity destinations to escape the increasingly squalor of the city.

An important exception to the pattern of urban embellishment witnessed in continental Europe emerged in Britain and Ireland, which maintained very different urban landscape

forms. While tree-lined walkways were still laid out in some towns, most were relatively small compared to the monumental promenades derived in France, and many were in parks, gardens, or well outside of town. Building on a precedent from the preceding century, one of the important urban forms were residential square gardens. In 1700, London had nine residential squares but only six had gardens. By 1780, the city had gained an additional eight, all of which had gardens; and gardens were added to two of the earlier squares. Lawrence notes, however, that as trees in the older squares grew to maturity, some people complained about the dank shade they generated.

He also finds that the main attribute of these residential squares was visual, and they were intended to enhance surrounding property value. Most residents of these early squares were aristocrats with large country properties, and creating a semblance of their preferred rural landscape had strong appeal, of which developers and landlords were well aware. Gardens in public residential squares also prevented other uses including market vendors, loitering by the homeless, and dumping of garbage. Beginning in 1726, such uses inspired residents adjacent to squares to address such unbridled public access, ultimately leading to the Enclosure Acts. The first such act, for St. James Square in 1726, allowed surrounding residents "to make a rate on themselves for raising money sufficient to clean, adorn, and beautify the said square, and to continue the same in repair" (12 Geo I c. 25, in Lawrence 2006, 79).

Other British cities also created residential squares, some of which included gardens. One of the more novel green urban interventions was in Bath, the premiere spa in Britain, characterized by recreational and leisure. Here, John Wood (the elder) built Queen's Square in the 1720s, and in the 1730s he began the Parades: a square block of terraced houses facing out in four directions, the north side looking over an existing tree-lined promenade and the south over an envisioned garden that was never built. In the 1750s he began another unusual form, the circular Royal Circus, consisting of three arcs of unified terraces surrounding an open space paved with stone. Following the elder's death, John Wood the younger, completed the Circus and added a great open half oval called the Royal Crescent. With townhouses aligned along the arc of the crescent in a colonnade, and overlooking an open lawn, Avon River, and the hills beyond, "it was as close to the landscape setting of an aristocratic country house as a city could achieve" (Lawrence 2006, 82). Influenced by the naturalistic English style of gardening that is one of the noteworthy innovations of the period (Bending 2013), these landscape works gradually gave Bath a new urban form, and other resort towns developed a similar mix of urban and garden landscapes.

Reflecting this commingling of the urban and the rural, royal parks on the west side of London became increasingly more important as the urban fringe approached.[6] Despite

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[6] Royal parks and woodlands along the peri-urban fringe were common throughout Europe dating to the medieval era (Forrest and Konijnendijk 2005; Konijnendijk 2008).

attempts to limit access, St. James and Green Parks were essentially open to anyone who was well dressed, while Hyde Park was accessible to people of virtually all classes. This period also witnessed the emergence of commercial pleasure gardens (e.g. Vauxhall and Ranelagh) dedicated to refreshment and entertainment. In addition to facilities for drinking, eating, music, and dancing, these spaces included enclosed gardens, a promenade, and small side alleys among trees and shrubbery.

Eighteenth century England would also give rise to a naturalistic landscape style of gardening that led to the conversion of formalistic baroque gardens across the country, which directly influenced 19th century urban parks worldwide. Under the hand of designers including William Kent and Lancelot "Capability" Brown, the garden presented an idealized view of nature that drew heavily upon pictorial representations of landscape. This ascendant style was also accompanied by what has been called the cult of the tree in Britain. Says Lawrence (2006, 92), "where the baroque saw trees as elements of architectural composition and often pruned and pleached them severely, in the second half of the 18th century, trees were liberated, even venerated." This reflected Enlightenment thought that elevated nature as the inspiration and ideal for human conduct.

Actors & Drivers

Similar to the 17th century, allées were planted to display their creator's power and

beneficence (e.g. royalty in France and local rulers in Germany), and there is a notable

lack of these rows of trees in merchant towns and free cities of the period. The

boulevards, *places,* and statues of royalty repeated in cities throughout the realm were

also intended to reinforce a sense of nationhood. Moreover, there was considerable

economic value associated with trees in cities. In Nantes and Lyon, as well as in British

examples, private developers were the primary actors in tree planting.

Lawrence (2006) emphasizes that this market-driven rationale to plant trees in cities is

something that clearly emerges between 1700 and 1780. This occurred despite a

prevailing ambivalence amongst architects and critics. In a 1748 competition to design a

new *place* Royal in Paris, only one of 19 proposals contained trees. Voltaire's 1749 *Des

embellisements de Paris* said nothing of trees. Similarly, French architects Marc-Antoine

Laugier (1753) and Pierre Patte (1769) saw little role for trees within a city (in Lawrence

2006). In Britain, an anonymous author of *Critical Observations on the Building and

Improvements of London* in 1771, generally attributed to John Smith, goes one step

further and argues that, "*rus en urbe* is a preposterous idea at best" (in Lawrence 2006, 90).[7]

Yet, other writers did encourage planting trees in towns. Thomas Fairchild, a professional gardener in London, published *The City Gardener* in 1722, and advocated that squares be planted with a diversity of species that hold interest year round. Danish architect Johann Peter Willebrand published *Grundriss einer schönen Stadt* (plan of a beautiful city) in 1775, and in two short passages praises trees inside a city: in *Platzen* and in front of houses. Likewise, Spaniard and Enlightenment polymath Antonio Ponz published eighteen volumes between 1774 and 1794, wherein he approved of new trees in the *Ramblas* and in front of the citadel, praising the green leafy town of Aranjuez and advocating for planting trees in the countryside to protect soil and enhance views from towns.

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[7] Roman poet, Martial, coined the phrase "rus in urbe" to denote the virtues of urban greenery, suggesting that the ideal town environment would offer the benefits of countryside within its walls (Bohn's Classical Library 1897).

PART 2

Trees in the Historical U.S. City

Colonial Settlements (1600–late 1700s)

For European immigrants settling in New England in the 1600s, the forest harbored real and imagined dangers, i.e. "*horror sylvaneum*" (Grey and Deneke 1986, 3). It was also something to be conquered, and early settlers spent much effort clearing the forest for agriculture and timber products, gaining essential survival resources including wood for homes, fences, and fuel.

Unlike European colonial settlements in Asia and Africa where fortified outposts had to contend with other commercial empires and military concerns, early North American colonial towns – especially British and Dutch centers along the mid-Atlantic – were intended primarily for habitation by European settlers. In smaller towns, detached houses occupied the majority of the urban area. Even in large cities such as New York, Philadelphia, and Charleston, where most people lived in houses built adjacent to one another with shared walls, detached houses were common. During this formative period, streets were generally so narrow as to preclude tree planting and open space often manifested itself at a meetinghouse lot adjacent to a church. It was not until the 1800s that these spaces were converted into public property. These early common spaces were

rarely planted with trees (Lawrence 2006); stumps often being the only evidence of the former forest (Ricard 2005).

However, not all urban trees were cut in the colonial era. Ricard (ibid) cites evidence that communities planted and protected shade and ornamental trees as early as the mid-1600s. Salem, Massachusetts, passed and then reiterated a law in 1656–1657 directing that no trees could be cut on public land without permission from a magistrate unless it was for wood for housing, fencing, or for shipbuilding. New Haven, Connecticut, organized local beautification efforts as early as 1686; and in 1693, Reading, Massachusetts recognized the need for more shade trees.

During this period individual trees – especially the American elm (*Ulmus americana*) – sometimes held totemic significance (Campanella 2003). In Connecticut and western Massachusetts, isolated elms endowed space with meaning as a civic centerpiece, a relic of antiquity, or a monument to specific historical events or persons. Campanella describes, for example, the close association of home and elm during this early settlement period, where the ground surrounding large elms was often selected as a sheltered place to erect a house. Colonial homesteaders planted trees for sentimental reasons as well, to celebrate the establishment of a new home, or to commemorate family events such as birth, betrothal, or marriage. And one of the most potent symbols of political resistance leading to independence was an elm, the Tree of Liberty in Boston, under whose

branches crowds gathered and fomented a revolutionary spirit. "In the department of silent propaganda…no single venture paid richer dividends than the Tree of Liberty," argued one commenter (in Schlesinger 1952); and each of the original thirteen American colonies designated a Liberty Tree or built in artificial equivalent (Campanella 2003). (see Figure 2.1).

Figure 2.1: "Liberty Tree" (F.S. Hassam, Liberty Tree, Liberty Hall, 1891) in Campanella 2003, 35.

One of the more prominent urban public spaces to be planted with trees prior to independence was Boston Commons. Purchased by the city in 1634 and intended for cattle grazing and militia training, a committee was formed in 1661 to protect the few

remaining trees (including a large elm), the common was partially improved in the 1720s for better recreational use, and in 1723 a row of English elms (*Ulmus procera*) was planted along Common (later Tremont) Street, in what came to be called the Mall. This was fenced for protection from animals in 1733, and a second row of trees was planted in 1734, creating the most important public promenade in a colonial American town (ibid).

Most early New England towns responded primarily to the unique conditions of the local landscape, and were laid out with little regard for formal urban planning principles. New Haven, Connecticut is an exception. Here, nine large square blocks established a spatial framework: a central block was kept open with a church and burial ground at its center until 1759, when it was partially graded, old stumps were removed, and a row of trees was planted along a new road across its center. Also of note, as early as 1686 trees were planted in front of the house on Elm Street owned in 1748 by James Pierpont (Lawrence 2006), a Congregationalist minister credited with cofounding Yale University (Yale University Library 2014).

In the mid-Atlantic colonies, there was also variation in town plans and open space provision. Founded in the 1620s by the Dutch, Nieuw Amsterdam – later New York City – began haphazardly around a fort at the southern tip of Manhattan, and streets were laid out mostly perpendicular and parallel to the curving shore. These streets were narrow, with the exception of Broad-way, a wide road leading north from the fort, and Broad

Street, which had a canal excavated down its center. While tree-lined canals were the

single most important urban planning feature being implemented in the Netherlands, the

canal system in Nieuw Amsterdam was very limited, and according to Lawrence (2006),

included no trees. He further concludes that while trees may have been planted in front of

some buildings, there is no direct evidence of them until after the British takeover in

1664. Then, several places of public recreation were established that incorporated

greenery and trees. This included Trinity Church, a bowling green just north of the fort,

and several commercial pleasure gardens in the early 1700s.

In 1708, official minutes of the city council formally sanctioned planting trees in front of

houses, as people were apparently doing so and coming into conflict with local leaders.

According to Lawrence, the clearest graphic evidence for street trees in New York City

emerges in 1731, with a view by William Burgis showing three streets surrounding the

New Dutch Church, a sidewalk protected by a railing, and a row of trees planted at

regular intervals (see Figure 2.2). By 1748, trees planted in front of individual house were

a distinct feature of the city. American sycamore *(Platanus occidentalis)* and black locust

(Robinia pseudoacacia) were common, and trees were planted in a manner generally

lacking clear pattern. This unsystematic pattern was also expressed in Albany, and

reflected the preferences of individual property owners. Unlike anything found in

England, it can also be seen as the echo of Dutch tradition, and the total effect was that of

a disconnected network of treed spaces (ibid).
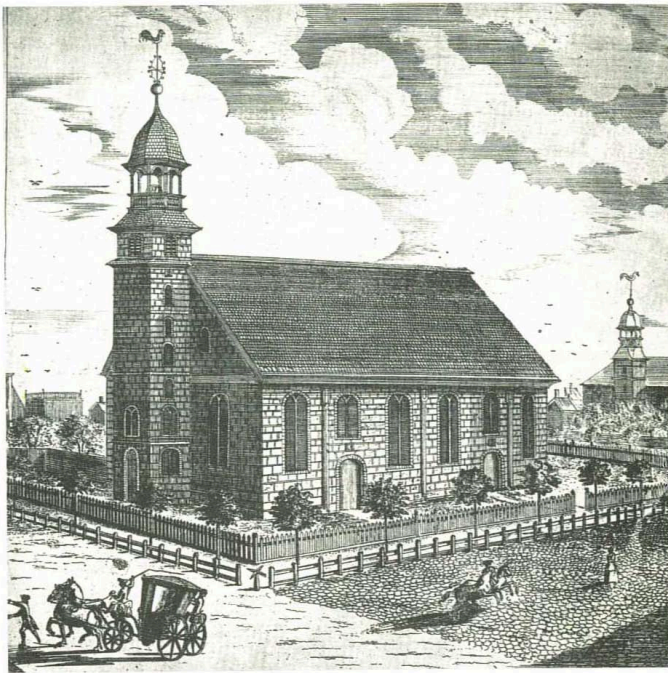
Figure 2.2: The recently completed New Dutch Church in New York City as portrayed by William Burgis in 1731 (Collection of the New York Historical Society, in Lawrence 2006, 119).

In colonial Philadelphia, William Penn's 1683 plan for a "greene country towne" and the intended capital city was unique in its time for the generous provision of open space via five public squares, spacious streets, and large lots for individual homeowners. Remarking on the plan's scaffolding of public squares, Campanella (2003, 110) finds that the city "had an abundance of verdure from the start," and "the earliest extant plan clearly indicates trees bordering each of these spaces." Lawrence (2006, 125), however, concludes that the plan originally laid out between the Delaware and Schuylkill Rivers was too large for the number of people inhabiting the city in the 18th century. By the time of independence the built-up area had spread west from the Delaware scarcely one-third

of the way to the Schuylkill, "and the squares were simply not important in the colonial period." The primary way that trees were visible in the public landscape was in private gardens, and while various sources advocated for street trees, he finds no published views of Philadelphia streets until after independence. In 1774, the Philadelphia Contributionship – a fire insurance company founded by Benjamin Franklin and others – announced its intention to refuse insurance to houses with trees too close. Yet, Lawrence surmises that these trees must have been few prior to the 1770s, and that there was no systematic planting of trees in this colonial city.

The southern colonies were dominated by a rural settlement pattern, and Charleston may have been the only true city in the region during the period.[8] By the mid-1700s, the most significant vegetated features in the urban landscape were the large private gardens of wealthy property owners. While separated from the street by high walls, the canopy of these garden trees could spread out over the footway and part of the street, providing some shade and giving the town a semi-forested appearance.

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[8] Lawrence (2006, 129) remarks that Savannah was not founded until 1733, and while its plan created a unique urban landscape including a series of open squares, these spaces were not planted with gardens until after independence, and "it would appear that trees were not planted along the streets before then either."

Actors & Drivers

Lawrence (2006) finds that trees in the public landscape of colonial towns in North America were planted almost exclusively by individual property owners. These were mostly homeowners who were inspired to beautify and perhaps shade the space adjacent to their houses. Trees were also planted by institutions such as churches and religious houses, or on the rare plot of common land that the public used for recreation, such as in Boston and New York City. But individual initiative predominated, and while "the combined efforts of many such individuals could enhance the public environment was undoubtedly understood…that the citizenry should collectively act through the government to accomplish something similar seems to have been out of the question" (ibid 132).

Ricard (2005), on the other hand, documents 17th century instances of public sector engagement in tree planting and protection, in Salem and Reading, Massachusetts and New Haven, Connecticut. Campanella (2003), in turn, illustrates the totemic significance of individual American elm trees in New England towns. In this case, trees became important gathering spaces and potent symbols of political resistance.

Early Republic (1780–1820)

In the years following independence from the British crown, the new republic gave rise to many new ways of using trees in cities. Some of this was in all likelihood inspired by a

fresh sense of cultural autonomy. Economic freedom fueled a rising leisure class. Above all, this was a period of tremendous population growth in cities: Between 1775 and 1820, Boston grew from 16,000 to 43,000, New York City grew from 25,000 to 124,000, and Philadelphia grew from 40,000 to over 100,000. This population growth was accompanied by a rising tide of civic improvement, leading to "an interconnected networks of tree-lined streets, private yards and gardens, green squares, public promenades, and public parks" (Lawrence 2006, 159). The net effect was a substantial increase in tree planting in the built-up areas of towns, and in more forms and settings than before.

Street Trees & Policies

The years following independence witnessed a dramatic shift in popular attitudes towards street trees, as well as shifting preferences for specific species. In New York City, a 1789 ordinance prevented tree planting south of the Common except around churches or other public buildings, and in 1791 another ordinance banned street trees anywhere. But this was repealed only 10 days later, and in 1793 and 1794 several individuals in the proscribed area were given permission to plant trees in front of their houses. Five years later a policy was adopted allowing trees on any street over 40 feet wide, in 1806 the city recommended that residents plant trees in front of their houses, and by 1810 fines were imposed on anyone doing damage to street trees. In other words, municipal policy went

first from hostility and grudging acceptance to encouragement and outright protection of trees along city streets in merely 21 years (Lawrence 2006).

Philadelphia lacked municipal policy toward street trees, but it too experienced a similar change in popular opinion. Drawing upon fire insurance policy records, a 1796 city plan by John Hills, and the engraved views of William Burch published between 1790 and 1800, Lawrence describes Philadelphia as a late 18th century scene of enthusiastic tree planting by individual homeowners. But the city also experienced contentious political struggles regarding the propriety of trees along city streets. Leading insurance companies refused to issue policies to property owners with trees close to buildings in the belief that trees posed a fire hazard, and they secured passage of a 1782 bill in the state legislature requiring removal of all street trees in Philadelphia. This instigated a backlash, including a major newspaper editorial and a citizen-signed petition asking for repeal of the law, to which the General Assembly complied. Ten years later a faction in the Common Council proposed an ordinance to empower the city to remove all trees, but it failed to pass a majority vote. Later resolutions indicated that individually planted trees were tolerated but not encouraged, and while the city did plant trees in the public open spaces it controlled, such as Centre Square and Southeast square, most trees were planted by individuals (ibid).

By 1818 street trees lined Philadelphia's principal thoroughfares (Campanella 2003), and interest in tree planting sparked a nationwide fashion for Lombardy poplars (*Populus nigra italica*), the most widely planted tree in American cities for a generation. Introduced around 1780, the easy transplanting and rapid growth of this non-native species meant that relatively large trees could be established in a few years, and the Lombard's narrow, columnar form may have made it easier to install along narrow streets, resulting in an instant effect on the urban landscape. The tree's scenic qualities were also enhanced by political and cultural symbolism: its vertical form distinguished it from other flora and came to represent innovation; the tree's Latin name denoted a certain populism; and its association with Northern Italy suggested classical refinement. The tree took America by storm, and New York, Boston, and Philadelphia planted hundreds along their main streets. In 1803 Thomas Jefferson lined Pennsylvania Avenue in Washington, D.C. with double rows of poplars from the White House to the Capitol (Campanella 2003) (see Figure 2.3). Views of New England towns at this time show Lombards along streets and in some commons, and by 1810 trees were found along streets in Ohio Valley cities including Cincinnati and Pittsburgh (Lawrence 2006).
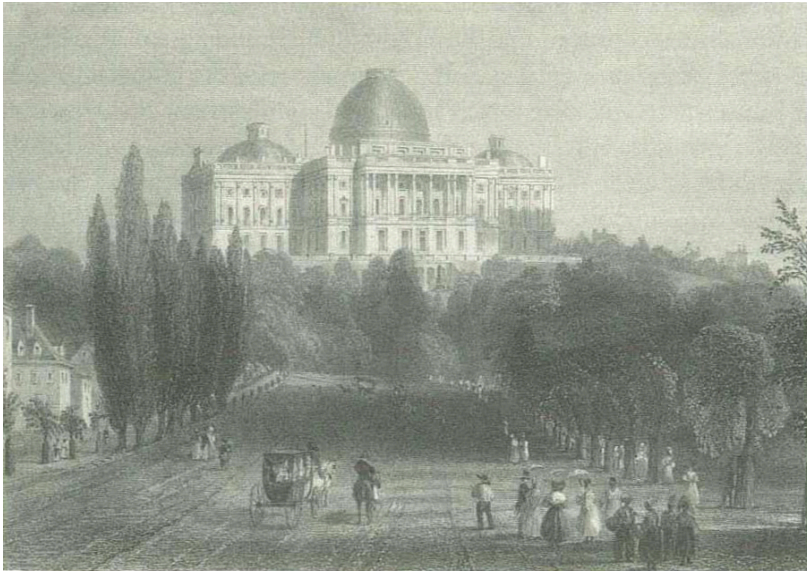
Figure 2.3: View of Pennsylvania Avenue and the Capitol, Washington, D.C., by William Bartlett in the 1830s, showing some of the Lombardy Poplars planted according to the plan drawn up by Thomas Jefferson in 1803 (Lawrence 2006, 169).

Yet, only two decades later, popular horticultural taste did an about-face. Where exotic species were once prized for their sophisticated allure, an ascendant interest in the American landscape and native plants resulted in the Lombardy poplar soon being perceived more "as the fabled hydra than a product of Eden" (Brewster 1859, in Campanella 2003, 81). Leading this charge were prominent figures including Supreme Court justice Oliver Wendell Holmes, who ridiculed the tree as sentries of the Old World, and landscape designer Andrew Jackson Downing, who once championed exotic trees but now advocated for natives. Downing held especially strong contempt for Tree-of-Heaven (*Ailanthus altissima*), whose aggressive growth and noxious odor made it unpleasant and difficult to manage. Downing's (1852) critique also compared this non-native plant to

"the treacherous heart of the Asiatics" and "the miserable pigtail of an Indiaman," and Campanella suggests that the shift in arboreal allegiance reveals the racist underbelly of mid-19th century America: a nativism that increased more and more as foreign immigration escalated toward mid-century. "If the Lombards lost their appeal because their symbolism was exhausted, the ailanthus was purged because it was the Other in sylvan form" (Campanella 2003, 82). By the 1830s most towns had removed the poplars and replaced them with other trees, especially the American elm.

In the slower-growing towns of the south, Charleston maintained the colonial pattern of houses perpendicular to streets with the vegetation of side gardens reaching across walls and providing shade. Responding to Savannah's growth, major streets were planted with double rows of trees, and many side streets were also planted, albeit less regularly. In New Orleans – now part of the expanding republic following the 1803 Louisiana Purchase – outer defensive walls were replaced by a series of streets with double rows of trees, reflecting a French influence that is distinct among American cities (Lawrence 2006).

During this early Republican period, some state and territorial legislatures began to take notice of shade and ornamental tree protection. For example, an 1802 shade tree act in the legislature of New York State provided that "along the border of any highway, not less than three rods wide, the private owner of the adjoining land might plant a row of trees,

provided they were placed at least six feet apart in the row. This law gave an action in trespass against anyone who should injure or destroy trees so planted" (Kinney 1917, in Ricard 2009, 96). And Zube (1973, 149) cites "an act passed in 1807 in the territory of Michigan, dealing with Detroit, which called for a double line of trees on both sides of 120-foot avenues and for trees to be planted in 'clumps or groves . . . of an elliptical shape" on both sides of 200-foot avenues. This act also provided for residential squares, probably similar in concept to those of London, that were to be 'planted with trees or otherwise improved and ornamented.'"

Public Parks & Squares

In the early republican period, public open spaces were also undergoing transformation and gaining increasing importance in civic life. It is important to note, however, that our contemporary understanding of public space as being accessible to all did not fully emerge until the mid-1800s, prior to which civic space meant places dedicated to public institutions (Jackson 1984). In 1817, for example, the Common Council in New York City voted to plant trees and grass in the area immediately adjacent to the new city hall and to open it to the public as a park, but its small size and minimal planting made such a moniker questionable. To the south, Bowling Green and the Battery were other significant public open spaces with trees prior to 1820, and combined with intermittent street trees, created a nascent network of greenery (ibid).

In Philadelphia, efforts to improve public lands as parks began with the State House

Yard. Used as a public walk as early as 1763, the yard was replanted in 1785 and in 1811

a surrounding wall was lowered to increase access. In 1799, Centre Square (now the site

of City Hall) was leveled and planted with Lombardy poplars around the pump engine

house. According to Lawrence (2006), the most significant public space improvement in

Philadelphia occurred at Southeast Square (now Washington Square), where a fairly well-

to-do group of residents petitioned the Common Council in 1802 to improve a portion of

the square – then being used as a horse and cattle market – as a public walk. The council

appointed a committee to study the matter and reported back with a supportive response.

Yet, the city was unwilling to fund improvements, and it was not until 1817 that

municipal investment to transform the space to a park began in earnest, with a botanic

garden of trees and shrubs.

In Savannah, there were 15 public squares in 1790 and most were planted by the turn of

the century eliciting accolades from visitors. Lawrence also references newly planted

street trees, and finds that even more than New York or Philadelphia, Savannah "was a

truly green town by 1820" (p. 174).

Actors & Drivers

Lawrence (2006, 159) suggests that the new uses of trees in Early Republic cities were

inspired, in part, by a desire to distinguish the nascent nation from Britain, "in self-

consciously symbolic ways." The post-independence rage for Lombardy poplars, for example, has been attributed to an interest in classicism and the antique world, lending the young nation an air of cultural refinement and sophistication (Campanella 2003). Yet, within the span of a few decades the fashion for exotics swiftly shifted to outright disdain, reflecting an ascendant interest in native flora that bordered on xenophobia. In this regard, symbolism and the search for national identity were important drivers of tree planting in the early republican era.

Increasing economic freedom and transfer of power from the aristocracy to the bourgeoisie led to a growing leisure class and purchasing power for luxury goods and adornments, such as houses and gardens. Combined with massive population growth in large cities, this gave rise to a new material culture that included public access to amenity spaces planted with trees – a process that would characterize U.S. cities through the 19th century (Lawrence 2006).

Reflecting the preceding colonial era, individual property owners were the primary actors of tree planting in the early post-independence years. Prior to the 1820s, most American towns relied upon property owners to maintain the abutting section of street and sidewalk. Local governments routinely passed ordinances directing residents to fulfill their civic duty and keep sidewalks and streets in good repair, issuing fines when property owners failed to pave them or allowed them to become obstructed. If individual

street trees were deemed to be obstructions or hazards, they were prohibited; otherwise, they were tolerated (ibid).

Individuals were also powerful advocates and instigators of tree planting beyond their property. Such a person was James Hillhouse of New Haven, at various times a U.S. Senator, U.S. Representative, and treasurer of Yale College. In 1786 he promoted a public subscription to pay for planting elms in the city's central square, known as the Green, and in 1787 he led a campaign to run a new street through the middle of the Green, with rows of elms. After completion in 1792, he funded an extension of the street through his own lands and made it a grand way, 150 feet wide and lined with elms.

This pattern of leadership by one individual or a small group was repeated in other towns. In Boston, the architect Charles Bullfinch returned from studies in England to design and build the Tontine Crescent, featuring a strip of grass and trees known as Franklin Place. He also led efforts to improve Boston Common, including an 1803 campaign that raised private money to pay for planting a new promenade. Likewise, in Newburyport, Massachusetts, Edmund Bartlett, the architect and eldest son of the town's wealthiest merchant, led a range of greening initiatives. In 1800, he organized citizens and paid for the construction of a tree-lined promenade, known as Bartlett's Mall.

While individuals were the primary agents of urban tree planting in the early Republican era, there is also evidence of state and territorial level legislative support for urban tree planting in Massachusetts, Michigan, and New York (Ricard 2009). This public sector engagement was a harbinger of the increasingly active role that municipal authorities would play in tree planting towards the end of the following century.

The Industrial Era (1820–1920s)

European and North American cities in the 19th century were greatly transformed by the Industrial Revolution, a major turning point in history when manufacturing transitioned from the human hand to machines. Prior to the 1820s, the locus of this activity took place near energy sources, water mills, and coalfields, often far from large cities. But as manufacturing moved into cities, the urban fabric underwent significant changes, including much of the infrastructure we today take for granted: street lighting; systematic house numbering and postal service; water supply and distribution; and waste disposal. This was also a period of explosive population growth. Between 1790 and 1920, the U.S. population expanded from 4 million to 106 million people; only 5% of the 1790 population lived in cities whereas the majority of people lived in cities by 1920 (Birch 2009).

The physical and institutional infrastructure of cities was not prepared for this unprecedented urban growth, resulting in lamentable living conditions: horrible air

quality from coal-fired factories; contaminated drinking water; deficient sewerage and solid waste management; traffic-choked streets littered with animal corpses and manure; inefficient movement of goods and services; tenement housing with little fresh air or light; hazardous and unethical working conditions; and extreme income disparities. These conditions inspired a rising tide of social reform and noteworthy precedents in American urban planning history, including the Chicago World's Fair of 1893 and the City Beautiful Era, which offered a clean, orderly antidote to the squalor of the industrial city.

A unifying thread in many of the social reforms during this period is the amelioration of health and well-being through improvements in the physical fabric of the city. This included substantial increases in vegetation, such as trees along streets and in new types of public parks, park systems, parkways, and residential open spaces. Combined, these new urban forms created an immense arboreal landscape in most American cities by the early 20th century (Lawrence 2006).

Public Parks, Park Systems, and Parkways

The parks movement was one of the most prominent expressions of urban improvement and reform during the latter 19th century (Schuyler 1986). Prior to the 1850s, large cities refurbished and replanted small parks to accommodate growing populations, but few new parks were created in major cities. In smaller towns by contrast, especially those in the West, hundreds of small parks (generally one or two per municipality) were laid out, and

the old village commons of Northeast villages were improved as public parks for the first time. Lawrence (2006) observes that small town parks have been largely overshadowed by the vast public parks that emerged in large U.S. cities during the latter part of the century. Smaller U.S. cities, for example, experimented with new park forms, which extended the range of urban open space and left an imprint that is still with us today.

One of these is *the courthouse square*, often comprising an entire city block with a central administrative building such as the county courthouse or city hall surrounded by turf and trees. These green spaces were often the only public parks in small towns during the early half of the 19th century, and they are now a fixture in hundreds of municipalities across the country. Lawrence observes that each places the center of government in an idyllic green setting, and the symbolism of America as a civilized democracy emerging from the virgin landscape of a new continent is hard to miss. Another small town innovation was the centrally sited *village green*. Reflecting the precedent of New Haven described above, many villages in New England, New York, and Pennsylvania planted trees in these spaces and along adjacent streets in the service of "village improvement." This movement to beautify small towns would flourish in the latter half of the century, and fuel a wave of elm tree planting that represents a unique moment in the history of U.S. urban greening, described in greater detail below.

In some large cities, *cemeteries* were created to serve the dual purpose of burying the dead and functioning as a public park. Drawing upon the precedent of Père-Lachaise Cemetery in Paris, Mount Auburn Cemetery in Cambridge, Massachusetts was the first American example in 1832. Philadelphia's Laurel Hill Cemetery and Brooklyn's Greenwood Cemetery were built by 1840, and by 1850 more than half a dozen cities had followed suit. These cemeteries were the first large, publicly accessible U.S. parks designed in the picturesque landscape style, reflecting a highly visual Romantic sensibility that would inform the design of large urban parks in the latter half of the 19th century (ibid).

By the mid-19th century, *large parks* in Britain were attracting much attention. While traveling through England as a journalist in 1850, Frederick Law Olmsted, Sr. visited 125-acre Birkenhead Park and was thoroughly impressed. "And all this magnificent pleasure-ground is entirely; unreservedly, and for ever the people's own. The poorest British peasant is as free to enjoy it in all its parts as the British queen" (Olmsted 1852, 72). Prominent opinion makers advocated for the establishment of a large park in New York City. Referencing the pleasure grounds of London, Paris, and Vienna, Downing argued in a series of essays that the city needed a large park commensurate with its aspirations. Likewise, both candidates for Mayor of New York in 1850, and William Cullen Bryant, editor of the *New York Post*, called for the creation of a large urban park (Martin 2011). Echoing the ''lungs of the city'' rationale for urban green space during

this period,[9] sanitary and public health reformers, including the American Medical Association's Committee on Public Hygiene (1849), also advocated for the creation of parks (Schuyler 1986, 61).

It is in this context that Olmsted and partner Calvert Vaux won a public design competition in 1858 to build a new Central Park for fast-growing New York City. Unlike many of the other submissions that featured formal elements such as statues and fountains, and associational references to subjects including U.S. history and world geography, Olmsted and Vaux's plan – entitled Greensward, an English term for a large, unbroken swath of land – was decidedly naturalistic. A visual composition inspired by the pastoral aesthetic of vast lawns, groupings of trees, and open water, 778-acre Central Park became a major innovation in urban form and very influential for other cities (Beveridge 1995; Rybczynski 1999). Today it is the most visited urban park in the United States and receives over 38 million visitors per year.[10]

Philadelphia held a competition for the design of Fairmount Park in 1859, although work was not completed for another 20 years, and Baltimore's Druid Hill Park began in 1860.

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[9] London's parks were first labeled ''The Lungs of London'' in the 18th century by – it is claimed – British Prime Minister William Pitt the Elder (1766–1768). The term would later be consistently used to advocate for parks, whether in Berlin, Paris, or New York (Ward Thompson 2010).

[10] Rebecca Stern (Director of External Affairs, Central Park Conservancy), in communication with the author, January 2012.

After the Civil War, there was an outburst of large urban park building, including: Brooklyn's 585-acre Prospect Park in 1868; Chicago's 1,055-acre South Park in 1871; and Boston's Back Bay Fens. Designed by Olmsted Sr., the latter formed an important section in the Emerald Necklace, a seven-mile system of interconnected parks that became the nation's first comprehensive metropolitan *park system* (Spirn 1985).

In addition to the large urban park and park system, Olmsted, Sr. and Vaux pioneered the idea of a citywide system of parks connected by *parkways* in Buffalo (Martin 2011).[11] Anticipating the city's expansion, the firm of Olmsted, Vaux and Company proposed in 1868 and succeeded in building three parks in the northern, largely unbuilt part of Buffalo: the Front, a 32-acre site overlooking the Niagara River and Lake Erie; the Parade, a 56-acre tract along the eastern edge of the city; and The Park (presently Delaware Park), 350 acres of land to the north in an area that was hardly inhabited. Connecting these parks were parkways – 200-foot wide ''sylvan tributaries''– that acted as extensions of the park experience, allowing one to travel six miles from the Front to The Parade under a canopy of green (Kowsky 1987).

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[11] Lawrence (2006, 244) notes that the idea for vegetated parkways connecting parks had been proposed earlier by developer John S. Wright for Chicago in 1849. Schuyler (1986) also describes how Olmsted, Vaux and Company urged the creation in 1865 of a parkway system leading to Brooklyn's Prospect Park, but due to financial constraints including the economic panic of 1873, the project was unrealized, and two major parkways, Ocean and Eastern, stand today as a partial example of their vision.

In both Boston and Buffalo, park and parkway systems were built in advance of the urban

development that would follow, and by the end of the century, comprehensive park

systems were partially or completely developed in Atlanta, Kansas City, and

Minneapolis. In preserving large tracts of natural land in and near cities, the 19th century

urban parks movement can be understood as early expressions of environmental

awareness and green infrastructure (Eisenman 2013), where natural areas were

understood to be valuable on their own terms and worthy of protection.

This seminal moment in America urban park history has also been described as the era of

the Pleasure Ground, characterized by naturalistic use of trees, curvilinear paths, and

other landscape elements including meadow, placid water, rustic structures, and limited

floral displays. Intended uses included strolling, carriage racing, bike riding, picnics,

rowing, classical music, and non-didactic education (Cranz 1982; Cranz and Boland

2004).

Street Trees, Village Improvement, & the American Elm

The tree-lined parkways of Buffalo are notable in that they blurred the line between street

and park. Laid out with bridal trails for recreational horse riding, and central medians

planted with grass, shrubs, and trees, these verdant corridors were meant to permeate

residential neighborhoods and provide alternate routes of travel that could serve both

recreational and transportation needs. While unique in their design and systematic

connection to parks, the Buffalo parkways reflected a nationwide surge in street tree planting in the latter 19th century.

The tree-lined multi-way boulevard of Commonwealth Avenue in Boston set an early precedent in the 1850s, and similar tree-lined avenues became the favored location for the wealthiest citizens in cities nationwide, establishing "millionaire rows" as a distinct American landscape type. Other prominent examples included: Fifth Avenue in New York City; Massachusetts Avenue in Washington, D.C.; Monument Avenue in Richmond; Euclid Avenue in Cleveland; Delaware Avenue in Buffalo; Vandeventer Place in St. Louis; and St. Charles Avenue in New Orleans (Lawrence 2006).

Even more pervasive was the widespread planting of trees along ordinary residential streets. Lawrence notes that in Europe, a large boulevard might be the only tree-lined street in a neighborhood, while most residential streets in the United States were planted with trees. This owed much to the village improvement movement and rural beautification societies that spread across New England towns in the mid-19th century. Documenting this "organized collective action to improve the public realm," Campanella (2003, 83) identifies Sheffield, Massachusetts as the beginning of the village improvement movement, where "the American elm was established as the principal tool of spatial beautification." The town was already well known in the region for its great Sheffield Elm, a local totem since the community's founding in 1733. But in 1846, two

young men rallied their fellow citizens to organize a "Tree Bee," resulting in the planting of 1,000 American elms, including a column of trees fronting main street.

Sheffield's Tree Bee was unprecedented in New England, and it captured the imagination of progressive intellectuals including a local minister named Orville Dewey, who in 1852 established the first village improvement society in America. Tellingly, it was named the Elm Tree Association, with a mission to bring spatial beauty to Sheffield by improving fields and public places, by grading walkways, and more than anything, by planting elms throughout the town. One year later, the village improvement movement received support from the Massachusetts General Court, which passed a statute authorizing the formation of organizations dedicated to village improvement, and enjoying the same rights, powers, and privileges accorded to libraries and lyceums. Within months, a second village improvement society was founded in nearby Stockbridge and elm-planting fever spread across New England. By the 1880s, 23 village improvement organizations had been formed in Massachusetts and another 50 in Connecticut, where New Haven would achieve fame as the City of Elms and the era itself became known as the Great Planting (ibid)[12] (see Figure 2.4).

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[12] Campanella (2003) notes that "tree societies" had actually emerged in larger towns and cities prior to the village improvement movement. As early as 1844, Keene, New Hampshire had a Forest Tree Society dedicated to elm tree planting on its commercial street. Portsmouth, New Hampshire had a similar group active prior to 1850, and citizens of Springfield, Massachusetts organized in the 1840s to plant elms on Federal Street.

Figure 2.4: Elm-lined Temple Street in New Haven, Connecticut, c. 1865 (Courtesy of the New Haven Colony Historical Society, in Campanella 2003, 106).

Described by French botanist François André Michaux as "the most magnificent vegetable of the temperate zone" (Rutkow 2012), the American elm possessed a range of physical qualities that made it well suited for urban planting. Elms are hardy, adaptable to a range of soil types, and fast growing. In as little as 15 years, a sapling elm can attain sufficient height to provide shade and transform the spatial envelope of the street, "something of no little value to a nation in a hurry" (ibid 121). The trunk is erect and typically does not branch out until high above the street, allowing air to circulate beneath,

and traffic and building facades to remain unobstructed. The leaves yield a dappled shade, providing shelter from the sun but allowing sunlight to reach the ground. And when planted as a street-side colonnade, the fountain-like form of the American elm creates a canopy of verdure described as nothing less than "tabernacles of the air"[13] and "a Gothic cathedral in sylvan form" (ibid 134). Reminisced one Bill Chittick, "when you came into any town in New England the landscape changed, you entered this kind of forest with 100-foot arches. The shadows changed. Everything seemed very reverent, there was a certain serenity, a certain calmness" (in McCombs 2001) (see Figure 2.5).

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[13] Henry Ward Beecher quoted in the City of Cambridge Report of the General Superintendent of Parks (1894, 76).
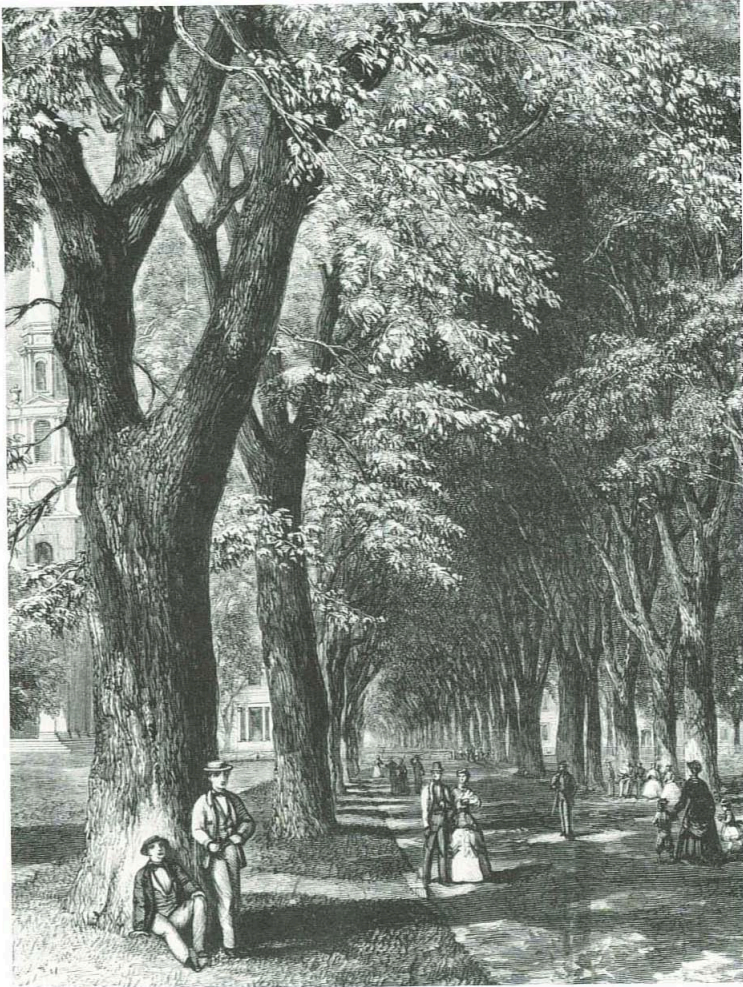
Figure 2.5: The "elm arcade" on Temple Street, New Haven, c. 1870, detail from Appleton's Journal (in Campanella 2003, 132).

So compelling was this interplay of city and sylva, "that elm culture eventually was exported to nearly every region of the United States, until the elm was not only a Yankee icon but an American one" (ibid 139). Urban areas from coast to coast were soon filled with broad avenues shaded by elms. The streets of Minneapolis featured 600,000

specimens. Detroit and Cincinnati each hosted 400,000 trees. Dallas added another

150,000. Sacramento, California, possessed as many elms as New Haven. There were

clusters of 10,000 or more ornamental elms in every state, and by the 1930s some 25

million had been planted nationwide (Rutkow 2012).

Yet, not long after the American elm transformed New England's cities, the tree faced the

first of many challenges that would ultimately lead to its demise. As early as the 1860s,

modernization transformed semi-rural New England streets into an intensively managed

corridor accommodating a range of transit and urban services requiring infrastructure for

water, gas, and telephones in the 1880s, and electricity in the 1890s. The widening of

streets to accommodate increasing traffic caused considerable loss of elms. For those that

remained, environmental stress made the tree more susceptible to diseases and pests, and

an invasion of elm leaf beetles attacked New Haven's trees first in the 1890s and again in

1908 (ibid). This was a precursor to Dutch elm disease, which would ravage the nation's

elm population in the mid-20th century.

Residential Landscape Forms

In residential areas, the individual practice of planting street trees in front of homes

continued, and new landscape forms also emerged. Borrowing a British tradition,

residential squares were adopted as a model in certain neighborhoods during the 1820s

and 1830s. The first were in Hudson Square in New York City and Wooster Square in

New Haven, followed by Pemberton and Louisburg Squares in Boston. In the 1830s

Pemberton and Louisburg Squares were built in Boston, the latter still surviving as a

private square in the Beacon Hill neighborhood. Gramercy Park in New York City was

also built at this time and survives today as a private square; but the model of an

exclusive, gated park was hard to rationalize in the egalitarian American mind and was

not commonly replicated.

By the 1840s in New York City, Madison Square, Tompkins Square, Union Place (now

Union Square), and Washington Square made improvements as public parks, becoming

local nuclei for residential development. These green squares often attracted the elite,

such as Lafayette Park adjacent to the White House in Washington, D.C. Yet class

inequality still existed. Blackmar (1989) has documented how the New York City

government refused to create public squares downtown where the working poor lived,

while altering the street system to allow for privatized enclosure of Gramercy Park and

spending public dollars to create parks as amenities in wealthy neighborhoods.

Unlike large cities where rowhouses predominated, in many small towns residential areas

of detached houses surrounded by lawns and gardens on tree-lined streets were common

prior to the 1850s. As the nation expanded westward major cities emerged, and by the

1840s most interior towns followed East Coast fashion by planting trees in wealthy

residential areas. Trees were also planted in the commercial districts of U.S. towns and

cities. Yet, many of these were removed in the latter 19th century for a range of reasons including: concerns that trees obstructed storefront and advertising signs; difficulty of maintaining trees in space shared with horses which would gnaw on the bark; and the need to widen streets as traffic increased (ibid).

In the latter half of the century, planned developments of single-family detached houses started being built along the suburban fringe. Early precedents include Llewellyn Park (1857) west of Manhattan in New Jersey, and Riverside near Chicago. Designed by Olmsted, Vaux and Company in 1869, roughly a third of the 1,560 acre Riverside site was designed as public greens and commons (Rybczynski 1999). Yet with the emergence of automobile mass-production in the 1910s and 1920s, the suburban subdivision – characterized by individual detached houses on private lots of turf and trees – would become the dominant residential form in the 20th century.

Early Urban Forestry & Tree Warden Laws

Urban forestry is often claimed to have emerged in 1965 at the University of Toronto (Grey and Deneke 1986; Jorgensen 1986; Johnston 1996),[14] due in part to an explosion of urban forestry activity in the late 20th century. But as described above, volunteer involvement in urban tree planting has occurred throughout much of U.S. history. The

[14] Jorgensen (1986) claimed that the combination of the words 'urban' and 'forestry' came about in 1965 at the University of Toronto in response to a request for a name or title to a graduate student's study of the success and failures of municipal tree planting projects in a borough of metropolitan Toronto.

first use of the term "urban forestry" has been dated to 1894 in Cambridge,

Massachusetts[15] and some contend that urban forestry has its professional origins in the

late 19th century along with the beginnings of professional forestry (Ricard 2005;

Konijnendijk et al. 2006). This historical oversight may be due to the challenges of

defining urban forestry. For example, 'shade' and 'ornamental' were terms applied to

urban public trees and their management throughout the 1800s, and since the late 19th

century there have been professionals who practiced at the municipal level but were

identified by related terms, including city forester, city arborist, municipal forester,

municipal arborist, or tree warden (Konijnendijk et al. 2006).

Ricard (2005) points to the emergence of "tree warden laws" in Massachusetts (1896)

and Connecticut (1901) as a pivotal moment in the institutionalization of urban forestry.

As described earlier, the management of public shade trees had become an important

responsibility of municipal governance by the late 19th century. Yet the boundary

between private property and the public right-of-way was often unclear. In the absence of

an official designation of what constituted a public shade tree, their planting and

protection usually relied upon an individual whose property abutted the public way-of-

way – a situation that did not comport with the rational approach to late 19th century city

management. From this emerged a series of municipal laws that clarified and codified the

management of urban trees.

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[15] See the City of Cambridge *Report of the General Superintendent of Parks* (Cook 1894, 71–72).

In New England, the 1890s "Nail" laws clearly distinguished which shade trees were public. In 1890, the Massachusetts Acts and Resolves stated that driving into the relevant trunk a nail or spike with the letter M impressed on its head designated a public shade tree. Connecticut passed a similar law in 1893, except its certified nails and spikes bore the letter C. Six years later, Massachusetts codified the "Nail" laws into what became known as the tree warden laws, enabling towns to appoint individuals responsible for the care and protection of public trees. In 1899, these laws were amended to require that all Massachusetts cities and towns appoint a tree warden. Connecticut again followed suit, passing tree warden-enabling legislation in 1901 and mandating tree warden appointments in 1918. Both states then designated all trees and shrubs growing in the public "way-of-way" as public shade trees (Ricard 2005).

Actors & Drivers

The 19th century represented a transition from the pre-industrial city, whose planning considerations were based on aesthetics and visual order, to the industrial city, where transportation, public health, and social order drove planning efforts. The physical changes to city form that drove tree planting in American urban landscapes during this period mostly involved the creation of new residential districts through private initiative, and public parks, park systems, and parkways through local governmental initiative and urban design experts, notably Frederick Law Olmsted, Sr. and his sons in the latter half of the century. Individuals continued to plant street trees in front of their homes, and

Campanella (2003, 108) frames the "Yankee urban forest as a democratic project," unlike the trees bestowed upon European cities as public improvements by the king, pope, or emperor, which he describes as "noblesse oblige with an arboreal twist." Central to American greening was the public spirited individual, exemplified by Hillhouse in New Haven, Bullfinch in Boston, and numerous others whose "sylvan largesse" abounds in local histories of 19th century New England (ibid 103). Enterprising philanthropists would often enlist the support of their fellows, and this type of private initiative was often supported by community leaders and sometimes by the municipality itself. In other words, 19th century tree planting in U.S. cities was a largely volunteer activity.

For some, tree planting became a "civic obsession" (Lawrence 2006, 246). In 1872, former Nebraska governor J. Sterling Morton established Arbor Day and over 1 million trees were planted in his home state on the inaugural holiday. The observance of Arbor Day spread to cities across the country, even desert settlements such as Tucson, Arizona. Here, passage of Arbor Day legislation by lawmakers in 1901 led to 10,000 trees being planted in 1907 and 1908 – roughly one tree for every other citizen – transforming the landscape within the decade (McPherson and Haip 1989) (see Figure 2.6).
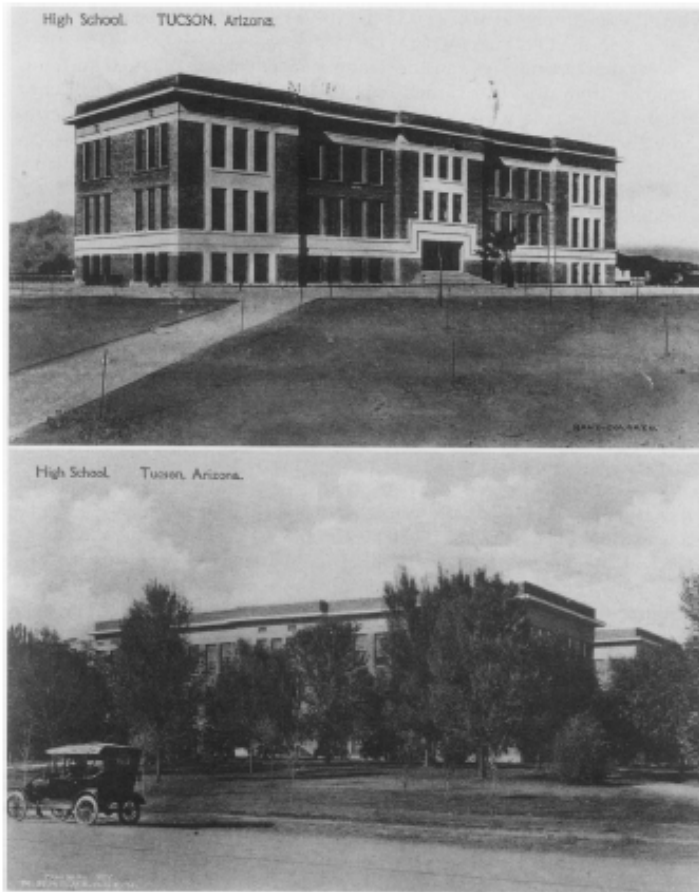
Figure 2.6: Arbor Day plantings like those at this Tucson high school circa 1909 (top) resulted in substantial tree cover by 1915 (bottom). (Reproduced courtesy of the Arizona Historical Society, Tucson. In McPherson and Haip 1989, 439).

According to Cohen (2004, 32–33), the emergence of Arbor Day in the Great Plains was informed by joining the 19th century notion that "rain follows the plow"[16] with "rain

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[16] "Rain follows the plow," describes a now-discredited theory of climatology that was popular in the American West in the late 19th century. Attributed to land speculator and author Charles Dana Wilber (1881), this belief held that increased human settlement and agricultural cultivation in the arid plains would yield increased rainfall, rendering the land more fertile and lush as population increased. Cohen

follows the tree." Indeed, Arbor Day set a precedent for tree planting in bioregions that are not naturally forested (Pincetl et al. 2013). Cohen (2004, 22) also points to evidence that Arbor Day advocates framed tree planting as an act of patriotic duty and ethical conduct, and he contends that, "in many ways, this is the starting point of the tree planting thread of the American environmental discourse." The holiday has since spread to the rest of the country. While the function of Arbor Day is to focus public attention on tree planting writ large, the festivities associated with it every year capture public attention in cities throughout the nation (Miller 2007).

The emergence of Arbor Day coincided with the birth of the American Forestry Association (AFA), now called American Forests, a nonprofit group whose tree planting mission had two distinct tracks: 1) planting trees for ornamental and other nonindustrial purposes, with a constituency of mostly urban homeowners; and 2) stocking forestland for timber purposes, with a constituency primarily of rural landowners. By 1899, the group had grown to 1,250 members, many of whom were active in tree planting advocacy in Washington, D.C. and elsewhere. American Forests would become a prominent advocate of 20th century tree planting in U.S. cities (Johnston 1996), discussed further below.

(2004, 32) cites Walter Kollmorgen (1969) as calling George Perkins Marsh's *Man and Nature* (1864) the "bible of the rainmakers of the west." Yet, in the Foreword to a new edition of Marsh's classic work, William Cronon (2003, xxvii) cites evidence that Marsh thought the theory "vague and contradictory."

The emergence of American Forests had a domino effect that soon prompted state

forestry associations in Connecticut, Massachusetts, Pennsylvania, and Wisconsin. Some

of these state forestry associations would become prominent advocates of urban forestry.

For example, the Massachusetts Forestry Association led by Harris A. Reynolds from

1911 until his death in 1953, led regional efforts to promote town forestry and organizing

meetings of the Northeastern States Conferences on Town Forests in 1940 and 1941

before the war intervened. Reynolds is considered the "Father of Town Forests," having

written voluminously on and promoting the development of managed forests owned by

municipalities (Ricard 2009).

As tree planting initiatives grew, they inevitably became more organized, reflected in the

village improvement movement that blossomed forth in the latter half of the century and

gained legal support at the state level in Massachusetts. Real estate developers were also

responsible for tree planting. In Cambridge, Massachusetts, elms were often installed in

front of new homes to attract buyers. But just who owned all of these trees was unclear,

and the new municipal government "waged a turf battle in its determination to prove

itself an able keeper of the public realm" (Campanella 2003, 113). By the end of the

century, management of street trees emerged as a legitimate area of municipal

responsibility and part of modern urban management practice. The complexity of the

industrial street demanded intensive management, and the increasingly complex matrix of

pipes and wires in ground and overhead – as well as new concerns over municipal

liability – transformed the act of planting a street tree. Once an act of personal or philanthropic initiative, street trees were now becoming significant elements of urban infrastructure.

This reflected a larger movement toward scientific management and expertise in the 19th century city, and the industrial city also birthed the "the unlikely hybrid known as urban forester" (ibid 120), a profession that would gain significant traction in the latter third of the 20th century. This rational approach to urban trees sought to impose a new standard of formality and order on the streetscape. Said the General Superintendent of Parks for Cambridge, Massachusetts: "Good taste demands the observance of two rules as essential in street tree planting. First, that but one variety of tree shall be planted upon a street, and, second, that the trees shall be planted at uniform distances" (Cook 1894, 73).

Increasing specialization was also reflected and advanced through a burgeoning literature. Ricard (2009) describes *Practical Suggestions for Tree Wardens* (MFA 1900) as one of the first booklets to appear, and *The Tree Doctor* by John Davey (1901) as probably the first book on commercial arboriculture. William Fox produced an early book on street and highway tree planting (1903), and Bernard Fernow (1910) published *The Care of Trees in Lawn, Street, and Park.* Other notable publications include William Solotaroff's *Shade-trees in Towns and Cities* (1911), Ben Y.S. Morrison's (1913) *Street*

and Highway Planting, and George Stone's (1916) *Shade Trees, Characteristics, Adaptation, Diseases, and Care.*

While these actors laid the foundation for professionalization and institutionalization of urban forestry, the original aspiration to green cities a few decades prior can be attributed to a blooming Romanticism, generally understood as a movement that emerged in the mid-18th century to counteract the Enlightenment and its scientific rationalization of nature. This movement was marked first and foremost by a reverence for the mysteries of the natural world. Rather than trying to explain or rationalize nature, those who later would be deemed Romantics embraced its mystery and grandeur (Casey 2008). In the United States, this found expression in the Hudson River School painting of Thomas Cole and Asher B. Durand, and the writing of Ralph Waldo Emerson and Henry David Thoreau. The latter wrote eloquently of the elms in his native Concord, Massachusetts, and he often voiced a preference for trees over people. "I have seen many a collection of stately elms . . . which better deserved to be represented at the General Court than the manikins beneath . . . a fragment of their bark is worth the backs of all the politicians in the union" (Thoreau 1949).

This subtle misanthropy colored the Romantic view. It also reflected the "antiurban roar in the national literary pantheon" of the period (White and White 1962, 353), extending an antipathy toward urbanism that dates to Thomas Jefferson, who famously compared

cities to sores on the human body (Glaab 1976). By the time of the Civil War, fears of the Dickensian city of Europe had arrived in America, and to the Romantic American mind it appeared entirely plausible that an *urban pastoral* could be realized. In so doing, the great moral, spiritual, and psychological value of nature could uplift, and indeed reform, urban denizens (Campanella 2003).[17] A prominent advocate for this line of thinking was Andrew Jackson Downing (1848), who believed that gardening was, "next to religion . . . the great humanizer of the age." He held the American elm in especially high regard. "Show us a Massachusetts village, adorned by its avenues of elms . . . and you also place before us the fact, that it is there where order, good character, and virtuous deportment most of all adorn the lives and daily conduct of its people" (Downing 1849). Indeed, planting trees in cities was associated with a non-verbal but highly visible message that doing so was "an act of public good," albeit "defined by the wealthy" (Lawrence 2006, 262).

The Romantic mind also championed social cohesion, and for village improvement and elm planting pioneer, Orville Dewey (1856), this was an essential driver of urban greening. Committed to improving the human condition in the here and now, he believed that planting trees would serve "a common interest and common feeling" among citizens

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[17] Frederick Law Olmsted, Sr. believed in the uplifting qualities of *rus in urbe*, and he is often situated as a primary actor in the Romantic move to green cities. But he was decidedly pro-urban (Eisenman 2013), and Menard (2010, 509) describes Olmsted's view of the city as "one of the most positive and liberating forces in human history."

and seek "to remove prejudices, and bring us nearer together." Lawrence (2006, 219), however, finds that the leafy new middle-class residential areas of American cities in the early 19th century were imitations of aristocratic taste, and that tree-clad environments were adopted as a status symbol: "The city tree became a consumer good, a commodity, as much as the house, the carriage, the clothing, and the furniture."

Public health was also an important driver of 19th century urban infrastructural advancement, and the nation's leading public health authorities identified open green space as a critical measure. Reflecting the prevailing miasma theory of disease,[18] the American Medical Association's Committee on Public Hygiene stated in 1849: "The necessity for public squares, tastefully ornamented and planted with trees, cannot be too strongly urged upon public attention, as one of the most powerful correctives to the vitiated air within reach of the inhabitants of a populous place" (in Schuyler 1986). Benjamin Ward Richardson's vision for Hygeia – an utopian City of Health (1876)[19] –

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[18] Popularized in the Middle Ages, miasma theory held that diseases such as cholera, chlamydia, and Black Death were caused by noxious air. This was disproved in 1854 when British physician John Snow traced an outbreak of cholera in London to a polluted water well, a discovery that is considered the beginning of the science of epidemiology and of modern germ theory, where the mechanism of disease transport is through viral or bacterial microorganisms. However, it was not until the late nineteenth century that this was generally accepted (Koch 2004).

[19] Richardson described this vision in an 1875 speech to the Health Department of the Social Science Congress in Brighton, U.K. The written record of this address exists in an 1876 letter to Edwin Chadwick, a 19th century English social reformer known for his efforts to improve sanitary conditions and public health.

also identifies gardens and vegetation as salutary urban design elements. Not only would vegetation purify the air and provide a physical buffer against the diffusion of bad air (or *mal'aria*),[20] it was thought to improve mental condition. Indeed, urban parks were considered public "sanitariums" and "therapeutic landscapes" (Dümpelmann 2013, 20), and Olmsted, Sr. advocated to incorporate natural scenery in cities, "to give the mind a suggestion of rest from the devouring eagerness and intellectual strife of town life" (1871).

Public health undergirded the City Beautiful movement, a major early 20th[th] century influence on urban design wherein parks and vegetation were prominent design elements. The profound influence of this ascendant aesthetic norm even reached arid western cities such as Oakland, where City Beautiful advocacy led to "massive afforestation" in the early 1900s (Nowak 1993). Aesthetic beauty could also spawn outright competition between places from vastly different bioregions. Said one 1908 politician in arid Tucson: "The people in the east have an idea that all the vegetation that can survive in Arizona soil is cactus and soap weed, but I expect to see the day when there will be no other city in the country that will be beautified with trees as will the Old Pueblo" (in McPherson and Haip 1989, 439)

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[20] The term "mal'aria" originated in the 18th[th] century to describe an "unwholesome condition of the atmosphere attributed to marshy districts of Italy and other hot countries; any febrile disease thought to be caused by this" (OED 2014).

In addition to health and aesthetic concerns, Dümpelmann (2013) attributes 19th century

public parks to economic deliberations based on the increase of land value and

productivity. "A working class with easy access to open green space was thought to be

healthier and, consequently, more productive" (ibid). She also argues that park creators

tried to impose middle-class mores and values on the working poor, with varying success.

In order to achieve the desired behavior, and prevent rallies and public gatherings that

might threaten the social hierarchy, authorities established regulations for proper use, and

employed park keepers to supervise and patrol the parks.

The technological innovation of the period also facilitated international travel and

communications, increasing the exchange of ideas and reducing national differences in

the way that trees were employed in cities. Dümpelmann posits that, "as entire cities …

were turned into gardens . . . the Western world also became increasingly uniform" (p.2).

Indeed, by the early 20th century, planting trees in American urban landscapes had

become an established practice, and city trees were becoming a global phenomenon that

would establish the green city ideal as "a model for the world" (Lawrence 2006, 221).

The Modern Metropolis (1920s–1960s)

The mid-20th century witnessed an expansion and decentralization of settlement patterns

that would have been unfathomable to the 19th century mind. This important inflection

point in urban history was precipitated by the mass-production of automobiles starting in

1914 and unprecedented road building abetted by the U.S. Federal Aid Highway Act of 1956, leading to unbridled freedom of movement for a burgeoning middle class. Likewise, mass-production of inexpensive single-family houses and federal home financing initiatives such as the National Housing Act of 1934 greatly facilitated home ownership. Combined with so-called "white flight" from urban centers triggered in part by racial fears,[21] these macroeconomic forces fueled what Lewis Mumford (1925) famously coined The Fourth Migration,[22] an urban development pattern that distributed population and urban functions across a sprawling metropolitan landscape. What began as a suburban trend in the mid-1920s became a suburban tide in the 1950s, and by 1970 more Americans lived in suburbs than in either central cities or rural areas (Hayden 2003).

Historical treatments of urban trees have not directed much attention to the 1920-1960 period. Lawrence (2006) addresses city trees from the Renaissance through the 19th century. Campanella (2003) focuses on the 19th century rise and 20th century fall of a particular tree, the American elm. While much of Cohen's (2004) work is situated in the

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[21] While racial fears were a factor in 20th century white flight, it should be noted that this process began as early as the 1920s – prior to the mass emigration of Southern blacks to Northeast, Midwest, and Western cities – when suburban America was already growing at twice the rate of central cities (Klaus 2008).

[22] Mumford identified a "First Migration" of pioneers that had settled the continent, a "Second Migration" from the farms to the factory towns, and a "Third Migration" to the great metropolitan centers, which had become the industrial and financial core of the country (Fishman 2005).

20th century, it focuses on the institutional and discursive contours of American tree planting writ large, rather than urban trees per se. Most histories of urban forestry start in the mid-1960s (Grey and Deneke 1986; Jorgensen 1986; Johnston 1996; Miller 2007), while others highlight the seminal tree planting work of the late 19th and early 20th century Progressive Era (Ricard 2005; Konijnendijk et al. 2006). Moreover, there are limited studies that have investigated how overall tree cover in cities has changed over time (Nowak and Greenfield 2012b).

In light of the decentralizing pattern that characterized 20th century American cities, one might presume that as suburban development crept across an increasingly vast terrain and converted agricultural and natural lands into roads, residential subdivisions, strip malls, and commercial parking lots, metropolitan tree cover declined. However, several studies show the opposite. Through an analysis of historical imagery and documents, Nowak (1993, 313) describes the "massive afforestation" of Oakland, California in the early 1900s, where a pre-settlement canopy cover of roughly 2% in the 1850s increased to 19% in 1991. Moreover, the city's original species composition exploded from approximately 10 tree species in 1850 to more than 350 by the late 20th century.

An historical assessment of tree cover in Los Angeles shows a similar increase through the 20th century. Tree densities sampled from all 15 city council districts in the 1920s, 1950s, and 2006 indicate that while there is variation among districts, there has been a

significant overall increase in tree cover. Specifically, the mean tree density in Los

Angeles increased from roughly 40 trees per hectare in the 1920s to over 100 trees per

hectare in 2006 (Gillespie et al. 2012) – a more than twofold increase. A companion

study reinforced that trees on public and private lands are generally the first planted in

suburbanizing areas, and over time tree density on private land increases more than on

public land (Pincetl et al. 2013).

In Arizona, however, the "great horticultural experimentation" that transformed "Tucson

from a dusty desert city into a garden oasis" by the early 20th century, witnessed an

equally dramatic return to a native landscape ideal in the ensuing decades (McPherson

and Haip 1989, 437). This was initially sparked by the introduction of air conditioning in

the 1940s, which reduced the appeal of shade trees. This technical advance also led to

shifting leisure preferences, as golf, swimming, and tennis became more popular than

residential landscape gardening. By roughly 1950 there was little public interest in tree

planting, and over the next 20 years residents began converting their horticultural

plantings to low-maintenance native flora. This emerging preference for locally adapted

vegetation gained additional traction in the 1970s, when environmental awareness

spawned increased concern about limited water supply, leading to wide acceptance of

desert landscaping and a substantial decline in trees (see Figure 2.7).

Figure 2.7: In Tucson, eucalyptus and chinaberry trees lined University Avenue circa 1925 (top), but only stumps and holes were evident in 1989 (bottom) (Top image courtesy of the Arizona Historical Society; bottom image by Chris Mooney, in McPherson and Haip 1989, 444).

In the Northeast, environmental historian Ellen Stroud (2012) has document the 20th century rebound of the region's forests. She reveals how a landscape that was more than three-fourths forested when Europeans landed at Plymouth in the early 1600s, and that

was more than three-fourths deforested during the Industrial Revolution in the mid-1800s, became more than three-fourths forested once again today. By her own account this seems counterintuitive, especially in a region of tremendous urbanization and population growth. And while Stroud does not focus on city trees per se, she illustrates that in the 20th century Northeast region, "interactions between city and hinterland went in both directions, creating a new wildness of metropolitan nature: a reforested landscape intricately entangled with the region's cities" (ibid 10).[23]

Despite increasing metropolitan canopy cover in Los Angeles, tree density in "urbanized lands" such as Hollywood peaked in the 1940s and quickly declined (Pincetl et al. 2013). This would be in keeping with a nationwide trend toward urban abandonment, leading to "depopulated inner-city epicenters of urban crisis" that reached a nadir in the 1970s (Fishman 2005). The continuing decimation of the American elm further suggests a mid-20th century decline of trees in the most urbanized parts of cities.

Decline of the Elm

The same spirit of improvement that once championed elm tree planting in the late 19th century laid the foundation for its 20th century demise. As described above, this began with street modernization leading to outright removal and environmental stresses that

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[23] See also Jim Sterba's *Nature Wars: An Incredible Story of How Wildlife Comebacks Turned Backyards into Battlegrounds* (2012).

made elms more susceptible to disease and insect pests that had posed only minor threats in the past. The tiny elm bark beetle would prove to be particularly destructive.

Deriving its name from the nationality of the pioneering researchers who isolated the contagious fungal agent (*Ophiostoma ulmi),* Dutch elm disease ravaged European landscapes in the early decades of the 20th century, and by the 1930s it was endemic from Scandinavia to the Balkans. In the U.S., the disease initially spread slowly in parts of southern New York and New Jersey in the early 1930s, and by the end of the decade there does not seem to have been a single infected tree in Massachusetts (Campanella 2003). Yet, throughout the 1930s professional journals of forestry, city planning, and landscape architecture published articles and editorials advocating action against the looming arboreal plague, and one commenter remarked that in some east coast cities American elms constituted up to three-quarters of the urban canopy (Bartlett 1930).

Campanella (2003) documents how over the course of the next several decades, both natural and anthropogenic forces converged to wipe out the American elm population despite federal engagement. In 1935, President Roosevelt authorized over $2.5 million and by that summer more than 600,000 elms in New York, Connecticut, and New Jersey were destroyed in an effort to halt the disease. By August 1936, nearly 1.3 million elms had been removed or destroyed. Then the Great Hurricane of 1938, with an eye-of-the-storm spanning forty miles, crashed into Connecticut and in a matter of hours New Haven

(the City of Elms) lost 13,500 of its trees and another 7,000 were severely damaged. All

told, the behemoth storm destroyed more than a million trees across the Northeast,

leaving an immense swath of detritus. This was heaven for the elm bark beetle, which

breeds in the inner bark of dead wood. In the four years prior to the storm, the area of

Connecticut infected by the disease increased by approximately 47%; in the four years

after, the infected zone increased 258% (ibid).

The Dutch elm plague coincided with the outbreak of World War II, which substantially

diminished management capacity and by 1952 all of New England was under siege.

During the war, a new pesticide, DDT (dichloro-diphenyl-trichloroethane), was used to

destroy malarial mosquito populations, control the spread of typhus, and delouse

concentration camp refugees, and it was credited with saving millions of lives. After the

war, civilian applications of DDT emerged, and the pesticide became the chief means of

combating the contagion spread by the elm bark beetle. One survey showed that by 1948,

nearly 200 Massachusetts municipalities were spraying elms with DDT. The public

remained largely unaware of this until Rachel Carson began serializing *Silent Spring* in

the *New Yorker* in June 1962. She exposed the dangers of pesticides in general and took

special aim at the widespread application of DDT to combat elm disease. When published

as a book later that year, Carson's exposé became a seminal text in the nascent

environmental movement and the tide swiftly turned against the use of DDT to combat

elm disease. Moreover, research soon showed that applying DDT to tree canopies did little to stop elm contagion (ibid).

Through the 1970s, Dutch elm disease ravaged New England and moved rapidly across the Midwest, killing some 400,000 elms per year (ibid). By the 1980s, the epidemic had claimed more than 77 million trees nationwide (Rutkow 2012). Campanella describes this as an ecological catastrophe unparalleled in American history, and he contends that it was human design that stacked nature's deck against the tree.

"Elm Street was, in spite of it natural appearance, a highly artificial creation. *Ulmus americana* is a solitary tree, and it almost never occurs naturally in pure stands. Planting these trees in such great numbers, and in such close proximity, left them in a profoundly unsustainable condition. It was only a matter of time before a pandemic of some kind swept through this manmade forest and set things right. Nature has an uncanny tendency to maintain its own equilibrium, irrespective of human wishes. America's affection for the elm created the most extensive urban forest in history; but it also set the stage for a plague of unprecedented proportions. The ubiquity of the elm was its own downfall; the tree was loved to death" (ibid 166) (see Figure 2.8).

Figure 2.8: Gillette Avenue in Waukegan, Illinois, 1962 (top) and 1972 (bottom) after Dutch elm disease forced the removal of the trees (Courtesy of John P. Hansel, Elm Research Institute, Westmoreland, New Hampshire; in Campanella 2003, 168).

Urban Parks

A retrospective assessment of urban parks provides an important lens through which to assess trees in cities over the past century. In *Politics of Park Design: A History of Urban Parks in America*, Galen Cranz (1982) identified four distinct eras, the last three of which emerge in the 20th century. Despite the achievements of the urban parks movement

between 1850 and 1900, described by Cranz as Pleasure Grounds, the working class seldom used these parks because they were far from the tenements. Consequently, small park advocates sought to establish parks on a few square blocks in the inner city. Eventually this movement merged with those advocating playgrounds for children, resulting in the Reform Park era between 1900 and 1930. These parks were small and symmetrical, with no illusion of countryside or nature, and emphasized special play equipment for children.

As elucidated by Cranz and Boland (2004), municipal leaders during the first two eras enumerated the various social goals that parks served: to reduce class conflict, to reinforce the family unit, to socialize immigrants to the American way of life, to stop the spread of disease, and to educate citizens. In contrast, a new era was claimed in 1930 when Robert Moses was appointed commissioner of New York City's Park Department. For him, parks had become a recognized governmental service requiring no justification. Instead, he and park departments nationwide established uniform standards and extended service to the suburbs and urban areas that had not yet received parks or playgrounds, commencing the era of the Recreation Facility between 1930 and 1965. Here, asphalt tennis and basketball courts, gravel baseball diamonds, turf football fields, steel playground equipment, and swimming pools and beaches promoted active recreation and athletics. Other prominent landscape elements included chain link fences, brick and cinder-block structures, and expanses of blacktop for driving and parking.

Vegetation is noticeably lacking from Cranz's (1982) account of American urban parks though the first two-thirds of the 20th century, suggesting little new planting of trees in spaces often associated with greenery.

Actors & Drivers

During this period, civic leaders and municipal officials continued to lead tree planting efforts. In Oakland, civic improvement and the City Beautiful movement inspired a citizen committee in 1903 to persuade the municipality to initiate a street tree planting program. In 1932 the city began to designate "official trees" for each street to ensure uniform planting, and in 1948, all existing street trees were classified as either: 1) official, 2) interim, or 3) unofficial (Nowak 1993). In Gillespie et al.'s (2012) longitudinal account of trees in Los Angeles, the drivers and actors of tree planting are not directly identified, but it is quite likely that civic improvement and City Beautiful norms based on more humid bioregions predominated.

In Tucson, technological innovation leading to mechanical cooling fundamentally changed both lifestyles and the urban landscape. Here, residential gardening in sweltering heat soon fell out of favor, and local preferences for low-maintenance locally adapted landscaping soon gained favor. This norm gained additional traction as limited water supply became a real concern. In other words, desert landscaping become fashionable for

some during the 1950s, and for others it became an economic and environmental

necessity in the1970s (McPherson and Haip 1989).

The mid-century onslaught of Dutch elm disease prompted substantial federal

engagement. The Department of Agriculture bureau of entomology and plant quarantine

established a Dutch elm disease laboratory in Morristown, New Jersey in the summer of

1934, and the Works Progress Administration (WPA) supplied funds to hire men to

combat the invader. In 1934, the WPA allocated $527,000 toward eradication work. The

following year, President Roosevelt authorized $2.5 million to continue the fight, and by

1936 "the campaign resembled a military operation" (Campanella 2003, 153). The bureau

of entomology and plant quarantine had 1,400 scouts in the field, scouring streets,

roadside, and woodlands for telltale 'flagging' – withered, desiccated leaves at the top of

the crown. Following World War II, this federal bureau also began experimental spray

application of DDT to healthy elms, a strategy supported by scientists at the University of

Massachusetts.

In spite of federal engagement to eradicate Dutch elm disease, which included urban

trees, the federal government paid little attention to urban forestry prior to 1965. Shade

and ornamental tree care was organized exclusively at the local, municipal level with

limited examples of state policy including Connecticut, Massachusetts, Michigan, and

New Jersey (Ricard 2009).

CHAPTER III

(Part 3)

Trees in the Contemporary U.S. City

The Anthropocene Awakening (1970s – current period)

In dialectical response to the excesses of industrial modernity, the 1960s gave rise to a

postmodern revolution predicated on the dramatic expansion of civil liberties, an

increasingly global worldview, and a flowering of ecological consciousness (McIntosh

2007). Growing concern about the environment was amplified by pioneering books such

as Aldo Leopold's *A Sand Count Almanac* (1949), which expanded the scope of ethics to

non-human life, and Carson's *Silent Spring* (1962), documenting the poisoning of the

earth by chemicals. Likewise, a series of well-publicized environmental abuses

dramatized the mounting devastation (Shabecoff 2003).[24] This fomented a nationwide

upwelling of concern and the birth of the modern environmental movement. U.S. Senator

Gaylord Nelson from Wisconsin would tap this latent energy by calling for an

'Environmental Teach-In,' yielding the first Earth Day event on April 22, 1970. In coast-

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[24] Noteworthy examples include: the Cuyahoga River in Cleveland, Ohio bursting into flames due to the
heavy concentration of inflammable industrial chemicals in its waters; a massive oil spill from a rig off the
coast of Santa Barbara, California; the choking of Lake Erie by phosphates; and dense smog cloaking many
major cities. In addition to physical pollution, a legal suit filed by a coalition of citizens in the lower
Hudson Valley to stop hydroelectric utility, Consolidated Edison, from cutting away part of Storm King
mountain near the river to build a power generator, resulted in the first legal judgment enshrining the
precedent that aesthetic impacts can be considered in development projects.

to-coast rallies, 20 million Americans – 10% of the population – took to streets, parks, and auditoriums to demonstrate for a healthy, life-sustaining environment (Earth Day Network 2011). Congress and President Nixon responded to the mounting ecological crisis by passing the most sweeping environmental legislation in the history of the United States (Daniels 2009).[25]

This fertile period in the early 1970s also witnessed the emergence of "sustainable development." According to Kidd (1992), the term sustainability was first used in a 1972 British book, *Blueprint for Survival,* which laid out normative concepts for the future of humanity. In the U.S, the term was employed in 1974 to denote a no-growth economy, and it would gain use in technical and policy documents throughout the 1970s and 1980s, culminating in the widely cited Brundtland Commission report (1987), which emphasized intergenerational equity. Portney and Berry (2010) trace the emergence of the sustainable city concept to this normative aspiration.

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[25] The first of these was the National Environmental Policy Act (NEPA), which required environmental impact assessments on all federal projects that might significantly affect the environment. This created an important new demand for environmental planners with the ability to conduct land use suitability assessments based, in part, on the layering methods of Ian McHarg. NEPA also created the Council on Environmental Quality (CEQ) to advise the president on environmental matters, and the U.S. Environmental Protection Agency (EPA) to implement and enforce the Act. Over the next several years, a raft of top-down federal environmental laws emerged that made pollution control and clean-up, and environmental protection, an important part of American life. This legislation yielded important reductions in air and water pollution, although 40% of America's waterways still remain unfit for drinking or swimming (Daniels 2009).

More recently, atmospheric chemist Paul Crutzen (2002) coined the term

"Anthropocene" to describe the beginning of a new geological era in which the actions of

people can be traced in all the biophysical systems of Earth — from the microscopic to

the entire planet. As world historian David Christian (2012, n.p.) has commented:

"Climate change, acidification of oceans, high rates of extinction, and deforestation are

all linked and have to be seen as expressions of a single phenomenon: the astonishing

technological creativity of our species that has culminated in the Anthropocene epoch."

This contemporary insight reflects the expanding scope of environmental consciousness

and concern that emerged four decades ago, and it establishes a backdrop for exploring

the outputs, actors, and drivers of urban greening in the late 20th and early 21st century.

Outputs

City Trees & Canopy Cover

As described in the previous section, there is a surprising dearth of scholarly research

historicizing 20th century urban trees. Such assessment is complicated by the period's

substantial suburban development, expanding the urban footprint and making distinctions

between 'city' trees and 'urban' trees complex. According to Moll (1989): "Out where

greenways merge into the countryside, our knowledge of the urban forest gets very

sketchy" (Kindle location 448). He suggests that expanding cities and suburbs annexed

existing trees from once-rural landscapes, and while "the amount of such area being

converted is not known…estimates range from 300,000 to 1 million acres a year."

Yet, peer-reviewed longitudinal studies in Oakland and Los Angeles show a significant increase in urban canopy cover across the 20th century (Nowak 1993; Gillespie et al. 2012), and Los Angeles has become markedly greener since the mid-1970s (Pincetl et al. 2013). This late 20th century trend is supported by tree surveys conducted in 1980 and 2003/2005 in six Midwestern cities (Hutchinson, Minnesota; Lincoln, Nebraska; and Bowling Green, Bucyrus, Delaware, and Wooster in Ohio). Here, a count of the 25 most common species on both public and private land showed a total of 8,980 trees in 1980 and 10,924 in 2003/2005: an increase of 21.7% (Wade and Kielbaso 2013).[26] Across the conterminous United States, urban canopy cover is today estimated at 35.1% (Nowak and Greenfield 2012a),[27] whereas Moll (1989) estimated nationwide urban canopy cover in the late-1980s at roughly 30%. Most telling, perhaps, tree canopy cover across the conterminous United States is estimated at 34.2%; slightly *less* than the average canopy cover in urban areas. In other words, there is currently no statistical difference between urban percent tree cover and rural – or nonurban – percent tree cover (Nowak and Greenfield 2012a).

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[26] This study also found that the health of trees declined as they grew larger and older, and because there were more large trees than small trees in 2003/2005, the overall condition is worsening. Thus, the authors conclude that "if trees were being planted at the same earlier rates this would not likely be the case" (Wade and Kielbaso 2013, 269).

[27] This differs significantly among states and region. In predominantly grassland states, urban development tends to increase percent tree cover, whereas urban development in forested regions tends to decrease percent tree cover relative to rural lands (Nowak and Greenfield 2012a).

In one of the few longitudinal studies to depict urban canopy cover change nationwide,

Nowak and Greenfield (2012b) paired aerial photographs in 20 conterminous U.S. cities

– defined by census incorporated or designated place boundaries – spanning three to six

year periods between 2001 and 2009, and found that tree cover was reduced, on average,

by roughly 0.27%/year. However, the authors note that tree cover loss in these cities is

likely higher than urban land across the conterminous United States by a factor of

roughly six. That is because the 20 cities covered in this study do not represent the entire

urban area. Moreover, they are relatively major cities with large population densities that

likely face increased development pressures compared to the average urban landscape,

which includes smaller, less densely populated areas. The authors also point out that the

city boundary of these smaller places is often in forested regions that may include non-

urban lands.

The counterintuitive findings described above may be due to the convergence of two

forces: subdivisions being built primarily on agricultural lands that already lack trees; and

suburban preferences for a pastoral aesthetic of sylvan canopy and lawn. Such is the case

of my childhood home in Silver Spring, Maryland, a suburb of Washington, D.C. that

abuts the capital city but extends into former agricultural lands that are now dominated by

single-family subdivisions. Figure 3.1 shows aerial photographs from 1936 and 2000,

with our neighborhood (formerly Gum Springs Farm) demarcated by a yellow dotted line

and my family's house identified by a red square. These aerial images show new

residential development occurring on agricultural lands, with patches and corridors of forest remaining intact. Photographs from the lot on which our house was sited also show a net increase in vegetative and sylvan cover between 1971 and 2005 (see Figure 3.2).

1936   **2000**
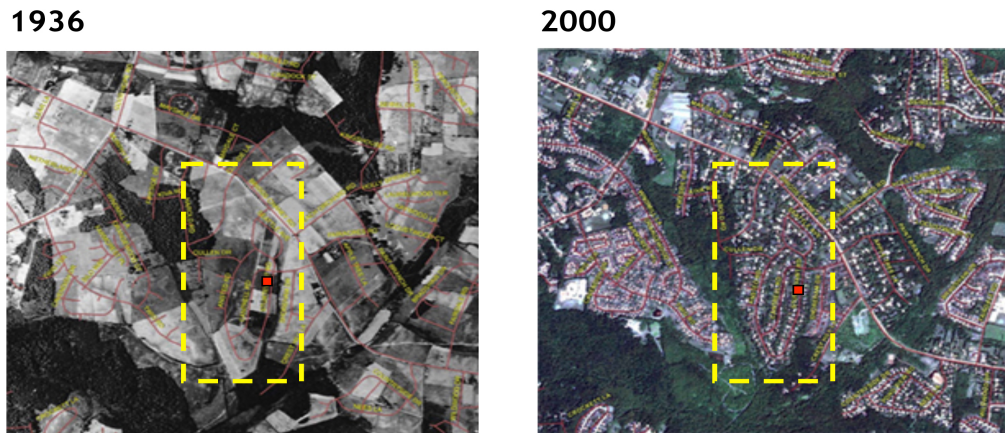
Figure 3.1: Gum Springs Farm, Silver Spring, Maryland, in 1936 and 2000. Aerial photographs Courtesy of Washington, D.C. Council of Governments and the Maryland-National Capital Park and Planning Commission.

1971

2005

Figure 3.2: Author's childhood home in Silver Spring, Maryland, 1971 and 2005.

In the most urbanized areas of cities, some studies do suggest a late 20th century decline in trees. In Hollywood, Los Angeles, trees peaked in the 1940s and quickly declined (Pincetl et al. 2013). Also in Los Angeles, tree canopy is highest in low-density residential areas (31%) and lowest in industrial and commercial areas (3% to 6%) (Gillespie et al. 2012). Self-reported responses to surveys of urban foresters from the late 1980s through mid-1990s also suggest a general decline in the condition of urban forests (Johnston 1996). In 1987, for example, the American Forestry Association surveyed the condition of street trees in twenty cities, and only one (Lansing, Michigan) planted as many trees as it removed. One third of the cities planted a tree for every eight trees removed, and about half the cities surveyed replanted merely one-quarter of their losses (Moll 1989). It is possible that these trends reflect the urban abandonment and disinvestment that characterized the mid- and late- 20th century.

Urban Parks

In the 1960s, Cranz (1982) suggests that urban parks departments responded to pervasive urban decline by adopting an Open Space model, where "anything goes:" small, irregular spaces in the city saved from the fate of urbanization, with fluid perimeters where the park flowed into city and the city into park. Such a case is Paley Park, a privately owned public space in Manhattan often championed as an exemplar of the "vest pocket park," where trees are incorporated as architectural elements. Yet, the overarching trend in public parks of the period is one of dwindling budgets and staff, and declining

maintenance and appearance, resulting in parks becoming perceived and real havens for crime. To attract enough people to make them safe, park managers resorted to "electrified programming," which often took the form of concerts, festivals, and theater. But in this era of urban decline, new tree planting does not seem to figure prominently.

In the 1990s, Cranz and Boland (2004) argue that a new era in park planning emerged: the Sustainable Park. Unlike the four previous eras that responded to social concerns, they posit that this new park type addresses ecological concerns through: 1) self-sufficiency in regard to material resources and maintenance, (2) solving larger urban problems outside of park boundaries, and (3) creating new standards for aesthetics and landscape management in parks and other urban landscapes. As regards trees, the authors suggest that the Sustainable Park protects existing specimens and emphasizes planting of native species for ecological benefits.

More recently, Peter Harnik (2010) observes a different trend. He posits that today, the open space limitation of increasingly built-out cities is sparking creative approaches to park making. Most of these innovations enhance or create new open spaces in the existing urban fabric, yielding new surfaces for greening and tree planting such as: decking and greening over highways; removing parking; restoring riparian greenways; planting rooftops; converting landfills to parks; and building community gardens. In addition to vegetated walls (a contemporary greening trend that does not necessarily

qualify as park space), the retrofitting trend observed by Harnik responds as much to human aspirations for urban livability as it does to concerns about environmental sustainability. Echoing Fishman's (2005) argument that we have entered a Fifth Migration based on reurbanization of inner-city districts that were previously depopulated, Harnik (2010, 1) further contends that contemporary urban greening innovation reflects a resurgent interest in city living: "With the rebirth of the city has come the rebirth of the park."

Large-scale Planting

The last decade has witnessed a profusion of new tree planting in cities, and large-scale initiatives are emblematic of this sylvan bloom. Young (2011) documented eight large U.S. cities and one metropolitan county that established massive tree planting goals between 2004 and 2008, with pledges to collectively introduce nearly 11 million trees (see Figure 3.3). New York City is well on its way to meeting its goal of one million trees, having planted over 900,000 as of August 2014 (City of New York 2014a). Philadelphia is also committed to planting a million trees throughout its 13 metropolitan counties, and is currently about a third of the way toward its goal (Plant One Million 2014). In addition, cities are now commonly conducting urban tree canopy cover assessments and in many cases establishing new canopy cover goals (Kollin and Schwab 2009).

City	Launch date	Planting goal (# of trees)	Planting goal (# of years)	Total trees planted (11/30/2010)
New York City	2008	1 million	10	379,170
Los Angeles	2008	1 million	"several"	250,000
Houston	2008	1 million	5	400,000
Salt Lake County	2007	1 million	10	150,538
Sacramento	2005	5 million	20	40,882
Denver	2006	1 million	19	191,366
Seattle	2007	650,000	30	125,000
Baltimore	2006	a	30	28,000
Albuquerque	2004	75,000	2	30,000
Totals		11 million		1,594,956

Note: a. The City of Baltimore set doubling the city's canopy cover (from 20% to 40%) as their goal, rather than the planting of a specified number of trees.

Figure 3.3: City tree planting initiative launch dates, targets and performance (in Young 2011).

Citizen-Based Groups

The surge in tree planting described above has a precedent two decades prior. In Los Angeles, a citizen-based tree planting organization named TreePeople initiated a campaign to plant a million trees prior to the Los Angeles Olympic games in 1984. This was inspired, in part, by a 1981 Air Quality Management Plan drafted by the City of Los Angeles Planning Department that called for the planting of a million trees to help comply with the air-quality standards of the 1970 Clean Air Act. The city estimated that it would take 20 years to plant the trees at a cost of $200 million (TreePeople 2014), and when mature the trees would be capable of filtering up to 200 tons of particulate smog from the air every day (Johnston 1996).

TreePeople is one of the nation's early citizen-based local tree planting groups. The nonprofit was created in 1978 by Andy Lipkis, who found his lifelong calling at the age of 15-years-old when he got inspired to repair the smog damaged forests of the San Bernardino Mountains by collaborating with two dozen summer campers to transform a parking lot into a meadow of smog-tolerant trees. This passion led to a series of grassroots activities that broke new ground for urban forestry in several important ways. The work was led by people who did not have a professional background in urban tree management, sowing the ground for countless such groups today. The 1984 Million Tree Campaign was also the first major urban forestry project to employ advertising and marketing techniques to promote its message. Its imaginative campaign captured the attention of the media not just in California but also nationally, and it galvanized the participation of thousands of Angelenos in tree planting schemes. It also attracted substantial commercial sponsorship to finance the project, and demonstrated the power of the urban forestry vision to engage the public, private and voluntary sectors in greening activity (ibid).

TreePeople has continued to develop a range of projects that involve local residents in planting and caring for trees. Its Citizen Forester program trains volunteers to become catalysts for action in their own neighborhoods and has encouraged countless local projects. Similarly, Tree Tenders was established in Philadelphia in 1993 by the Pennsylvania Horticultural Society and it has trained over 4,000 volunteers to plant and

care for trees throughout the region (PHS 2013). Today, there are countless citizen based tree planting groups across the country.

New Technology & Tools

Abetted by swiftly evolving digital technology, municipal tree planting initiatives are now supported by the emergence of new tools. OpenTreeMap® (2014), for example, is "a unique collaborative platform for crowd-sourced tree inventory, ecosystem services calculations, urban forestry analysis, and community engagement." This mobile citizen science program exists as an open source project or as a monthly subscription service, and can be used in a single municipality or over a broader geographic region with many communities or organizations. The main functional features of this tool include the capacity to: add trees to the system individually or by datasets; search for trees by species, location, or advanced filters such as diameter, date planted, or tree characteristics (flowering, native, etc.); edit and add information about existing tree records; upload tree photos; make inventories public or private as the user wishes; customize all geographic and database search options, maps, and stewardship activities; export tree lists as digital files; and automatically calculate ecosystem services (e.g. greenhouse gas reduction, stormwater management, energy use, air quality) based on a tree's species and diameter. To calculate ecosystem services, this program – like many citizen-based tools – uses i-Tree, described further below.

OpenTreeMap is just one of more than a dozen mobile and web-based technologies that
enable citizens to identify, locate, inventory, valuate, visualize, or assess community trees
and forests. Ian Hanou, founder of Plan-It Geo, LLC, has aggregated some of these North
American tools (Tree Link News 2014):

- vTree (Virginia Tech) – Available in the iTunes and Google Play stores, this
  tree identification application includes a catalog of more than 950 North
  American trees.

- Tree$ense (Davey Resource Group) – Mobile web application calculates the
  monetary value of individual trees.

- Colorado Tree Finder (CO State Forest Service) – Available in the iTunes
  store, this native mobile iOS app locates state champion trees. It is specific to
  Colorado but is an example of how mobile apps may be used to promote trees.

- Tree Trails (Texas Forest Service) – Available in the iTunes store, this mobile
  web app allows users to identify specific trees and map their own trails and
  connect with other users. It is specific to Texas but is another example of how
  mobile applications can be used creatively to promote trees.

- i-Tree (USFS/Davey Institute) – A publicly available tree inventory tool for
  assessing and quantifying urban forest structure, function, and value, this suite
  of tools includes new enhancements to products such as iTree Canopy and
  iTree Design along with more online marketing resources and video tutorials.

- rePhoto (ImageQuest) – Enables users to match and string together a series of photos taken and is used to monitor how trees grow and change in concert with their environment.

- Open Tree Map Azavea/Urban Ecos) – Allows users to contribute to a crowd-sourced inventory of trees.

- WalkScope (PlaceMatters) – Collects and maps users' movements and experiences. It offers the potential to prioritize urban forestry management actions, such as tree planting, to favor locations with high pedestrian activity.

- Stew-MAP (Center for Neighborhood Technology) – Facilitates spatial mapping and assessment of volunteer environmental stewardship organizations and nearby restoration sites.

- Urban Forest Cloud (Tree Plotter and Canopy Planner tools | Plan-It Geo) – Allows clients and other users to inventory, assess, track, monitor, share and query a variety of urban forest data and ecosystem service values from i-Tree in real-time without GIS/GPS software using interfaces tailored to the needs of the tree manager.

- Story Maps (Esri ArcGIS Online) – Helps people to share cultural information and community stories through an on-line GIS interface. Tell the story of a neighborhood, street, or heritage trees in your community with this product. See an example from Plan-It Geo.

- ecoSMART (USFS / Others) – Currently in the beta phase, this app intends to measure the carbon and energy benefits of trees and landscapes.

- Digital Coast (NOAA) – Extensive suite of tools for coastal communities to assess and analyze existing environmental conditions, change scenarios, and environmental vulnerabilities.

- Forest Planner (EcoTrust) – An online tool for forest management and scenario planning in Oregon and Washington.

Undergirding many of these citizen science tree-mapping tools are new software programs that quantify the environmental and economic benefits of trees. In 1995, American Forests introduced CITYgreen®, which used Geographic Information Systems (GIS) to quantify urban ecosystem services. In 2010, however, American Forests made a strategic restructuring decision to "not try to keep up with the technology race and instead refocus our urban forestry resources," and the organization stopped housing this software. Today, CITYGreen resides with its originator, Gary Moll, at the Global Ecosystem Center.[28]

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[28] Personal e-mail communication with Ian Leahy at American Forests, August 13, 2014.

One of the most prominent contemporary urban forestry tools is i-Tree, formerly known as UFORE (urban forest effects).[29] In the mid- to late 1990s, researchers in Baltimore, New York, and Syracuse established permanent vegetation-monitoring plots to assess long-term vegetation changes (Nowak, Kuroda, and Crane 2004). Likewise, scientists conducted a three-year study to quantify the effects of urban vegetation on the local environment in Chicago (McPherson, Nowak, and Rowntree 1994). These efforts led to the development of software to assess urban forest structure and functions: the UFORE model (Nowak and Crane 2000). Over time, a collaboration amongst several partners to expand the development of this and other urban forest computer programs evolved into a suite of free software tools known as i-Tree, released in 2006. These partners currently include: the U.S. Forest Service; The Davey Tree Expert Company; Arbor Day Foundation; Society of Municipal Arborists; International Society of Arboriculture; and Casey Trees (i-Tree 2014b). Alliances such as this are now being formed elsewhere in the world. In the U.K., the Arboricultural Association and consulting companies Forest

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[29] One of the i-Tree suite of tools is i-Tree Streets, which is an adaptation of the Street Tree Resource Assessment Tool for Urban forest Managers (STRATUM) developed by researchers at the USDA Forest Service, Pacific Southwest Research Station. The STRATUM application was conceived and developed by Greg McPherson, Scott Maco, and Jim Simpson. James Ho conducted original STRATUM programming. The numerical models that STRATUM uses to calculate tree benefit data are based on years of research by Drs. McPherson, Simpson, and Qingfu Xiao (UC Davis). Reference city data on tree growth and geographic variables were developed under the direction of Paula Peper, Kelaine Vargas and Shelley Gardner (i-Tree 2014a).

Research and Treeconomics have signed a Memorandum of Understanding to implement
i-Tree across the country.[30]

According to Driscoll et al. (2012), calculations provided by the i-Tree model have been
used to inform urban forestry management and policies throughout the world. These
authors have aggregated evidence for a wide range of ways that consultants, managers,
and local citizens use i-Tree results to guide urban forestry activity such as: building
financial support for urban forestry programs; linking local tree data with the U.S.
Conference of Mayors Climate Protection Agreement; support public outreach campaigns
on the benefits of trees; developing urban forest strategic management plans; securing
financing for tree planting and management; and combating invasive pests. Most of the
data collected and analyzed through i-Tree are used to encourage municipal, county, and
state leaders to establish or improve urban forestry programs, to recognize the role that
trees play among urban natural resources, and to focus funds to improve stewardship.

As of Driscoll and colleagues' publication in April 2012: more than 8,200 unique users in
99 countries had downloaded i-Tree, representing a 30% per year growth rate since its
release in August 2006; traffic on the i-Tree Web site had increased roughly tenfold since
the release of version 3.0 in June 2009 and continued to increase; and about 20,000
unique visitors accessed the i-Tree Web site every three months. In addition, between 50

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[30] Personal communication with Cecil C. Konijnendijk, September 21, 2014.

and 100 journal articles and reports had been published in which the software was used, and the numbers increased annually. As of April 2014, 10,361 unique users in the United States and 13,840 unique users worldwide had downloaded i-Tree software, a 69% increase over two years. In 2013, roughly 31,400 unique visitors accessed the i-Tree website every three months, a 57% increase over the previous year.[31]

The software is continually being updated and improved, and the most recent 2014 version expands the capabilities of its two most widely-used applications, both of which generate volumetric and monetary data based on the environmental function of trees. i-Tree Canopy estimates annual pollution removal, annual carbon sequestration, and total carbon storage based on canopy cover. i-Tree Design forecasts the cumulative benefits and values of individual or groups of trees over a specified time period, for environmental functions including air quality improvement, carbon dioxide reduction, energy related outputs, and the benefit and value of each tree since planting.

Depiction and analysis of urban trees has also been enhanced by LIDAR (Light Detection and Ranging), a remote sensing technology that uses light in the form of a pulsed laser to measure variable distances to the Earth (see Figure 3.4). These light pulses – combined with other data recorded by the airborne system – generate precise, three-dimensional information about the shape of the Earth and its surface characteristics, including

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[31] Based on data provided by Al Zelaya, i-Tree Technical Services, August 18, 2014.

vegetation heights, structures, and densities (Alonzo, Bookhagen, and Roberts 2014;

USFS 2014).
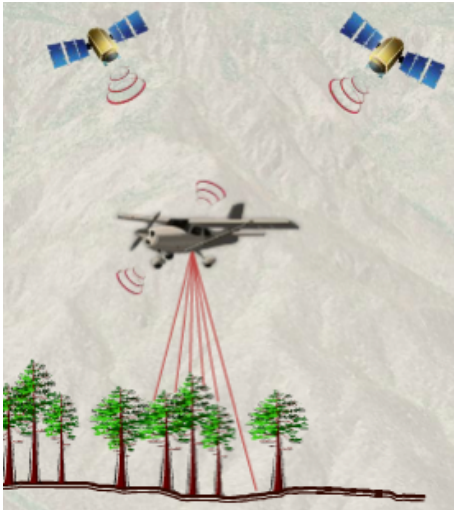
Figure 3.4: LIDAR uses light pulses from airborne systems to depict the earth's surface, including vegetation height, structure, and density (Image: Remote Sensing Applications Center).

Another new tool is EnviroAtlas, a web-based program created by the EPA that allows

users to explore the many benefits people receive from nature, otherwise known as

ecosystem services. Key components of EnviroAtlas include: an interactive map with

broad scale data for the lower 48 states and fine scale data for selected communities; an

Eco-Health Relationship Browser that cites research on the human health benefits of

nature; and links to other GIS and analysis tools (such as i-Tree) and information on

ecosystem services.

Urban Forestry Master Plans

In recent years, U.S. cities have begun to undertake urban forestry master plans. These are different from management plans, which emerged with the rise of urban forestry in the 1970s and function primarily as operational documents. Management plans typically cover three to five year periods and identify responsibilities, timelines, and budgets for activities such as tree planting, pruning, and removal. They tend to be undertaken by public works and parks departments, and cover trees within the jurisdiction of these agencies. Urban forestry master plans, on the other hand, are future-oriented documents covering 15 to 20-year periods and rarely address budgets. They tend to include public, nonprofit, and private actors, and lay out a vision for trees across the entire city.[32]

The Davey Resource Group, a horticultural and environmental services consulting firm with a nationwide practice, has led the development of roughly 10 such plans.[33] A recent example is the Pittsburgh Urban Forest Master Plan, coordinated by nonprofit organization Tree Pittsburgh (2012). This initiative began in 2010 with an Urban Forest Master Planning Symposium that convened over 50 key stakeholders from Pittsburgh, the region, and the nation. By early 2011, funding was secured from local foundations, the Pittsburgh Shade Tree Commission, and the USFS. The plan was produced by the Davey Resources Group and released in 2012.

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[32] Personal telephone and e-mail communication with Josh Behounek at Davey Resources Group, October 2, 2014.

[33] Ibid.

The document is organized around four principal sections: "what we have" (state of existing forest); "what we want" (vision); "how we get there" (goals); and "how we are doing" (monitoring). The main body of the document focuses on the third section regarding implementation. Here, actors currently engaged in tree planting are identified and recommendations are provided to enhance collaboration. Existing studies on the urban canopy are summarized along with recommendations for future research. Current and possible tree planting percentages are provided for 90 discrete neighborhoods within the city (Figure 3.5). Strategies are outlined for enhancing public engagement through neighborhood initiatives, coordinated outreach campaigns, and volunteerism. Current funding sources and levels are summarized along with recommendations for future financing. Current and future tree management and protection practices are outlined, as well as goals related to invasive diseases and the role of trees in preserving Pittsburgh's local character.

Specific implementation targets are also identified and include: a goal to increase current canopy cover from 42% to 60% over the next 20 years; a goal to incorporate urban forestry practices into the city's stormwater management plan; and a goal to establish a comprehensive tree emergency and response and recover plan. All of the aforementioned recommendations and goals are supported by case studies from precedents in other cities, and they are summarized in tables that identify the various stakeholders who may play a role in implementation.
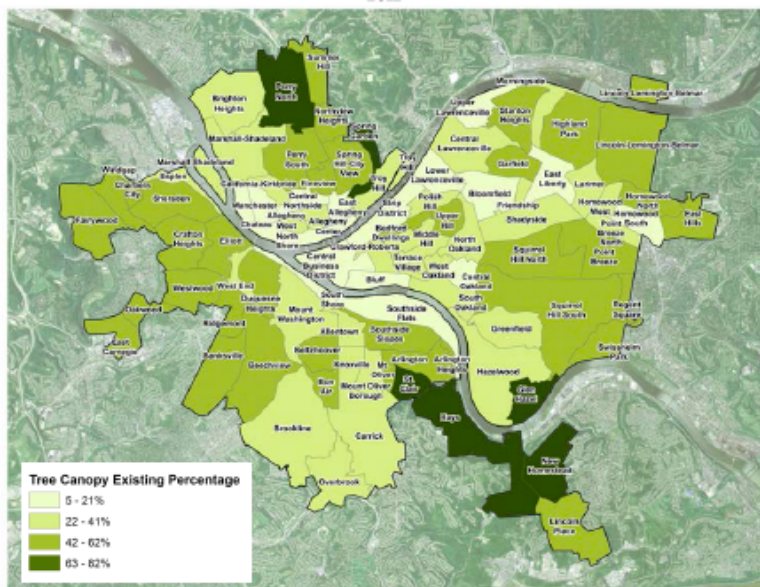
Figure 3.5: 2012 Tree canopy in Pittsburgh neighborhoods (Source: Tree Pittsburgh).

Actors

In *Planning the Urban Forest,* an advisory report published by the American Planning

Association, Kollin and Schwab (2009) identify three tiers of actors.

> • The *first tier* includes arborists, urban foresters, and parks managers. Arborists
>
> are trained in the art and science of individual tree management, which includes
>
> pruning, planting, and other functions to maintain tree health. The International
>
> Society of Arboriculture (ISA) manages the certification program for professional
>
> arborists. Foresters, on the other hand, typically have a four-year baccalaureate
>
> degree in forestry and are trained to analyze and understand whole ecosystems.
>
> States and other professional organizations such as the Society of American
>
> Foresters offer licensing and credentialing. Parks managers also play an

important role in tree planting and have their own university programs and
certifications standards

• The *second tier* includes allied professionals that provide programmatic support
in carrying out urban forestry programs. This includes urban planners, who
interact with first tier actors to integrate forestry goals into citywide plans and
policies, such as site plan review, establishing tree planting and preservation
requirements, acquiring open space, etc. This tier also includes planning
commissioners, public works department, architects, engineers, and consultants.

• The *third tier* consists of citizens, developers, and elected officials. As described
above and below, citizen-based groups have played a major role in urban tree
planting since the 1970s. Some developers, in turn, recognize the value of
protecting and incorporating trees in projects, and mayors who champion urban
tree planting "can leave their mark for decades to come" (ibid 17).

Large-Scale Tree Planting Campaigns

The broad depiction above focuses on the disciplinary role of urban forestry actors.
However, assessments of contemporary large-scale urban tree planting practice in the
U.S. suggest a more complex picture, including prominent engagement by municipal
officials. Interviews with 58 stakeholders in six cities and one county that are pursuing

large-scale tree planting found that mayors were the primary source of vision for such

greening initiatives (see Figure 3.6) (Young and McPherson 2013). Respondents placed

the majority of management activity with city parks departments, the mayor's office and

local nonprofits, while few emphasized corporate or advisory board participation. Despite

strong engagement by municipal officials, the authors caution that this does not

necessarily translate into institutionalization as most cities relied heavily on short-term,

contract labor for stewardship.

City	Mayor	Staff	City council	Non-profits	Private sector
New York	10	2	0	8	0
Los Angeles	14	0	0	0	0
Houston	2	0	0	4	1
Salt Lake County	12	3	0	0	0
Sacramento	0	1	1	9	0
Denver	10	0	0	0	0
Total	48	6	1	21	1

Figure 3.6: Source of large-scale tree planting vision, by number of respondents (Young and McPherson 2013).

In an earlier study of large-scale tree planting campaigns in eight large U.S. cities

(Albuquerque, Baltimore, Denver, Houston, Los Angeles, New York, Sacramento,

Seattle) and one metropolitan Salt Lake County, Young (2011) found that municipalities

employed a spectrum of planning strategies, from highly institutionalized, data-driven

projects to decentralized, grassroots efforts. Importantly, he found that most programs

lack access to traditional infrastructure funding and that initiatives lost momentum when

mayors who launched tree planting initiatives were not reelected. The programs tended to use cost-based budgeting and relied upon city general funds, grants, as well as private/corporate donations for support. This raises important questions about the long-term viability of large-scale tree planting initiatives, and the degree to which such programs are provided the fiscal and managerial support of traditional (grey) infrastructure.

Addressing urban forestry more broadly, Konijnendijk van den Bosch (2014) posits that recent history has seen the emergence of a new "hybrid model" involving public and private actors, as well as civic society. This supports Campbell's (2013, 344) in-depth assessment of New York City's initiative to plant one million trees, a campaign comprised of the Department of Parks and Recreation (DPR) and nonprofit group New York Restoration Project (NYRP), and "carefully negotiated via City Hall at its outset" with initial philanthropic funding. This hybrid institution is characterized by joint goals, a formalized Memorandum of Understanding, and a shared public identity through its website, logo, branding, and messaging.

Campbell (2014) describes a three-fold rationale behind the partnership. First, it was a strategy to leverage municipal funding with private dollars. MillionTreesNYC attracted $10 million in donations from the Bloomberg Philanthropies and David Rockefeller. Then NYRP secured corporate sponsorship from Toyota, BNP Paribas, and Home Depot,

more than doubling the organization's budget from $6 million in 2007 to $13 million 2010. Second, the project sought to employ the strengths of each partner, wherein the large-scale tree planting expertise of DPR balanced by the outreach and marketing savvy of NYRP. Third, the initiative needed both partners to plant across land jurisdictions: DPR would plant street trees, in parks, and reforest thousands of acres of 'natural areas;' NYRP would plant on public housing grounds, schoolyards, 'publicly accessible private lands,' and give away trees to residents.

Of note, the idea to plant one million trees originated with Bette Midler, singer, performer, and founder of the NYRP. Her announcement of this goal at a spring 2006 picnic fundraiser surprised many at both DPR and the NYRP, who did not view NYRP as having an urban forestry agenda or expertise. But Midler's celebrity provided a platform for courting donors, attracting media attention, and gaining audience with public officials (ibid). Not long thereafter, leadership at the Mayor's Office, DPR, and NYRP worked together to craft the MillionTreesNYC campaign, which became a core component of PlaNYC 2030, Mayor Bloomberg's executive led initiative for long-term sustainability.

PlaNYC has been critiqued for lacking transparency (Angotti 2010), and some argue that large-scale tree planting was used to help cement stronger public buy-in for the overarching sustainability plan. As Campbell (2014) notes, the million trees goal was in fact released to reporters one day in advance of the public release of PlaNYC on April 22,

2007 (Rivera 2007). Yet, she describes how leaders of MillionTreesNYC realized that the campaign would be a substantial actor in the organizational landscape of the city, and they crafted roles for allies by creating an Advisory Committee of roughly 400 individual members from 109 organizations who worked through seven thematic subcommittees.

This undergirds Campbell's (2014) characterization of MillionTreesNYC as one of 'networked governance,' where dozens of civic, public, and private actors were brought into the campaign as advisors. The role of these advisors varied over time and across issues. Yet, while the intention of the Advisory Committee was one of shared governance, it did not always live up to this ideal. "Civil society groups are invited into policymaking and implementation of both PlaNYC and MillionTreesNYC in a controlled, formal manner such as in public comment periods, consultations, and advisory boards. Only certain, professionalized nonprofit groups with access to key resources, such as elite ties, are able to trump this process and insert themselves in a central role, as illustrated by New York Restoration Project (NYRP)" (L. K. Campbell 2013, 339). She also finds that, "for the most part, the public is viewed as recipients or *consumers*: of messages, of educational activities, of stewardship programs, of trees, and of ecosystem services" (L. K. Campbell 2014, 255).

Within this governance network the DPR occupies a central position, with a far greater number of ties than any other node. See Figure 3.7, where blue nodes represent

government groups, yellow nodes are civic groups, and red nodes are business groups.
This reinforces Campbell's (2013) narrative account of the importance of DPR to the
MillionTreesNYC campaign, from the earliest stages of PlaNYC goal-setting throughout
all stages and sites of implementation.
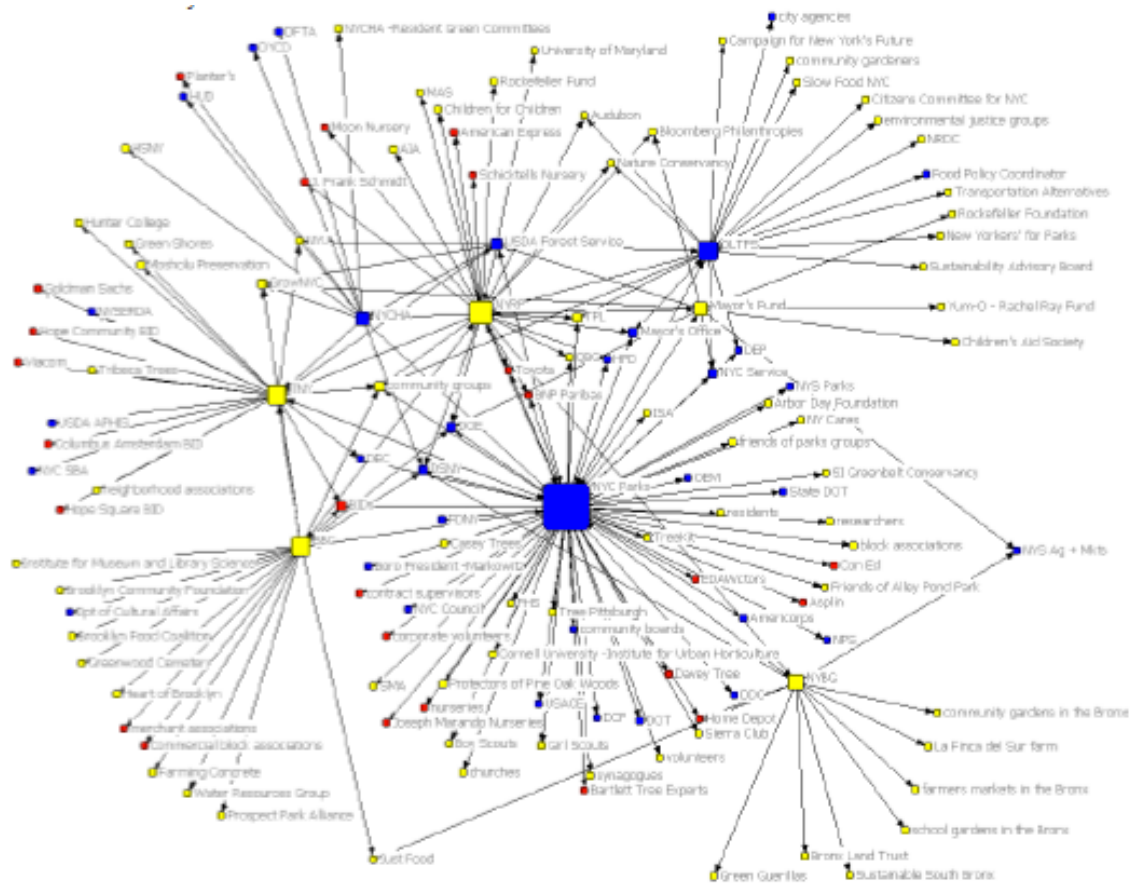
Figure 3.7: New York City urban forestry network map illustrates how the Department of Parks and
Recreation (blue square in middle) occupies a central role (L. K. Campbell 2013).

In an assessment of Million Trees Los Angeles (MTLA), Pincetl (2010a, 236) also found that multiple nonprofit and city agency programs were involved in planting and maintaining trees, resulting in a partnership approach that can be described as, "coproduction, in which the Mayor's Office serves to control, direct, and supervise the participation of differentiated public and private entities, dispersed across the city." Here, the idea to plant a million trees emerged in 2005 as part of Antonio Villaraigosa's mayoral campaign pledge to make Los Angeles the greenest city in the nation. Shortly after coming into office in 2006, Villaraigosa assigned the development of MTLA to one of his appointed public works commissioners.

In an effort to build interagency and multi-stakeholder collaboration in support of the program, the commissioner created a steering committee representing city departments (e.g., the Urban Forestry Division of the Public Works' Department of Transportation, the Los Angeles Department of Water and Power [LADWP], and the Planning Department), academic advisors, and existing nonprofit tree planting organizations such as TreePeople, which had initiated a million tree campaign in 1984. Unlike MillionTreesNYC, which received $400 million in public support, MTLA had little

personnel and funding, and the plan relied upon established tree planting organizations in the city to execute most of the program.[34]

According to Pincetl (2010a), the program itself is located in the Mayor's Office, but its nonprofit foundation, which funds portions of the program, is located in the Department of Public Works. Tree stock is provided through funding by the municipal utility, the Los Angeles Department of Water and Power, and funding is derived from multiple sectors, including private, federal, state, and municipal sources.

Local Community Groups & Umbrella Groups

The hybrid (Konijnendijk van den Bosch 2014), networked (L. K. Campbell 2014) and coproduced (Pincetl 2010a) character of contemporary municipal tree planting is made possible by the grassroots environmental activism that germinated in the 1970s. Of note, over 90% of contemporary urban environmental stewardship organizations were founded since 1970, and this has been attributed to the rise in urban 'self-help' social movements during the period (Svendsen and Campbell 2008). In New York City, such grassroots organizations created a heterarchic (i.e. non-hierarchical) and polycentric governance effort, which has been attributed to an ability to work across scales and sectors (Connolly et al. 2013). Also in New York City, an assessment of contemporary environmental

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[34] Pincetl (2010a) attributes Los Angeles's constrained fiscal budget to low local property taxes (stemming from Proposition 13 in 1978) and legislation inhibiting revenue generation (Proposition 218 in the mid-1990s).

stewardship groups found that the most common sites for engagement were parks (41.3%), community gardens (40.5%), and street trees (23.9%) (Fisher, Campbell, and Svendsen 2012), all of which share vegetation as a common thread. Here, most groups (51.2%) created prior to 1970 scored high on a professionalization index; over half (59.2%) of those founded between 1970 and 1990 scored low on the index; and an overwhelming majority (72.0%) of groups started since 1990 scored low on the index.

Johnston (1996) describes TreePeople in Los Angeles as probably the most influential of the city-based volunteer sector urban forestry organizations in the United States, one that played a unique role in the development of the movement. Today there are countless such groups. In New York City alone, there are more than 120 groups dedicated to street tree planting and over 200 engaged in parks (Fisher, Campbell, and Svendsen 2012). The groups are highly decentralized, which has prompted the emergence of umbrella organizations.

The Alliance for Community Trees (ACTrees) was founded on Earth Day in 1993, and has grown into a network of more than 200 nonprofits, municipalities, and partners that promote the environmental, economic, public health, and social benefits of trees and urban forests. Local ACTrees member organizations have planted over 15 million trees across the U.S. and Canada with help from over 5 million volunteers. In February 2013, ACTrees and partners from the Sustainable Urban Forests Coalition met with 60

Congressional offices during a 5th annual Policy Summit, and advocated for support of

the U.S. Forest Service's Urban & Community Forestry Program, and continued funding

for urban forestry research (ACTrees 2014).

The Sustainable Urban Forest Coalition (SUFC) is comprised of 28 national

organizations working to advance a unified urban forest agenda. Launched in 2004

through a gathering convened by the U.S. Forest Service, the group is composed of city

planners, educators, landscape architects, nonprofit leaders, scientists, arborists, foresters,

nurserymen and women, and other professionals who care for, monitor and advocate for

trees and urban forests, which it defines as "the sum total of all trees (on private and

public lands) and green space that provide essential environmental, health and economic

benefits to a community" (SUFC 2014). The Coalition has also been a partner in the

development of the Vibrant Cities/Vibrant Communities Initiative, described below.

Arbor Day Foundation

A prominent protagonist in late 20th and early 21st century urban tree planting is the

Arbor Day Foundation, created in 1971 to commemorate and capitalize upon the

centenary of J. Sterling Morton's holiday for trees. Founded by fellow Nebraskan, 21-

year-old John Rosenow, the organization's original mission was to raise awareness about

Arbor Day and about trees by awarding prizes and generating public recognition of

laudable tree planting projects. In its first 10 years the Foundation also served as an

information clearinghouse for related work. Over time, this activity has evolved into more than a dozen discrete programs, several of which have a direct connection to urban tree planting.

Tree City USA® began in 1976 and has become, according to Cohen (2004), the Foundation's most successful program and enduring link with the public. The program targets municipal forestry staff nationwide, coordinates with the U.S. Forest Service and the National Association of State Foresters, and is cosponsored by the U.S. Conference of Mayors and the National League of Cities. Communities achieve Tree City USA status by meeting four core standards intended to promote sound urban forestry management: maintaining a tree board or department; having a community tree ordinance; spending at least $2 per capita on urban forestry; and celebrating Arbor Day. There are currently more than 3,400 Tree City USA communities, which are home to over 135 million people or about one-third of all Americans (see Figure 3.8).

Figure 3.8: A Tree Pittsburgh intern leads elementary school children to point and shout "Grow Tree, Grow!" to a newly planted Dawn Redwood (*Metasequoia glyptostroboides*) on Arbor Day. Source: Tree Pittsburgh.

The Tree Line USA® program recognizes best practices in public and private utility arboriculture, with the goal of protecting and enhancing the urban forest. The Foundation collaborates with the National Association of State Foresters on this program, and has established five criteria that utility companies must achieve. Trees for America® is the Foundation's primary direct outreach effort to the public, offering ten trees – from a selection of over 100 species – in exchange for basic membership, which includes newsletters, a tree planting and maintenance guide, and discounts on additional tree purchases. This program is based upon the Foundation's belief that "each of us has a responsibility for wise environmental stewardship" (Arbor Day Foundation 2014). In

fiscal year 2012-2013, members received over 6 million trees for planting in yards, acreages and neighborhoods (Arbor Day Foundation 2013a).

During the same fiscal year, the organization had $40.7 million in total revenue and support. A little over $1 million came from federal grants through the U.S. Department of Agriculture, U.S. Department of Housing and Urban Development, and U.S. Department of Interior. Nearly $1.3 million came from corporate sponsors, of which Toyota Foundation contributed $1.1 million (ibid). Much of Toyota's funding is directed to the Tree Campus USA program, started in 2008 with the car company's support, wherein some 200 universities are honored with program membership based on five criteria aimed at promoting healthy trees and engaging students and staff in environmental stewardship. A 2013 press release celebrating the five-year partnership emphasized climate change mitigation as one of the important outcomes of the program. "The 200,000 trees on the University of California, San Diego, campus remove 10,000 tons of carbon dioxide emissions from the atmosphere every year, helping to reduce total campus emissions by 5% in a heavily populated and auto-reliant metropolitan area" (Arbor Day Foundation 2013b).

Cohen (2004) analyzed the Foundation's communications to identify the rationale it employs to promote tree planting. One overarching theme he identifies is a dialectic that frames trees as a solution to both natural and man-made problems. These problems

include summer winds, soil erosion, "sun-baked" cities, and the greenhouse effect. To the latter, Cohen points to a membership solicitation that exhorts individuals to "personally help avoid" global climate change, exclaiming that: "America desperately needs more trees – now!" (ibid 58). This reflects recurring themes of wise stewardship and wise environmental management. He also points to evidence that equates tree planting to a patriotic act and one that builds moral fiber.

American Forests

In an historical treatment of urban forestry in the United States, Johnston (1996, 263) contends that it would be difficult to overestimate the influence of American Forests (formerly the American Forestry Association). "Without the AFA's commitment and leadership, urban forestry may have remained a largely professional and academic preoccupation without any significant impact on government policy or public attitudes." He marshals evidence that the organization was largely responsible for the political lobbying which led to the creation of the USDA Forest Service in 1905, and following the first National Urban Forestry Conference in 1978 – a landmark event that brought together some 450 researchers and practitioners and firmly established the urban forestry concept – the organization "decided to place its considerable influence and resources behind the development of a national urban forestry movement."

The organization rapidly became a catalyst for urban forestry and was instrumental in establishing the National Urban and Community Forestry Leaders Council in 1981, later to be called the National Urban Forest Council (NUFC), which continues to be a non-governmental group with a mission to represent all the elements of the urban forestry movement. In the ensuing years, American Forests led the second, third, fourth, and fifth National Urban Forestry Conference in 1982, 1986, 1989, and 1991, respectively.

In 1989, American Forests launched a national campaign to involve the private and voluntary sectors in a huge tree planting effort throughout the United States. Called Global ReLeaf, the project focused on tree planting and management in local communities as a way to help mitigate global climate change. Johnston references TreePeople's citizen-based initiative to plant one million trees in Los Angeles as inspiration for this effort, and he contends that the significance of Global ReLeaf was not just its success in encouraging community action and attracting private sector sponsorship on a national scale. "For the first time, [American Forests] was able to link urban forestry and the planting and care of trees in local neighborhoods with global environmental issues. It successfully harnessed growing public concern about the global environmental crisis and channeled it into a major new driving force for the urban forestry movement" (1996, 266).

This interpretation is supported by Cohen (2004, 68), however, he attributes Global

Releaf's inception to less altruistic motives. American Forests in the 1970s to mid-1980s

was in many respects "moribund . . . suffering from low membership and a lack of clear

purpose." As one board member phrased it in 1984, the organization was "for everything

and against nothing" (ibid 172). Cohen credits Global Releaf with rescuing American

Forests, giving it a broader constituency and increased revenue, and signaling the

transition from an organization focused on forestry policy and science to a popular

citizens group.

An early working document for the program was entitled "ReLeaf for Global Warming:

A National Citizen's Action Campaign," and one of the goals was to "create, publicize,

and report progress on a national citizen's campaign to plant 50 million new trees in

energy-conserving locations in the United States by 1992." Yet, one board member

expressed concerns that the organization was on controversial grounds scientifically,

suggesting "that sufficient areas for planting on a scale to affect global warming are not

available in the United States" (ibid 76).

Nevertheless, American Forests used the Global ReLeaf program to advance fund raising

and tree planting efforts directed at two principal audiences: corporations and the general

public. For example, to determine the number of trees that should be planted to offset

carbon emissions, the program offered a calculator tailored to the individual. "The

average American is responsible for about 10 tons of CO_2 emissions. You can plant 30

Global ReLeaf trees right now to offset that annual carbon debt" (ibid 86).

Marketing campaigns and related communications adopted messages that essentially

frame tree planting as an environmental panacea. "Plant a tree, cool the globe." "Every

time you plant a tree, you're helping to solve what may be the greatest environmental

problem of our lifetime, global warming." "Won't you do your part to help cool the

globe" (ibid 78). "Everyone wants to save the world" – tree planting is "a way to get

started" (ibid 88). In some cases advertising went so far as to conflate the purported

benefit of tree planting with the purchase of fossil fuel burning automobiles, which are a

major source of the carbon emissions that cause climate change:

> "Chevrolet/Geo Environmental, American Forests, and The National Fish &
>
> Wildlife Foundation are helping to make the world a better place to live . . . but is
>
> that thanks to you? If you've purchased a new Chevrolet/Geo car or truck, making
>
> it possible for Chevrolet/Geo dealers to support environmental restoration and
>
> education . . . The answer is yes."

Some board members expressed apprehension. "I am still concerned about the program

and our organization being discredited if we continue to pursue corporate sponsors who

have a very strong incentive to make the public think that planting trees is a more

effective means of offsetting global warming than is changing their behavior" (ibid). The

list of corporate sponsors in 1994 included Texaco Corporation, American Electric

Power, and *Business Week.* By 1996 the fundraising and tree planting potential of Global

Releaf had grown into American Forests' flagship program, and $2.8 million in grants

supported 340 projects.

Today, the American Forests features a "carbon footprint calculator" on its website, and

has roughly 50 corporate sponsors, across a range of products and services. Notably

lacking from this list are major oil and automobile companies. The organization defines

its mission as being "committed to raising awareness about the vital benefits our urban

forests provide and the science-based tools that are out there to best assess those

benefits." Stated benefits include: clean air and water; climate change mitigation; lower

utility bills; increased property value; increased retail commerce; reduced stress; greater

social cohesion, and reduced noise. Many of these benefits are presented in economic

terms, based on research by the U.S. Forest Service: "Urban forests are estimated to

contain about 3.8 billion trees, with a structural asset value of $2.4 trillion . . . Urban trees

in the lower 48 states store 770 million tons of carbon, valued at $14.3 billion, and

remove approximately 784,000 tons of air pollution annually, with a value of $3.8

billion" (American Forests 2014a).

The organization is chair of the policy work group and member of the steering committee

for the Sustainable Urban Forest Coalition (SUFC). The organization has also conducted

its own research and cites a 2001 finding that "634.4 million trees were missing in

America's urban areas due to development and other factors" (American Forests 2014b).

More broadly, the organization sponsors conferences on urban forestry, and advocates on

behalf of urban forest legislation and support. In 2013, for example, the organization

identified the "10 Best Cities for Urban Forests," based on six criteria: Civic engagement

in maintaining the urban forest; Urban forest strategies and city greening to address city

infrastructure challenges; Accessibility of urban forest and greenspaces to the public;

Overall health and condition of the city's urban forest; Documented knowledge about its

urban forests; and Urban forest management plans and management activities.

U.S. Forest Service

According to Silvera Seamans (2013), federal urban forestry legislation began with the

1962 President's Outdoor Recreation Resources Review Commission, which first

designated "urban forestry" as an autonomous division with the U.S. Forest Service. The

primary federal agency charged with developing policy for trees and forests is the U.S.

Forest Service (USFS), an agency in the U.S. Department of Agriculture. The USFS was

established under that name in 1905 through the leadership of Gifford Pinchot, who

restructured and professionalized the management of the nation's forests. In the early 20th

century, federal agencies such as the USFS were new and represented a substantial

expansion in federal scope and responsibility (Pincetl et al. 2013), yet, it was not until the 1960s that the USFS formerly engaged the urban environment.[35]

A pivotal moment came in 1968, when the Citizens Advisory Committee on Recreation and Natural Beauty, chaired by Laurence S. Rockefeller, submitted its Second Annual Report to the President of the United States. Part of the report emphasized that urban trees were not being inadequately managed, and it recommended that:

> "an urban and community forestry program be created in the United States Forest Service. The program should encourage research into the problems of city trees, provide financial and technical assistance for the establishment and management of city trees and develop Federal training programs for the care of city trees" (in Grey and Deneke 1986, 7).

The President's acceptance of this report has been described as the official recognition of urban forestry in the United States (ibid), and it laid the foundation for increasing federal engagement in urban forestry in the ensuing decades. In 1971, Congressman Sikes of Florida introduced the Urban Forestry Act, which was passed in 1972 and included an amendment to the Cooperative Forestry Act of 1950, tasking the USFS with developing an active program in urban forestry (ibid). Many states followed suit by amending their

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[35] Oddly, a self-commissioned history of the USFS in 2005 never once mentions urban forestry (Williams 2005).

own cooperative forestry laws with provisions for urban forestry initiatives. A few years later the Cooperative Forestry Assistance Act of 1978 expanded the federal government's commitment to urban forestry by authorizing the Secretary of Agriculture to provide financial and technical assistance to state foresters. Administered by the USFS, this led to a jump in funding for urban and community forestry assistance from $60,000 in 1977 to $3.5 million the following and subsequent years (Ricard 2009).

The legislation is generally credited with launching the USFS's direct involvement in urban forestry with states, municipalities, and non-governmental organizations, and it is responsible for much of the recent expansion of urban forestry in the United States, especially since 1990 (Konijnendijk et al. 2006). The act stipulates that:

1) the health of forests in urban areas and communities, including cities, their suburbs, and towns, in the United States is on the decline;

2) forest lands, shade trees, and open spaces in urban areas and communities improve the quality of life for residents;

3) forest lands and associated natural resources enhance the economic value of residential and commercial property in urban and community settings;

4) urban trees are 15 times more effective than forest trees at reducing the buildup of carbon dioxide and aid in promoting energy conservation through mitigation of the heat island effect in urban areas;

5) tree plantings and ground covers such as low growing dense perennial turf grass sod in urban areas and communities can aid in reducing carbon dioxide emissions, mitigating the heat island effect, and reducing energy consumption, thus contributing to efforts to reduce global warming trends

6) efforts to encourage tree plantings and protect existing open spaces in urban areas and communities can contribute to the social well-being and promote a sense of community in these areas; and

7) strengthened research, education, technical assistance, and public information and participation in tree planting and maintenance programs for trees and complementary ground covers for urban and community forests are needed to provide for the protection and expansion of tree cover and open space in urban areas and communities (in Cohen 2004, 105–106).

According to Konijnendijk et al. (2006), the legislation is also one of the first and most widely quoted definitions of urban forestry, noteworthy for its inclusion of the individual tree:

"The term 'urban forestry' means the planning, establishment, protection, and management of trees and associated plants, individually, in small groups, or under forest conditions within cities, their suburbs, and towns" (in Miller 1988, 35)

This federal assistance was responsible for many tree planting and management

initiatives, and by 1982 every state was engaged in some form of urban forestry

(Johnston 1996). However, with the election of President Reagan in 1981, federal

assistance for urban forestry declined from $3.5 million to $2.1 million by the end of his

eight-year administration (Abbott 1992, in Johnston 1996). Despite this lull, things would

soon improve again under President George H.W. Bush, who was very supportive of tree

planting (Ricard 2009).[36] Sensing a more receptive political climate, Congressman Jim

Jontz from Indiana introduced the Urban and Community Forestry Act to Congress in

1989, with a goal to expand the authority of the USFS through the cooperative forestry

system. Authored with substantial input from James Lyons, a staff member on the House

Agricultural Committee, and Gary Moll, Director of Urban Forestry with American

Forests, the legislation was proposed in 1989 and formed the precursor to the urban

forestry language of the Forestry Title in the 1990 Farm Bill. This expanded the role of

the USFS by amending the Cooperative Forestry Assistance Act of 1978, and increased

the urban forestry appropriation tenfold: from $2.8 million in 1990 to $27.1 million in

1991 (ibid). The legislation also included a section on Urban and Community Forestry

Assistance, calling for the establishment of a National Urban and Community Forestry

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[36] Ricard (2009) cites Bush's relationship with Trammel Crow, a powerful developer and campaign supporter, for putting tree planting on the President's agenda. Yet, none of Ricard's interviewees could explain why Crow advocated for tree planting.

Advisory Council (NUCFAC) to provide direction, guidance and a voice for the urban

forestry movement to the Secretary of Agriculture (Johnston 1996).

This marked the beginning of a new phase in U.S. urban forestry, including a significant

increase in professional status, prestige, staff, and funds. Based on in-depth analysis

conducted for a PhD dissertation, Ricard (2009) also concludes that this "punctuated

moment in the evolution of federal urban forestry policy" (p. 333) established an "urban

forest policy monopoly" consisting of the USFS, state foresters, and American Forests in

concert with congressional legislators, staff, and committee.

Today, the USFS is actively engaged in research and manages seven research stations.

The Northern Research station has over 175 scientists, and includes Urban Field Stations

in Baltimore, Chicago, New York and Philadelphia. The model for one of the most

widely used urban forestry tools, i-Tree, was developed by USFS scientists, who actively

publish in academic literature and are significant actors in the urban forestry discourse. In

2004, the agency convened the nation's leading urban forestry organizations, leading to

the Sustainable Urban Forests Coalition. Reflecting the challenging macroeconomic

conditions of the period, the Coalition recently lobbied Congress to maintain FY 2014

funding at no less than FY 2012 enacted levels for the Urban and Community Forestry

program at $31.3 million. In its letter to Congressional leaders supporting this effort, the

Coalition described the goal of the Urban and Community Forestry program as assisting "cities, suburbs, and towns to maximize tree canopy and resulting environmental services" (SUFC 2013).

Together with the New York Restoration Project (New York City's primary nonprofit tree planting partner), the USFS also launched in 2010 the Vibrant Cities and Urban Forests Task Force, a group of 25 experts on urban ecosystems and urban forests drawn from across the nation and representing a broad range of disciplines. In 2011, the Task Force issued *Vibrant Cities and Urban Forests: A National Call to Action*, setting forth 12 recommendations and action steps for promoting urban forests at the local, state, regional and national levels.

Speaking to the importance of the USFS, Johnston (1996, 270) asserted that any significant reduction in the agency's support for urban forestry "could have disastrous consequences for the movement." The agency has been at the forefront of urban forestry since the late 1970s and provided much needed support through financial and technical assistance, conducting research, promoting information exchange and fostering partnerships between relevant organizations, not only on a federal basis but also at the state and city level. Indeed, the ascendance of the federal government via the USFS is a noteworthy characteristic in the contemporary constellation of urban greening actors.

Drivers

Ecosystem Services for Sustainability

The late 20th and early 21st century has witnessed mounting concern about ecological

degradation and sustainability. As described above, the 1960s revolt against the excesses

of industrial modernity gave rise to a popular environmental movement that included

sweeping federal legislation to control pollution. It also yielded a flowering grassroots

activism that included municipal tree planting groups. An umbrella organization that

emerged from this decentralized activity was the Alliance for Community Trees

(ACTrees), and its original mission statement reflects the aspiration underlying

community-based tree planting: "The ACT mission is more than just planting trees. We

believe the simple act of planting a tree provides a formula for healing our

neighborhoods, our society and our world. Planting and caring for trees is a simple form

of community service by which every individual can directly improve the environment

right where we live. This is citizen volunteerism for maximum funding leverage. This is

urban renewal from within" (ACTrees 1993).

This speaks to the holistic goals of sustainability, which is a prominent motive underlying

large-scale tree planting initiatives now underway in cities across the country (Young

2011). New canopy cover goals also figure prominently in municipal sustainability plans

(City of New York 2010; City of Philadelphia 2011a). Yet, sustainability has been

critiqued for being too vague and all-encompassing (S. Campbell 1996), and difficult to translate into terms that can guide public policy.

Ecosystem services emerged in the late 1990s as a way to address this gap. "In other words, if we actually lived in a world that was ecologically sustainable, socially fair and where everyone had perfect knowledge of their connection to ecosystem services, both market prices and surveys of willingness-to-pay would yield very different results than they currently do, and the value of ecosystem services would probably increase (Costanza et al. 1997, 258). This logic would soon gain traction in urban tree planting. Prior to the late 20th century, planting trees in cities for environmental goals was largely based on intuition or extrapolated from studies of rural woodlands and forests. Over the past three decades, however, the role of the street tree has transitioned from one of aesthetics and civic improvement to one of environmental service provision (Silvera Seamans 2010; Silvera Seamans 2013). A similar shift is likewise occurring in urban green space management writ large (Wolf 2008; Young 2010; Pincetl et al. 2013).

Silvera Seamans (2013, 2) describes this phenomenon as "the mainstreaming of the ecological street tree," wherein "the science of assessing ecosystem services [has] 'fixed' a new role for city trees and in particular, street trees." She contends that this new rationale is intimately related to sustainability, and that it is being institutionalized: "urban forestry actors increasingly characterize the street tree using ecosystem services

discourse and . . . urban forestry science is used to support ecological claims made about street trees" (ibid. 9). Based on case studies in northern California cities Palo Alto, Sacramento, and San Francisco, Silvera Seamans identifies three factors driving the emergence of an ecosystem service-based tree planting rationale: 1) a local legacy of tree planting; 2) proximity to a major urban forest research station; and 3) individual actors. For example, particulate matter research by UC Davis scientist Thomas Cahill was used to validate the air quality benefits of urban forest expansion in Sacramento. Likewise, the assessment tools, data, and translation of ecosystem services into monetary terms by the former Center for Urban Forest Research at the USFS Pacific Southwest Research Station played a significant role.[37] Describing the ability to quantify benefits in economic terms, one interviewee said, "that can only be verified by virtue of the urban forest research station. What they have done is absolutely probably the biggest paradigm shift, the biggest shift, leapfrog in urban forestry" (ibid 7).

Although the Cooperative Forestry Assistance Act of 1978 predated the emergence of the ecosystem services construct (Costanza et al. 1997; Daily 1997), the environmental function of urban trees is essentially codified in this seminal legislation, which highlights such sylvan mechanisms as atmospheric carbon dioxide reduction, carbon dioxide emissions reduction, and urban heat island mitigation. Quantifying and monetizing

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[37] CUFR is now called the Urban Ecosystems and Social Dynamics Program at the USFS Pacific Southwest Research Station.

ecosystem services is also the primary output of i-Tree, one of the most widely used tools

supporting urban forestry whose distribution is growing at an exponential rate. In

scholarly literature, there were no articles directly applying ecosystem services to cities

prior to 1995, but since then over 450 articles have been published, with *Landscape and*

Urban Planning journal leading the way (Hubacek and Kronenberg 2013). Ecosystem

service provision has also been framed as a normative aspiration for urban planners (APA

2013; Young 2013), and as a primary outcome of green infrastructure, a related construct

informing contemporary urban greening (Benedict and McMahon 2002; Young 2010;

The Conservation Fund 2011; Eisenman 2013).[38]

Indeed, now "in the 21st century, the potential value of urban ecosystem services for

improving the urban environment has penetrated the popular literature and influenced

people's imagination; tree planting programs are an application of these ideas" (Pincetl et

al. 2013, 477). Yet, scholars offer several cautionary notes about the ascendance of

ecosystem services as the dominant rationale for urban trees. Said Silvera Seamans

(2013), urban forestry advocates represent street tree expansion as a type of

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[38] Benedict and McMahon (2006, 1) originally conceived of green infrastructure as "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife." It has since gained significant traction as a stormwater management strategy, in response to more stringent regulations and the cost of repairing and expanding traditional (grey) stormwater systems (City of Philadelphia 2011b; City of New York 2012)

"sustainability fix" for cities (While, Jonas, and Gibbs 2004);[39] yet, this type of "environmental panacea" might obscure not only the actual causes of poor environmental quality but inhibit more substantive solutions (Cohen 1999). Cities are mainstreaming ecosystem services at the policy level, but delegating tree care to residents – "where the latter may negate the former" (Silvera Seamans 2013, 9). Indeed, tree mortality studies suggest that many trees may not survive to provide the ecosystem services that motivate planting campaigns (Roman 2014). Framing trees as a biotechnology may diminish attention to cultural ecosystem services (Konijnendijk van den Bosch 2014) as well as the biophilic, or aesthetic, role of trees.[40] Indeed, a biotechnological approach to urban sylva discounts the important role of trees as urban design elements, including such factors as form, size, color, seasonal interest, and smell; placemaking; visual screening; noise and traffic barriers; and traffic calming.

In addition, citywide introduction of green infrastructure generates a host of costs, management, and urban design challenges that raise important questions about municipal governance (Pincetl 2010b), a topic that has been neglected in urban ecosystem services research (Ernstson et al. 2010). Urban trees do not merely generate benefits, they can also

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[39] While et al. (2004, 551) frame sustainable development as "the search for a spatio-institutional fix to safeguard growth trajectories in the wake of industrial capitalism's long downturn, the global `ecological crisis' and the rise of popular environmentalism."

[40] Silvera Seamans (2013) used the term "biophilic role" in this instance, but in a personal e-mail exchange she clarified that her understanding of biophilia equates to the aesthetic allure and benefit of trees.

create health problems (Dales et al. 2008; Cariñanos and Casares-Porcel 2011; Jariwala et al. 2014) and disservices (Lyytimäki et al. 2008; Pincetl 2010b; Escobedo, Kroeger, and Wagner 2011; Roy, Byrne, and Pickering 2012). Moreover, the scientific claims that underlie ecosystem service arguments for urban tree planting may be flawed, and this may lead to less-than expected outcomes (Pataki et al. 2011; Pincetl et al. 2013; Pataki et al. 2013; Whitlow et al. 2014).

Concern about the application of ecosystem services in cities is further problematized by the critique of ecosystem services writ large, in that it commoditizes nature (Rees 1998; McCauley 2006; Kosoy and Corbera 2010) and emphasizes utilitarian values (Soma 2008; Spash 2008) (see Figure 3.9).[41] Indeed, nonmaterial cultural values have received little attention in the growing body of ecosystem services research (Chan 2012; Daniel et al. 2012), while others suggest that ecosystem services do not merely reflect an objective biophysical reality – they must also be understood and studied as a social practice (Ernstson and Sörlin 2013).

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[41] This logic seeks to bring nature's services into the calculations of economically rational actors. If under capitalism people must ultimately privilege economic rationality, then nature's services must be calculated if they are to be valued (Armitage 2013).

Figure 3.9: Tags like this one, placed on new tree plantings along popular pedestrian routes in Chicago, convey the monetary value of urban ecosystem services to the general public. The tag says: "This tree gives back $1,436 worth of environmental benefits over the next 15 years." (Photo by Tomasz Jelenski [2011], in Hubacek and Kronenberg, 2013).

Intercity competition, Environmental Justice, and Public Health

As noted by Young and McPherson (2013), mayoral offices are principal drivers of large scale tree planting (see Figure 3.6). This suggests that as cities compete against one another to draw entrepreneurial talent to their local economies (Jonas and While 2007; Florida 2008), the contemporary bloom of municipal greening may be due, in part, to intercity competition.

In New York City, a set of interwoven drivers emerged as the project evolved. Initially, bureaucrats at the Department of Parks and Recreation (DPR) used STRATUM to

quantify and monetize the benefits of trees to make their case. Campbell (2014, 246)

asserts that the effect of street trees upon real estate value and commercial activity was

especially attractive to Mayor Bloomberg, "who viewed investments in green

infrastructure as part of a strategy to attract global talent to live and work in New York

City." This led City Hall in 2007 to commit approximately $400 million in capital funds

to DPR for urban forestry, leading one official to frame the initiative as the most

significant change in municipal urban greening since the Parks Department first funded

citywide curbside tree planting under Robert Moses in 1934 (ibid) (see Figure 3.10).

8 regional parks	$386 million
290 open schoolyards	$96 million
36 field lighting sites	$42 million
25 synthetic turf fields	$22 million
800 greenstreets	**$15 million**
natural area reforestation	**$150 million**
220,000 street trees	**$226 million**
Total capital budget:	$937 million
7-year pruning cycle	$2.7 million
Stump removal	$2.0 million
Maintenance staff (227)	$10.4 million
Total annual expense budget increase	$15.1 million

Figure 3.10: New York City DPR's PlaNYC funding with urban forestry related capital funding in bold
(Source: NYC DPR. 2011. "MillionTreesNYC-PlaNYC." Presentation. May 16, 2011. In Campbell 2014).

However, once the project gained traction and moved into implementation, the rationale

shifted to one of environmental justice and public health. This transformation is

encapsulated in a stakeholder interview by Campbell (2014):

"We started doing the math with [DPR] about where there were and were not

street trees, [and] it became clear that this was an initiative as much or more about

environmental justice as it was about creating elite property values. And so once

we set the goal that says, 'Look, every place that it is feasible to put a sidewalk

tree, we would like to put a sidewalk tree,' you immediately have a policy that

fills in the valleys. And, frankly, there aren't that many places on the Upper East

Side that you can put more street trees, but there are lots of places in the South

Bronx. And so it was one of these things that turned a transition from a hard

infrastructure plan into a sustainability plan, and an elitist, global competitive

story into a quality for all story, [this] is to my mind a lot of the magic of what we

did."

Indeed, DPR bureaucrats were cognizant of the way trees had been unevenly distributed

over the past several decades, in part because street trees were previously planted through

a request-based system. Managers saw MillionTreesNYC as a chance to correct these

inequalities by planting first in neighborhoods that were most lacking in canopy cover.

This built on an existing DPR program that preceded PlaNYC called "Trees for Public

Health," which targets six neighborhoods for tree planting because they have fewer than

average street trees and higher than average rates of asthma among young people (City of

New York 2014b) (see Figure 3.11).

Figure 3.11: Trees for Public Health Neighborhoods (City of New York 2014b).

In Los Angeles, the million tree planting campaign also assumed an environmental justice orientation. Soon after Mayor Villaraigosa took office, the city contracted with Greg McPherson – a scientist at the USFS's former Center for Urban Forest Research – to conduct a canopy cover analysis. This quantified and monetized the value of planting a million more trees, including improved air quality ($53 million to $83 million), reduced carbon dioxide ($5.1 million to $8.3 million), energy savings ($75 million to $117 million), stormwater management ($97 million to $153 million), and aesthetic and other benefits ($1 billion). The study also mapped the distribution of trees in the city and the potential of different council districts for more trees (reflecting land use types, urban

densities, and income). An important insight that emerged was that low-income

communities of color had the least canopy cover and often the highest population

densities, and one of the program's explicit missions was to help redress this inequality

(Pincetl 2010a).

Federal Engagement

A major force driving the formal and institutional emergence of urban forestry in the

1960s was the recognition by foresters that the political power base had shifted to cities

and that they had to deal increasingly with the demands of urban residents (Johnston

1996). Indeed, prior to 1965, federal urban forestry policy was essentially absent in the

United States, but this would change in the ensuing decades as the USFS, in partnership

with other advocates, increasingly turned its attention to urban areas (Ricard 2009).

Prominent scholars identify the USFS's direct engagement in urban forestry, especially

after the 1990 Farm Bill, as "responsible for much of the recent expansion of urban

forestry in the United States" (Konijnendijk et al. 2006, 95).

Summary

In the early 17th century colonial period, common open spaces in the U.S.A. were rarely

planted with trees and streets were generally too narrow for tree planting. In some

instances, individual trees, especially the American elm, held totemic significance. In the

early 18th century, Boston Commons drew upon European Baroque influence and

established a double row of English elms, creating the most important public promenade in an American colonial town. In 1708, the city council of New York City sanctioned the planting of trees in front of houses, as people were apparently already doing so; and by mid-century, trees planted in front of individual houses were a distinct feature in New York City and Albany. By and large, colonial instances of tree planting reflected the preference of individual homeowners resulting in an unsystematic pattern.

The years following independence in 1776 witnessed an early tide of civic improvement and a shift in popular attitudes towards trees, leading to a nascent network of street trees, green squares, public promenades, and private yards and gardens (Lawrence 2006). In the span of merely two decades, a fashion for nonnative Lombardy poplars would turn to outright disdain, as preferences for native flora took root. Individuals were still the primary actors of tree planting, be it for public promenades in Boston and Newburyport, Massachusetts, or in front of homes in Philadelphia and New York. Local government relied upon individual property owners to maintain abutting sections of street and sidewalk. If individual trees were deemed to be obstructions or hazards, they were prohibited; otherwise, they were tolerated. Yet, vegetation was still not a prominent element in most American cities before 1850 (Campanella 2003, 110).

The 19th century industrial city inspired an explosion of reform-based urban design interventions, including street tree planting and new types of public parks, park systems,

parkways, and residential open spaces that created an immense arboreal landscape in most U.S. cities by the early 20th century. Predicated on the prevailing miasma theory of disease, public health figured prominently as a rational for increasing vegetation in cities. The greening impulse can also be attributed to the Romantic spirit that informed intellectual thought during the period. The village improvement movement of New England triggered widespread planting of American elms, which became a principal tool of city beautification and a national icon. The period was marked by active engagement of public-spirited individuals as well as local government, and by the end of the century management of street trees was a legitimate arena of municipal responsibility. The era gave rise to tree planting advocacy through Arbor Day and the American Forestry Association (now called American Forests), and it also witnessed scientific and professional specialization in urban trees.

Historical treatments of urban trees have not directed much attention to the 1920-1960 period. This is complicated by the sprawling urban development pattern of the 20th century, making distinctions between city trees and urban trees complex. Peer-reviewed studies show increasing urban canopy cover across the 20th century in Los Angeles and Oakland, California, landscapes that lack much canopy cover in their native condition (Nowak 1993; Gillespie et al. 2012). Arid Tucson, Arizona also increased canopy cover until mechanical cooling was introduced mid-century, after which residential gardening decreased as a leisure-time activity and landscape preferences switched to native drought-

tolerant flora (McPherson and Haip 1989). Yet, tree-density in highly-urbanized

Hollywood in Los Angeles peaked in the 1940s and quickly declined (Pincetl et al. 2013).

Urban parks during the period focused largely on playgrounds and recreation, wherein

vegetation is virtually absent as a design element (Cranz 1982). Combined with massive

elm tree devastation, the story that seems to emerge from this period is one of stagnating

or declining trees in city centers amidst increasing canopy cover across an expanding

urban metropolis. This may be due to conversion of unforested cropland to suburban

residential subdivisions, and the sylvan, pastoral aesthetic preference of this land use

type.

With the bloom of environment consciousness in the 1970s, urban tree planting gained

powerful new advocates through local grassroots groups and federal engagement via the

USFS (Johnston 1996). The 1968 Citizens Advisory Committee on Recreation and

Natural Beauty recommended that an urban and community forestry program be created

in the USFS. The 1978 Cooperative Forestry Assistance Act increased funding for urban

forestry activity from $60,000 in 1977 to $3.5 million. Following a decline in the 1980s,

the 1990 Farm Bill increased funding for urban and community forestry tenfold to $27.1

million in 1991. This legislative sequence established a new phase in U.S. urban forestry,

including a significant increase in professional status, prestige, staff, and funds. Based on

in-depth analysis, Ricard (2009) also concludes that this established an "urban forest

policy monopoly" consisting of the USFS, state foresters, and nonprofit group American

Forests in concert with congressional legislators, staff, and committee.

Federal introduction in urban forestry over the past few decades has essentially mirrored

a historically significant shift in the underlying rationale for urban tree planting. Prior to

the late 20th century, trees were planted in cities primarily for goals relating to aesthetics

and civic improvement. Stated another way, trees were employed as urban design

elements. But over the past three decades, this rationale has fundamentally shifted to one

of environmental service provision. This phenomenon is now "being institutionalized . . .

urban forestry actors increasingly characterize the street tree using ecosystem services

discourse and . . . urban forestry science is used to support ecological claims made about

street trees" (Silvera Seamans 2013, 9). Indeed, a widely used technological tool

supporting urban forestry today is i-Tree, which quantifies and monetizes ecosystem

functions such as air pollution removal, carbon dioxide sequestration, and stormwater

management. This software is based on a model developed by USFS scientists (Nowak

and Crane 2000), and since i-Tree's launch in 2006 the tool has witnessed a meteoric rise

in usage (Driscoll et al. 2012), with some 14,000 unique users worldwide today.

Despite its rising popularity, urban ecosystem services is an open frontier of scientific

inquiry (Gómez-Baggethun and Barton 2013), and scholars highlight substantial

problems with an ecosystem service based approach to urban greening. This includes

concerns about flawed science, generating false expectations of a panacea that diverts attention from the underlying sources of environmental decline, and not accounting for the disservices, costs, and management challenges of substantial sylvan infrastructure. Importantly, a biotechnological orientation does not necessarily account for trees as components of urban design. These urban concerns are supported by critiques of the ecosystem services construct writ large: that it commoditizes nature and marginalizes cultural values. Yet, case studies of large-scale tree planting initiatives in Los Angeles and New York suggest that while ecosystem services may serve as an up-front rationale, environmental justice concerns inform where and how these programs are implemented

This inquiry also revealed some notable research gaps. There seems to be a lack of scholarly literature depicting urban trees and urban tree planting in the 1920s-1960s period, after the Progressive Era bloom of greening and before the emergence of grassroots and federal engagement in urban forestry that accompanied the modern environmental movement. Despite the substantial surge of urban tree planting interest and advocacy commencing in the latter third of the 20th century, there are also limited studies investigating how overall tree cover in cities has changed (Nowak and Greenfield 2012b; Roman 2014).

Likewise, I was unable to identify any historical assessment of the citizen-based tree

planting movement that emerged in the 1970s.[43] This is especially noteworthy

considering that over 90% of contemporary urban environmental stewardship

organizations were founded since 1970 (Svendsen and Campbell 2008), and in New York

City alone there are more than 120 groups dedicated to street tree stewardship and over

200 engaged in parks (Fisher, Campbell, and Svendsen 2012). This supports Pincetl et

al.'s (2013) assertion that there has been little research on the historical, cultural, political

or institutional origins of large-scale tree planting initiatives witnessed in cities across the

country today. Moreover, few studies have addressed changing ideas, policies, and

attitudes related to urban green space (Clark and Jauhiainen 2006).

Finally, a couple overarching patterns emerge from this history of trees in U.S. cities.

First, there seems to be a strong correlation between urban investment and greening. The

first substantial era in urban greening emerged in response to explosive 19th century

population growth in the industrial city and through civic improvement. Following mid-

20th century depopulation and decline in American inner cities, there is now a resurgent

interest in urban living, and with it, investment and innovation in municipal parks and

greening. "From coast to coast America's cities are today on an upward trajectory . . .

Cities are continually pushed to meet and exceed their competition or they begin to lose

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[43] In addition to review of literature, I reached out to Anthony Le and Sara Anderson with ACTrees, Erika Svendsen at the USFS Northern Field Station, and Mindy Maslin with the Pennsylvania Horticultural Society's TreeTrenders program.

out. That challenge is met by parks as much as, or more than, any other amenity" (Harnik 2010, 5).

Second, it is possible that urban areas and cities nationwide are greener today than ever before. This counterintuitive proposition is problematized by limited longitudinal data in the 20th century, as well as varying distinctions between 'city' and 'urban' area. With that said, there were almost no trees in the public landscape of colonial settlements, and prior to the mid-19th century trees were at best a minor presence in U.S. cities (Campanella 2003; Lawrence 2006). Yet, by the early 20th century, American cities were characterized by "an immense arboreal landscape" (Lawrence 2006). Studies in Los Angeles (Gillespie et al. 2012), Oakland (Nowak 1993), and six Midwest cities (Wade and Kielbaso 2013) show substantial increases in canopy cover through the 20th century.[44] And today, there is no statistical difference between urban percent tree cover and rural – or nonurban – percent tree cover (Nowak and Greenfield 2012a). This raises important questions about the contemporary rationale to vegetate cities.[45]

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[44] For additional context: The Northeast U.S. region was more than three-fourths deforested by the mid-1800s, but today it is more than three-fourths forested once again (Stroud 2012).

[45] Current interest in street tree planting may extend beyond the U.S. In Paris between 1895 and 1995, street trees increased by 3% to roughly 88,000. Since the late 1990s, the number of street trees has surged by more than 12%, reaching over 100,000 today (Laurian 2012).

Third, as trees have become increasingly common elements in the urban fabric, government engagement has increased. Prior to the 19th century, trees were planted and managed primarily by individual property owners, even in public spaces such as streets and squares. Yet, by the end of the 19th century trees were a significant component of municipal governance (Campanella 2003; Lawrence 2006). Today, city mayors are the primary source of vision underlying large-scale tree planting initiatives (Young and McPherson 2013), and the federal USFS may be the most influential actor in urban forestry (Konijnendijk et al. 2006). Amidst this increasing governmental presence, contemporary urban tree planting practice is characterized by a hybrid (Konijnendijk van den Bosch 2014), networked (L. K. Campbell 2014) and coproduced (Pincetl 2010a) governance model that includes public, nonprofit, and private actors.

Fourth, it is hard to divorce the greening impulse from the utopian impulse. From the late 19th century bloom in urban park building and tree planting through the contemporary greening renaissance, an aspiration to create a better world is clearly discernible. In the 19th century, this was reflected in a reform movement laced with romanticism and reverence for the natural world, wherein gardening – and its urban expression through greening – was as Downing (1848, n.p.) famously expressed, "the great humanizer of the age." Not only was nature understood as a civilizing agent, it also reflected a universal human calling. "This yearning after the lost garden, must indeed be strong to force us, so many thousand years afterwards, to combat with the elements, to struggle with barren

soil, almost to war with nature, in order to realise [sic] some of those early dreams of our race – those recollections which ever haunt us of a lost paradise."

More than a century later, the formalization of urban forestry in the United States was also "something of a visionary movement, not concerned simply with highlighting the technical deficiencies in current standards of planting and management but inspiring the public with a vision to join with professionals and create the 'green' cities of the future. This visionary approach has sometimes delved into the philosophical and spiritual aspects of urban tree planting and management, giving a moral dimension to the movement" (Willeke 1986, in Johnston 1996). Said Grey (1984, 317), "urban forestry is more of a cause than a reality in the United States."

To the extent that such idealism is alive today, it is surely informed by the profound ecological problems facing civilization in the early 21st century. It is no hyperbole to suggest that the epochal environmental challenges presented by anthropogenic species extinction and climate change present an existential threat unlike anything in human history. As we now grapple with the implications of the Anthropocene, making meaning of urban greening assumes heightened significance.

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CHAPTER IV

Urban Greening in Planning Discourse / Urban Ecosystem Services

Introduction

To situate contemporary municipal greening practice within urban planning scholarship,

this chapter summarizes the results of a systematic review of four leading U.S. urban

planning journals for articles addressing the terms "greening" and "green infrastructure."

This is followed by a review of recent books and reports that address these terms, as well

as books and book chapters on "urban ecosystem services." The chapter concludes with a

brief discussion of insights and gaps relevant to municipal greening practice.

Peer-reviewed U.S. Urban Planning Journals

In each of the four leading U.S. urban planning journals – *Journal of the American*

Planning Association, Journal of Planning Education and Research, Journal of Planning

History, and Journal of Planning Literature – a search for the terms "greening" and

"green infrastructure" was conducted. Bibliographic records for these journals extended

back to 1979, 1981, 2002, and 1996 respectively. To ensure the greatest possible capture,

searches were conducted in each of these journals for "all words in full text." This

yielded 156 citations, many of which incorporated the search terms only in the

bibliography. The remaining 65 articles were reviewed, summarized, and ranked for

relevance to urban greening,[1] defined here as the introduction or conservation of vegetation in cities. See Table 1 at the end of this chapter for a full review. Only a handful of articles from these peer reviewed U.S. urban planning journals addressed "greening" as defined above. When terms such as "greening" or "green cities" were used, they generally referred to the broader concept of environmental sustainability, and tended to focus on issues related to growth management at the metropolitan fringe and climate change mitigation (e.g. energy-efficient buildings; mass-transit; and alternative energy sources). This represents a noteworthy gap in the urban planning literature, especially in light of the field's 19th century roots in urban parks (Schuyler 1986), long-standing aspiration to integrate nature with city (Hirt 2011), and engagement in environmental issues more broadly (Birch and Silver 2009; T. L. Daniels 2009).

The following is a summary of the most salient articles, in descending order of relevance to this particular inquiry. In "Greening the Rust Belt: A Green Infrastructure Model for Right Sizing America's Shrinking Cities," Schilling and Logan (2008) have authored one of the only articles in the U.S. urban planning literature to explicitly address "urban greening" as defined above, and one of a few to frame green infrastructure (GI) as an urban planning and design strategy – in this case, for shrinking cities. The authors identify five common "right-sizing" strategies for shrinking cities, and offer a three-pronged model for converting vacant lands to GI: 1/ Instituting GI plans and programs; 2/

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[1] In this ranking scheme, 1 equals the most relevant and 5 equals the least relevant.

Creating vacant land banks; and 3/ Building consensus through collaborative planning.

They distinguish GI within cities from GI on the urban periphery, and offer a typology of

such elements (see Figure 4.1). They identify leading urban greening programs in

Philadelphia, Toronto, and Lawrence MA, and five lessons learned from these pioneers.

Of particular relevance for this dissertation, they also summarize urban greening benefits

(see Figure 4.2). They advocated a "varied uses" approach, and conclude that conversion

of vacant lands to GI can increase value of adjacent properties, reduce stormwater,

increase access to healthy local foods, and more important, rebuild social capital by

engaging citizens in collaborative planning.

Green infrastructure within cities

Neighborhood, city, and regional parks
Playgrounds, play areas, ball fields, and recreation centers
Community gardens
Recreational trails and greenways
Surplus or underused private and public land used for passive or active
  recreation
The "urban forest" including street trees and parkland trees
Public landscapes, quadrangles, and plazas
Landscape streetscapes, gateways, and highway verges
Waterfronts
Green roofs
Abandoned land that can be converted to new green spaces
Commercial agricultural and forestry sites

Traditional green infrastructure on the urban periphery

Waterways
Wetlands
Woodlands
Wildlife habitats
Greenways
Parks
Conservation lands and corridors
Working farms
Ranches
Forests
Riparian floodplains

Figure 4.1: Elements of green infrastructure. From Schilling and Logan (2008, 454), who synthesized
material from Carrol (2007) and Randolph (2003)

Urban greening effect (sources)	Environmental	Social	Economic
Provide opportunity to create community through social interactions (Coley, Sullivan, & Kuo, 1997)		X	
Reduce ADHD in children (Taylor, Kuo, & Sullivan, 2001)		X	
Improve self-discipline in inner-city girls (Taylor, Kuo, & Sullivan, 2002)		X	
Reduce crime (Kuo & Sullivan, 2001b) and domestic violence (Kuo & Sullivan, 2001a)		X	
Increase physical activity opportunities (Kahn et al., 2002)		X	X
Increase potential consumer spending (Wolf, 2005)			X
Address flooding and reduce storm water runoff (Carroll, 2006; Kloss & Calarusse, 2006)	X		X
Increase property values (Voicu & Been, 2008; Wachter, 2004; Wachter & Gillen, 2006)			X
Increase access to healthy, local food (American Planning Association, 2007; Baroff, 2006; Hung, 2004)	X	X	X
Reduce urban heat island effect (Hardin & Jensen, 2007)	X		

Figure 4.2: Summary of urban greening benefits (Schilling and Logan 2008, 455)

In "Planting the Living City: Best Practices in Planning Green Infrastructure - Results from Major U.S. Cities," Young (2011, 368) argues that: "Most contemporary urban GI endeavors in the U.S. are small, individual projects rather than integrated, community-wide efforts. This underinvestment has left planners with little experience in developing GI at a metropolitan scale." This study draws upon stakeholder perspectives on the successes and setbacks in planting, stewardship, business, and outreach plans for large-scale tree planting initiatives (TPI) in eight major U.S. cities and one metropolitan county (see Figure 4.3). The study is noteworthy in that it is the only paper identified in the four reviewed planning journals that explicitly addresses urban trees. Young found that cities employed a spectrum of planning strategies to advance TPI, ranging from highly institutionalized, data-driven initiatives to decentralized, grassroots efforts. Participants

viewed TPI as bringing GI to the mainstream; however, uncertainties in funding and long-term stewardship belie this perspective.

Lacking access to traditional infrastructure financing, several TPI used creative development and contracting strategies to maintain program funding and momentum, while others stagnated. Additionally, programs lost momentum when mayors who launched TPI were not reelected. Successful underfunded initiatives focused on community-level engagement. However, institutionalized, diverse funding structures and robust, agency-level commitment to maintaining and expanding urban forests were considered most effective in advancing urban forestry-based GI. Overall geographic distribution of TPI, and the relatively sophisticated financial and institutional approaches achieved by New York and Seattle, provide insight into possible national strategies to advance metropolitan-scale GI. Similarly, Los Angeles's and Baltimore's use of focused corporate sponsorship and community engagement to advance underfunded programs could inform international GI efforts. Accessing traditional infrastructure financing mechanisms and institutionalizing stewardship plans are fundamental to long-term expansion and maintenance of investments in metropolitan GI.

City	Launch date	Planting goal (# of trees)	Planting goal (# of years)	Total trees planted (11/30/2010)
New York City	2008	1 million	10	379,170
Los Angeles	2008	1 million	"several"	250,000
Houston	2008	1 million	5	400,000
Salt Lake County	2007	1 million	10	150,538
Sacramento	2005	5 million	20	40,882
Denver	2006	1 million	19	191,366
Seattle	2007	650,000	30	125,000
Baltimore	2006	a	30	28,000
Albuquerque	2004	75,000	2	30,000
Totals		11 million		1,594,956

Figure 4.3: City tree-planting initiative launch dates, targets and performance (Young 2011, 369)

In "The Compact versus the Dispersed City: History of Planning Ideas on Sofia's Urban Form," Hirt depicts the history of planning in Bulgaria's capital and argues that "Sofia's planning has been persistently shaped by two perennial dilemmas—how to reconnect the city with nature and how to define its relationship with the region." The study includes an insightful summary of the "city-nature" discourse in four phases: *Monumental Cities* (penetration of dense urban fabric with vast public parks); *Garden Cities* (regional dispersal into new towns with greenbelts); *City Efficient* (towers in the park); and *City Sustainable* (human scale green space in existing city and land preservation outside of city). Interestingly, Soviet architects equated urban "greening" with decentralization.

In "The Evolution of Green Community Planning, Scholarship, and Practice: An Introduction to the Special Issue," Berke (2008) identifies five primary dimensions of American environmental thinking that have influenced the evolution of human settlements during city planning from the late 19th century onward: 1) harmony with natural systems; 2) human health; 3) spiritual well-being and renewal; 4) livable built

environments; and 5) fair-share community. The piece closes by listing three priorities, one of which is, "identifying effective requirements and incentives that stimulate community and household behaviors aimed at environmental protection, mitigation and adaptation to climate change, and integration of green infrastructure into neighborhoods" (Berke 2008, 404). The article's strong anthropocentric emphasis on human health, well-being, livability, and green infrastructure is noteworthy.

Lastly, Gober, et al. (2010) address the cost-benefit of increasing urban vegetation to cool arid cities such as Phoenix, in "Using Watered Landscapes to Manipulate Urban Heat Island Effects: How Much Water Will It Take to Cool Phoenix?" This study found that "increasing irrigated landscaping lowers nighttime temperatures, but this relationship is not linear; the greatest reductions occur in the least vegetated neighborhoods. A ratio of the change in water use to temperature impact reached a threshold beyond which increased outdoor water use did little to ameliorate UHI effects" (p. 109). Thus, "there is no one design and landscape plan capable of addressing increasing UHI and climate effects everywhere. Any one strategy will have inconsistent results if applied across all urban landscape features and may lead to an inefficient allocation of scarce water resources." "Efforts to increase vegetative cover should concentrate on neighborhoods with the least vegetation, where substantial gains in cooling can be achieved with minimal additional water use" (p. 119).

Recent Books and Reports

Reflecting contemporary interest in municipal greening, the American Planning

Association (APA) recently published a new Planning Advisory Service report entitled

Green Infrastructure: A Landscape Approach (2013, 1), which "explores the unifying

concept of landscape as green infrastructure—the visible expression of natural and

human ecosystem processes that work across scales and contexts to provide multiple

benefits for people and their environments." According to authors Rouse and Bunster-

Ossa, "green systems are *active*, *visible*, and *integrated* into the human-shaped landscape

– a fundamental paradigm shift" (p. 2).

By way of introduction, the publication offers a history and description of key GI

concepts and principles including: interdisciplinary collaboration across multiple scales

and for multiple functions; stormwater management; hubs and links; ecosystem services

and public health. The report identifies four scales of GI relevant to urban planning

practice: region; local government; neighborhood; and site. This broadly corresponds to

the transect developed by Plater-Zyberk and Company, which the report incorporate as a

planning tool (see Figure 4.4). At the local government scale, which may be most

relevant to the inquiry of this dissertation, GI planning tools include: comprehensive

plans; functional master plans; development regulations and codes; and capital

improvement projects.
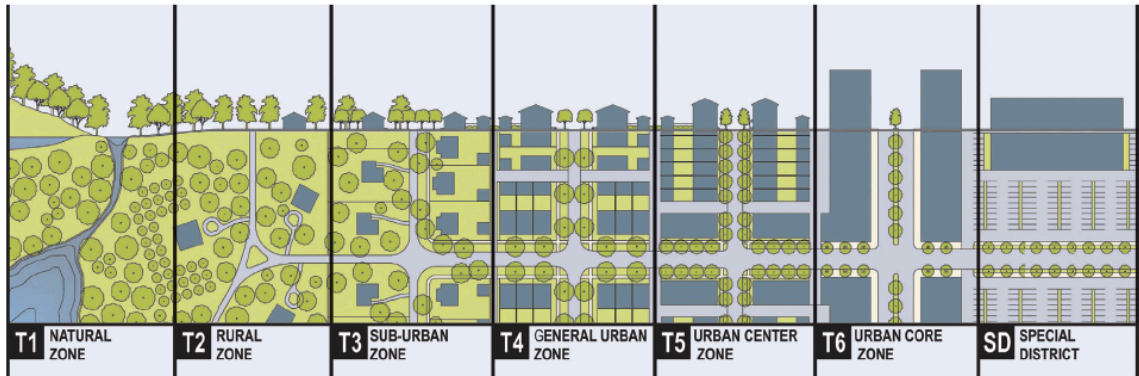
Figure 4.4: The Transect, by Plater-Zyberk and Company.

The report provides 11 cases studies organized by region, large city, smaller communities, and parks, greenways, and river corridors. These case studies are assessed based on six criteria: multi-functionality; connectivity; habitability; resilience; identity; and return on investment. In large cities such as Seattle, WA and Philadelphia, PA as well as smaller communities such as Lancaster, PA, and Lenexa, KS, green infrastructure is framed as providing multiple benefits, however, stormwater management is a principal driver. The publication then offers a "Model Regulatory Framework for GI," based on an initial inventory and evaluation of existing regulations. The inventory section offers a useful list of core GI regulations typically found in municipal codes. Reflecting GI's emphasis on physical and institutional integration, the evaluation section offers a sample framework for assessing how existing regulations work together to promote green infrastructure and where gaps exist.

This publication provides useful direction for incorporating GI in urban planning and design. However, it also reveals a noteworthy gap. The report places significant emphasis on human health, stating for example that: "Public health is an overarching concern that cuts across the triple bottom line of sustainability" (p. 13). And, "this underscores the potential of linking green infrastructure to public health" (p. 16). Importantly, the publication's primary conceptual diagram frames "public health outcomes" as the fundamental purpose of green infrastructure (see Figure 4.5). Yet, the report dedicates less than one page and only three citations to assessment of peer-reviewed literature on human health benefits of green infrastructure (p. 13-14). This suggests an *a priori* presumption of human health benefits.
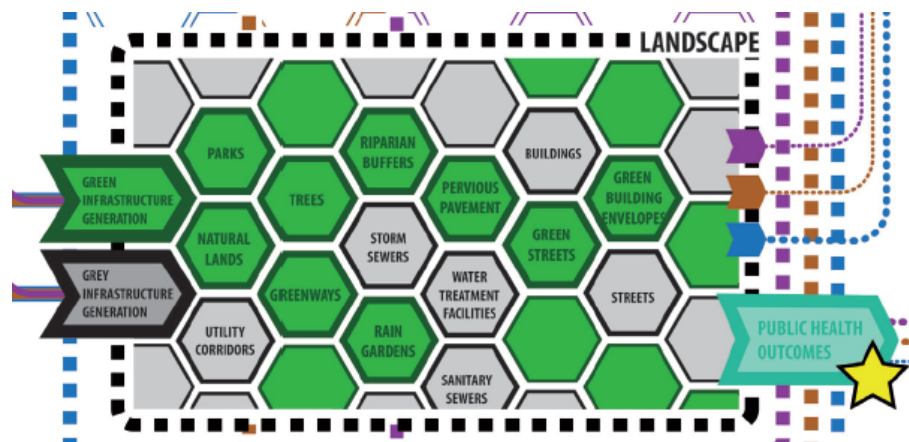
Figure 4.5: Green and grey infrastructure are subsystems that together make up the urban landscape. Source: David Witham, WRT, in APA (2013, 16).

The APA's attention to urban greening and GI is also reflected in *The Environmental Planning Handbook for Sustainable Communities and Regions* by Tom Daniels (2014).

In this update to the original edition published in 2003, Chapter 19, "Making Green Cities, Suburbs, and Metro Regions," outlines numerous types and benefits of implementing GI into the planning process. And while numerous cities now aspire to become "the greenest city in America," this goal faces systemic challenges, including: (a) America's fragmented local government structure; (b) competition among local governments for property tax and sales tax base; (c) proliferation of school districts; and (d) an antiurban bias. Yet, Daniels observes that in the wake of the Great Recession of 2007–2009, new interest in urban living has emerged amongst empty nesters and young adults, and an important element for cities in retaining residents and attracting new ones is the quality and energy efficiency of buildings and transportation systems as well as green space. Importantly, "how the built environment interacts with the natural environment gives a community or region its visual identity and greatly affects environmental quality and public health." Moreover, green elements such as parks, greenways, trails, highway medians, green streets, rain gardens, green roofs, trees, and urban agriculture provide ecosystem services, such as infiltrating stormwater, reducing flooding, filtering water before it enters waterways, and giving off oxygen.

Daniels notes that the National Recreation and Park Association has recommended that urban areas should provide a variety of parks according to the following acreages per 1,000 people: Neighborhood parks: 1–2 acres per 1,000 population; Community parks: 5–8 acres per 1,000 population; Regional or city parks: 5–10 acres per 1,000 population;

Trails: 0.5 acres per 1,000 population. Based on these recommendations, Daniels estimates that in a city of 100,000, this equates to 1,100–2,000 acres of parkland, with an overall ratio of 11 to 20 acres per 1,000 people. Options include trails, community gardens, pocket parks, tree plantings – all of which take up a small amount of land – as well as sensitive environmental lands such as steep slopes, floodplains, and wetlands, which should be conserved.

Another form of green space provision identified in the publication is urban forestry. Nonprofit organization American Forests recommends the following minimum tree canopy cover for cities and suburbs east of the Mississippi River: (a) overall 40% tree canopy, (b) 50% tree canopy in suburban residential areas, (c) 25% tree canopy in urban residential areas, and (d) 15% tree canopy in central business districts. Urban agriculture, in turn, can generate a significant proportion of a city's vegetables and provide green space, recreation, and opportunities for social interaction. In suburbs and shrinking cities, restoration is another way to green communities, especially in vacant land, contaminated 'brownfield sites,' and along riparian corridors in floodplains.

Reflecting emergent interest in GI (also know as low-impact development) for stormwater management, Daniels highlights vegetated roofs and bioretention swales and rainwater harvest gardens as important design types. A number of cities such as Philadelphia and Portland have created stormwater utilities to charge property owners a

fee based on the amount of impervious surface on their property (known as individual parcel assessments).

Daniels highlights the five main design elements – districts, paths, nodes, landmarks, and edges – by Kevin Lynch as a framework for greening communities. For example: green roofs and ground-level planters are appropriate for high-density districts. In residential or mixed used commercial and residential districts, rain gardens, pocket parks, and smart streets not only support the district's identity but also make it more environmentally friendly. Tree-lined streets make attractive paths and can be combined with traffic-calming devices to slow traffic in residential and mixed-use districts. Trees, flowers, and parks make nodes especially attractive for pedestrians and bicyclists. Plantings also enhance landmarks, giving them a garden-like setting while also absorbing stormwater. Trees and green space, in turn, can create edges to separate districts and provide buffers between potentially incompatible land uses.

Daniels concludes by identifying the various stages in the planning process where green elements can be introduced and conserved. This includes: Inventory and Analysis of existing green infrastructure; incorporation of green goals and objectives in the Comprehensive Plan; and Action Strategy to meet these goals, such as tree planting, impervious surfaces fees and green infrastructure incentives; Zoning Ordinances that limit development on steep slopes, floodplains, and coastal areas; Subdivision

Regulations that require planting of trees and other vegetation to absorb stormwater; Capital Investment Projects that treat green infrastructure as conventions grey infrastructure; and Development Review checklist that incorporates the green elements described above.

Broadening to a more discursive treatment, *Growing Greener Cities: Urban Sustainability in the Twenty-first Century,* (2008) is an edited volume that takes an expansive view on urban greening as part of larger move toward 'green cities' and 'urban sustainability.' This ranges from "supporting regional ecosystems, and improving the functioning of municipal infrastructure to the valuation of greening in real estate...it also includes building energy-efficient and resource-conserving homes and providing multipurpose, varied size open space...and urban agriculture" (p. 1). Edited by Eugenie Birch and Susan Wachter, the volume includes 19 chapters organized in three sections: "Greening at Every Scale: Nation to Roof Tops," which focuses on outputs; "Getting Greening Done," which focuses on process; and "Measuring Urban Greening," which focuses on outcomes. The editors reinforce that, "green cities have one central feature in common: they take full advantage of their natural environments to sustain human health" (p. 4). Several chapters touch on themes germane to this inquiry. In the opening chapter, "Taking the Initiative: Why Cities are Greening Now," Tom Daniels contends that cities have recently seen an upsurge in greening – from green roofs to new parks to tree planting to more energy efficient buses – because "city leaders are recognizing that a

cleaner environment is needed both to provide residents with a good quality of life and to compete in the global economy" (p. 11). Set against the hallmark federal legislation that made important advances in environmental protection four decades ago, Daniels suggests that "cities are [now] aware that they have to take responsibility for their environmental quality" (p. 13).

In Chapter 4, "Greening Cities: A Public Realm Approach," Alexander Garvin argues that "the current approach to greening is largely reactive and conservative, not the routinely progressive part of the development process that it should be" (p. 60). In keeping with the chapter title, he further contends that, "we need to place people at the center of our thinking, making human activity and public participation important elements of the planning process." Garvin highlights the pioneering work of Frederick Law Olmsted, Sr., who "always conceived of parks and people together" (p. 66). His central thesis is that, "public realm improvements present the single greatest opportunity to make our cities greener," and that "we must think of the public realm as the framework around which private property owners develop" (p. 83). This is also the overarching thesis of Garvin's book, *Public Parks: The Key to Livable Communities* (2011).

In Chapter 9, "Blue-Green Practices: Why They Work and Why They Have Been So Difficult to Implement Through Policy," Charlie Miller identifies four expressions of an emerging design type that deserves special attention: green roofs; courtyard landscapes

that incorporate biofiltration and rainfall harvesting with water reuse; living walls; and green façades or vine walls. Miller attributes the term "blue-green technologies" to Joachim Tourbier 35 years ago, and it is worth noting the functional similarity of this concept to contemporary application of GI to stormwater management. Miller explores precedents and design/policy considerations for each of the aforementioned technologies, and he dedicates a section to impediments for widespread adoption. Here, he identifies two principal challenges: first, most benefits associated with these practices will be realized over long periods of time, which makes direct assessment difficult; second, the conservative nature of environmental regulations leads to an "accretionary approach" to embracing new approaches.

Chapter 16, "Metro Nature: Its Functions, Benefits, and Values," addresses "the places where people live, work, learn, and play in cities" (p. 295). Here, Kathleen Wolf explores two topics: the historical roots of American attitudes toward nature; and how to justify public expenditures for natural resources that offer little promise of generating marketable goods. On the latter, she presents a set of valuation concepts that situate metro nature in economic terms, as this is the lens that informs much of public policy and research. Wolf's historical account spans: the agrarian predilections of the founding fathers, in particular Thomas Jefferson; the wilderness glorification of 19th century romantics, personified in Henry David Thoreau; the preservation versus conservation debates of the early 20th century, expressed through John Muir's spiritualization of

untrammeled nature and Gifford Pinchot's utilitarian management of natural resources for public activities and commercial uses; the mid-20th century emergence of a new ecological ethic articulated by Aldo Leopold and Rachel Carson; and finally, the raft of federal environmental protections that emerged in the early 1970s. Reflecting on the nation's environmental discourse, Wolf argues that "a consistent, antiurban, antimodernism message lies just below the surface" (p. 298), and that this impedes a more robust embrace of urban greening. Here, she highlights the built work and writing of Frederick Law Olmsted, Sr. as a noteworthy precedent.

Wolf then addresses the practical challenges of contemporary greening, noting that ecosystem services and green infrastructure are the conceptual frameworks guiding much of the research on this phenomenon. These relatively new constructs share two understandings: 1) they require identification of the resource or service being supplied by a natural system and the "consumer unit" of society being served (i.e. city, nation, or planet; and 2) their economic valuation is based on public goods theory, which seeks to explain behaviors regarding the use and exchange of nonmarket goods and services.

To this end, Wolf identifies and elaborates upon various approaches to valuing and rationalizing what she calls "metro greening." This includes valuation methods such as hedonic pricing, travel costs, avoided costs, replacements costs, factor income, and contingent valuation. It also includes valuation examples, incorporates special sections on

the valuation of human benefits and services such as physical health, mental health, and social ecology. Wolf concludes the chapter by exploring next steps in a metro nature agenda, including research needs and gaps. Here, she offers 3 broad trajectories: 1) Comprehensively assessing the human services provided by metro nature over the human lifecycle; 2) Exploring how cultural background and preferences inform responses to difference forms of metro nature; and 3) Using land use type as a vehicle for researching these questions.

Chapter 17 of this edited book, "Green Investment Strategies: How they Matter for Urban Neighborhoods," by Wachter et al., explores urban greening as an important component of "place-based investments." The authors point out that place-based investments (PIBs) have now joined traditional business location factors such as the availability of raw materials or port access, as important determinants of economic growth. Yet, researchers have only begun to study PIBs. Addressing this gap, the chapter summarizes research on PIBs in Philadelphia, which included improvements to public spaces in commercial corridors, vacant land management, and neighborhood greening through tree planting along streets and parks. These interventions yielded noteworthy outcomes: 1) clearing and greening a vacant lot led to a 17% increase in the value of adjacent properties; 2) streetscape improvements increased the value of homes near the corridor by 28%; and 3) homes located in business improvement districts (BIDs) were valued 30% higher than comparable homes not in BIDs.

Switching to the European context, Jens Lachmund's *Greening Berlin: The Co-Production of Science, Politics, and Urban Nature* (2013), offers an in-depth case study that traces the process by which urban land-use planning in Berlin became "fundamentally ecologized." Here, "species protection emerged as a common focus of scientific and political concern," materializing "in new ways of planning and managing urban space" (p. 2). Lachmund offers the term *nature regime*, or more specifically *biotope-protection regime*, as a construct for assessing how this phenomenon evolved. He argues that the "knowledge generation" of ecologists conducting field studies in urban settings combined with an emerging politics of nature, "exceeded the formal boundaries of institutionalized science" (p. 221) and resulted in "the proliferation of *phantom biotopes* [that] kept green planning initiatives moving, that otherwise would have suffered from a lack of financial resources, or the lack of political concern" (p. 220).

At the outset, Lachmund articulates two of the book's goals: 1/ to shed light on the changing place of nature in the modern city; and 2/ to understand the political use of science in an important environmental conflict. He supports his critique by first tracing the history of urban greening in Berlin, classified in four periods that broadly reflect that of other western cities. He then explores in greater depth the post-war decades wherein ecologists extended their field of study to urban sites, and how this process gradually transformed bombed-out and formerly industrial places of rubble and decay to, "ruderal habitat with an interesting successional pattern." Lachmund also documents how an

ascendant ecological narrative turned "pleasant recreation spaces for human visitors into biotopes," and how a green space's embellishment by gardeners became "a threat to its potential of biodiversity" (p. 88).

An important manifestation of this "ecologization" of the city was the 1984 creation of Berlin's Species Protection Program, the promulgation of which Lachmund documents in granular detail. Unlike earlier eras in urban greening that responded to public health, recreation, and aesthetic demands, this program "acknowledged wildlife species, their biotopes, and the ecosystems of which they formed a part as new entities that belonged to urban space." The author also reinforces how ecologists and landscape planners were "accredited with authority in matters that touched on normative questions" (p. 122). Moreover, the ecologists who led the research "became directly involved in the institutional negotiation of a policy" (p. 123) and the political context of the Species Protection Program influenced the methods and communication of ecological research. While only a few of the wastelands that ecologists wanted to protect were eventually excluded from urban development, they became emblematic of a new form of green space: *the urban nature park.*

In sum, *Greening Berlin* offers a cautionary tale wherein "the knowledge generation of a specialized field . . . began to occupy a central role in the policy making of urban nature . . . and redrew the cultural and political map" of the city (p. 228). Reinforcing that

important innovations in the field sciences have often been connected to specific places Lachmund argues that, "Berlin has played a similarly pivotal role for the emergence of an *ecology of city*" (p. 221). Indeed, the city's pioneering creation of the *Biotope Area Factor*[2] suggests this is true.

In *Green Cities of Europe: Global Lessons on Green Urbanism* (2012), Timothy Beatley's edited volume serves as a follow-up to his 2000 publication, *Green Urbanism: Learning From European Cities*. Beatley has been studying sustainable urbanism in Europe for some 20 years, and as he notes in the introduction to this most recent offering, many European cities "possess . . . the essential qualities of sustainable place-making and urban sustainability that we aspire to in the U.S." (Kindle location 153). While the green cities narrative addressed in this book embraces everything from energy-efficient building design to environmentally friendly transportation practices, Beatley's recent work emphasizes the physical greening of cities with plant material.[3] This reflects his increasing interest in *biophilia*, a theory advanced by renowned ecologist E.O. Wilson, which suggests that, "humans have coevolved as a species to need nature, that it is not optional but rather essential for emotional (and physical) health and well-being."

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[2] The BAF is a municipal ordinance that establishes a minimum threshold of plant material that a site must contain, and cities including San Francisco and Washington, D.C. have implemented similar policies.

[3] See Biophilic Cities (Beatley 2011)

Curating seven case studies from local experts, Beatley demonstrates how European

cities are pioneers in urban greening. Many cities either mandate or subsidize green

features in new urban developments and in the retrofitting of existing urban areas. In

several Dutch, German, and Austrian cities there have been long-standing green rooftop

programs. Linz, Austria often requires building plans to compensate for the loss of green

space taken by new development, and green roofs have been a common response. This

city, like many others in Europe, also provides a subsidy for retrofitting existing rooftops

with a vegetated roof – paying up to 35% of the cost of installation. Many other

innovative urban greening strategies can be found in these cities, from green streets and

bridges to urban stream daylighting.

Another innovative form of greening documented in this book are vegetated walls, which

offer benefits similar to green rooftops such as cooling structures and reducing energy

consumption, decreasing stormwater runoff, and even providing habitat for birds and

invertebrates. These planted facades also enhance the visual greenness of cities and are

"popping up all over Europe" (Kindle location 325), including prominent buildings such

the CaixaForum Museum in Madrid, the eight-story Athenaeum Hotel in London, and the

Musée de Quai Branly in Paris.

The book includes case studies on Paris, Freiburg (Germany), Copenhagen, Helsinki,

Venice, Vitoria-Gasteiz (Spain), and London. A common theme that emerges is a surging

interest in urban greening. Beatley readily acknowledges that differences in the American and European socio-political context may explain why green city ideas have gained greater currency and application in Europe. These distinctions include: "a more limited land and resource base, a long history of urban living, a stronger planning and regulatory system, a parliamentary political system that often gives greater representation to green concerns, and stronger cultural support for a variety of green city ideas (e.g., public transit, pedestrian environments, energy conservation)" (Kindle location 475). But as the author points out, "Nevertheless, these compelling European examples will and must find ever-greater currency on the American scene, as the environmental challenges we face become ever more serious (e.g., climate change, declining oil supplies, severe water shortages) and the inherent merits of these forms of green urban living become ever more obvious" (ibid).

Peter Harnik picks up this challenge in *Urban Green: Innovative Parks for Resurgent Cities* (2010). Recognizing the rising interest in, and the challenge of, creating parks in "built-out" municipalities, Harnik offers an informative and practical survey of innovative approaches to 21st century park making. The book is organized in two parts.

Part 1, entitled "Of Cities and Parks," describes how the urban ills of the 19th century industrial era spawned the first wave of city parks, but with the advent of the car and suburbanization in the mid-20th century, popular interest in urban parks waned. In light

of this trend, argues Harnik, it made sense that people did not want to pay both a

mortgage for a house and a private yard, as well as taxes for a park. Yet, he posits that the

tide is now turning. "From coast to coast America's cities are today on an upward

trajectory. Cities are continually pushed to meet and exceed their competition or they

begin to lose out. That challenge is met by parks as much as, or more than, any other

amenity" (p. 5). Based on this premise, Harnik offers six strategies to create great urban

parks:

> *1) Park Provision:* Citing various efforts to establish a universal standard for
> urban parkland provision, Harnik argues that it is more instructive to compare the
> amount of park acreage in cities of the same approximate density type.
>
> *2) Kinds of Parks:* Shunning the traditional classification of "passive" versus
> "active" recreation as overly simplistic, he proposes the following taxonomy:
> Traditional Team Sports (soccer, baseball, basketball); Less Traditional Sports
> (skateboarding, in-line skating, frisbee golf); More-Active Non-Sports
> (walking/hiking, dog walking, horse riding); Less-active Non-Sports (picnicking,
> painting, wildlife photography); Other generally considered positive (napping,
> talking on phone, using computer); Other generally considered negative
> (selling/buying drugs, drawing graffiti, fighting).

3) Park Type Provision: Reflecting the inadequacy of a universal standard, it is more important to devise a public process that identifies priorities in each specific community, rather than adopting a conventional standard such as "acres per 1,000 people."[4]

4) Stimulating Use: For a park to be well used, it must be safe and clean. Other factors include proximity, accessibility, moveable chairs, inspiring horticulture, sculpture, food, fitness equipment, and inspiring programming such as music and theater.

5) Neighborhood Uniqueness: Population density is the most important factor in ascertaining park need. Poorer neighborhoods have greater need for public parks then wealthy areas. Car availability makes local parks less of a priority. Bike access and good sidewalks leading to parks increases use. Lower-income communities with single parents juggling multiple jobs have less time, and greater need for local parks.

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[4] Harnik notes that in 1943 the American Society of Planning Officials proposed 10 acres for every 3,000 residents in cities with populations exceeding 1 million. At this standard, over half of Manhattan would need to be dedicated to parkland!

6) Master Planning: Done right, a well-executed planning process "won't be perfect for anyone, but it will good for everyone" (p. 54) and "a plan without a timeline and a budget should more accurately be called a hope" (p. 58).

Part 2, entitled, "Finding Park Space in the City' identifies 15 strategies to increase municipal parks. Of these, 11 address existing urban spaces relevant to greening, described below.

1) Buying It: The Trust for Public Land has documented that two decades of ballot measures show voters have overwhelmingly supported expenditures on land conservation and parks, including liberal cities such as Seattle and tax averse ones like Colorado Springs. Parks are also increasingly being viewed as critical to municipal economic development. When Boeing Corporation located its new headquarters in Chicago, which has been undergoing a major green makeover, instead of the other front runner, Dallas, the latter increased its funding of the parks department for an ambitious "Renaissance Plan."

2) Utilizing Urban Redevelopment: With the continued decline of urban industrial uses, especially in the Northeast and Midwest, new parks are key components of urban renewal.

3) Existing Urban Spaces:

• *Community Gardens*: A 2007 study by New York University found that gardens in New York's poorest neighborhoods lifted property values by up to 9.4%.

• *Old Landfills*: The EPA estimates that 3,500 landfills have closed since 1991. Size, location, and cost make landfills attractive opportunities for new parks.

• *Wetlands & Stormwater Storage Ponds*: Doubling as walking, running, and cycling space, Staten Island Bluebelt is a marquee example of stormwater storage ponds serving multiple functions.

• *Rail-to-Trails:* More than 130,000 miles of rail corridors have been abandoned, of which merely 15,000 miles have been converted to trails. In addition to recreational value, rail trails also have ecological and historical value.

• *Rooftops*: Landscape architect Tom Balsley calls rooftops "the greatest untapped open space opportunity in America."

• *Sharing Schoolyards*: Otherwise described as "parks for a limited constituency," the main hurdle to schoolyard sharing is institutional and managerial. In 1996,

Chicago Mayor Daley announced a program to convert 100 asphalt schoolyards into small parks.

• *Covering Reservoirs*: In 2005, the EPA published the Long Term 2 Enhanced Surface Water Rule, mandating all newly constructed "finished water reservoirs" to be covered. Technical options include a floating cover, lightweight aluminum, and wood, concrete, or steel, of which the latter grouping is required for a park. While costly, a Seattle example shows that the cost of purchasing a similar amount of other parkland would cost 85% as much as a concrete cover.

• *River and Stream Corridors:* Creating greenways along waterways is a big opportunity, especially in flood-prone areas where structures should be removed. Upzoning neighborhoods adjacent to a widened waterway, thus allowing greater density, height, dwelling units and property tax revenue, is another way to promote and pay for riverside greenways.

• *Cemeteries*: Prior to the advent of public parks in the 19th century, cemeteries were the primary manicured public greenspace in cities. Today, public access to cemeteries varies and many cemeteries remain private. This category of green space faces challenging jurisdictional constraints.

• *Boulevards & Parkways*: When Frederick Law Olmsted created the first parkways, they were more "park" than "way", but this changed significantly in the 20th century with the arrival of the car. To re-envision these green travel corridors requires thinking of them as places, "outdoor rooms that are shared by a broad community, not just the automobile."

• *Decking Highways*: There are currently 24 such projects currently underway in the U.S., a dozen more in the planning phase, and numerous opportunities abound. At Boston's famous Central Artery (a.k.a. "Big Dig"), $40 million of the $14 billion price tag was attributable to the mile-long stretch of four parks that opened to the public in 2008.

In another publication offering practical guidance for greening cities, the Urban Land Institute in conjunction with the Centre for Liveable Cities has published *10 Principles for Liveable High-Density Cities (2013)*. This succinct document uses Singapore as a case study to establish 10 strategies for making dense cities more livable. Third amongst these principles is: "Draw nature closer to people." This wording is noteworthy in that it flips the ubiquitous phrasing – draw people closer to nature – on its head. In so doing, it reinforces an emergent urban greening paradigm focused on the site and neighborhood scale stitching of greenery into the urban fabric. More explicitly, the report cites Singapore's strategy of providing "pervasive greenery," with a goal "to cloak spaces with

green wherever the eye could see" (p. 26). This expresses itself through vegetated roofs

and building facades, 'skyrise greenery,' landscaped balconies and bridges, street trees,

riparian greenways, treetop pedestrian bridges, and parks. The publication is noteworthy

in that it frames urban greening as an anthropocentric priority in the service of livable

cities.

This theme also undergirds *Community Livability: Issues and Approaches to Sustaining

the Well-Being of People and Communities* (2012), an edited volume that explores what

is meant by the term "livable communities." Combining theory and practice, Fritz

Wagner and Roger Caves have curated material from field experts and evidence from

international, state and local perspectives. Contributions are organized in three sections:

1/ Policy and Governance; 2/ Experiences in Communities; and 3/ Specific Interventions.

The latter section includes two chapters of direct relevance to this dissertation. Likewise,

a case study in section one assesses a partnership to deliver GI as a livability policy and

governance tool.

In chapter four, "Creating Sustainable Communities: A Trans Atlantic Perspective,"

Shaw et al. describe how advocates in the North West of England are increasingly

emphasizing the multifunctional benefits of GI. Here, 11 economic benefits of GI have

been identified: gaining products from the land; promoting recreation and leisure

activities; promoting tourism; improving labor productivity; promoting economic growth

and investment; enhancing land and property values; promoting health and well-being; enhancing the quality of place; flood alleviation and water management; climate change adaption and mitigation; and protecting land and promoting biodiversity. Organized as ecosystem services (see MEA 2005a), these benefits are distributed as follows: Supporting (1); Provisioning (1); Regulating (2); and Cultural (7).

In keeping with this strong cultural services orientation, the Liverpool City Council in collaboration with Liverpool Primary Care Trust, which is responsible for planning National Health Service (NHS) care for the people of Liverpool, commissioned the Mersey Forest team to develop a GI strategy for the city. This partnership is noteworthy for its collaboration across disciplines including public policy, health, and forestry. Another noteworthy characteristic is the strong health and well-being orientation of this GI initiative. As evidence, the authors specifically highlight that Liverpool has the lowest mental health ranking in the region, and the parts of the city that have the lowest quantity, quality, and access to multi-functional green space are those parts of the city exhibiting the worst indicators of health and well-being (i.e. North Liverpool). The plan then goes on to suggest that individual well-being could be enhanced through investment in GI. According to the authors, the North West England precedent with GI planning has been so persuasive that GI is now being promoted by the central government as a policy principle to be integrated into a spatial planning and placemaking agenda. Published in

2009, "World Class Places: The Government's Strategy for Improving Quality of Place"

includes the quality and quantity of GI as a critical component of placemaking.

In chapter 10, "Envisioning a City's Green Infrastructure for Community Livability,"

Rottle and Maryman frame "the history of city-making" as a "dialectic between natural

and cultural forces," wherein "a more sophisticated, complicated, and ultimately rich

version of human settlement has begun to emerge, fostering a fused ecology of green

infrastructure that benefits both ecological and cultural concerns." As context, this

chapter echoes a theme articulated in the book's introduction – "one of the first principles

of smart growth is neighborhood livability" – by emphasizing that "urban density

strategies may only be successful if cities are satisfying places to live, providing the same

infrastructure for livability that sells buyers on the promises of the suburbs" (Kindle

location 5186).

The body of this chapter is a case study of Open Space Seattle 2100, a participatory

public planning process (led by the chapter's authors) to protect an open space system for

the ensuing hundred years while accommodating an anticipated doubling of the city's

population over the same period. While this process acknowledges the multifunctional

characteristics of natural lands, there is little in the case study that distinguishes this

project from conventional open space planning. And despite the chapter's promising title,

the text does not succeed in advancing understanding of how GI promotes community

livability. The terms 'livable' and 'livability' surface only five times in the entire chapter, and three of these uses are in reference to initiatives other than the Seattle project addressed by the authors. Moreover, the text does GI a disservice by convoluting its meaning and expanding its purview to include everything from public art installations and outdoor theaters to solar panels and wind turbines – none of which reflect the wildlife habitat, stormwater management, and ecosystem service values that undergird the historical scaffolding of GI. In so doing, the authors subject GI to the sort of "sustainability scope creep" that the APA warns against in *Green Infrastructure: A Landscape Approach* (2013, 82).

In chapter 12, "Livability, Health, and Community Design," authors Kennedy and Dannenberg address one of the dominant concerns that has sparked converging interests in planning and public health by focusing initially on correlations between urban form, physical activity, and obesity. Other sections address traffic related injury risk, healthy food environments, noise, social capital, mental health, and air quality, wherein the authors make no mention of vegetation. The chapter also includes a section on Parks and Greenspace, which "make a city more livable for those residing and visiting there, and such features impact our health and well-being" (Kindle location 6552). As evidence, the authors rely upon secondary references from a non-peer reviewed report by the Trust for Public Land (2006), and specifically mention air pollution mitigation and asthma, as well as psychosocial associations with attention deficit disorder, coping mechanisms, social

contact, and cognitive development in children. This section also emphasizes equitable provision and access to parks and greenspace.

Urban Ecosystem Services: Books and Book Chapters

As noted in the discussion on the history of U.S. urban trees (see Chapters II and III), ecosystem services has emerged as a principal driver of municipal tree planting (Silvera Seamans 2013; Young 2013), and urban greening writ large (Wolf 2008; Young 2010; Pincetl et al. 2013). The following section provides a high level review of book chapters and reports that apply the ecosystem services construct to urban settings. In particular, this literature is assessed for its relevance and applicability to urban greening, defined here as the introduction or conservation of vegetation in cities and urban areas. These titles were identified and reviewed in September 2014.

As background, the economically oriented metaphors of "environmental services," "public services of global ecosystems," "nature's services," and "ecosystem services" appeared in the biological literature during the 1970s. According to Norgaard (2013), the most cited paper of this era was written by Walter Westman (1977), who assuaged his discomfort about describing nature in the materialistic terms of economics by prefacing his paper with a quote from William Wordsworth: "To me the meanest flower that doth blows can give, Thoughts that do often lie too deep for tears."

In the 1990s, Gretchen Daily(1997) and Robert Costanza (1997) elevated ecosystem

services as a way to demonstrate – often in quantitative and monetary terms – humanity's

dependence on the biosphere for its survival. In a ground-breaking and controversial

study, Costanza et al. (1997) classified 17 ecosystem services for 16 biomes across the

entire planet, and estimated the value of these services in a range between US$16-54

trillion per year, with an average of US$33 trillion per year. This paper describes services

other than "recreation" and "cultural" as "negligible" in the "urban biome" (p. 256).

Under the auspices of the United Nations, the ecosystem services construct was later

popularized through the Millennium Ecosystem Assessment (MEA) (2005a, V), which

describes ecosystem services as "the benefits people derive from ecosystems."

Approximately 1,360 experts from 95 countries were involved as authors of the

assessment reports, as participants in the sub-global assessments, or as members of the

Board of Review Editors. The scope of the initiative was global/sub-global, and in

Volume 1: Current State and Trends (MEA 2005b), urban areas are identified as one of

10 ecosystem types from which services may be derived. There is, however, little

characterization or assessment of these services, and urban areas are generally framed as

a source of degradation to "adjoining . . . and distant ecosystems" (p. 18)

A noteworthy outcome of this report is a conceptual framework that shows linkages

between ecosystem services and human well-being (see Figure 4.6). These linkages are

classified in four categories: *supporting* services such as soil formation, photosynthesis, and nutrient cycling; *provisioning* services such as food, water, timber, and fiber; *regulating* services that affect climate, floods, disease, and water quality; and *cultural* services that provide recreational, aesthetic, and spiritual benefits.
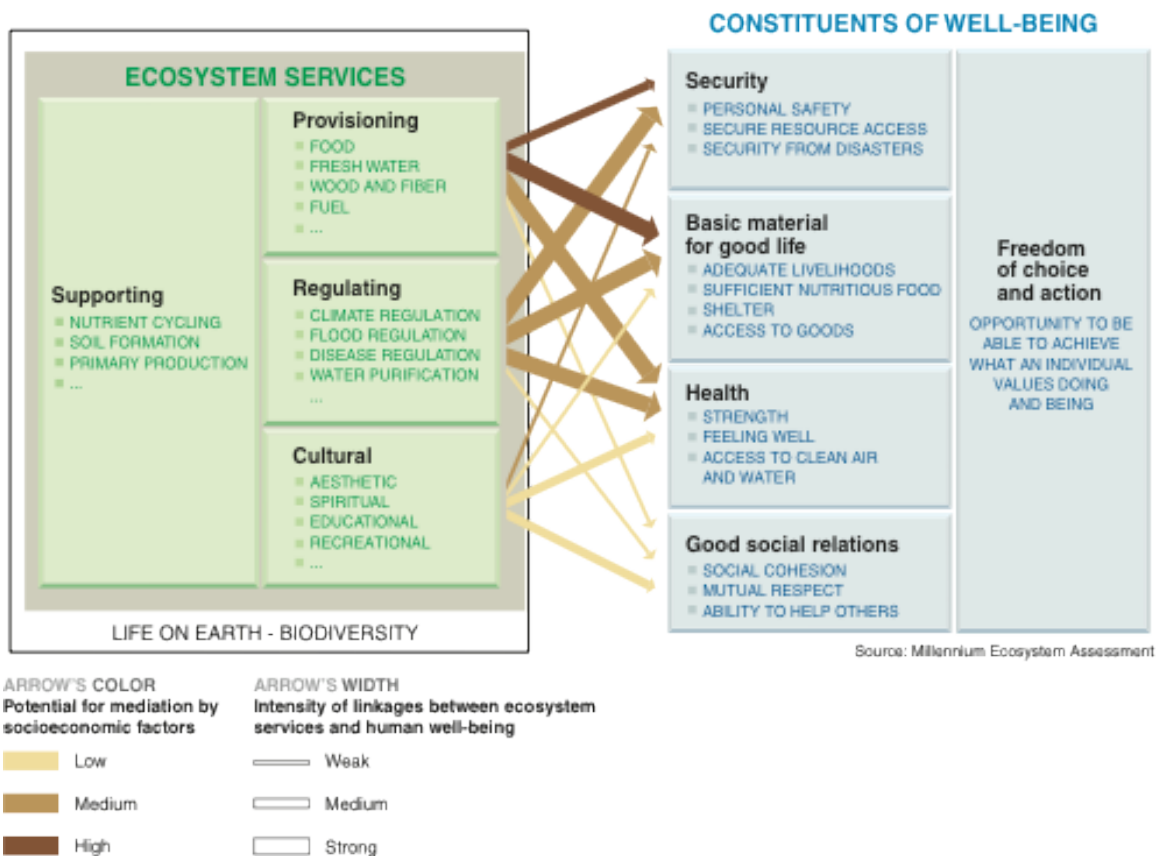
Figure 4.6: Linkages between ecosystem services and human well-being (MEA 2005a, VI) [Courtesy of World Resources Institute].

This diagram also shows the "multiple constituents" of human well-being that are fundamentally supported by global and sub-global ecosystem services. These include:

"*basic material for a good life,* such as secure and adequate livelihoods, enough food at

all times, shelter, clothing, and access to goods; *health,* including feeling well and having

a healthy physical environment, such as clean air and access to clean water; *good social*

relations, including social cohesion, mutual respect, and the ability to help others and

provide for children; *security*, including secure access to natural and other resources,

personal safety, and security from natural and human-made disasters; and *freedom of*

choice and action, including the opportunity to achieve what an individual values doing

and being" (p. V). In addition, this illustrative conceptual framework depicts the potential

for mediation of certain ecosystem services by socioeconomic factors (color of arrows)

and the intensity of linkages between ecosystem services and human well-being (width of

arrows).

In *Ecosystems and Human Well-Being: Health Synthesis (2005c, 14)*, one of five

thematic synthesis reports produced by the MEA, another conceptual diagram frames

human health as "the central aspect" of ecosystem services (see Figure 4.7).
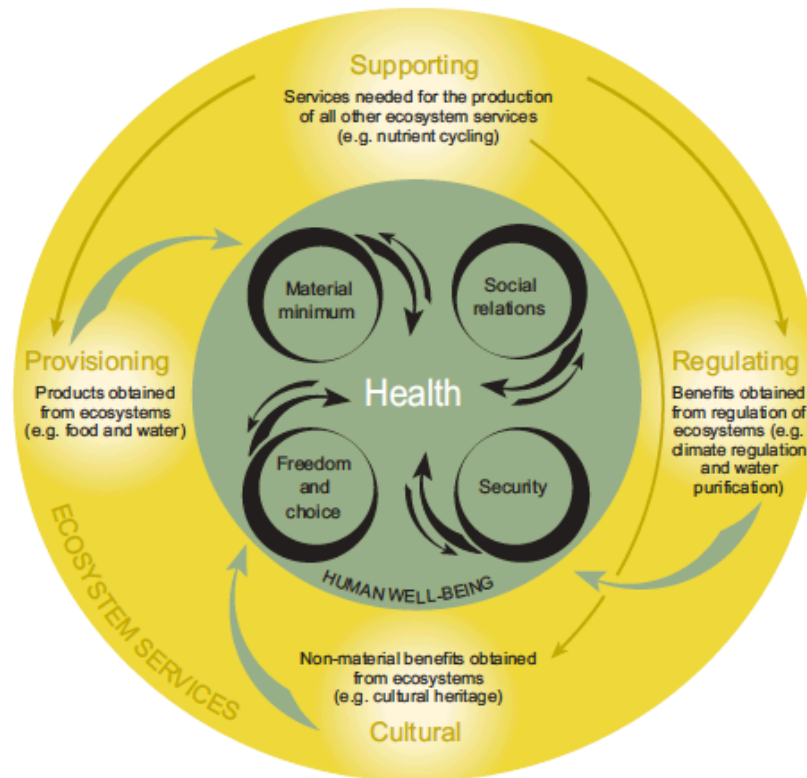
Figure 4.7: Associations between health, other aspects of human well-being and ecosystem services (MEA 2005c, 14).

Several books have recently emerged that apply the ecosystem services construct to the urban setting. One example is "Urban Landscapes and Ecosystem Services" a chapter authored by Breuste et al., in the edited volume *Ecosystem Services in Agricultural and Urban Landscapes* (2013). Here, Breuste et al. define urban ecosystem services (UES) as those "requested and provided in urban areas and cities" (p. 87), and they pursue a line of thinking focused on "the process of urbanization," where cities are primarily consumers

and degraders of nearby and distant ecosystem services. While it is true that the "net flow of ecosystem services is invariably into rather than out of urban systems" (Sandhu and Wratten 2013, 11),[5] this approach to UES is problematic for several reasons:

> 1) Framing UES as the nearby and distant ecosystem services that cities both request and degrade is premised on a logic that does not distinguish between urban and non-urban ecosystem services.
>
> 2) It does not acknowledge the biophysical and sociopolitical reality of urban greening practice, which usually occurs within the jurisdictional limits of a municipality and/or within neighborhoods and sites nested in cities;[6]
>
> 3) It does little to inform urban greening practice and to help local decision makers.

In addition, Breuste et al. erroneously attribute their definition of UES to Bolund and Hunhammar (1999), one of the first and most cited studies to explore ecosystem services generated in urban settings. This seminal article identifies "*internal* urban ecosystems" as the object of study, and the authors clearly state that, "the aim of [the] paper is to analyze

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[5] Other scholars also emphasize that most ecosystem services consumed in cities are generated by ecosystems located outside of cities themselves, often across the globe (Rees 1992; Rees and Wackernagel 1996; Folke et al. 1997; Deutsch and Folke 2005).

[6] For example, Tree Pittsburgh (2010) describes its urban forest as "all of the trees within the city boundaries." Green Area Factor policies apply to sites within the jurisdictional limit of the authorizing municipality (Keeley 2011). Green roof policies are usually undertaken by municipal authorities for application within the city's jurisdiction (Eisenman 2007; Carter and Fowler 2008).

the ecosystem services generated by ecosystems *within* the urban area" (p. 293). They describe urban ecosystems as "all natural green and blue areas *in* the city;" and they identify seven different urban ecosystems, "even if almost all areas *in* cities are manipulated and managed by man" (p. 294). Furthermore, the title of the paper – "Ecosystem services *in* urban areas" – should remove any doubt as to Bolund and Hunhammar's intention (p. 293, italics in preceding quotes by author for emphasis).

This volume does not address literature on disservices, costs, management, and design issues associated with citywide green infrastructure. In addition, Breuste et al. cite little research on human health outcomes, a principal benefit of ecosystem services according to the MEA (2005a; 2005c). This results in a rather limited discussion. On the UES of recreation, for example, the authors assume a one-to-one correlation between vegetative cover and recreational value, but they do not unpack the constituents of recreation. Thus, they largely overlook literature that explicitly addresses links between urban green space and physical activity/obesity, assessed in Chapter V (e.g. Kaczynski and Henderson 2007; Kaczynski and Henderson 2008; Lachowycz and Jones 2011; Lachowycz and Jones 2014). The publication also does not give much attention to cultural ecosystem services, wherein recreation is an important constituent.

In "Ecosystem Services and the Green City," a chapter in the edited volume *Growing Greener Cities: Urban Sustainability in the Twenty-first Century* (2008), Hirsch

highlights the economic and environmental outcomes that natural settings provide cities. By example, he points to the drinking water provided to New York City by upstate watersheds, and the storm surge protection provided to New Orleans by coastal wetlands. To elevate these services in public sector decision making, Hirsch identifies and elaborates upon four strategies: 1) Government funded restoration projects; 2) Fee systems, where those who damage ecosystem services pay a charge for doing so; 3) Subsidiary programs, whereby governments subsidize private actions to preserve and enhance ecosystem services; and 4) Trading systems that allocate a property right in the ecosystem service and then allow regulated parties to meet environmental requirements by purchasing this right.

Reflecting the approach of other chapters reviewed above and below, Hirsch frames UES as *outside* of the city proper. This perspective does not reflect the political, biophysical, or cultural reality of urban greening practice, which occurs primarily, if not exclusively, *within* cities. This distinction is not minor, and it has potentially important implications for UES research and urban greening practice.

In one of the few pieces to situate UES within urban planning practice, Johan Colding's chapter, "The Role of Ecosystem Services in Contemporary Urban Planning," in *Urban Ecology: Patterns, Processes, and Application* (2011), concerns itself with the effects of urban sprawl by reviewing two approaches to addressing this problem: smart growth

planning and green infrastructure. Reflecting the orientation of the chapters described above and below, the text acknowledges arguments that urbanization is a process that has deleterious effects on surrounding landscapes, wildlife habitat, and ecosystem services. But Colding takes a somewhat contrarian position, marshaling evidence in support of the argument that, "the urban matrix is often more heterogeneous than often recognized, contributing to habitat diversity and thereby increasing landscape diversity" (p. 237). Moreover, "much urban and suburban land-use positively contributes to the generation of ecosystem services and that opportunity exists to improve intensively managed landscapes to further bolster this potential" (p. 235). For example, three semi-natural areas in Stockholm may provide a range of ecosystem services (see Figure 4.8).

	Allotment areas	Domestic gardens	Golf courses
Provisioning services			
Fire wood		X*	
Food (fruits & vegetables)	X*	X*	
Ornamental resources (flowers)	X*	X*	
Cultural services			
Aesthetic values	X	X	X
Inspiration	X*	X*	X*
Nature education	X*	X*	X
Recreation	X*	X*	X*
Social relations	X*	X	X*
Regulating services			
Air filtration	X	X	X
Erosion regulation	X	X	X
Noise reduction	X	X	X
Nutrient retention (in ponds)			X
Pest regulation	X	X	X
Regulation of microclimate	X	X	X
Surface water drainage	X*	X*	X*
Supporting services			
Habitat for flora & fauna	X*	X*	X*
Soil formation	X	X	X
Seed dispersal	X	X	X
Pollination	X*	X*	X
Water cycling	X	X	X

Figure 4.8: Potential ecosystem services provided by three semi-natural areas in Stockholm (Colding 2011).

Colding also critiques the smart growth and green infrastructure approaches to curbing

sprawl because of their compact growth orientation and overarching goal to steer

population into "the labyrinths of dense city cores, with little access to natural habitats,"

which he describes as "utterly old-fashioned" top-down planning (p. 237). He further

notes that, "while human activity destroys ecosystems at an alarming rate, people are also

important for generating and sustaining ecosystem services. More studies need to be

conducted to assess whether the environmental benefits of planning compact cities

overweigh those of dispersed settlement growth. Until we gain more knowledge, a

desirable planning strategy would be to foster approaches and urban designs that

qualitatively improve the urban landscape." This points to important research needs in

urban planning and design, yet "ecosystem services is barely found in the urban planning-

oriented literature to date" (p. 236).

Colding's chapter highlights the need for more nuanced and complex thinking on UES,

and he calls for greater engagement in this issue amongst urban planners. This echoes the

book's introduction, which states as one of its goals the exploration and suggestion of

"innovative and adaptive urban planning scenarios" (p. 2). "If scientists want to enhance

the use of their research in the planning process, it is vital to understand where inputs into

the process are possible and how it should be done" (p. 3). Indeed, "one of the aims of

this book is to provide scientific understanding suitable for application in urban planning"

(p. 3), and "it is hoped that this book will provide a compilation of information that will be useful to ecologists, planners, designers, and landscape architects" (p. 4).

In light of this framing, it is surprising – and rather troubling – that only four of over 60 contributing authors to this volume carry titles or affiliations suggesting any disciplinary background in urban planning or allied design field. Likewise, few contributors represent the humanities and social sciences, and the vast majority of authors are natural scientists. This is problematic when the introduction openly acknowledges that, "urban ecological studies … vary from plant or animal studies in the urban setting, to the integrated study of ecological and social systems" (p. 2).

This natural science orientation is reflected in *Urbanization, Biodiversity, and Ecosystem Services: Challenges and Opportunities*, edited by Elmqvist et al. (2013). This 755-page edited volume was prompted by the Convention on Biological Diversity. As the title suggests, the publication focuses on "global urbanization and the multiple impacts on biodiversity and ecosystem services" (p. ix). Similar to Breuste et al. (2013) above, it addresses "the process of urbanization, rather than an assessment of cities per se" (p. x), and it frames cities largely as consumers and degraders of ecosystems.

One chapter by Gómez-Baggethun et al. (2013) explicitly addresses UES. The authors state that their focus is on "services provided within urban areas." Yet, they qualify this by reinforcing that: "the relevant scope of urban ecosystem analysis reaches beyond the

city area itself; it comprises not only the ecological infrastructure within cities, but also the hinterlands that are directly affected by the energy and material flows from the urban core and suburban lands" (p. 177). Thus, their analysis includes examples such as water supplied to New York City by the eight-county Catskill/Delaware and Croton watershed region extending some 140 miles north of Manhattan. This gravity-fed, naturally filtered drinking water system is indeed a groundbreaking precedent in watershed protection, and a stellar example of regional GI. However, it extends far beyond the physical, conceptual, and political scope of "urban greening," as exemplified by the MillionTreesNYC program whose goal is "to plant and care for one million new trees across the City's five boroughs" (City of New York 2014).

This highlights definitional problems currently circulating in UES literature (as described above), and it illuminates a mismatch between UES discourse and urban greening practice. Gómez-Baggethun et al. do a commendable job of classifying important ecosystem services, functions, and disservices in urban areas. They cite findings on the economic valuation of five urban ecosystem services (air purification, microclimate regulation, carbon sequestration, water regulation, and aesthetic information). They identify the role and challenge of economic valuation of ecosystem services in urban planning across regional, neighborhood, site, and building scales. And they ground this analysis in three case study cities. Yet, the section on "health values" is only two

paragraphs long. This is problematic, as health is framed as a principal outcome of both ecosystem services (MEA 2005a; MEA 2005c) and green infrastructure (APA 2013).

In addition, the sections on "urban policy and governance" and "urban planning and design" make no reference to the large-scale tree planting programs, canopy cover assessments and goals, green streets projects, green roof and wall initiatives, and green area ratio policies that undergird contemporary urban greening practice. This results in a narrative that is largely divorced from contemporary urban greening and offers little meaningful guidance for municipal actors.

Gaps and Insights

This section identifies noteworthy gaps and insights that emerged from this literature review.

Lack of Urban Planning Engagement

Even though the APA now describes green infrastructure as a "fundamental paradigm shift" in the "human-shaped landscape" (2013, 2), only a handful of peer-reviewed articles in U.S. urban planning journals address "green infrastructure" or "greening" as the act of conserving or introducing vegetation in cities. Likewise, urban planners are largely absent from the UES discourse (Colding 2011). Why haven't urban planners published more on this topic? What does this say about the evolution of the field? Do

planners not conceive of vegetation as urban infrastructure worthy of the same
institutional and financial support as other capital investments and traditional grey
infrastructure? If so, what hurdles does this present to institutionalizing green
infrastructure.[7] Moreover, what value might urban planners bring to research on UES,
green infrastructure, and municipal greening practice?

Gap between UES Theory and Urban Greening Practice

 There are conflicting definitions of UES circulating in the literature. Some assess the
functions and services provided by vegetation and ecosystems *in* cities and urban areas
(Bolund and Hunhammar 1999; Escobedo, Kroeger, and Wagner 2011; Pataki et al.
2011; Pincetl et al. 2013; Nowak et al. 2013). Others address the ecosystem functions and
services provided *to* cities and urban areas,[8] as well as those generated in cities and urban
areas (Hirsch 2008; Breuste, Haase, and Elmqvist 2013; Jansson 2013; Gómez-
Baggethun et al. 2013; Sandhu and Wratten 2013). The substantial difference between
these approaches muddles scholarly discourse and weakens the capacity to inform urban
greening practice. Moreover, framing UES as the nearby and distant ecosystem services

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[7] At the turn of the 19th century, stewardship of the urban forest had become a municipal responsibility. In 1894, the city of Cambridge, MA published a *Report of the General Superintendent of Parks,* stating that "trees are amongst the most valuable of the municipal properties" (Campanella 2003, 118–119).

[8] The *TEEB Manual for Cities: Ecosystem Services in Urban Management* (2011) does not explicitly refer to "urban ecosystem services," but it focuses primarily on the services provided to cities by nearby ecosystems.

that cities both use and degrade is premised on a logic that does not distinguish between

urban/local and non-urban/global/regional ecosystem services

There is also a fundamental mismatch in scales between UES theory and urban greening

practice. The latter usually occurs at nested scales within the jurisdictional limit of cities.[9]

Yet, the accepted conceptual framework guiding UES research is the one developed by

the MEA (Gómez-Baggethun et al. 2013; Jansson 2013), which encompasses the global

and sub-global ecosystems that support human life. It is quite likely that the relationship,

direction, and strength of services provided by ecosystems in urban areas – highly altered

biomes that occupy .5% of the Earth's land area (Schneider, Friedl, and Potere 2009;

Angel et al. 2011)[10] – are likely to be dramatically different from global ecosystem

services. This reveals a substantial gap between ecosystem services theory and urban

greening practice.

Inattention to Public Health: Assumption of Benefits?

The MEA (2005a) identifies human health as an important constituent of well-being and

the principal outcome of ecosystems services (see Figure 4.6) as well as "the central

[9] Tree Pittsburgh (2010) describes its urban forest as "all of the trees within the city boundaries." Green Area Factor policies apply to sites within the jurisdictional limit of the authorizing municipality (Keeley 2011). Green roof policies are usually undertaken by municipal authorities for application within the city's jurisdiction (Eisenman 2007; Carter and Fowler 2008). See introduction to this prospectus.

[10] The MEA estimates that less than 3% of the Earth's land surface is urban (MEA 2005b)

aspect" of ecosystem services (see Figure 4.7). The APA describes public health as the principal outcome of GI (see Figure 4.5). And a survey of U.S. municipal arborists found that over 80% ranked human health as a very or moderately important objective of urban forestry (Young 2010). In other words, human health is one of – if not the – dominant rationales underlying ecosystem services, GI, and urban greening. Yet, public health literature and expertise is largely absent from the literature reviewed above. Moreover, Hubacek and Kronenberg (2013) assessed 463 articles addressing UES: of 18 journals that have published at least five or more papers, not one is from public health; and when characterizing this literature in five categories, none explicitly addresses public health. This reveals a pressing need for review of scholarly literature on the human health benefits of urban vegetation (see Chapter V).

Scope Creep

As GI gains prominence, its definition and purpose is becoming diluted. This is evidenced by Rottle and Maryman's (2012) description of "public art installations," "outdoor theaters," "solar panels" and "wind turbines" as GI. These landscape features have nothing to do with the network of green spaces (Benedict and McMahon 2006) and stormwater management function that undergird GI research and practice (Prince George's County, MD 1999; Eisenman 2005; City of New York 2012; LIDC 2014). In so doing, the authors subject GI to "sustainability scope creep," a concerned expressed by Rouse and Bunster-Ossa (APA 2013, 82).

Cautionary Tale

According to Lachmund (2013), West Berlin's late 20th century experiment in urban ecology gave rise to an ''urban nature regime that exceeded the formal boundaries of institutionalized science'' (p. 221) and ''fundamentally ecologized'' land use planning (p. 2). More broadly, "little attention has been paid to the role of science in the shaping of nature in cities. Science is mostly treated as an explanatory resource to account for the ecological impact of cities on nature, or the effects that environmental degradation has on urban life. What is missing is a systematic exploration of the ways in which the practice of environmental sciences has become a constitutive part of the dynamics of nature politics and spatial development in cities" (p. 5).

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Table 1

JOURNAL OF THE AMERICAN PLANNING ASSOCIATION
"Greening" (60) + "Green Infrastructure" (19) (All words in full text)

Article	Summary	Rank
Greening the Rust Belt: A Green Infrastructure Model for Right Sizing America's Shrinking Cities. Joseph Schilling & Jonathan Logan. Volume 74, Issue 4, October 2008, p. 451-466	Identifies GI and urban greening as a strategy for "right-sizing...shrinking cities." Offers a 3-pronged model for converting vacant lands to GI: 1/ Instituting GI plans and programs; 2/ Creating vacant land/GI banks; 3/ Building consensus through collaborative planning. Differentiates urban GI from metropolitan GI, and creates a typology of GI elements. Also provides a summary of urban greening benefits in three categories: economic; environmental; and social. Based on review of 6 leading municipal programs, concludes that conversion to GI can "increase value of adjacent properties, reduce stormwater, increase access to health local foods, and more important, rebuild social capital by engaging citizens in a collaborative planning."	1
Planting the Living City, Robert F. Young, Volume 77, Issue 4, October 2011, p. 368-381	Study explores stakeholder perspectives on successes and setbacks of planting, stewardship, business, and outreach plans for large-scale tree-planting initiatives (TPI) in 8 major U.S. cities and one metropolitan county. Author found that cities employed a spectrum of planning strategies to advance TPI, ranging from highly institutionalized, data-driven initiatives to decentralized, grassroots efforts. Participants viewed TPI as bringing GI to the mainstream; however, there are uncertainties regarding funding and long-term stewardship. Lacking access to traditional infrastructure financing, several TPI used creative development and contracting strategies to maintain project funding and momentum, while others stagnated. Programs lost momentum when mayors who launched TPI were not reelected.	1
Using Watered Landscapes to Manipulate Urban Heat Island Effects: How Much Water Will It Take to Cool Phoenix? Patricia Gober et al. Volume 76, Issue 1, December 2009, p. 109-121	Addressing the cost-benefit of increasing urban vegetation to cool arid cities such as Phoenix, study found that "increasing irrigated landscaping lowers nighttime temperatures, but this relationship is not linear; the greatest reductions occur in the least vegetated neighborhoods. A ratio of the change in water use to temperature impact reached a threshold beyond which increased outdoor water use did little to ameliorate UHI effects." Thus, "there is no one design and landscape plan capable of addressing increasing UHI and climate effects everywhere. Any one strategy will have inconsistent results if applied across all urban landscape features and may lead to an inefficient allocation of scarce water resources." "Efforts to increase vegetative cover should concentrate on neighborhoods with the least vegetation, where substantial gains in cooling can be achieved with minimal additional water use."	2
Transect Planning, Andrés Duany & Emily Talen, Volume 68, Issue 3, September 2002, p. 245-266	Introduces and describes transect planning, which is based on the creation of a set of human habitats that vary by their level and intensity of urban character along a rural-urban continuum. "The transect is designed to strengthen the integrity of each immersive environment and can be used as a new, alternative approach to conventional zoning systems."	2

Rank = relevance to urban greening, defined here as the introduction or conservation of vegetation in cities.

Scale: 1=most relevant; 5=least relevant.

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Table 1

JOURNAL OF THE AMERICAN PLANNING ASSOCIATION
"Greening" (60) + "Green Infrastructure" (19) (All words in full text)

The Evolution of Green Community Planning, Scholarship, and Practice: An Introduction to the Special Issue. Philip R. Berke. Volume 74, Issue 4, October 2008, p. 393–407	Assesses the evolution of discourse on "green community planning" and identifies 4 consistent themes: bioregionalism; increasing scientific evidence for incorporating green elements; poor integration of green dimensions in future plans; and resulting dissatisfaction. Also identifies 5 primary dimensions of American environmental thinking that have influenced the evolution of human settlements during the modern era city of planning from the late 19th century onward: harmony with natural systems; human health; spiritual well being and renewal; livable built environments; and fair-share community. Closes by listing 3 priorities, one of which is, "identifying effective requirements and incentives that stimulate community and household behaviors aimed at environmental protection, mitigation and adaptation to climate change, and integration of green infrastructure into neighborhoods." — 2
A Review of "Green Cities of Europe: Global Lessons on Green Urbanism" Timothy Beatley (Ed.). (2012). Washington, DC: Island Press.	Review of Beatley's edited volume *Green Cities of Europe* based on 7 case studies describing five types of green city initiatives: 1) Sustainable land use and mobility: Paris, Freiburg, Copenhagen, Helsinki, Vitoria-Gasteiz, London. 2) Energy and climate protection: Paris, Freiburg, Copenhagen, Helsinki, London. 3) Climate adaptation: Paris, Venice, London. 4) Pollution remediation: Copenhagen, Venice, Vitoria-Gasteiz, London. 5) Green infrastructure: Paris, Copenhagen, Helsinki, Vitoria-Gasteiz, London. Randolph suggests that GI and pollution remediation are the 2 where the U.S. is making progress on par with Europe. See summary in chapter for review of relevant chapters. — 2
Review of "Growing Greener Cities: Urban Sustainability in the Twenty-First Century"; Stephan Schmidt; Volume 76, Issue 3, June 2010, p. 381	Reviews an edited volume that takes a broad view on greening that equates the term with "green cities" and "urban sustainability." This ranges from "supporting regional ecosystems, and improving the functioning of municipal infrastructure to the valuation of greening in real estate...it also includes building energy-efficient and resource-conserving homes and providing multipurpose, varied size open space...and urban agriculture." Book includes 19 chapters organized in 3 sections: "Greening at Every Scale: Nation to Roof Tops," which focuses on outputs; "Getting Greening Done," which focuses on process; and "Measuring Urban Greening," which focuses on outcomes. The editors reinforce that "green cities have one central feature in common: they take full advantage of their natural environments to sustain human health." See text in chapter for details on relevant chapters. — 2

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JOURNAL OF THE AMERICAN PLANNING ASSOCIATION

Table 1

"Greening" (60) + "Green Infrastructure" (19) (All words in full text)

Citation	Description	Rank
Preserving Biodiversity Challenges for Planners, Timothy Beatley Volume 66, Issue 1, March 2000, p. 5-20	Frames biodiversity protection as a priority for planners because of the habitat loss and fragmentation that accompanies urbanization and sprawl. Beatley emphasizes and reflects the original conception of green infrastructure: "the idea that preserving forests, wetlands, and rivers is as essential as building roads, power lines, and airports – indeed, more important in the human life-support functions they provde. These elements of the natural environment are not expendable or optional, but essential as the term *infrastructure* implies." Reinforces that "wilderness habitat and green space should penetrate into the very core of our cities."	2
Innovation and Climate Action Planning: Perspectives From Municipal Plans. Ellen Bassett & Vivek Shandas. Volume 76, Issue 4, September 2010, p. 435-450	Evaluated the content of 20 Climate Actions Plans (CAP). Informants reported that their CAPs favored actions that were highly visible (e.g., tree planting), which was framed as mitigation, not adaptation. Only five of the plans address climate change adaptaton and there was no evidence of a completed strategy.	3
Planning for the Disposal of the Dead, Carlton Basmajian & Christopher Coutts 76, Issue 3, June 2010, p. 305-317	Facing a growing elderly population and constraints on urban space, authors argue that "thoughtfully designed small community burial grounds could provide valuable green spaces." Indeed, "many municipalities consider cemeteries part of their green infrastructure, and in some places residents use cemeteries for recreation." "Designs that accommodate multiple uses and conservation space might bring burial facilities back into community life and simultaneously contribute to a community's green infrastructure."	3
Open Space Communities: Resident Perceptions, Nature Benefits, and Problems with Terminology. Rachel Kaplan, Maureen E. Austin & Stephen Kaplan; Volume 70, Issue 3, September 2004, p. 300-312	Addressing the lack of clarity surrounding term "open space," the authors argue that "while many of the issues raised by Benedict and McMahon (2002) are central to the intentions of open space preservation, their "green infrastructure" designation is unlikely to resolve the terminological problem for professional and lay groups. It is the authors' belief that residents, wildlife, and the environment would all benefit if the expression "conservation development" replaced "openspace development" as the official designation of these more environmentally sensitive patterns of habitation."	3
A Trail Across Time: American Environmental Planning From City Beautiful to Sustainability, Thomas L. Daniels, Volume 75, Issue 2, March 2009, p. 178-192	Identifies 5 eras in the historical evolution of environmental planning:1/Urban park & conservaion; 2/Regional ecological planning & science; 3/Birth of environmental planning; 4/ 1980s backlash and rise of NGOs/Land Trusts; 5/Global Sustainability. Frames urban greening as initatives to promote sustainability. References public health and climate change, but not in the context of urban vegetation, GI, or ecosystem services.	3

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JOURNAL OF THE AMERICAN PLANNING ASSOCIATION

Table 1

"Greening" (60) + "Green Infrastructure" (19) (All words in full text)

Citation	Description	Rank
Greening Development to Protect Watersheds: Does New Urbanism Make a Difference? Philip R. Berke, et al. Volume Volume 69, issue 4, 2008, p. 397-413	Author argues that "new urbanist" development in greenfield and urban infill sites incorporates GI best management practices and protects watersheds more than conventional development. But because many new urbanist developments are sited in greenfields, they are less than ideal.	4
State and Municipal Climate Change Plans: The First Generation. Stephen M. Wheeler. Volume 74, Issue 4, October 2008, p. 481-496	"Plans dealt overwhelmingly with mitigation of emissions rather than adaptation to climate change. Only 6 of 29 states and 5 of 35 cities even mentioned the subject of adaptation in their documents. Almost all of these raised the subject as a topic for further research and planning. Many city plans did recommend steps to reduce urban heat island effects, primarily through urban forestry, which might be seen as adaptation strategies."	4
Review Essay: Works on Green Cities: From Potential to Imperative. Tom Daniels; Volume 74, Issue 4, October 2008, p. 521-522	Equates "city greening" with "sustainability," and offers a review of literature including: the original greening impulse expressed in Central Park; Howard's "Garden City"; Spirn, Campbell, Berke and Conroy's finding that sustainability plans do not dramatically differ from traditional CompPlans; LEED; Beatley's European Green Urbanism; and strong emphasis on reducing sprawl.	4
Learning from Europe, Ian Masser. Volume 58, Issue 1, March 1992, p. 3-8	Describes recent innovation in European cities related to the emergence of the EU. Includes a passage describing Germany's traffic calming scheme that involves a combination of speed reducing adaptations and environmental improvements designed to promote street greening.	4
One Hundred Years of City Planning's Enduring and Evolving Connections Eugénie L. Birch FAICP & Christopher Silver FAICP Volume 75, Issue 2, March 2009, p. 113-122	Introduces the centennial issue celebrating the field's 100-year anniversary, providing context for articles appearing in the issue, exploring the implications of the past for contemporary planning, and pointing to ideas for educating future city planners. "Contemporary urban design draws on other precedents laid out in 1909 that bear new labels today: streetscaping, traffic calming, and greening." "Planners' current priorities are to promote sustainability and green cities."	4
A Vision of Green: Lewis Mumford's Legacy in Portland, Oregon, R. Bruce Stephenson Volume 65, Issue 3, September 1999, p. 259-269	Examines Lewis Mumford's Regional Planning in the Northwest, a work activists used to promote and eventually create a Metropolitan Greenspace System. "Mumford envisioned Portland branching into a series of "urban inter-region[s]" (Mumford, 1939a, p. 11) that balanced function and aesthetics. He recommended greening the city's central core and enhancing the industrial and cultural base of smaller towns to foster the "reforestation" of urban culture and stem "social erosion" (p. 20).	4

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JOURNAL OF THE AMERICAN PLANNING ASSOCIATION

"Greening" (60) + "Green Infrastructure" (19) (All words in full text)

Table 1

Five Important Themes in the Special Issue on Planning for Water. Guest Editors G. William Page & Lawrence Susskind Volume 73, Issue 2, June 2007, p. 141-145	Frames GI as one of some 40 challenges for water planning.	4
From Growth Controls, to Comprehensive Planning, to Smart Growth: Planning's Emerging Fourth Wave. Timothy S. Chapin. Volume 78, Issue 1, 2012, p. 5-15.	Proposes "Optional Sector Planning" as a 4th wave of growth management based on "a powerful combination of the green regionalism approach described by Beatley (2010) and the transect planning model described by Duany and Talen (2002). The OSP process requires planners to develop a land use vision for the entirety of the property, akin to Duany and Talen's sector plan, by mapping conservation areas that will be protected, setting the urban pattern for any proposed development, and identifying needed infrastructure investments or green infrastructure systems (as per Beatley's [2010] green regionalism).	4
Netherlands Planning: The Higher Truth; Ernest R. Alexander Ph.D., AICP, Volume 67, Issue 1, March 2001, p. 91-92	Debates the merits of Eaten and van Roe's critique of The Netherlands Green Heart, a thinly populated area in the Dutch Randstad surrounded by 6 major cities. Argues that the the former's proposal for decentralized local authority will lead to provincial concerns and segregation.	5
When Fiction Conveys Truth and Authority, Michel Van Eeten & Emery Roe Volume 66, Issue 1, March 2000, p. 58-67	The Green Heart concept has been fiercely criticized for its fictional nature. According to these critics, since the Green Heart does not exist, it cannot be used to justify far-reaching policy measures. The authors propose planning approaches that depend much less directly on maps and cartographic imaging, and to deny the hegemony of planners by protecting the heterogeneous local communities which seek control over their own territories.	5
Using Land Inventories to Plan for Urban Agriculture: Experiences From Portland and Vancouver; Wendy Mendes et al. Volume 74, Issue 4, October 2008, p. 435–449	Explores the use of land inventories to identify city land with the potential for urban agriculture. Portland inventory both enabled integration of urban agriculture into planning and policymaking and advanced social and ecological sustainability. In Vancouver, similar integration was achieved, but the smaller scope of the effort meant it did little for public involvement and social sustainability.	5

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JOURNAL OF THE AMERICAN PLANNING ASSOCIATION **Table 1**

"Greening" (60) + "Green Infrastructure" (19) (All words in full text)

The 21st Century Urban University: New Roles for Practice and Research, Judith Rodin, Volume 71, Issue 3, September 2005, p. 237-249	Outlines Upenn's West Philadelphia Initiatives (WPI), a 5-pronged approach that has had significant results in neighborhood revitalization, including "actions aimed at increasing the safety and attractiveness of the area" . . . such as "planting of 450 trees and 10,000 spring bulbs, and the creation of 4 public and 3 children's gardens—which set the stage for the dramatic transformation of Clark Park from a dangerous, drug-infested space into a thriving recreational venue for children and the locale for a weekly farmers' market.	5
Fostering Green Communities Through Civic Engagement: Community-Based Envtl. Stewardship in the Portland Area; V. Shandas & W.B.Messer, 74(4) 2008, 408-418	Based on a case study of Portland's Community Watershed Stewardship Program (CWSP), concludes that programs encouraging the public to participate in environmental planning and stewardship need flexibility to allow innovation and accommodation in the planning process. The authors observe that community partners have great success completing projects they themselves initiate, and that are physically located nearby. Authors also found that developing a partnership with a local universtiy strenghens environmental stewardship.	5

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JOURNAL OF PLANNING EDUCATION RESEARCH
"Greening" (22) + "Green Infrastructure" (4) (All words in full text)

Table 1

Article	Summary	Rank
Sustainable urban forms: Their typologies, models, and concepts. Jabareen, Y. R. 2009 vol. 26, p. 38-52	Identified seven major concepts (compactness, sustainable transport, density, mixed land uses, diversity, passive solar design, and greening) frequently associated with sustainable urban forms.	4
Examining the Influence of Development Patterns on Flood Damages along the Gulf of Mexico, Samuel D. Brody, et al. 2011; vol. 31, 4: p. 438-448,	Examined 5 years of insured flood loss claims across 144 counties and parishes fringing the Gulf of Mexico. Study found that clustered, high-intensity development patterns significantly reduce amounts of reported property damage, while increasing percentages of sprawling, low-intensity development involving recent conversion of open space greatly exacerbated flood losses.	4
The Use of LEED in Planning and Development Regulation: An Exploratory Analysis. Rebecca C. Retzlaff 2009: vol. 29, 1: p. 67-77	Finds that elements often missing from building codes include sustainable planting requirements, siting, connectivity, and consistency with regional plans.	4
Myers, D. (1997). Anchor points for planning's identification. 16(3), p. 223–224.	ACSP committee identified "a focus upon improvement of human settlements" as one of the six "anchor points of planning's identification" (Myers, 1997, p. 223).	4
The Sustainable Communities Experiment in the United States: Insights from Three Federal-Level Initiatives. Carla Chifos; 2007; vol. 26, 4: p. 435-449.	Documents and analyzes a portion of the U.S. government's attempt to adopt the concept of sustainability after 1992. Identifies GI as a Strategic Opportunity Area in the 1996 President's Council on Sustainable Development. 21% of EPA Sustainable Development Challenge Grants, 4% of DOT's Transportation, Community, and System Preservation Pilot Program went to GI-focused projects.	4

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JOURNAL OF PLANNING EDUCATION RESEARCH

Table 1

"Greening" (22) + "Green Infrastructure" (4) (All words in full text)

Citation	Description	Rank
Book Review: Edward T. McMahon Conservation Communities: Creating Value with Nature, Open Space, and Agriculture. Washington, DC: Urban Land Institute, 2010. Shelley S. Mastran, 2011; vol. 31, 1: p. 108-109.	McMahon argues that the majority of new development will take place in greenfields largely because of the limited supply and high cost of urban land. Thus, it is critical that such greenfield development is done right. In conservation development, open space (GI) is not an afterthought or casual set-aside; it is a critical, even the main, feature of the development project.	4
Local Government Efforts to Promote the "Three Es" of Sustainable Development: Survey in Medium to Large Cities in the United States; Devashree Saha and Robert G. Paterson. 2008; vol. 28, 1: p. 21-37.	Instead of adopting sustainable development as a holistic framework, cities are adopting sustainability initiatives in a piecemeal, ad-hoc manner. Moreover, very few cities exhibited a broader level commitment to the concept, as evidenced by presence of sustainability plans, indicators measuring progress toward sustainability goals, or an office and staff devoted to sustainability activities. Additionally, there was little evidence that cities are connecting sustainability to equity and social justice issues.	4
Making Local Planning Work for Urban Agriculture in the North American Context: A View from the Ground. Joël Thibert, 2012; vol. 32, 3: p. 349-357.	Addresses role of urban agriculture in planning, based on case studies in Toronto, Montreal, and Detroit.	5
Integrating Hazard Mitigation into New Urban and Conventional Developments; Philip R. Berke et al. June 2009; vol. 28, 4: p. 441-455.	Using 33 matched pairs of New Urban and conventional low-density developments, the study examines how well New Urban developments located in hazardous areas incorporate hazard mitigation techniques. Findings indicate that New Urban developments are compounding the growing risk to hazards by potentially adding higher density development than in the past.	5
Urban Climate Adaptation in the Global South: Planning in an Emerging Policy Domain. JoAnn Carmin, et al. March 2012; vol. 32, 1: p. 18-32.	Examines the initiation and development of adaptation planning in two cities in the global south: Durban and Quito. Focuses primarily on factors and processes influencing institutional and policy change, finding that both cities were motivated by endogenous factors. Makes no explicit reference to vegetative impact on urban heat island, nor specific policy outputs or outcomes.	5

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JOURNAL OF PLANNING EDUCATION RESEARCH

Table 1

"Greening" (22) + "Green Infrastructure" (4) (All words in full text)

Book Review: Sustainability Education: Perspectives and Practice Across Higher Education, Stephen M. Wheeler, March 2012; vol. 32, 1: p. 125-127.	Cites an analysis of articles in the *International Journal of Sustainability in Higher Education*, which since the journal's founding in 2000 have focused mainly on "campus greening" rather than pedagogy.	5
Innovations in Urban Design and Urban Form: The Making of Paradigms and the Implications for Public Policy, Ajay M. Garde, Fall 2008; vol. 28, 1: p. 61-72.	Makes a loose reference to "green development" as an "integrative" urban design paradigm.	5
When City and Country Collide: Managing Growth at the Metropolitan Fringe, Robert D. Yaro, Winter 1999; vol. 19, 2: p. 213-214.	Reviews T. Daniel's book on suburban sprawl, depicting the metropolitan fringe as both a place and a process. 3 migrations:19th century indsutrial centralization; mid-20th century suburbanization; late 20th century extension to metropolitan fringe.	5
Local Knowledge in Action: Valuing Nonprofessional Reasoning in the Planning Process; Ann Van Herzele December 2004; vol. 24, 2: p. 197-212.	Drawing upon a case study in Antwerp, finds that participants wanted to enjoy both form and functions together, and that the "the interweaving of different functions should be more integrated within the greening."	5
Food Justice Movements: Policy, Planning, and Network; Gerda R. Wekerle June 2004; vol. 23, 4: p. 378-386.	Examines the emergence of food justice movements through the lens of social movement theories, which emphasize the politics of place as a resource and strategies of networked movements operating across scales.	5

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JOURNAL OF PLANNING EDUCATION RESEARCH

Table 1

"Greening" (22) + "Green Infrastructure" (4) (All words in full text)

Review: The Politics of Civic Space in Asia: Building Urban Communities, by Amrita Daniere and Mike Douglass. London: Routledge. 2008. 239 pages. Gary Hack, 2009; vol. 28, 4:	In this book review of Asian public space making, there is one reference to "residents . . . . interested in other environmental issues (such as neighborhood noise, irresponsible dog ownership, or congestion) as they were in greening the surroundings of their housing estate."	5
Response to "Post-Disaster Planning in New Orleans" J. Phillip Thompson, March 2009; vol. 28, 3: p. 403-404.	Frames post-disaster planning as an important launch point to "invigorate urban planning, particularly as neighborhoods and cities begin to tackle the problem of greening cities."	5
Book Review: Gary Hack, Eugenie L. Birch, Paul H. Sedway, and Mitchell J. Silver, eds: Local Planning: Contemporary Principles and Practice. Nancy Frank. 2010; vol. 30, 2: p. 211-212.	In this review of one of the principle texts in U.S. urban planning, Frank finds that "the index was disappointing for using the book as a reference—a common use of past versions of the 'Green Book.'" To test this, I searched for "greening" and "green infrastructure" in the Green Book. While the latter appears in a few places within the book, these terms do not appear in the index.	5
"Overcoming Barriers to Ecologically Sensitive Land Management: Conservation Subdivisions, Green Developments, and the Development of a Land Ethic. "Thompson, Robert H. 2004. 24: p. 141–53.	This article identifies 3 categories of potential barriers to better individual land management: barriers to recognizing environmental problems, internal barriers to action, and external barriers to action. Authors find that tndividual property owners have a tremendous impact on the environment; the relatively small impacts of numerous private property owners can add up to big environmental problems. For green developments to be successful, residents must understand their design, support their goals, and act as responsible land managers.	5

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JOURNAL OF PLANNING HISTORY
"Greening" (9) + "Green Infrastructure" (11) (All words in full text)

Table 1

Article	Summary	Rank
Book Review: Nature and the City, Thaisa Way, November 2011; vol. 10, 4: p. 356-364.	A review essay including 10 books, several of which I have read. Argues that human and natural histories tend to be treated as discrete subjects, thus, "Cities seem an apt domain to consider overlapping narratives of human and natural histories." *"Our assumption that the city should be green is a particularly recent viewpoint."* Concludes that "this renewed reading of urbanism may well offer a narrative that engages "humans as the biologic agents of history that the science of climate change suggests" (Chakrabarty 2009).	2
The Compact versus the Dispersed City: History of Planning Ideas on Sofia's Urban Form, Sonia Hirt, May 2007; vol. 6, 2: p. 138-165.	Depicting the history of planning in Bulgaria's capital, argues that "Sofia's planning has been persistently shaped by two perennial dilemmas—how to reconnect the city with nature and how to define its relationship with the region," and the significance of these relationships in the evolution of planning thought." Offers one of the best, succint summaries of the "city-nature" discourse that I've read. 4 Phases: *Monumental Cities* (penetration of dense urban fabric with vast public parks); *Garden Cities* (regional dispersal into new towns w/ greenbelts); *City Efficient* (towers in the park); *City Sustainable* (human scale green space in existing city and land preservation outside of city). Interestingly, Soviet architects equated urban"greening" with decentralization.	2
The Planner in the Garden: A Historical View into the Relationship between Planning and Community Garden. Laura Lawson. May 2004; vol. 3, 2: p. 151-176.	A historical review of community garden programs in the United States since the 1890s reveals an ambivalent relationship between community gardens and the planning profession. On one hand, garden programs are praised and supported as local action to serve environmental, social, and individual objectives. On the other hand, because they are perceived as opportunistic and temporary, community gardens are largely ignored in long-range planning.	3
Urban Blueways: John Ormsbee Simonds and Riverfront Planning. Edward K. Muller. November 2012; vol. 11, 4: p. 308-329., first published on May 23, 2012	Reviews the work of John Ormsbee Simonds, who "advocated, and consulted on, the transformation of several city riverfronts during the 1960s and 1970s." Simonds viewed central riverfronts as the keystone of a system of metropolitan blueways or protected water-based park lands and corridors. His planning efforts, and those of others like him, laid the foundations for the waterfront redevelopment movement's sweeping success in the closing decades of the twentieth century.	4

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JOURNAL OF PLANNING HISTORY

Table 1

"Greening" (9) + "Green Infrastructure" (11) (All words in full text)

Conferences. Laura K. Swartzbaugh, Ben Schrader, and Bruce Stephenson August 2002; vol. 1, 3: p.245-261.	Analyzes 2002 ACSP panel discussion through lens of American anti-urbanism. Author argues that green infrastructure can provide the "connective tissue" in the transect oriented model, and that 'greenway oriented development' (GOD) might supercede TOD.	3
The River and the Region: The Chattahoochee River and the Atlanta Regional Commission. Carlton Basmajian November 2011; vol. 10, 4: p. 310-355.	Describes the legal case between Alabama and Florida over the water rights of the Chattahoochee River, resulting in a settlement that would curtail Atlanta's future withdrawals from the river and undermine the region's pro-growth agenda.	5
Projecting Sprawl? The Atlanta Regional Commission and the 1975 Regional Development Plan of Metropolitan Atlanta. Carlton Basmajian May 2010; vol. 9, 2: p. 95-121., first published on May 12, 2010	Examines the process of writing Atlanta's 1975 regional development plan, which used a 30-year model resulting in "the building of a vast, low-density landscape, exactly as the model predicted." Provides "a case example of the role of planning technologies in shaping regional planning discourse in the latter part of the twentieth century."	5
From Freeway to Parkway: Federal Law, Grassroots Environmental Protest, and the Evolving Design of Interstate-35E in Saint Paul, Minnesota. Christopher W. Wells February 2012; vol. 11, 1: p. 8-26.	In 1972, an anti-freeway movement in St. Paul, Minnesota, successfully halted construction of the final leg of I-35 into the downtown. Protesters ultimately failed to generate the political support necessary to cancel the Interstate, but when the last leg of I-35E opened in 1990, it was not as a classic urban freeway, but as a "parkway" replete with various "green" features.	5
One Hundred Years of City Building: New Accounts, New Interpretations. Eugenie L. Birch. August 2003; vol. 2, 3: p. 273-277.	Review essay, drawing from Max Page's "The Creative Destruction of Manhattan:" "He looks at 'hot' and 'cold' real estate development, historic preservation, greening, and collective and individual remembrance "to link the history of various city-building efforts—usually told separately—by showing how the politics of place pervaded and shaped these efforts" (p. 11).	5

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JOURNAL OF PLANNING LITERATURE

Table 1

"Greening" (34) + "Green Infrastructure" (7) (All words in full text)

Article	Summary	Rank
The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health Frank, Lawrence D., Engelke, Peter O. Nov 2001; vol. 16: p. 202-218	Reviews current public health, planning, and urban design research to determine: first, how walking and bicycling might be critically important exercise behaviors for improving public health; second, how urban form affects the frequency of walking and bicycling as a form of physical activit; and third, how the public health considerations outlined in this article might reorient planners' thinking toward the realization of health-promotive environments. Makes no reference to "green," "greenery," "plants," "trees," or "nature". Thus, draws no association between greening and walking/biking. Finds that the "impact of micro-scale urban form features have been, to a large extent, neglected in the transportation planning literature."	2
Land Preservation: An Essential Ingredient in Smart Growth; Tom Daniels and Mark Lapping; February 2005; vol. 19, 3: p. 316-329.	Frames land preservation as a critical smart growth strategy. Tools include land acquisition (often via land trusts), PDR, TDR, cluster development, and large-lot zoning. Reinforces McQueen and McMahon's (2003) advocacy of green infrastructure planning in which land preservation serves to "integrate land use planning and biodiversity, or to shape and direct growth" (p. 134). Discusses land preservation in urban and suburban areas (parkland, and greenways and trails) and in the countryside (natural areas, farmland, and forestland). In cities, land preservation increase nearby real estate values and can expand the municipal property tax base. In Philadelphia, vacant land restoration was framed as an urban revitalization strategy. Chattanooga is creating a 75-100 mile riverside greenway and trail system, and many places are establishing ROW along utitiy corridors to create trail networks.	2
The Need for a Communicative Approach to Improve Environmental Policy Integration in Urban Land Use Planning Simeonova, Vanya, van der Valk, Arnold; Feb 2009; vol. 23: p. 241-261	Article seeks to show how a communicative approach can be used to improve Environmental Policy Integration (EPI) in the urban planning context, based on a literature review of organization theory and communicative planning. Found that if not attentive, the "compact city concept . . . can add to the impoverishment of innercity areas by increasing some environmental problems such as congestion, noise, air pollution, and the disappearance of urban green areas (Breheny 2002; Thomas and Cousins 1996; De Roo 2003). Emphasizes equity.	4

Rank = relevance to urban greening, defined here as the introduction or conservation of vegetation in cities.
Scale: 1=most relevant; 5=least relevant.

JOURNAL OF PLANNING LITERATURE

Table 1

"Greening" (34) + "Green Infrastructure" (7) (All words in full text)

		Rank
Growth Management in the United States, 2000-2010: A Decennial Review and Synthesis Weitz, Jerry, Nov 2012; vol. 27: p. 394-433.	Synthesizes literature on growth management published between 2000 and 2010 in selected planning periodicals. Finds that scholarship on growth management during the last decade has blossomed within 6 categories: smart growth, urban form, environment and sustainability, participation and public opinion, tools and techniques, and analysis and evaluation. Makes no reference to "GI" and only mentions "greening" in reference to other's work.	4
Book Review: Gottlieb, Robert. 2007. Reinventing Los Angeles: Nature and Community in the Global City. 2007. Cambridge, MA: MIT Press. 430 p. Daniels, Tom	Gottlieb makes a case for reviving nature and community in LA by focusing on: 1) water policy; 2) cars and freeways; and 3) immigration and globalization. A centerpiece in this proposed transformation is restoration of the concrete-lined LA River, which is indicative of Gottlieb's proposition that "Los Angeles . . . needs an urban nature agenda." Daniels finds this position lacking. He points out that Gottlieb offers few suggestions for funding such an agenda, and that he glosses over socio-economic tensions which greening is unlikely to assuage.	4
Is it Safe to Walk? Neighborhood Safety and Security Considerations and Their Effects on Walking Loukaitou-Sideris, Anastasia Feb 2006; vol. 20: p. 219-232	Focuses on the safety of neighborhood surroundings and explores how it influences physical activity. Integrates literature from public health, criminology, and planning to identify, qualify, and evaluate the link between safety and security considerations and physical activity. Makes no reference to "greening" nor "street trees." Identifies "planters" as a traffic calming strategy.	4
Visioning: Did Anybody See Where It Came from? Shipley, Robert, Newkirk, Ross Journal of Planning Literature, May 1998; vol. 12: p. 407-416	Surveys a wide range of planning-related periodical literature and analyzes the history, rise, and geographic distribution of the use of the terms vision and visioning. References William Penn's 117th century "greene countrie towne"vision for Philadelphia.	4
How to Support Avian Diversity in an Urban Landscape: A Bibliograpyh. Tereza Urbanova. November 2009; vol. 24, 2: p. 123-136.	Annotated bibliography identifies and describes literature on avian species response to urbanization and provides general recommendations for supporting avian diversity within the urban landscape, e.g. maintaining native vegetation, deadwood, and other nesting structures, managing the landscape surroundings, increasing foliage and height diversity, designing buffers that reduce undesirable influences, integrating urban parks into the native habitat system, reducing the effects of urbanization on once remote natural areas, and developing monitoring programs that measure fitness and promote education, among others (Marzluff, John M., and Kern Ewing. 2001. *Restoration Ecology* 9:280-92.	4

Rank = relevance to urban greening, defined here as the introduction or conservation of vegetation in cities.

Scale: 1=most relevant; 5=least relevant.

JOURNAL OF PLANNING LITERATURE
"Greening" (34) + "Green Infrastructure" (7) (All words in full text)

Table 1

Citation	Description	Rank
Implementing Natural Hazard Mitigation Provisions: Exploring the Role That Individual Land Use Planners Can Play Stevens, Mark. May 2010; vol. 24: p. 362-371	Makes a case for why natural hazard mitigation planning researchers should extend their focus beyond planning agencies to individual planners and the influence they can have on fostering hazard mitigation in new development projects.	5
Green Buildings and Building Assessment Systems: A New Area of Interest for Planners. Retzlaff, Rebecca C. Aug 2009; vol. 24: p. 3-21	Introduces the concept of green buildings and building assessment systems, and identifies 6 themes: scope, weighting, subjectivity, rigor, adaptation, and life cycle analysis. Outlines a broad research agenda that can advance discussion on the role of planning in green building issues, and argues that planning needs to take a more assertive role in green buildings add more comprehensiveness to the issue. Suprisingly, no mention of GI.	5
Evaluating the Benefits of Peri-Urban Agriculture; Catherine Brinkley Journal of Planning Literature, August 2012; vol. 27, 3: p. 259-269.,	Uniting literature from farmland preservation, growth management, food systems, economics, bioengineering, and environmental studies, this article provides an overview and valuation of the services that farms provide for urban areas. The market value of farmland services varies from $37,541 to 124,000 per acre depending on the method of analysis and location of the farm, suggesting strong implications for land-use planning, economic opportunities, and ecosystem infrastructure in peri-urban areas.	5
The Uses of Social Network Analysis in Planning: A Review of the Literature. C. Scott Dempwolf and L. Ward Lyles. February 2012; vol. 27, 1: p. 3-21.	Argues that social network analysis (SNA) has the potential to advance and operationalize certain aspects of communicative planning theory. Relates SNA to "the connections between biological network analysis . . . to conserve and manage lands to promote such goals as ecosystem health and creation of green infrastructure that provide ecosystem services."	5

Rank = relevance to urban greening, defined here as the introduction or conservation of vegetation in cities.

Scale: 1=most relevant; 5=least relevant.

CHAPTER V

Human Health Benefits of Urban Vegetation

"Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity."
   - World Health Organization (2012a)

Introduction

An important finding that emerged from Chapters II and III is that the role of urban trees has recently undergone a shift from beautification and civic improvement to provision of ecosystem services. This new rationale reflects urban greening writ large (Wolf 2008), "where the potential value of urban ecosystem services for improving the urban environment has penetrated the popular literature and influenced people's imagination (Pincetl et al. 2013, 477).

Chapter IV illustrated noteworthy gaps in the urban ecosystem services (UES) and green infrastructure (GI) discourse. In particular, UES and GI literature frame human health as a principal outcome; yet there is little reference to public health scholarship. This suggests that there may be an *a priori* assumption of benefits undergirding contemporary urban greening, which highlights a pressing need for review of scholarly literature on the human health benefits of urban vegetation.

Drawing upon public health research, this chapter examines peer-reviewed literature on

human health benefits of urban vegetation and green space.[1] There is a sizable literature

on this subject (Ward Thompson, Aspinall, and Bell 2010). Over the past decade,

numerous studies have illuminated a beneficial association between nearby nature and a

range of human health indicators and outcomes, including: self-reported physical and

mental health (de Vries et al. 2003; van Dillen et al. 2012); perceived general health

(Maas et al. 2006) and health-related quality of life (Stigsdotter et al. 2010); clusters of

physician assessed morbidity (Maas, Verheij, et al. 2009); non-accidental mortality

(Villeneuve et al. 2012); risk of stroke mortality (Hu, Liebens, and Rao 2008); human

immune function (Q. Li 2010); mental distress and life satisfaction (White et al. 2013);

risk of small for gestational age births (Donovan et al. 2011); birth weight in a lowest

socio-economic group (Dadvand, de Nazelle, Figueras, et al. 2012); type 2 diabetes

mellitus (Astell-Burt, Feng, and Kolt 2013); levels of income-related health inequality

(Mitchell and Popham 2008); and survival of senior citizens (Takano, Nakamura, and

Watanabe 2002).

Other studies present contradictory results. Richardson et al. (2010) showed no

correlation between green space and cardiovascular disease. Mitchell and Popham (2007)

found that a higher proportion of green space in an area was generally associated with

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[1] While green space may include water features, wildlife, and built facilities that support use or other associated functions, its defining characteristic is vegetation (Jorgensen and Gobster 2010).

better human health, but in lower income suburban areas more green space was associated with worse health. This reflects a nationwide U.S. study showing that all cause mortality was significantly higher in more vegetated cities, which also tend to have a more sprawling land use pattern and auto-dependent life style (E. Richardson et al. 2012).[2]

On the whole, the literature suggests compelling human health arguments for conserving and introducing vegetation in cities and urban areas. Yet, the mechanisms underlying the correlation between greenery and human health are not clear. Based on existing research, de Vries (2010) identified four potential mechanisms: better air quality; increased physical activity; and improved mental health and social cohesion. These four potential health benefits structure the literature review undertaken in this chapter. In addition, the chapter includes a section on urban heat island (UHI) mitigation and heat related morbidity and mortality, as extreme heat is expected to be the most important weather-related killer in the U.S. for many years to come (Sheridan, Kalkstein, and Kalkstein 2009), and the cooling potential of urban vegetation is a compelling adaptation strategy.

Drawing upon literature identified in common search engines (Avery Index to Architectural Periodicals; GreenFILE; ISI Web of Science, MEDLINE) through August

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[2] Richardson et al. hypothesize that the health benefits of green space evidenced in other studies may be "easily eclipsed" by health risks associated with the car dependent lifestyle of U.S. suburbs (2012, 160).

30, 2013, plus indices in relevant books, reports, and articles, the chapter is structured in

five sections: 1) air quality and asthma; 2) urban heat island (UHI) mitigation and heat

related morbidity and mortality; 3) physical activity and obesity; 4) mental health; and 5)

social cohesion. When available, peer-reviewed reviews in scholarly journals serve as

the primary data source. Twenty such reviews were identified, the findings of which were

classified and aggregated by: method (qualitative or quantitative); whether or not the

review was systematic or not; and by the direction of evidence (i.e. "+" = beneficial

effects cited; "+/-" = mixed effects or weak evidence cited; and "-" = no effects or

disservices cited). See Table 2.

Exceptions

In addressing air quality and UHI effects, this review encompasses certain urban

ecosystem *functions*: the "intermediate effects of forests on pollutants and other

environmental processes . . . [and] resulting benefits for human well-being" (Escobedo,

Kroeger, and Wagner 2011, 2078). However, the chapter's primary focus is on direct

human health outcomes and public health literature, situating this review in a definition

of ecosystem *services* as "the satisfaction of human needs and wants specified in the

medical/psychological/social domain" (Daniel et al. 2012, 8813). Consistent with other

reviews on the human health outcomes of urban vegetation (see Table 2), this framing

explains why stormwater management and climate change mitigation are not included in

the main body of this chapter.[3] However, stormwater management is a noteworthy driver

of contemporary urban greening that has been identified by the IPCC as a potential

climate change adaptation strategy (Revi et al. 2014), and a brief review of the

stormwater effects of urban vegetation/trees is in order.

Despite the success of 1970s federal regulation, some 40% of U.S. waterways are still not

fit today for drinking or swimming (Daniels 2009). This is largely due to non-point

source (NPS) pollution from agriculture and urban stormwater runoff. Unlike point

sources of water pollution such as industrial and sewage treatment effluent, NPS

pollution is generated across the entire landscape, when rainfall, snowmelt, or irrigation

runs over land or through the ground, picks up pollutants, and deposits them into rivers,

lakes, and coastal waters or introduces them into ground water. Agriculture is the primary

source of NPS pollution, degrading 60% of impaired river miles and half of the impaired

lake acreage in the U.S. However, runoff from urbanized areas is the leading source of

water quality impairments to estuaries (EPA 2014).

Urban landscapes with 50%–90% impervious cover can lose 40%–83% of rainfall to

surface runoff, in contrast to forested landscapes which lose about 13% of rainfall inputs

to runoff from similar precipitation events (Bonan 2002). When impervious surface

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[3] See Ch. VI for discussion of climate change mitigation potential of urban vegetation.

runoff enters storm drains, it carries pollutants with it, and in many older cities this polluted runoff is often released directly into streams, rivers, and lakes without any treatment. This increased pollutant load can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies, and make aquatic recreational areas unpleasant and unsafe for people (EPA 2003).

For example, urban and suburban runoff from roofs, roads, and parking lots can contain significant concentrations of copper, zinc, and lead (Whipple et al. 1983; Bannerman et al. 1993), which can have toxic effects in humans. Combined with lawns, these surfaces also generate large loads of bacteria in stormwater (Bannerman et al. 1993; K. D. Young and Thackston 1999), and urban runoff is responsible for an estimated 47% of the pathogen contamination of Long Island Sound (EPA 1994). Likewise, exposure to bacteria and parasites from swimming and other forms of recreation in water contaminated with urban runoff and storm drains has caused numerous cases of illness, including ear and eye discharges, skin rashes, and gastrointestinal problems (e.g. Haile et al. 1999; Rose et al. 2001).

Over the past decade, U.S. cities with combined sewer systems and associated combined sewer overflows (CSOs) have started turning to GI as a cost-effective alternative to the large tunnels and treatment plants associated with conventional grey infrastructure (e.g.

City of New York 2012; City of Philadelphia 2011).[4] Indeed, vegetated landscape

elements designed to absorb water – such as bioswales, rain gardens, and green roofs –

have been identified as a means to reduce both the amount of urban stormwater runoff

and its pollution load (Shuster, Morrison, and Webb 2008). However, Pataki et al. (2011)

find that few studies demonstrate that these features improved water quality, and that

more field studies are needed to assess nutrient and contaminant transformations in

stormwater mitigation features to understand how their designs can be more effectively

optimized.

For example, green roofs can retain 25% to 100% of rainfall, depending on roof slope,

soil depth, and amount of rainfall. Yet some research shows that green roof runoff

includes increased levels of nitrogen and phosphorus due to leaching from the substrate

(Oberndorfer et al. 2007). In one of the first studies to assess the field performance of

rainwater harvest gardens, Dietz and Clausen (2005) found that rain gardens worked well

for overall flow retention, but had little impact on pollutant concentrations in the

percolate (hydrologic flow through substrate).

Urban trees are another important component in the GI stormwater management toolkit.

This is based on the recognition that urban sylva: intercepts rainfall and temporarily

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[4] Roughly 772 U.S. cities – concentrated in the Northeast, Great Lakes regions, and the Pacific Northwest – have combined sewer systems (EPA 2012).

stores rainwater on the canopy surface (Xiao and McPherson 2003); directs precipitation into the ground through trunk flow (M. S. Johnson and Lehmann 2006); and takes up pollutants (Szabo, Osztoics, and Szilagyi 2001) and stormwater through the roots (Bartens et al. 2008). Some studies address granular, technical questions such as: the capacity of a tree box filter located adjacent to an impervious parking lot to treat suspended solids and heavy metal concentrations (Geronimo et al. 2014); and the capacity of urban tree roots to penetrate and infiltrate stormwater in compacted and bioengineered structural soils that are common in the urban settings (Bartens et al. 2008; Bartens et al. 2009). But research on the citywide stormwater management magnitude and capacity of trees appears to be limited. Still, given the hydrologic effects of trees described above, it is reasonable to conclude that large stands of trees are likely to capture and infiltrate more stormwater than individual street trees.

Kirnbauer et al. (2013) used i-Tree Hydro (formerly UFORE-Hydro) to estimate the stormwater attenuation benefits derived from planting four monoculture species of deciduous trees on vacant and underutilized urban land parcels in Hamilton, Ontario. They found that the tree canopy layer was able to intercept and evaporate about 6.5%– 11% of the total rainfall that falls onto the crown across the seven years studied (for G. biloba, P.×acerifolia and A. saccharinum tree stands) and 17%–27% for the L. styraciflua tree stand. At a larger scale, Nowak (2006) also employed the UFORE-Hydro model in a 14.3 km^2 Baltimore, MD watershed – with an existing tree cover of 13.2% and

impervious cover of 29% – and found that increasing tree cover to 71% (while keeping

total impervious cover at 29%) would reduce total runoff in the watershed by about 5%

for the simulation period of the year 2000. It is worth noting, however, that a five-fold

increase in canopy cover is beyond the practical reality of most cities, and a 71% canopy

cover goal raises questions about appropriate tree planting norms and standards in urban

settings.[5]

Providing a synoptic overview, Pataki et al. (2011) describe the potential stormwater

mitigation magnitude of urban vegetation as high and the current level of uncertainty as

moderate; and the potential water quality mitigation magnitude as high with a high level

of uncertainty (see Figure 5.1). This is complicated, however, by the study's lack of a

critical examination of stormwater management in cities with combined sewers, where

quality and especially quantity of runoff is a factor, as the latter can trigger CSO events.

Of particular note regarding this chapter's focus on direct human health outcomes of

urban vegetation: human health risks associated with poor water quality from urban

stormwater have been highlighted in public health literature, and low-impact

development interventions that route runoff from impervious surfaces to natural or

constructed features have been identified as a strategy to mitigate this problem (Gaffield

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[5] Tree cover in urban/community areas in the U.S. is currently estimated at 35.1% – slightly greater than tree cover across the entire conterminous U.S., estimated at 34.2% (Nowak and Greenfield 2012).

et al. 2003). However, quantifying the public health benefit of improved stormwater management from implementation of GI in CSO cities may be difficult in the foreseeable future. Green infrastructure projects are often small, exploratory, opportunistic, and not implemented systematically on a watershed scale. They are also integrated with substantial investments in traditional grey infrastructure. These factors make it difficult to obtain a clear receiving water signal and to quantify associated public health outcomes (Robert Goo, Office of Water, pers. comm., 2013).

Ecosystem service	Potential magnitude	Current level of uncertainty
C sequestration	Low	Low
Net GHG emissions	Moderate	High
Local cooling	High	Moderate
Stormwater mitigation	High	Moderate
Water-quality mitigation	High	High
Air-quality mitigation	Low	High
General human health	Moderate	Moderate

Ecosystem disservice	Potential magnitude	Current level of uncertainty
Water use	High	Moderate
Net GHG emissions	Moderate	High
Source of allergens	High	Low
VOC emissions	Moderate	Moderate

Notes: GHG emissions are listed as both a service and disservice because the impacts of plants or soils may be either positive (net cooling) or negative (net warming) in hot climates. VOC = volatile organic compounds, which are precursors to the formation of ozone pollution.

Figure 5.1: Commonly discussed urban ecosystem services/disservices associated with biogeochemical cycles, with their potential magnitudes (relative to the scope of the associated environmental problem) and uncertainty levels (Pataki et al. 2011)

Consistent with related reviews (see Table 2), this chapter does not address direct economic effects of urban vegetation, the downstream effects of which may support human health. For example, some studies show a link between increased property values

and nearby green space (Conway et al. 2008; Melichar and Kaprov 2013) and street tree planting (Wachter and Wong 2008), as well as between trees and improved business district perceptions, patronage behavior, and product pricing (Wolf 2005).[6] Nor does this chapter address links between biodiversity and human health. This is a nascent body of research, and a recent review (published after the study described in this chapter) found that evidence is inconclusive and fails to identify a specific role for biodiversity in the promotion of better health (Lovell et al. 2014).

Urban greening elements covered in the main body of this chapter include trees, green space, parks, vegetated roofs, and living walls. The review does not address therapeutic and community gardens, which are linked to a range of human health benefits. While community gardens are important expressions of urban greening, their unique vegetative composition and distinct form of individual and social engagement lend these subjects to independent reviews. In addition, this chapter does not assess the methodological strength of individual or review studies. The principal aim here is to provide a high level assessment of how academic literature – especially public health scholarship – currently depicts the human health benefits of urban vegetation across a range of green elements. A summary of findings concludes the chapter.

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[6] Other studies show mixed results (Li and Saphores 2012; Saphores and Li 2012).

Air Quality & Asthma

Urban air pollution causes roughly 1.3 million annual human deaths around the world

(WHO 2013a) and it has been identified as a risk factor for cardiovascular disease and

asthma (WHO 2013b), the prevalence of which is rising in the developed and developing

world (Eder, Ege, and von Mutius 2006). In the U.S., the number of people diagnosed

with asthma increased by 4.3 million between 2001 and 2009 (CDC 2011), and the

American Lung Association (2013) identifies particulate matter (PM) and ozone (O_3) –

the most common air pollutants – as powerful triggers of asthma.[7] Municipalities have

identified tree planting as a strategy to reduce asthma (Baltimore Tree Trust 2013; City of

New York 2014), and stakeholders of large tree-planting initiatives in major U.S. cities

rank air quality improvement as important program objectives (R. F. Young 2011).

Air Pollution Removal by Trees

Of the 20 reviews identified in this study (see Table 2), Tzoulas et al. (2007) frame air

quality as a potential health benefit of GI, but the two papers they cite in support of this

are not original studies on this ecosystem function. Lee and Maheswaran (2011) make

one passing reference to improved air quality, but this was not featured in their

systematic review of health benefits of urban green space. A third review identified 34

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[7] Of the six criteria air pollutants regulated under the National Ambient Air Quality Standards (NAAQS) that cities, states, and metropolitan regions are required to meet, particulate matter is the leading air pollution health threat in the U.S., causing nose and throat irritation, respiratory ailments such as asthma, and premature death (Daniels and Daniels 2003).

studies reporting air quality benefits of urban trees, of which 20 addressed removal of

particulate matter (Roy, Byrne, and Pickering 2012).

Many studies reporting that urban trees can effectively remove airborne pollutants are

based on large-scale deposition models, of which i-Tree may be the most common.[8]

This software program generates impressive volumetric removal estimates. In New York

City, trees have been calculated to remove 2,202 tons of air pollution (CO, NO_2, O_3,

PM_{10}, SO_2) per year, valued at \$10.6 million (Nowak et al. 2007). Across the

coterminous U.S., urban trees are reported to remove 711,000 metric tons of air

pollution/year valued at \$3.8 billion (Nowak, Crane, and Stevens 2006).

As a percentage of total air pollution, however, "average percent air quality improvement

in cities during the daytime of the vegetation in-leaf season were typically less than 1%"

(ibid., 117). This supports the findings of a literature review, which found that average

published values correspond to a reduction in pollutant concentration (PM_{10}) by urban

vegetation of roughly 1% (Litschke and Kuttler 2008). Modeling studies that project the

effect of intentionally expanding canopy cover yield similar results: increasing tree cover

from 20% to 40% in urban areas between Washington, D.C. and central Massachusetts

would reduce eight-hour average ozone concentrations by 1% throughout the day

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[8] Formerly known as UFORE (Nowak and Crane 2000), i-Tree is a software suite developed by the USDA Forest Service (2014) that provides urban forestry analysis and benefits assessment tools. See Chapter III.

(Nowak et al. 2000, 1601); and planting 25% of potential areas in Glasgow, Scotland would reduce total PM_{10} by 0.4% (McDonald et al. 2007, 8462).

Some scholars contend that models for estimating the air pollution mitigation potential of urban vegetation are largely untested (Pataki et al. 2013), and that the underlying assumptions and methods of i-Tree are flawed (Whitlow et al. 2014b).[9] Only a few studies exist in which pollutant fluxes have been quantified within a forest or at the tree canopy where the uptake of pollutants actually occurs (Setälä et al. 2013). Employing passive air quality samplers in two Finnish cities, researchers found that air pollutant concentrations were slightly but often insignificantly lower under tree canopies than in adjacent open areas, suggesting that the role of foliage in removing air pollutants is insignificant (ibid).

Much of the literature addressing the effect of trees upon urban air pollution applies mean forest structure parameters across an entire city (Escobedo and Nowak 2009). However, vegetation is not uniformly distributed across urban areas (Zipperer, Sisinni, and Pouyat 1997; Escobedo et al. 2006), and city-scale studies do not account for how the complex geometry of the urban surface affects street-level concentrations where people are primarily exposed (Pugh et al. 2012). Models that focus on air circulation in city street

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[9] This issue has recently surfaced in the pages of *Environmental Pollution* journal as a substantial disagreement (See Nowak et al. 2013; Whitlow et al. 2014a; Nowak et al. 2014; Whitlow et al. 2014b).

canyons, for example, find that trees may *increase* air pollutant concentrations by obstructing wind flow and ventilation (Gromke and Ruck 2007; Gromke and Ruck 2009; Gromke 2011; Gromke and Ruck 2012; Wania et al. 2012). One study found that along roads, "the less trees, the lower the pollutant concentrations" (Vos et al. 2013, 117), leading to a conclusion that "it is scientifically not correct to plant roadside trees to improve the local air quality" (p. 119). Others argue that "urban greening initiatives whose focus is purely to increase urban tree coverage will fail to achieve their maximum air quality potential and may even worsen air quality in street canyons" (Pugh et al. 2012, 7693).

This supports the conclusion of the Dutch National Institute for Public Health and Environment that flora has a limited effect on reducing PM_{10} in and around cities (Wesseling, Beijk, and Kuijeren 2008), as well as the assertion of Pataki et al. (2011, 32): "the removal of atmospheric pollutants by vegetation is one of the most commonly cited ecosystem services, yet it is one of the least supported empirically." They describe the potential magnitude of air quality mitigation by urban trees as low and the level of uncertainty as high (see Figure 5.1).

In addition to urban canopy modeling and roadside research, other studies addressing local air quality effects of vegetation show mixed findings. A study of paired communities in Haifa, Israel found that neighborhoods with less tree canopy had higher

morning-noon concentrations of all PM size fractions in the spring and the summer

(Freiman, Hirshel, and Broday 2006). In Barcelona, Spain, a survey of 54 pregnant

women showed a correlation between more local vegetation and reduced exposure to air

pollution (Dadvand, de Nazelle, Triguero-Mas, et al. 2012). However, this study does not

seem to distinguish between type of vegetation, and it is possible that this finding is due

to forms of green cover other than trees, such as turf grass, which may retain particulates

more than other common urban surfaces such as asphalt, concrete, and gravel. Su et al.

(2011) showed that neighborhoods adjacent to public parks have the lowest O_3 but the

highest NO_2 and $PM_{2.5}$ concentrations. Cavanaugh et al. (2009) found a roughly 40%

PM_{10} reduction in a forested urban area; but it was not clear if this was due to vegetative

material or distance from pollution sources. Other studies find that urban woodlands may

degrade air quality through the emission of volatile organic compounds (VOCs) which

can exacerbate O_3 and $PM_{2.5}$ pollution formation (Chameides et al. 1988; Domm et al.

2008).

Green Roofs and Walls

None of the reviews in this study focusing on human health outcomes of urban vegetation

addressed air pollution mitigation via green roofs and walls. While rooftop planting is

becoming increasingly common, peer-reviewed literature on its air pollution reduction

potential is limited. A review by Getter and Rowe (2006) relied primarily on conference

papers. A more recent review by Rowe (2011) identified four studies and concluded that

the air pollution removal potential of *intensive* green roofs (large herbaceous plants, shrubs, and small trees requiring deep soil) is comparable to urban trees as reported by Nowak et al. (2006) – i.e. less than 1%. However, the weight-bearing constraints and expense of intensive green roofs are substantial; citywide installation of this technology in Chicago would cost \$35.2 billion (Yang, Yu, and Gong 2008). Addressing the more viable potential of *extensive* green roofs (smaller plants in shallow, lightweight growing media), Speak et al. (2012) found that implementation on all flat roofs across the city center of Manchester, U.K. could yield a 2.3% reduction in PM_{10}.

Vegetated walls are also emerging in practice and research. Some articles find that wall-climbing vegetation such as Boston Ivy (*Parthenocissus tricuspidata*) and English Ivy (*Hedera helix*) can reduce air pollution via deposition of dust (Köhler 2008) and particulate matter (Ottelé, van Bohemen, and Fraaij 2010; Sternberg et al. 2010). Using the UFORE deposition model, Currie and Bass (2008) found that green walls and roofs do not remove air contaminants as much as trees and shrubs. However, this study did not address the aerodynamic function of trees, which may increase street level air pollution. Vos et al. (2013) modeled a range of road and vegetation combinations and found that only high green barriers (plants growing up impermeable walls) lead to a significant improvement in air quality in the adjacent footpath. Importantly, the authors note that this benefit is attributed mainly to the impermeable core of the green barrier, as simulations with a bare solid screen (without the vegetation cover) yielded quasi-identical results.

This stands in contrast to Pugh et al. (2012), who estimated that green roofs and walls may reduce NO_2 and PM_{10} in street canyons up to 40% and 60% respectively, and that planted walls can remove nearly 10 times as much NO_2 and up to 12 times as much PM_{10} from pedestrian level air as vegetated roofs.

Asthma

The aforementioned studies address the ecosystem function of air pollution mitigation by urban vegetation – they do not directly measure human health outcomes related to air quality. Of the reviews identified in this paper, three address asthma.[10] Kuo (2013) cites a nationwide Dutch study where the annual prevalence rate of 15 of 24 disease clusters (including asthma), was lower in places with more green space in a 1 km radius (Maas, Verheij, et al. 2009). However, this study also found that the correlation was greatest in low-density urban areas, and in high-density urban areas there was no relationship. A review by Roy et al. (2012) cites three studies demonstrating increased allergy attacks linked to plant pollens, and frames asthma as a cost or disservice of urban trees. This echoes another review which finds that, "lack of planning in the design of urban spaces and in the choice of ornamental species has been among the factors triggering one of the most widespread diseases in urban populations: pollen allergy" (Cariñanos and Casares-Porcel 2011, 205). This paper cites data suggesting that people living in urban areas are

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[10] Asthma is a complex respiratory disease caused by the interaction of genetic and environmental factors (Drake, Galanter, and Burchard 2008); but the American Lung Association (2013) identifies air pollution as a powerful trigger of asthma.

20% more likely to suffer airborne pollen allergies than people living in rural areas (D'Amato et al. 2007), and it identifies nine causes of this allergenicity.

In material not covered by the above reviews,[11] Pilat et al. (2012) found no significant relationship between canopy cover and asthma rates in Texas metropolitan statistical areas. In New York City, Lovasi et al. (2008) initially found a link between street trees and lower prevalence of early childhood asthma. But this ecological study had methodological gaps (Zandbergen 2009).[12] Subsequent individual-level longitudinal research showed that local canopy cover offered no signification protective association with asthma, but instead, was associated with increased asthma and with allergic sensitization to tree pollen amongst 7-year-olds (Lovasi et al. 2013).

This echoes other public health research. Some tree species produce allergens that may trigger seasonal allergic rhinoconjunctivitis or asthma exacerbations in sensitized individuals (Dales et al. 2004; Ridolo et al. 2007). In New York City, tree pollen concentration peaks were followed by large increases in over-the-counter allergy

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[11] Donovan et al. (2013) found increased human mortality related to cardiovascular and lower-respiratory-tract disease following the loss of 100 million ash trees (*Fraxinus spp.)* due to an invasive beetle infestation. This regional study covering 1,296 counties did not, however, address the effect of urban vegetation per se.

[12] Lovasi et al. (2008) was limited by an ecologic design, wherein the neighborhood unit of analysis was larger than the 0.25 km buffer areas evaluated in Lovasi et al. (2013); it also did not consider the full geographic extent of urban trees due to a focus exclusively on street trees (ibid).

medication sales (Sheffield et al. 2011), and in the Bronx there exists a significant

association between tree pollen concentration and asthma-related emergency department

visits (Jariwala et al. 2011) and asthma-related hospitalization (Jariwala et al. 2014). In

10 Canadian cities, "several common tree pollens were an important cause of acute

exacerbations of asthma severe enough to require hospitalization" (Dales et al. 2008,

241).

These findings support research suggesting that people living in urban areas are up to

20% more likely to suffer airborne pollen allergies than people living in rural areas

(Ogren 2002; D'amato 2000; D'Amato et al. 2007). Importantly, "the prevalence of

allergic respiratory diseases is increasing in industrialized countries, so much so that it is

being called the 'epidemic of the 21st century.' The prevalence of plant-derived

respiratory diseases is higher in urban than in rural areas, and there is a large body of

evidence of an interaction between urban air pollution, mainly due to vehicle traffic and

plant-derived respiratory disorders" (D'amato 2000, 634).

Some atmospheric modeling studies such as those described earlier extend air pollution

mitigation assessments to human health prognoses. Tiwary et al. (2009) project that PM_{10}

reductions from a 10 x 10 km area of East London consisting of 75% grassland, 20%

sycamore maple (*Acer pseudoplatanus L.)* and 5% Douglas fir (*Pseudotsuga menziesii*)

would avert two deaths and two hospital admissions per year. Nowak et al. estimate that

PM$_{2.5}$ reduction from tree canopy in 10 U.S. municipalities saves on average one life per year per city (2013); and the removal of particulate matter by urban trees across the conterminous U.S. may lead to 850 fewer deaths and 670,000 fewer incidences of acute respiratory symptoms (2014). However, the assumptions, methods, and communication of findings from modeling studies such as these have been the subject of critique (Pataki et al. 2011; Pataki et al. 2013; Whitlow et al. 2014a; Whitlow et al. 2014b).

Urban Heat Island Mitigation & Heat Related Morbidity and Mortality

The urban heat island (UHI) effect refers to temperatures being warmer in cities than surrounding non-urban areas (Manley 1958; Unger 2004), resulting from factors associated with urbanization such as pavement, buildings, and loss of vegetation and accompanying evapotranspiration and shading (Oke 1982). The resulting temperature differential can reach 12°C (Voogt 2003; Vidrih and Medved 2013). This amplifies the risk of extreme heat events (EHEs), which have been linked to heat stroke (Piver et al. 1999) and account for a greater number of annual climate-related fatalities, on average, than any other form of extreme weather (Changnon, Kunkel, and Reinke 1996). Notable recent events include: the summer of 1980, when 10,000 U.S. deaths were attributed to extreme temperature (Ross and Lott 2000); the Chicago 1995 heat wave resulting in more than 500 heat-related deaths over five days (Whitman et al. 1997); and the August 2003 heat wave in Europe, associated with 70,000 additional deaths (Robine et al. 2008). Extreme heat is predicted to be the most important weather-related killer in the U.S. for

many years to come (Sheridan, Kalkstein, and Kalkstein 2009), and it may also lead to greater civil conflict (Hsiang, Meng, and Cane 2011).

Urban Heat Island Mitigation

Greening has been identified as a strategy to mitigate the UHI effect and increased temperatures resulting from climate change (Givoni 1991; Gill et al. 2007; Luber and McGeehin 2008; EPA 2013; Revi et al. 2014). Addressing this capacity, Bowler et al. (2010a) systematically reviewed 47 studies.[13] Most of the studies investigated air temperature within parks and beneath trees. Meta-analysis suggested that, on average, an urban park would be around 1°C cooler than a non-green site. There was some evidence that the cooling effect of a green area increases with its size, though it was not clear if there is a minimum size threshold or if there is a simple linear relationship to this cooling effect. A couple of studies also reported that the cooling effect of a park could extend into the surrounding area (Upmanis, Eliasson, and Lindqvist 1998; Chen and Wong 2006). However, Bowler et al. found that most studies had methodological limitations,[14] and concluded that "the impact of specific greening interventions on the wider urban area, and whether the effects are due to greening alone, has yet to be demonstrated . . . further empirical research is necessary (2010a, 147).

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[13] This included unpublished conference papers and doctoral dissertations.

[14] In an assessment of methods underlying 190 studies between 1950 and 2007, Stewart found that "nearly half of all urban heat island magnitudes reported in the sample are judged to be scientifically indefensible" (2011, 200).

Subsequent studies show that: more vegetated neighborhoods in the same city are cooler

(Buyantuyev and Wu 2010); parks reduce temperature in surrounding areas (Oliveira,

Andrade, and Vaz 2011; Papangelis et al. 2012; M. Tan and Li 2013), creating a "park

cooling island" (PCI) effect (Vidrih and Medved 2013); planting parking lots with trees

and/or grass may reduce surface temperature by over 7°C (Onishi et al. 2010); and street

trees cool pedestrian-level air (Shashua-Bar et al. 2010; Shashua-Bar, Tsiros, and

Hoffman 2010).

Addressing rooftops, Dvorak and Volder (2010) found that flora can reduce mean daily

temperature below the vegetated module by 27.5°C. Likewise, green façades may help to

cool the surface of buildings by up to 20°C (Mazzali et al. 2013), leading to greater

interior thermal comfort (Kontoleon and Eumorfopoulou 2010). Planted walls can also

reduce air temperature .60m away from the building façade by 1.25°C (Wong et al.

2010). Together, green roofs and walls may reduce street canyon temperature by up to

11.3°C for a desert city such as Riyadh, over 8°C for humid subtropical Hong Kong, and

more than 4°C in temperate London (Alexandri and Jones 2008). However, both a

literature review (Santamouris 2012) and a city-scale study of actual implementation

(Mackey, Lee, and Smith 2012) suggest that green roofs may be less effective at

mitigating the UHI effect than strategies to increase urban albedo.[15] Silva et al. (2010,
13) have concluded that, "increasing the albedo is the single most effective UHI
mitigation strategy."

Heat Related Morbidity and Mortality

Despite literature that substantiates the cooling effect of vegetation, there is relatively
little research assessing a direct relationship between urban flora and reduced illness or
death from extreme heat. None of the reviews on human health benefits of green space
identified in this paper addresses heat related morbidity and mortality. Factors identified
as increasing mortality risk during a heat wave include: being very old or young; being
homebound, confined to bed, or unable to care for oneself; being socially isolated; living
in poverty; being single; coming from a Black or racial/ethnic group; suffering from
psychiatric or cardiopulmonary, respiratory, and cerebrovascular diseases; living on the
top floor of buildings; and lacking air conditioning (especially in the U.S.) (Semenza et
al. 1996; Naughton et al. 2002; Lecomte and de Penanster 2004; Bouchama et al. 2007;
Fouillet et al. 2008; Basu 2009; Krau 2013; Madrigano et al. 2013).

Urban populations tend to have greater rates of heat-related morbidity and mortality than
suburban and rural areas (Buechley, Van Bruggen, and Truppi 1972; Jones et al. 1982;

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[15] This includes "cool roofs," which entail the application of highly reflective paints, tiles, and other
coatings that increase rooftop reflectance and reduce heat absorption.

McGeehin and Mirabelli 2001; Krau 2013). Yet, Hattis et al. (2012) found that an area's demographics were a more important heat-related mortality factor than degree of urbanization. Modeling the Chicago 1995 heat event, Johnson et al. (2012) concluded that socioeconomic factors accounted for roughly 70% of the variance in vulnerability, whereas environmental variables accounted for merely 12%.

Some studies have correlated environmental characteristics such as local surface temperature with greater risk of heat related mortality; but these studies did not explicitly identify an association with vegetative cover (D. P. Johnson and Wilson 2009; Smargiassi et al. 2009; Hondula et al. 2012). Others found that hotter Philadelphia neighborhoods were not more likely to report heat mortality during an EHE (Uejio et al. 2011), and a Barcelona study observed no significant modifying effect of percent tree cover upon heat related mortality between 1996 and 2006 (Xu et al. 2013).[16] Yet, Tan et al. (2007) partially attribute increased urban green space in Shanghai between 1998 and 2003 heat waves to decreased heat related deaths, and Vandentorren et al. (2006) found that more vegetation within 200 meters of a home was a protective factor in heat-related mortality during the 2003 EHE in France. A case–control study of the 1980 heat wave in St. Louis and Kansas City, Missouri, showed a significant decrease in risk of nonfatal heatstroke associated with self-reported increase in trees and shrubs around residences (Kilbourne et

[16] The authors note that there was little variation in percent tree cover across the study region, making it difficult to find an effect.

al. 1982). Yet, the authors reinforce that living in a well-landscaped home may indicate high socioeconomic status, which is inversely associated with heatstroke.

Physical Activity & Obesity

The world is experiencing a pandemic of physical inactivity (Kohl et al. 2012), as well as an obesity epidemic with particularly high prevalence in Europe, the Eastern Mediterranean, North America, and South America (James et al. 2001). In the U.S., obesity prevalence increased from 13% to 32% between the 1960s and 2004; and by 2015, 75% of adults are expected to be overweight or obese. Here, obesity has become an equal if not greater contributor to the U.S. burden of disease than smoking (Jia and Lubetkin 2010). While the etiology of obesity is complex (Bauman et al. 2012), it is believed to be most commonly caused by excess energy consumption (dietary intake) relative to energy loss via metabolic and physical activity (Ness et al. 2007; Wright and Aronne 2012). Urban parks and green space are commonly identified as strategies to address obesity and physical inactivity (NRphysical activity 2013; TPL 2013).

Correlates/Determinants & Domains of Physical Activity

Research on the correlates and determinants of physical activity has burgeoned in the past couple of decades and shows links with age, sex, health status, motivation, and self-efficacy (the confidence to be physically active on a regular basis). This research has focused mostly on individual level factors (Sallis, Prochaska, and Taylor 2000; Bauman

et al. 2012; Van Holle et al. 2012). More recently, literature has emerged on the built environment correlates and determinants of physical activity (Sallis, Linton, and Kraft 2005), which can have different associations with four *domains* of physical activity: recreation/leisure activity such as outdoor sports; transportation activity such as walking or biking to school; household activity such as cleaning; and occupational activity such as construction work (Owen et al. 2004; Giles-Corti et al. 2005; Sallis et al. 2006). Of these domains, recreation and transportation activity are most relevant for assessing urban greening effects.

Literature on built environment links with physical activity and obesity reveals complex patterns and is characterized by inconsistent associations (Davison and Lawson 2006; Feng et al. 2010; de Vet, de Ridder, and de Wit 2011). For example, several studies on recreation activity suggest that individual and social factors may be of equal or greater importance than the built environment (Giles-Corti and Donovan 2002; De Bourdeaudhuij et al. 2005; Ball et al. 2007; Wendel-Vos et al. 2007). Summarizing present knowledge on why some people are physically active and others are not, Bauman et al. (2012) concluded that few consistent environmental correlates have been identified for either transport or recreation activity. One review of 103 papers found that no environmental attribute was associated with objectively measured physical activity in more than 60% of results for children and adolescents (Ding et al. 2011).

The proportion of total physical activity derived from various domains is another important consideration. Bélanger et al. (2011) found that most adult physical activity occurs at home, on the way to work, or at work. Others assert that most physical activity is derived from transportation activity (Frank, Engelke, and Schmid 2003; de Vries et al. 2011). This may be especially true in urban settings (Rainham et al. 2012).

These background factors offer important context for a more narrow assessment of links between physical activity (PA) and urban vegetation (see Figure 5.2). There are few studies, for example, that have investigated the relationship between transportation activity and green elements while controlling for other potentially confounding variables such as residential density and land use mix (de Vries et al. 2011). A summary of nine systematic reviews of adult physical activity (covering 282 quantitative studies) found no consistent evidence of correlation between transportation activity and recreation facilities (including parks) or aesthetics (Bauman et al. 2012). In this review, the same held true for leisure activity. Amongst youth, a review of 24 studies on environmental determinants of active travel (Panter, Jones, and van Sluijs 2008) identified two papers that included street trees, neither of which found a positive association with walking or biking to school (Ewing, Schroeer, and Greene 2004; Evenson et al. 2006).

1/ Built environment links with PA reveal complex patterns and are characterized by inconsistent associations (Davison and Lawson 2006; Feng et al. 2010; de Vet, de Ridder, and de Wit 2011; Bauman et al. 2011).
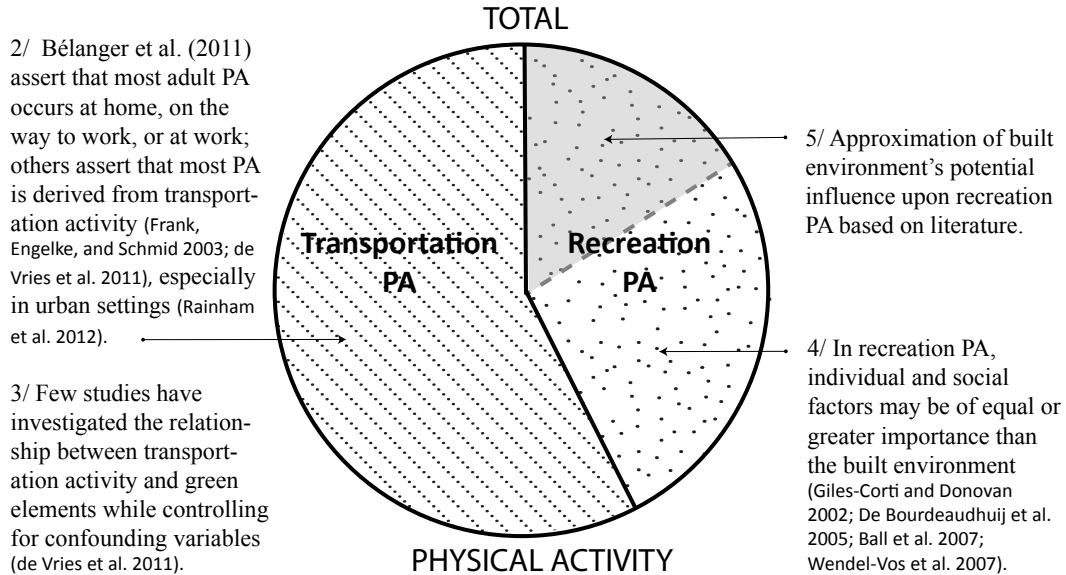
2/ Bélanger et al. (2011) assert that most adult PA occurs at home, on the way to work, or at work; others assert that most PA is derived from transport-ation activity (Frank, Engelke, and Schmid 2003; de Vries et al. 2011), especially in urban settings (Rainham et al. 2012).

3/ Few studies have investigated the relation-ship between transport-ation activity and green elements while controlling for confounding variables (de Vries et al. 2011).

5/ Approximation of built environment's potential influence upon recreation PA based on literature.

4/ In recreation PA, individual and social factors may be of equal or greater importance than the built environment (Giles-Corti and Donovan 2002; De Bourdeaudhuij et al. 2005; Ball et al. 2007; Wendel-Vos et al. 2007).

Figure 5.2: Background context for assessing links between physical activity and urban vegetation. Conceptual diagram by Theodore Eisenman (2014).

Parks, Green Space & Vegetation

Reviews have identified parks, green space, vegetation or the natural environment as potential built environment correlates of physical activity (Humpel, Owen, and Leslie 2002; Owen et al. 2004; Duncan, Spence, and Mummery 2005; Davison and Lawson 2006; Bauman et al. 2012) and obesity (Papas et al. 2007; Dunton et al. 2009; Feng et al. 2010; Kirk, Penney, and McHugh 2010). Specifically addressing the influence of parks and recreation settings (PRS), Kaczynski and Henderson (2007) reviewed 50 studies. Results concerning types of PRS were mixed, "but trails, parks, open spaces, golf courses, and natural settings were more likely to be associated with physical activity than

recreation centers, exercise facilities, and sports facilities" (ibid p. 345). Moreover, studies that examined the aggregate number of parks or amount of proximal parkland generally reported strong associations with physical activity. However, a later study on neighborhood parks found that size and distance were not significant predictors of physical activity (Kaczynski, Potwarka, and Saelens 2008), and another review found inconclusive evidence for understanding how PRS influence specific domains of physical activity (Kaczynski and Henderson 2008) (see Table 2).

Observing that reviews on physical activity in urban parks focused on quantitative research, McCormack et al. (2010) reviewed 21 qualitative studies and found the following vegetative characteristics to support park use and physical activity: attractive, well-maintained flora, and nature sounds, for aesthetic appeal; and trees for climbing. Some studies found that lack of shade from trees may discourage park use and physical activity. Another non-quantitative review found that while most studies show neighborhood open/green space to be associated with increased physical activity, the limited size of this effect highlights the need for complementary strategies that target individual and socio-environmental factors (Pearce and Maddison 2011).

While parks and open space are often associated with plant material, the degree of vegetative cover in outdoor recreational sites varies. Directly addressing green space as a correlate of obesity-related indicators including physical activity and weight status,

Lachowycs and Jones (2011) conducted a systematic review of 60 quantitative studies. Here, 33 out of 50 studies found a positive relationship or some weak or mixed evidence of an association between green space and physical activity, nine out of 13 reported a positive or equivocal relationship with body mass index (BMI), and three papers found some association with obesity-related health outcomes. Yet, about one-third of studies found no relationship, two found a negative relationship, and results were equivocal across many papers. The authors also observed that all studies were cross-sectional and suffered from methodological limitations. This supports a review of 35 papers including a critical evaluation of methodologies and grading of evidence (Lee and Maheswaran 2011). Here, some research and expert consensus suggests that green space can facilitate physical activity, but the authors conclude that evidence of a direct effect at present remains weak. These findings reflect an assessment of literature in book form stating that, "the strongest conclusion which can be reached is how little quality evidence there is about the association between natural environments and general levels of physical activity" (de Vries et al. 2011, 231).

Since the aforementioned reviews, studies have emerged that show mixed, inconclusive findings. Several papers find a positive link between green space/outdoor vegetation and physical activity or overweight indicators among adults (Branas et al. 2011; Toftager et al. 2011; Saelens et al. 2012; West, Shores, and Mudd 2012; Pereira et al. 2013); and youth (Grigsby-Toussaint, Chi, and Fiese 2011; Lovasi et al. 2011; Almanza et al. 2012;

Evans et al. 2012; Rainham et al. 2012; Saelens et al. 2012). Other studies yield mixed

findings (de Vet, de Ridder, and de Wit 2011; Cummins and Fagg 2012; Mytton et al.

2012; Coutts et al. 2013; E. A. Richardson et al. 2013); or no association (Prins et al.

2011; Van Holle et al. 2012; Schipperijn et al. 2013).

Mental Health

By 2020, worldwide depression is estimated to be the second leading cause of disability

adjusted life years (WHO 2012b). Americans spend some $300 billion/year on stress-

related illness (Hosey 2013), and nearly half will have a diagnosable mental illness in

their lifetimes (Kessler et al. 2005). This is of concern for city planning, as there is

evidence that urbanization is associated with higher incidence of mental disease

(Marcelis et al. 1998; van Os, Pedersen, and Mortensen 2004), mental illness (de Vries et

al. 2003) and greater difficulty coping with stress (Lederbogen et al. 2011). Likewise,

public health research confirms associations between mental health and physical settings

in cities (Guite, Clark, and Ackrill 2006).

Review of Reviews

With the exception of reviews focusing on a specific outcome of nearby nature such as

physical activity and obesity, all 10 reviews addressing broad health effects of green

space identified in this study featured mental health benefits (see Table 2). Bratman et al.

(2012) conducted a focused review on mental health effects of nature experience and

organized findings into three groups of outcomes: cognition; stress; and mood (i.e. emotion or affect). They also identified three kinds of nature exposure: images of nature; viewing nature through windows; and physical presence in nature.

Early research generated compelling findings from viewing nature in images (Ulrich 1979; Ulrich 1981) and landscape through windows (Moore 1981). In a classic study, Ulrich (1984) found that surgical patients assigned to rooms with windows looking out on a small stand of deciduous trees had significantly shorter postoperative hospital stays, received fewer negative evaluative comments in nurses' notes, and took less pain relief medication than matched patients in similar rooms with windows facing a brick building wall. This spawned a raft of research on the benefits of viewing nature. Velarde et al. (2007) identified over 100 studies of which 31 presented evidence of health effects from viewing landscapes through a window, looking at a picture or a video, experiencing vegetation around residential or work environments, or viewing natural landscapes during a walk. Most studies addressed an "urban" versus "nature" dichotomy, and natural scenes generally had a more positive effect compared to urban scenes.

Many studies have also focused on the mental effects of physical exercise in natural settings. One systematic meta-analysis of 25 papers found evidence of reduced anger and sadness after exposure to a natural environment compared to a more synthetic environment (Bowler et al. 2010b). There was also some support for greater attention after exposure to a natural

setting, but not when effect sizes were adjusted for pretest differences. Meta-analyses of other variables including physiological parameters such as blood pressure and cortisol concentrations were less supportive of a consistent difference; however, few studies were available for analysis.

Another quantitative assessment of 11 controlled trials compared the effects of outdoor exercise initiatives with those conducted indoors (Coon et al. 2011). Most trials (n=9) showed some improvement from exercise in natural settings across mental health metrics; however, findings were hampered by poor methodological quality and heterogeneity of outcome measures. An additional meta-analysis of 10 U.K. studies involving 1,252 participants found that exercise in every natural environment (e.g. urban green, countryside, forest) improved both mood and self-esteem. The mentally ill had one of the greatest self-esteem improvements (Barton and Pretty 2010).

Public health journals have published several reviews that identify mental health benefits of green space. Frumkin (2001) positioned the "biophilia" hypothesis that humans are innately attracted to other living organisms (Kellert and Wilson 1993), as a public health construct evidenced by four domains of nature contact: animals, plants, landscapes, and wilderness. He later identified contact with nature and associated physical and mental health benefits as one of four aspects of "healthy places" that offer promising opportunities for public health research (Frumkin 2003). Supporting this proposition,

Maller et al. (2005, 45) synthesized empirical, theoretical, and human health evidence

from viewing and being in green space, and framed nature contact as an "upstream health

promotion intervention for populations." They also emphasize an evolutionary context,

arguing that as a result of rapid urbanization, humans have never spent so little time in

contact with nature and the consequences of this are unknown (Katcher and Beck

1987).[17] Psychological benefits of nature contact identified in this study include:

restoration from mental fatigue; increased life satisfaction; coping with stress; restored

concentration; and increased productivity.

Framing landscapes as spaces between wild nature and the built environment, Abraham

et al. (2010) conducted a qualitative scoping review of 123 studies and found healthful

associations with attention restoration, stress recovery, and emotions. Largo-Wight

(2011) classified nature contact research into three categories: indoor plants, indirect

contact (via simulacra), and outdoor nature. The latter group included links to: less stress;

quicker recovery from stress; lower blood pressure; increased attentional capacity;

reduced ADD symptoms; reduced anger/aggression; improved emotional state; and

greater overall happiness.

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[17] Others emphasize that rapid urbanization and disconnection from the natural world reflects "a sharp break from the *longue duree* of human evolution" (Pretty and Barlett 2005, 302; Sullivan 2005).

In a systematic review of 35 studies addressing a range of human health benefits of urban green space, Lee and Maheswaran (2011) identified several positive mental health outcomes including self-reported reductions in stress, increased quality of life, and perceived general health. But they reinforced that studies tended to be qualitative and lacked robust evidence, and that this may be an inherent difficulty in quantifying non-physical health benefits. Kuo (2013), on the other hand, frames increased depression and anxiety disorder among some 20 other medical outcomes of "nature deprivation." She argues that the evidence now justifies discussion about the "dosage" of nature needed to promote health. Taking a different tack, Tzoulas et al. (2007) posit that healthy ecosystems and green infrastructure are the basis upon which ecosystems services yield human health and well-being benefits. They classified 21 studies by research design and types of effect. Of 10 groups of findings, nine addressed a mental health or subjectively determined outcome.

Other Studies

Subsequent research generally strengthens evidence and understanding of mental health benefits of nature contact in cities. Responding to the preponderance of cross-sectional methods in this literature, White et al. (2013) conducted an 18-year longitudinal study and found that on average, individuals living in urban areas with more green space have lower mental distress and greater life satisfaction – a positive measure of well-being. Likewise, van Herzele and de Vries (2011) found that residents of greener neighborhoods

report better general health and happiness; but only the latter indicator showed a significant difference. Despite evidence of nature contact benefits upon mood, there is little research on effects for people diagnosed with major depressive disorder (MDD). Addressing this gap, Berman et al. (2012) found that participants diagnosed with MDD had improved mood and memory (cognition) after a nature walk relative to an urban walk. Moreover, effect sizes for individuals with MDD were nearly five times those observed in another study with healthy individuals (Berman, Jonides, and Kaplan 2008), suggesting that people with depression benefit even more from nature contact. This seems to support Richardson et al. (2013), whose research suggests a dose-response relationship for mental health, with lower risks observed in successively greener areas.

Innovative methods are emerging in this literature. Using technology normally restricted to labs, research participants in Edinburgh, UK wore head-mounted EEG (electroencephalography), which records people's emotional states. Results showed lower frustration and attention, and higher meditation when moving into a green space zone; and higher attention when moving out of it (Aspinall et al. 2013). In Dundee, UK, research participants collected their own salivary cortisol data, showing that quantity of green space in the living environment was significantly correlated with both self-reported and objectively measured stress (Ward Thompson et al. 2012).

Social Cohesion

Defined as the social networks and norms of reciprocity and trustworthiness that arise

from them, social cohesion (or connectedness) is a powerful determinant of human health

(Putnam 2000; McMichael 2001). Among the refereed reviews identified in this paper,

eight cited positive effects on social cohesion (Frumkin 2001; Frumkin 2002; Maller et

al. 2005; Tzoulas et al. 2007; Velarde, Fry, and Tveit 2007; Abraham, Sommerhalder,

and Abel 2010; Lee and Maheswaran 2011; "Ming" Kuo 2013). These outcomes can be

broadly organized into anti-social behavior measured primarily through crime and

aggression, and a range of pro-social outcomes.

Anti-Social Behavior

When viewing images of urban parks (Schroeder and Anderson 1984; Talbot and Kaplan

1984) as well as commercial and residential parking lots (Shaffer and Anderson 1983),

studies have shown that people associate dense, unmaintained vegetation with feelings of

reduced security. Other studies confirm that plant material can augment fear of crime by

blocking views (Nasar and Fisher 1993; Kuo, Bacaicoa, and Sullivan 1998). Research on

parks and auto burglary found that thick vegetation makes it difficult to see in but

possible to see out – allowing criminals to observe potential victims as they park and then

walk away. Park vegetation can also facilitate escape (Michael, Hull, and Zahm 2001). A

clear theme from this early research is that shrubs, underbrush, and dense woods may

increase fear and support criminal activity by diminishing visibility, lending support to urban crime control strategies to remove vegetation (Michael and Hull 1994).

Other research, however, suggests that plant material can have an opposite effect by deterring criminal activity through different potential mechanisms. Well-maintained greenery may: 1) signal social ties and order, consistent with "broken windows" and "incivilities" theories (e.g. J. Q. Wilson and Kelling 1982; Brown, Perkins, and Brown 2004; Branas et al. 2011); 2) increase informal surveillance through more use of public space and increased "eyes on the street" (Jacobs 1961; Newman 1972; Kuo and Sullivan 2001a), which is a component of "routine activity" theory in criminology (Cohen and Felson 1979; Donovan and Prestemon 2012); and, 3) mitigate mental fatigue (S. Kaplan 1995; Kuo and Sullivan 2001b).

In pioneering work that directly examined links between vegetation and crime, Kuo and Sullivan (2001a) analyzed two years of police reports from more than 98 low-rise public housing buildings in Chicago and found systematically more violent crimes at buildings with the least vegetation. The authors ascribed these crime reductions to increased use of public green space (Coley, Sullivan, and Kuo 1997). Another study by Kuo and Sullivan (2001b) found that residents living in high-rise apartment buildings facing views of only concrete and asphalt reported systematically higher levels of household aggression and violence than did their counterparts living in identical buildings with views of trees.

Assessing 2,813 single-family detached homes in Portland, Oregon between 2005 and 2007, Donovan and Prestemon (2012) found that small, view-obstructing lot trees were associated with increased crime occurrence, whereas large lot trees and street trees in the public right-of-way tended to suppress crime. The authors posit that the presence of large trees may enhance informal surveillance by increasing use of public space, as well as signal neighborhood social control if the trees appear to be well cared for.

These studies focused on site and neighborhood scale settings. Addressing citywide effects at the census tract level, Wolfe and Mennis (2012) found that vegetation abundance in Philadelphia is significantly associated with lower rates of assault, robbery, and burglary, but not theft. Expanding the scope to an urban-rural metropolitan gradient in Baltimore, Troy et al. (2012) found that a 10% increase in tree canopy was associated with a roughly 12% decrease in crime. Moreover, public land trees had a greater negative association with crime than private land trees.[18]

A distinct form of greening has also been shown to reduce crime. Between 1999 and 2008 in Philadelphia, the Pennsylvania Horticultural Society (PHS) with community and municipal partners, cleaned up and greened over 4,400 abandoned vacant lots: a

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[18] This is complicated by an earlier finding that above a certain threshold of robbery and rape crimes, properties values adjacent to vegetated areas such as urban parks decrease (Troy and Grove 2008). While this study did not address a link between parks and crime per se, it suggests that the socio-economic setting of a park influences people's perception of its relationship to criminal activity.

treatment consisting of turf grass, tree plantings, and a low wooden post-and-rail fence around the perimeter. Based on regression-adjusted estimates applied to a 660-foot (202m) buffer around treated and untreated control lots, Branas et al. (2011) found that vacant lot greening was associated with consistent reductions in gun assaults. Garvin et al. (2013) conducted a follow-up study – the first randomized control trial of vacant lot greening – and found preliminary evidence for reduced violent crime and increased perceptions of safety.

Pro-Social Behavior

Research on the role of green space in promoting social connectivity is relatively limited (Maas, van Dillen, et al. 2009; Kaźmierczak 2013). Early work comes from a series of studies in two Chicago public housing developments with a predominantly African American population. In low-rise (two- to four-story) and high-rise (16-story) residential settings, Coley et al. (1997) observed that the presence of trees and grass attracted both larger groups and encouraged a greater mixture of adults and youths compared to areas without vegetation.[19] Moreover, the closer the trees were to residential buildings – and more visually and physically accessible – the more people spent time near them. Level of children's play and access to adults was approximately half in somewhat barren spaces compared to relatively green spaces (Taylor et al. 1998). These findings support a photo-

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[19] Criminologists have identified the importance of adult presence in juvenile crime control (Cohen and Felson 1979).

simulation study in which high-rise residents reported that the addition of trees and grass

to barren spaces was enough to dramatically change their responses – from spaces they

did not prefer to spaces they preferred quite a lot or very much (Kuo, Bacaicoa, and

Sullivan 1998).

Another study addressing the formation of Neighborhood Social Ties (NSTs) amongst

145 women in high-rise buildings found that individuals living next to greener common

spaces had more social activities and more visitors, knew more of their neighbors,

reported their neighbors were more concerned with helping and supporting one another,

and had stronger feelings of belonging. Mediation tests indicated that the greater use of

green spaces explained the link to NSTs (Kuo et al. 1998). The same seems to hold true

for the elderly. Interviews with 91 adults between the ages of 64 and 91 years-old showed

that use of green outdoor common spaces predicted both the strength of NSTs and sense

of community (Kweon, Sullivan, and Wiley 1998). An observational study in the low-rise

development found that compared to barren spaces, those with trees and grass supported

on average 83% more individuals involved in social activities (Sullivan, Kuo, and

Depooter 2004). By replicating and extending the findings of Coley et al. (1997) through

a different research design, the authors suggest that greenery may be a key component in

the creation of "vital neighborhood spaces." Another study encompassing four Dutch

cities found that residents of neighborhoods with more streetscape greenery reported less

acute health complaints and better mental health, and that this "could be fully explained by the stronger social cohesion in greener neighborhoods" (Groenewegen et al. 2012, 5).

However, other research shows different results. A population level study in the Netherlands concluded that people with more green space in their living environment felt less lonely; but they did not have more contact with neighbors and they did not receive more social support (Maas, van Dillen, et al. 2009). Addressing urban parks, Kaźmierczak (2013) found that social ties were more extensive for park visitors than for non-visitors, and some suggest that urban parks promote positive interaction between different ethnic groups (Seeland, Dübendorfer, and Hansmann 2009; Peters, Elands, and Buijs 2010). Yet, others find evidence of discrimination in urban parks (Gobster 2002; Byrne and Wolch 2009; Byrne 2012), and some find no relation between social capital and proximity to a park (Wood et al. 2008). Of note, the urban parks/social cohesion literature tends not to focus on the role of vegetation, which varies between settings. This complicates its inclusion in a narrative focusing specifically on human health benefits of urban greening.

Summary

Drawing upon public health scholarship, this review of human health benefits of urban vegetation reveals some unexpected findings. First, mental health and social cohesion are the most commonly cited benefits. Of the 20 reviews identified in this study (see Table

2), all 10 that address a range of human health outcomes identify mental health benefits. Bratman et al. (2012) limited their review to mental health effects of nature experience, and three reviews focused on psychological benefits of outdoor exercise (Barton and Pretty 2010; Bowler et al. 2010b; Coon et al. 2011). In sum, 13 of these 20 reviews identify psychological benefits related to stress, mood (affect), and cognition. Four reviews identified either mixed findings or weak methods, one of which acknowledged that "this may be due to the inherent difficulties in quantifying non-physical health benefits" (Lee and Maheswaran 2011, 213).

This body of research spans roughly three decades, includes subjective and physiological assessments in laboratory and real world settings, and has tested vegetation effects through images and video, window views, direct physical presence, and proximity. Bratman et al. (2012) classified five types of nature setting that have been explored, of which "urban green" space constituted 62% of studies – more than the other four categories combined (see Figure 5.3). The authors also reviewed prevailing theories explaining the mechanisms underlying observed psychological benefits,[20] and concluded that while details of disagreements may vary, the underlying postulate is that "the overwhelming evolutionary experience of human beings as a species involves natural

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[20] See Kaplan and Kaplan (1989) on attention restoration theory (ART), and Ulrich (1983; 1999) on psycho-evolutionary or stress reduction theory. See also biophilia theory (E. O. Wilson 1984; Kellert and Wilson 1993).

environments, and we are therefore predisposed to resonate with these surroundings, consciously or not" (p. 121).[21]
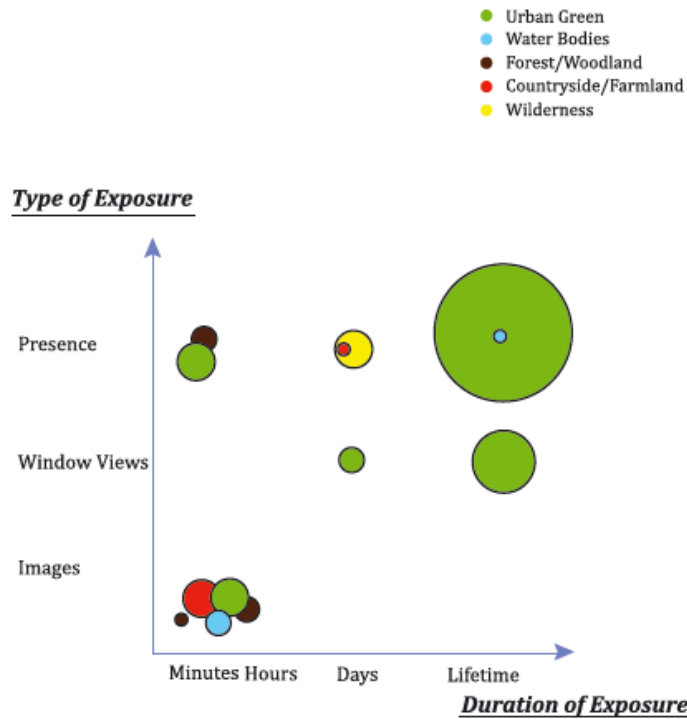
Figure 5.3: Distribution of psychological studies reviewed by Bratman et al. (2012).

Of the 20 reviews identified in this study, eight of the 10 that address a range of human health benefits cite social cohesion. One cited poor evidential strength, acknowledging the inherent difficulties in quantifying non-physical health benefits (Lee and Maheswaran 2011, 213). Yet, the findings of this chapter generally reflect the conclusion of a multi-year, multi-study Dutch research program under the rubric of "Vitamin-G" – for green

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[21] In evolutionary terms, "the urban environment is a spontaneous, changeable and historically unfamiliar habitat" (McMichael 2001, 252).

space (Groenewegen et al. 2006; Maas et al. 2006; van den Berg et al. 2010; van Dillen et al. 2012). These researchers found that vegetation is especially important for mental health, and at the urban neighborhood scale: "stress reduction and social cohesion, in that order, are the most important mechanisms in explaining the relationship between greenspace and health" (Groenewegen et al. 2012, 6).

While plant material can augment fear of crime by blocking views, several studies now link greener urban settings with reduced antisocial behavior expressed as decreased crime. While research on the role of green space in promoting pro-social behavior is relatively limited, positive findings include: more engagement in social activities; increased interaction between adults and youths; more children's play; better NSTs; and improved interaction between ethnic groups. Other studies found no correlation between social connectivity and green space/parks, while some find evidence of discrimination in urban parks.

A second overarching finding is that the literature reviewed here reveals research gaps and raises questions on some of the prominent drivers of contemporary greening. For example, there is currently little research directly linking green infrastructure to human health via stormwater management. Likewise, the converging forces of global climate change, UHI effect, and projected incidence of heat related morbidity and mortality suggest a strong argument for greening cities. Indeed, numerous studies point to the local

cooling capacity of parks and street trees. Green roofs and walls, in turn, cool buildings

and may also reduce adjacent air temperature. However, some studies suggest that

increasingly albedo (e.g. making dark surfaces white) is a more effective UHI mitigation

strategy than greening; and there is a noteworthy lack of scholarship linking vegetation to

reductions in heat related morbidity and mortality.

Reviews addressing the effect of green space and parks upon physical activity and

obesity related indicators show mixed, inconclusive findings and the influence of parks

and recreation settings upon different domains of physical activity such as recreation or

transportation is not clear. Moreover, transportation physical activity may account for a

greater proportion of total physical activity than recreation physical activity especially in

urban settings, and few studies have investigated the relationship between transportation

physical activity and green elements while controlling for confounding variables.

Combined with findings that individual and social factors may be of equal or greater

importance than the built environment in recreation physical activity, this review of

literature suggests that urban vegetation/green space may play a minor role in *total*

physical activity (see Figure 4.2).

Perhaps the most surprising finding of this literature review is the effect of trees upon

local air quality and asthma. Among the 20 reviews identified in this chapter, only two

address this topic in any depth that includes citation of original research. Roy et al.

(2012) reviewed 115 original studies and framed urban trees as both an ecosystem service (e.g. PM removal) and disservice (e.g. asthma). Cariñanos and Casares-Porcel (2011) focused exclusively on the role of urban vegetation as a contributor to pollen allergy, which they describe as one of the most widespread diseases in urban populations. Indeed, several public health studies link urban vegetation to exacerbation of asthma and allergic respiratory diseases. In sum, public health literature generally frames the air quality function of urban vegetation as a disservice.

This is not reflected in large-scale deposition modeling, which suggests impressive volumetric removal of air pollutants including particulate matter; even though the net effect upon total pollution loads is about 1%. The underlying assumptions, methods, and manner in which deposition modeling results are communicated is now the subject of critique.[22] Moreover, those who study the effect of trees upon air circulation at the street level and in urban canyons find that trees may increase pollution concentrations by reducing wind flow.

The findings of this literature review are not exhaustive and future studies will expand the knowledge base. This review aims to provide a high level assessment – drawing upon public health scholarship – of links between urban vegetation and human health. Findings are summarized along a relative scale in Figure 5.4.

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[22] See chapters VI and VII for further discussion of this topic.
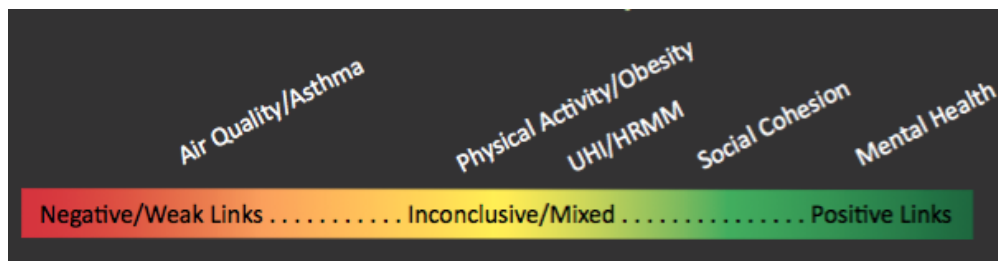
Figure 5.4: Relative scale of human health benefits of urban vegetation based on this review drawing upon public health scholarship. By author.

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Peer-Reviewed Reviews on Human Health Benefits of Urban Green Space

Table 2

#	Author(s)	Conc. Frame	Mthd	SYS	AQ*	AS	UHI*	HMM	PA	OB	MH	SC
1	Frumkin (2001)	"biophilia"	QuaL								+	+
2	Frumkin (2003)	"healthy places"	QuaL		§				+		+	+
3	Maller et al. (2005)	"upstream health"	QuaL								+	+
4	Kaczynski & Henderson (2007)	"PA & parks/rec. settings (PRS)"	QuaL	✓					+/-			
5	Tzoulas et al. (2007)	"green infrastructure & ecosystems"	QuaL	✓	+		+		+		+	+
6	Velarde et al. (2007)	"viewing landscapes"	QuaL	✓							+	+
7	Kaczynski & Henderson (2008)	"PRS and functions of PA"	QuaL	✓					+/-			
8	Abraham et al. (2010)	"health-promoting landscapes"	QuaL	✓					+		+	+
9	Barton & Pretty (2010)	"green exercise"	QuaN	✓							+	
10	Bowler et al. (2010)	"natural" vs "synthetic environments"	QuaN	✓							+/-	
11	McCormack et al. (2010)	"park use & PA"	QuaL	✓	†				+/-			
12	Cariñanos & Casares-Porcel (2011)	"urban green zones & pollen allergy"	QuaL	✓		-						
13	Coon et al. (2011)	"outdoor & indoor PA"	QuaN	✓	†						+/-	
14	Lachowycs and Jones (2011)	"green space & obesity"	QuaL	✓					+/-	+/-		
15	Largo-Wight (2011)	"healthy places & nature contact"	QuaL		§				+		+	
16	Lee & Maheswaran (2011)	"urban green spaces"	QuaL	✓					+/-	-	+/-	+/-
17	Pearce & Maddison (2011)	"PA, built environment & low SES"	QuaL						+/-			
18	Bratman et al. (2012)	"cognitive function & mental health"	QuaL								+	
19	Roy et al. (2012)	"urban tree benefits & costs"	QuaN	✓	+/-	-	+				+/-	+
20	Kuo (2013)	"nature deficit disorder"	QuaL			+			+		+	+

Key

"Mthd" (method) • "SYS" (systematic) • "AQ" (air quality) • "AS" (asthma) • "UHI" (urban heat island mitigation) • "HMM" (heat related morbidity & mortality) • "PA" (physical activity) • "OB" (obesity) • "MH" (mental health) • "SC" (social cohesion) • "+" (positive effects cited) • "+/-" (mixed effects or weak evidence cited) • "-" (no effects or disservice cite) • "†" (perceived AQ addressed) • "§" (only indoor AQ addressed) • "*" (ecoystem function) • Blank Space (not addressed or cited)

Range of human health outcomes addressed
Only mental health outcomes addressed
Only pollen allergies addressed
Only physical activity outcomes addressed

CHAPTER VI

Practitioner Perceptions of Urban Tree Benefits

"People recognize that things are out of whack, and they want to take responsibility. It's a persuasive message. I can't tell you how many times I've heard people say, 'I recognize that the global environmental is suffering, and I wanted to do something to make a positive change.'"

 - Tree Planting Practitioner, in interview with author

"The very power of trees, our love of them, and their prevalence in our cultural works and iconography, make the manipulation of trees, and more importantly, the idea of what trees can do, extremely problematic."

 - Shaul Cohen (2004, 2), in *Planting Nature: Trees and the Manipulation of Environmental Stewardship in America*

Introduction

Chapter III revealed that ecosystem services now constitutes a principal rationale for urban trees and urban greening writ large (Wolf 2008; Pincetl et al. 2013; Silvera Seamans 2013; Young 2013). Chapter IV illustrated noteworthy gaps in urban ecosystem services (UES) and green infrastructure (GI) discourse. In particular, UES and GI literature frame human health as a principal outcome, but make little reference to public health scholarship, suggesting that there may be an *a priori* assumption of health benefits undergirding contemporary urban greening. This underpins Question 2 of this dissertation: *How do urban greening practitioner perceptions of benefits compare to the scientific literature?*

To address this question, Chapter V summarized literature on the human health benefits of urban vegetation. This revealed some unexpected findings, including a psychosocial orientation to human health benefits of nearby nature, weak empirical evidence for air pollution mitigation (Pataki et al. 2011), and public health literature that frames urban trees and vegetation primarily as a contributing factor to respiratory allergy and asthma due to pollen, i.e. an ecosystem *disservice* (D'amato 2000; Dales et al. 2008; Cariñanos and Casares-Porcel 2011; Jariwala et al. 2011).

This chapter now compares the findings of the literature review with the perceptions of municipal tree planting organizations and leaders, a topic identified by Roy et al. (2012) as a research gap.[1] In addition to the health outcomes of urban vegetation summarized in Chapter V, this assessment of practitioner perceptions also addresses the role of urban trees in mitigating global environmental decline and climate change in particular, as the underlying intent of this monograph is to make meaning of contemporary urban greening. This phenomenon is set within two major historical trends: global urbanization; and an emergent awakening to the Anthropocene, characterized by concern about anthropogenic climate change and species extinction. Climate change has been described by U.N. Secretary General Ban Ki-moon as, "the defining challenge of our age" (Rosenthal 2007),

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[1] A systematic quantitative review of 115 original urban tree studies highlighted the need for research on the "attitudes of municipal managers . . . towards trees within urban environments" (Roy, Byrne, and Pickering 2012, 360).

and a U.N. panel recently issued its starkest warning yet: "The gathering risks of climate change are so profound that they could stall or even reverse generations of progress against poverty and hunger if greenhouse emissions continue at a runaway pace . . . Failure to reduce emissions could threaten society with food shortages, refugee crises, major flooding and mass extinctions" (Gillis 2014, online).

In the U.S., tree planting has been advocated by federal, corporate, and nonprofit actors as a strategy to mitigate global climate change (Cohen 2004). Globally, the 2014 Intergovernmental Panel on Climate Change (IPCC) has also identified afforestation as a potential strategy to remove CO_2 from the atmosphere. However, the IPCC emphasizes that "there is uncertainty about the potential for large-scale deployment" of carbon capture and storage strategies such as afforestation, and that these methods are "associated with challenges and risks" (Edenhofer et al. 2014, 12). Echoing this cautionary note, Unger (2014) argues that large increases in forest cover are unlikely to have a substantial effect on reducing greenhouse gases (GHGs) and "can actually make global warming worse."[2] At the urban scale, there is little empirical evidence that vegetation substantially reduces total urban CO_2 emissions (Pataki et al. 2009; Pataki et al. 2011; Pincetl et al. 2013). More important may be the management of rural forests for maximizing CO_2 uptake (Daniels 2010). In sum, there may be a science-practice gap

[2] In this New York Times editorial, Unger offers numerous arguments to back up this conclusion, the underlying scientific citations for which can be found on her personal website: http://environment.yale.edu/unger-group/nyt-op-ed/

regarding the mitigation capacity of urban trees upon both "localized exposure" to criteria air pollutants as well as "more distant and complex" links to global climate change via GHGs[3] – both of which share a primary source: fossil fuel emissions.

To test whether there is a perception versus science gap, this study first tabulated alleged benefits of urban trees in the web-based documentation – one of three forms of qualitative data (Patton 2002) – of 27 municipal, national, and nonprofit organizations engaged in or advocating for urban tree planting and cities identified as having exceptional urban forests. These organizations were identified in the literature and through Internet search. Following up on this document review, a survey and interview were conducted by telephone with 33 local managers of municipal tree planting in cities identified in literature as having large scale tree planting initiatives or exceptional urban forests.[4] Please see Chapter I for the methodological details of this assessment.

Findings

Review of web-based documentation of 27 municipal, national, and nonprofit organizations engaged in or advocating for urban tree planting and cities identified as having exceptional urban forests showed that 96% of tree planting organizations cited air

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[3] The Millennium Ecosystem Assessment (2005, Foreword) uses the terms "localized exposure" and "more distant and complex links" to distinguish between different scales of ecosystem service impact.

[4] In keeping with guidelines at the University of Pennsylvania Institutional Review Board, the personal and institutional identity of research subjects must remain anonymous.

quality improvement and the urban heat island effect as a basis for greening. Also, 93%

cited stormwater control benefits, 85% pointed to economic benefits, and 59% cited

carbon sequestration from urban trees as a strategy to mitigate global climate change.

Psychosocial outcomes emerged as a second tier benefit, cited by 63% respectively (see

Figure 6.1).
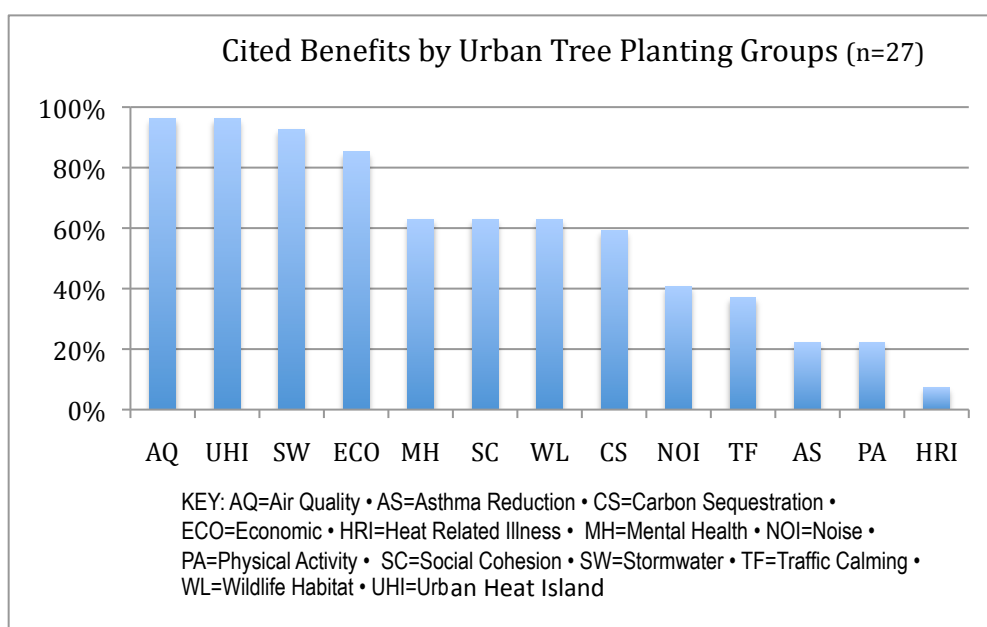
Figure 6.1: Benefits cited by 27 public and nonprofit organizations engaged in or advocating for municipal tree planting. *To facilitate legibility of graph, responses accruing to less than 5% of total are not included.

This review also revealed two urban tree planting projects explicitly predicated on asthma

reduction. Baltimore has a project called The Trees for Public Health (TPH) Initiative. In

November 2013, the mission for this project was "to increase our urban forest by fully

planting up low-income neighborhoods that have high asthma rates and sparse tree

canopies" (Baltimore Tree Trust 2013).[5] New York has a project entitled Trees for Public

Health Neighborhoods, which has established six target neighborhoods for tree planting

because they have fewer than average street trees and higher than average rates of asthma

among young people (City of New York 2014) (see Figure 6.2).

Figure 6.2: Trees for Public Health Neighborhoods (City of New York, 2014).

Following up on this document review, 33 local managers of municipal tree planting in

cities identified in literature as having large scale tree planting initiatives or exceptional

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[5] As of June 2014, the website for this initiative was updated and language relating to asthma was no longer present.

urban forests were surveyed and interviewed by telephone. The following findings are organized in two categories: 1) perceptions regarding the capacity of urban trees to reduce local exposure to air pollution; 2) perceptions regarding the capacity of urban trees to mitigate climate change and protect the global biosphere. See chapter VII for discussion on perceptions of how residents value urban trees.

Reducing Localized Exposure to Criteria Air Pollution

When asked to "list the top five human health and well-being (HHWB) benefits of trees in your city," 91% stated improved air quality. This was the most frequently cited benefit followed by urban heat island mitigation (85%), water quality improvement (73%), improved mental health (45%), greater social cohesion (33%), and increased physical activity (30%). See Figure 6.3.

"List the top 5 HHWB benefits of trees in your city"

KEY: AQ=Air Quality • AS=Asthma • BT=Beauty • CM=Crime • CP=CommPride • CS=Carbon Sequestration • FD=Food Source • HL=Healing • MH=Mental Health • PA=Physical Activity • Social Cohesion • Traffic Barrier • Urban Heat Island • Water Quality • Wildlife Habitat
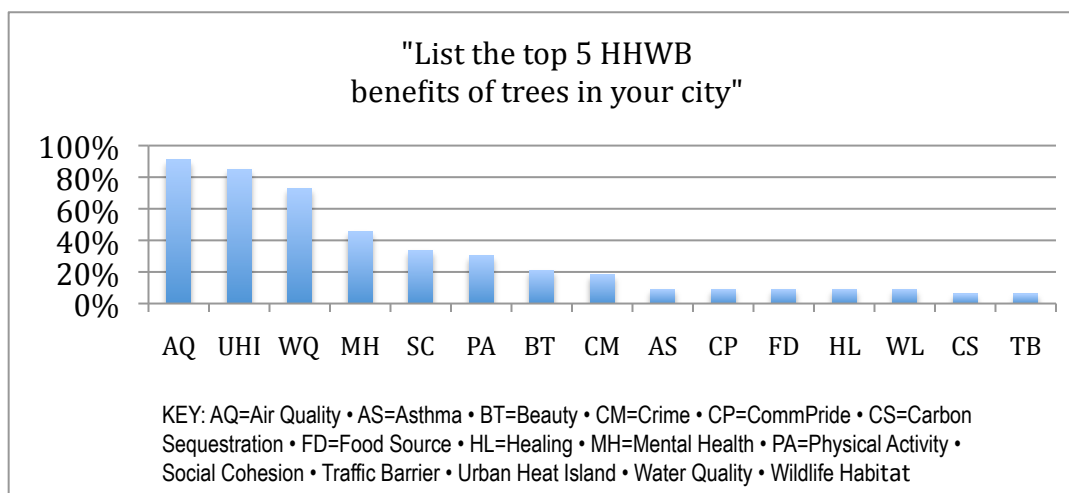
Figure 6.3: Human health and well-being benefits cited by 33 local leaders of municipal tree planting organizations. *To facilitate legibility of graph, responses accruing to less than 5% of total are not included.

When asked to rank these five HHWB benefits, air quality was the top-ranked benefit followed by UHI mitigation, water quality improvement, improved mental health, and greater social cohesion (see Figure 6.4).
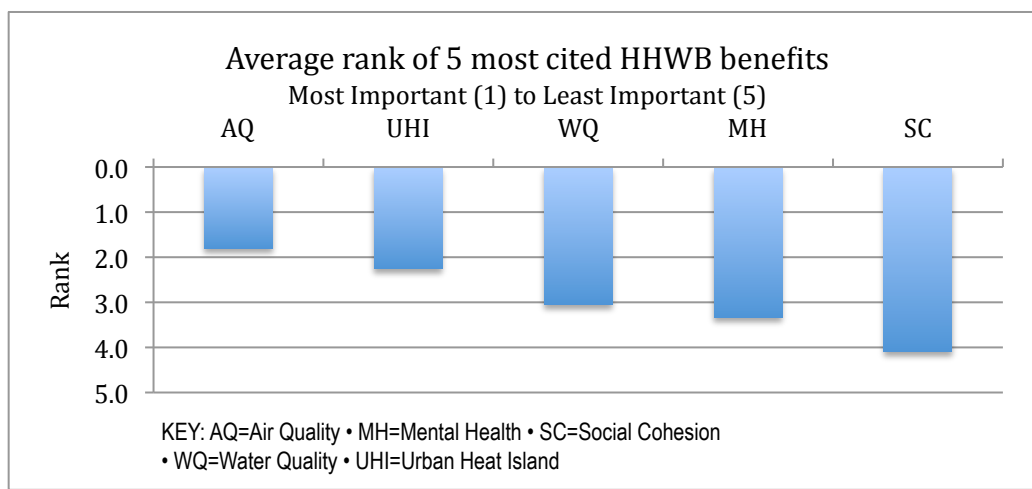
Figure 6.4: Average rank of five most cited HHWB benefits.

When asked to "list the top five contributions of trees to enhancing quality of life in your city," air quality improvement (63%) was the second-most common response after UHI mitigation (70%). Water quality benefits ranked third. See Figure 6.5.
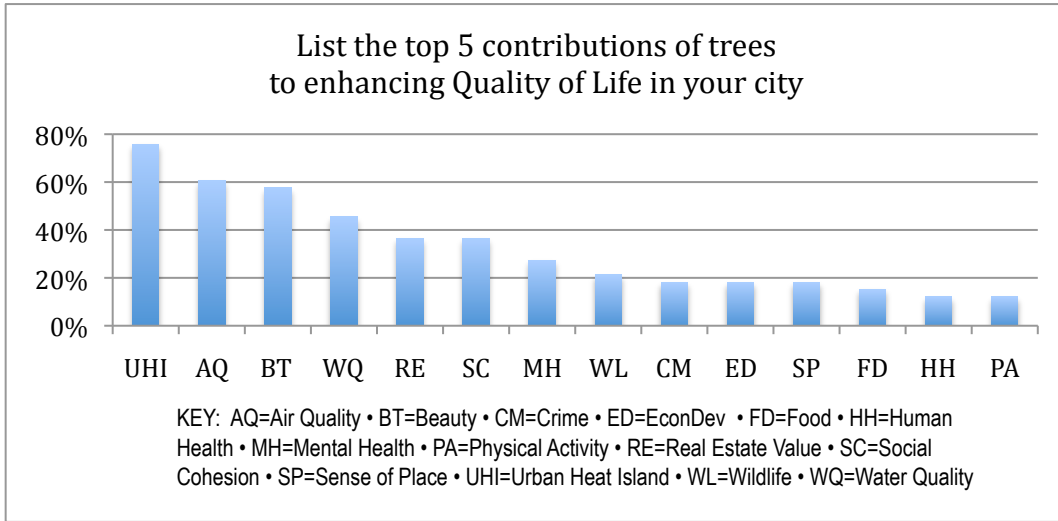
Figure 6.5: Quality of life benefits cited by 33 local leaders of municipal tree planting organizations.

*To facilitate legibility of graph, responses accruing to less than 10% of total are not included.

When asked to rank these quality of life benefits, air quality improvement was the top-ranked benefit, followed by water quality, beauty, UHI mitigation, and increased real estate value. See Figure 6.6.
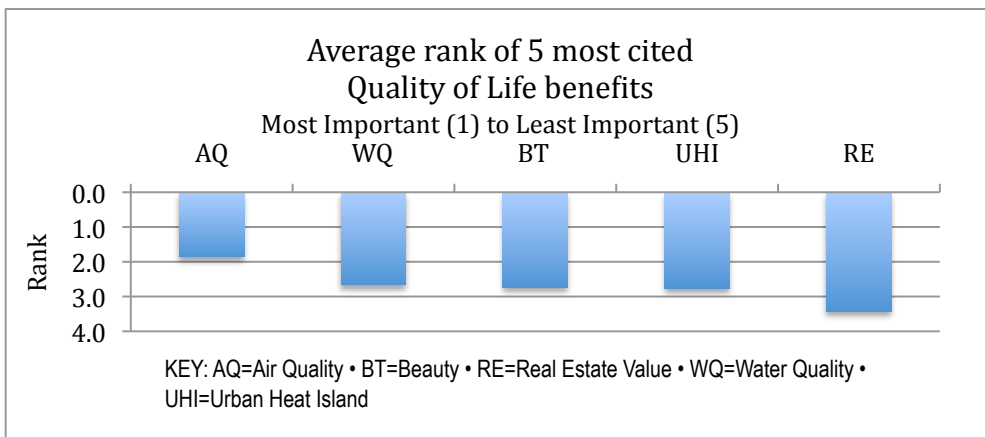
Figure 6.6: Average rank of five most cited quality of life benefits.

In a Likert scale question, 92% of respondents Strongly Agree or Agree with the statement: "Urban trees significantly reduce air pollution." See Figure 6.7.
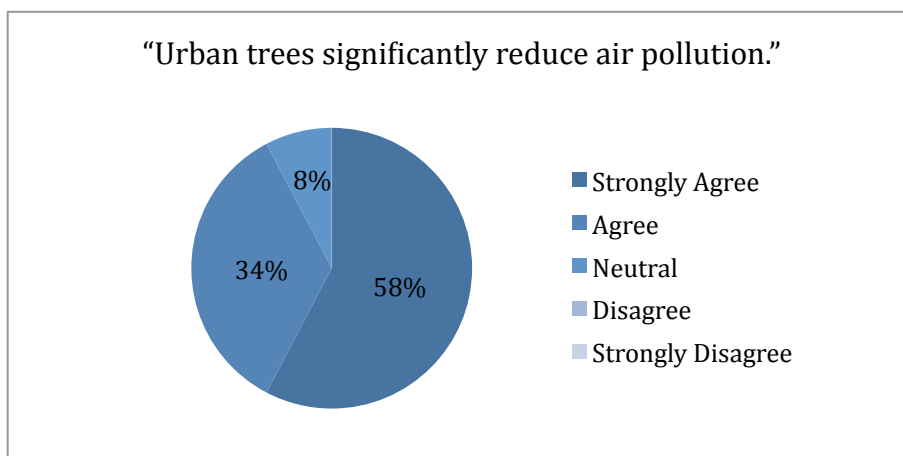
Figure 6.7: Likert scale response to statement: "Urban trees significantly reduce air pollution."

Mitigating Global Climate Change and Environmental Decline

In a Likert scale question, 64% of respondents Strongly Agree or Agree with the statement: "Conserving and planting trees in my city is an important strategy to mitigate global climate change." See Figure 6.8.
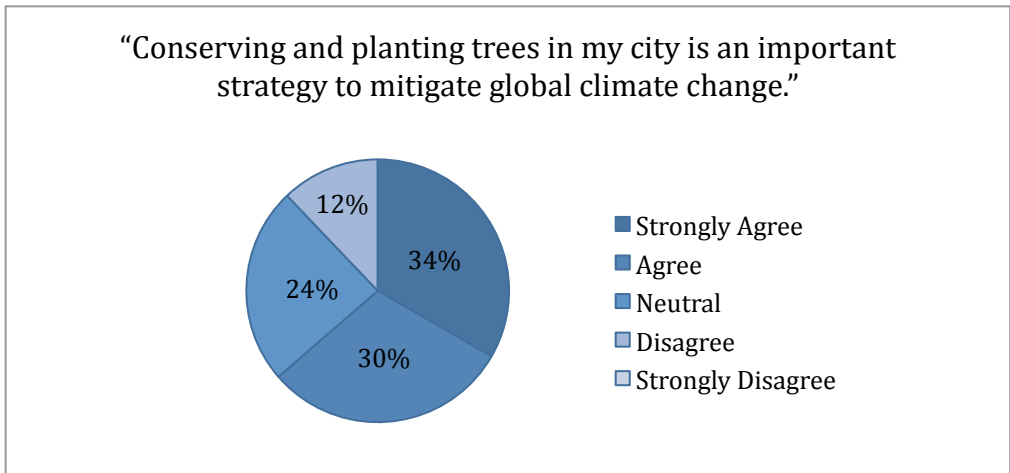
Figure 6.8: Likert scale response to statement: "Conserving and planting trees in my city is an important strategy to mitigate global climate change."

In a Likert scale question, 79% of respondents Strongly Agree or Agree with the statement: "Thinking globally and acting locally accurately depicts my approach to tree planting." See Figure 6.9.
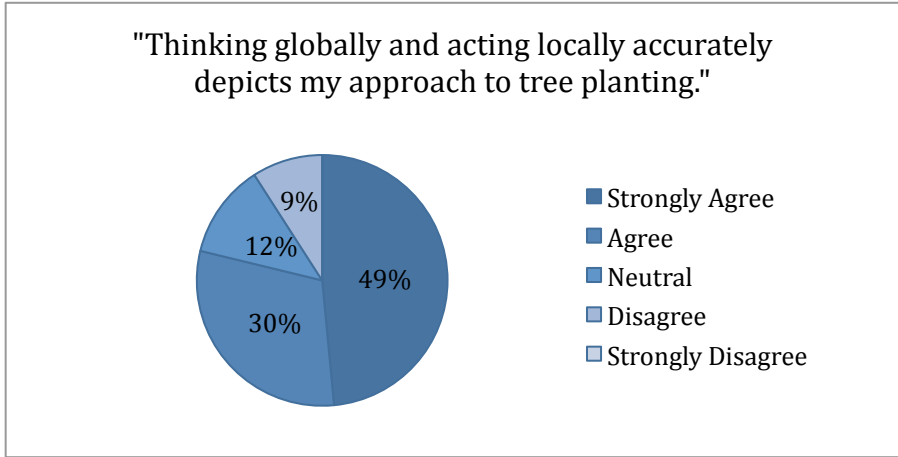
Figure 6.9: Likert scale response to statement: "Thinking globally and acting locally accurately depicts my approach to tree planting."

In a Likert Scale question, 82% of respondent Strongly Agree or Agree with the

statement: "Urban tree planting is an important strategy to protect the global biosphere."

See Figure 6.10.
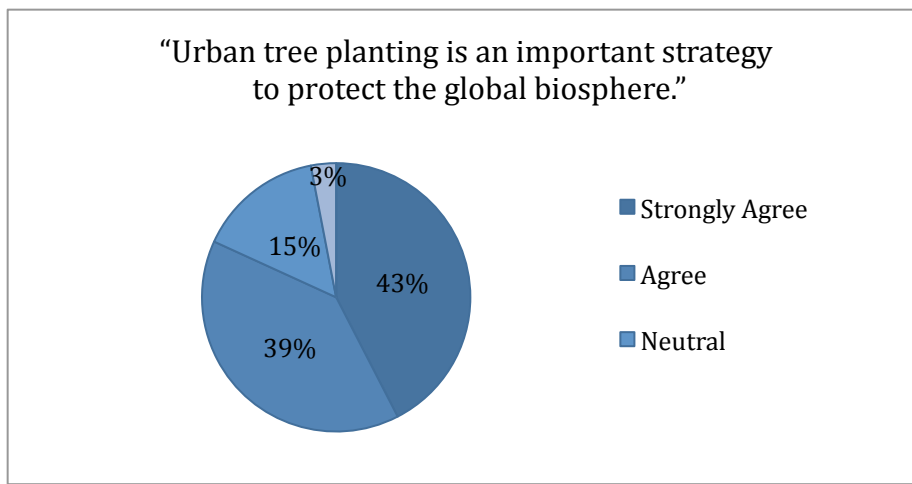
Figure 6.10: Likert scale response to statement: "Urban tree planting is an important strategy to protect the global biosphere."

In a Likert scale question, 91% of respondents Strongly Agree or Agree with the

statement: "Conserving and planting trees in my city will increase residents'

environmental stewardship." See Figure 6.11.
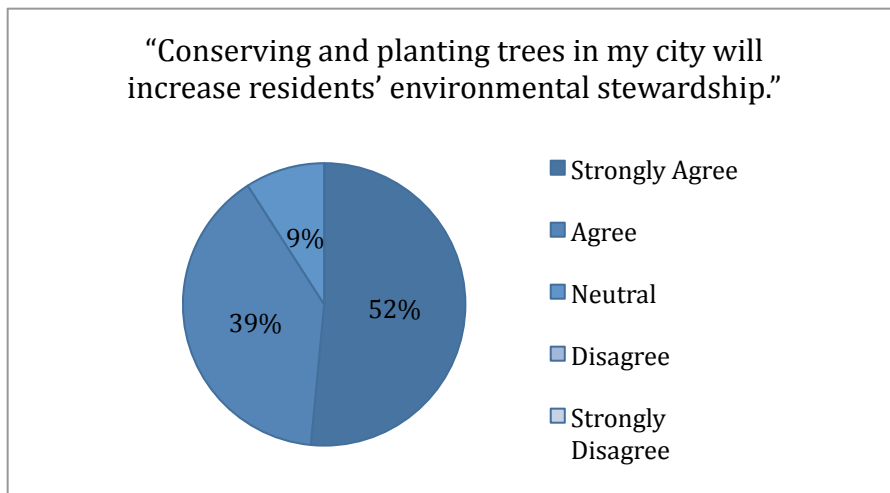
Figure 6.11: Likert scale response to statement: "Conserving and planting trees in my city will increase residents' environmental stewardship."

In a Likert scale question, 83% of respondents Strongly Agree or Agree with the statement: "The presence of urban trees increases residents' environmental stewardship."[6] See Figure 6.12.

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[6] To distinguish the act of tree planting from the mere presence of trees, this question was added roughly halfway through the survey. Thus, responses to this question are drawn from 18 participants.
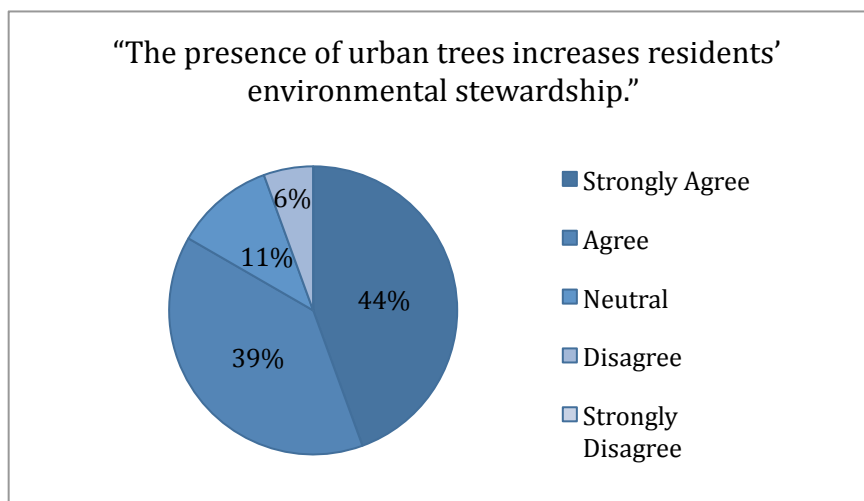
Figure 6.12: Likert scale response to statement: "The presence of urban trees increases residents' environmental stewardship."

Summary & Discussion

Some noteworthy themes and insights emerge from the survey results described above, which are summarized below and given nuance from the open-ended questions with participants that followed the structured survey (Hyman 1955; Patton 2002).

Strong Belief in Air Quality Improvement & Air Pollution Mitigation

Survey responses illustrate that urban tree planting managers in cities believe that trees play a major role in reducing air pollution and increasing local air quality: air quality improvement is the most cited of all HHWB benefits (see Figure 6.3), and 92% Strongly Agree or Agree with the statement that "urban trees significantly reduce air pollution" (see Figure 6.7). Most surprising, perhaps, is that air quality improvement is the second

most cited "quality of life" benefit (see Figure 6.5), and it is the highest ranked of all

quality of life benefits (see Figure 6.6). This strong perception of air quality benefits

stands in contrast to peer-reviewed literature, suggesting a potential science-practice gap.

Survey responses also illustrate that most urban tree planting managers believe that tree

planting is an important strategy to mitigate global climate change: 64% of respondents

Strongly Agree or Agree that "conserving and planting trees in my city is an important

strategy to mitigate global climate change." Managers also agree that stormwater control

is an important reason to plant trees.

Distracting Attention from the Actual Problem?

Localized air pollution and global climate change are human-made threats that share a

common source: fossil fuel emissions. Indeed, the modern industrial economy is rooted in

fossil fuel based energy, and weaning ourselves off of non-renewable polluting fuel is

one of the great 21st century challenges. This is made more complex by another trait of

the contemporary era, commonly described as "the information age" (Castells 1996), a

defining attribute of which is the unprecedented production and diffusion of information.

This can easily lead to "information overload" (Toffler 1970), where people have

difficulty understanding an issue and making decisions that can be caused by the

presence of too much data (Edmunds and Morris 2000; Yang, Chen, and Hong 2003).

This may be the case with global climate change (Moser 2010), as well as in

contemporary environmentalism, described by Castells (2010, 170) as "a cacophony of

theory and practice."

In light of the steady stream of media messages that compete for our attention, it becomes imperative, especially from environmental authorities, that communications addressing local and global air pollution do not distract public attention from the fundamental source of the problem. Yet, this may be occurring in the urban tree planting community. Said participants:

> – "I was recently in a meeting on air quality, and after a while I said: 'Isn't the big elephant in the room the car?!' We're going to need to see big policy changes to have a significant reduction in air pollution."

> – "I'm concerned sometimes that when people plant trees they think they can run their car 24-7."

> – "Tree planting is a good thing, but it provides only a small percentage of the job. And it does beg the question of if we're treating the symptom rather then the problem."

This is the message that is disseminated, perhaps unintentionally, by some municipal tree planting advocates. A 35-second animated film entitled "Cough Medicine" from the City of Milwaukee exemplifies this (see Figure 6.13). Here, a young man walks along a busy

highway. Trucks and cars zoom by, spewing plumes of pollution into the air as the

gentleman hacks and coughs his way along the road. The entire frame is shrouded in a

haze of grey. Then a tree suddenly drops out of the sky and lands with a thud in the path

of the pedestrian protagonist. Simultaneously, we hear the sound of a vacuum cleaner

clicking on as grey smog is sucked in by the tree, which adopts the anthropomorphic

behavior of gulping or inhaling pollution. As the screen clears to pollution-free white, the

frame cuts to a close-up of the man who coughs one last time as the tree taps him

lovingly on the back with a branch. He returns the favor with an appreciative upward

gaze. The film then cuts to a closing frame with the text, "Trees: The Natural Air

Cleaner," set in an informal, hand-drawn font. Surrounding this video frame are other

YouTube clips addressing topics related to actual cough medicine. The clip is viewable at

the following link: https://www.youtube.com/watch?feature=player_embedded&v=G2OJaCpi78g

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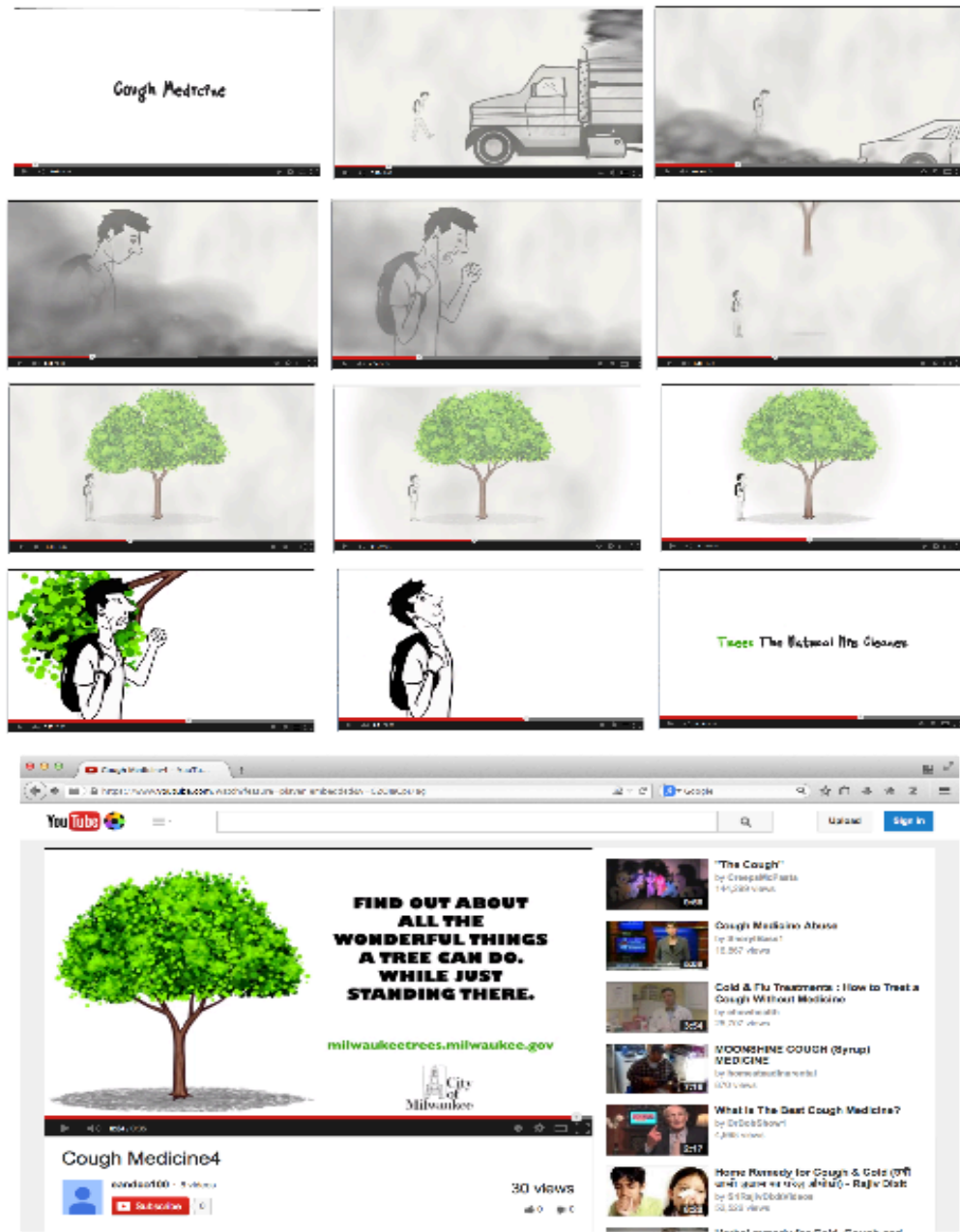
Figure 6.13: "Cough Medicine," video clip by MilwaukeeTrees and the City of Milwaukee.

Planting Trees for Sustainability or Moral Satisfaction?

The potential distraction identified above supports a more fundamental critique rooted in the premise that tree planting discourse and practice can direct attention to symptoms rather than causes. In *Planting Nature: Trees and the Manipulation of Environmental Stewardship in America,* Cohen (2004, 2) argues that "the very power of trees, our love of them, and their prevalence in our cultural works and iconography, make the manipulation of trees, and more importantly, the idea of what trees can do, extremely problematic." He continues: "It is not that tree planting is harmful to the environment, but that tree planting provides a proxy. The act substitutes cosmetic physical changes that are morally satisfying for the radical reorganization of society and culture that would address the underlying attitudes and actions that have led to such a widespread degradation of the natural and human world" (ibid 21). In addition to local air quality improvement, another case in which the science of urban trees may fall short of perceived benefits is climate change mitigation.

Climate Change Mitigation Potential of Urban Trees

In the urban context, many studies suggest that urban tree planting may be a meaningful strategy to mitigate global climate change through CO_2 sequestration (Akbari et al. 1992; McPherson, Nowak, and Rowntree 1994; Nowak and Crane 2002; Nowak 2006). The urban forest in Philadelphia, for example, is calculated to store about 530,000 tons of carbon valued at $9.8 million and sequester about 16,100 tons of carbon annually, valued

at \$297,000 per year (Nowak et al. 2007). Across the coterminous United States, urban

trees are estimated to store 700 million tons of carbon valued at \$14,300 million, and

provide a gross carbon sequestration rate of 22.8 million t C/yr value \$460million/year

(Nowak and Crane 2002). These calculations imply large volumetric storage and removal

of CO_2, and suggest that certifiable, tradable credits from forestland preservation and

management could support a cap-and-trade system as a cost-effective way to lower net

CO_2 emissions (Daniels 2010). But rural forests sequester much more CO_2 than urban

forests, as rural trees live longer and typically contain species that grow larger, such as

Douglas fir. Rural forests also have many more trees per acre on average (ibid).

Estimates of carbon sequestration by urban vegetation have rarely been compared with

the carbon emissions of cities to assess the potential importance of the former as a

mitigation strategy. The absence of such comparison made it difficult to assess whether

cities were meeting carbon mitigation goals (Pataki et al. 2006). A couple of studies have

since emerged that do this. Pataki et al. (2009) simulated the trajectory of CO_2 emissions

under urbanization scenarios in Utah's Salt Lake Valley and found that doubling tree-

planting density would offset less than 0.2% of total annual CO_2 emissions after 50 years.

Pincetl et al. (2013) then compared GHG emissions from Los Angeles (Ngo and Pataki

2008) with global average values of net primary productivity (NPP) (Saugier, Roy, and

Mooney 2001). They concluded that planting trees to reduce GHG emissions in arid Los

Angeles "would accomplish little while requiring substantial imported water" (Pincetl et

al. 2013, 482). Pataki et al. (2011) conclude that the potential of urban trees to sequester

CO_2 is low, and the current level of uncertainty regarding this mechanism is also low (see

Figure 6.14).

Ecosystem service	Potential magnitude	Current level of uncertainty
C sequestration	Low	Low
Net GHG emissions	Moderate	High
Local cooling	High	Moderate
Stormwater mitigation	High	Moderate
Water-quality mitigation	High	High
Air-quality mitigation	Low	High
General human health	Moderate	Moderate

Ecosystem disservice	Potential magnitude	Current level of uncertainty
Water use	High	Moderate
Net GHG emissions	Moderate	High
Source of allergens	High	Low
VOC emissions	Moderate	Moderate

Notes: GHG emissions are listed as both a service and disservice because the impacts of plants or soils may be either positive (net cooling) or negative (net warming) in hot climates. VOC = volatile organic compounds, which are precursors to the formation of ozone pollution.

Figure 6.14: Commonly discussed urban ecosystem services/disservices associated with biogeochemical cycles, with their potential magnitudes (relative to the scope of the associated environmental problem) and uncertainty levels [Pataki et al. 2011].

In addition to CO_2 sequestration, urban trees might mitigate global climate change

through microclimatic effects – such as cooling from shade and protection from winter

winds – that lead to less energy use in buildings and less GHG emissions (e.g. Heisler

1986; McPherson 1991; Akbari et al. 1992; McPherson 1992; Simpson 1998; Akbari

2002; Simpson 2002; Pandit and Laband 2010; Chagolla et al. 2012; Berry, Livesley, and

Aye 2013; Sawka et al. 2013; Akhamphon and Akhamphon 2014; Balogun, Morakinyo,

and Adegun 2014; Millward et al. 2014). According to Donovan and Butry (2009),

research addressing this potential generally falls into two categories: (1) small-scale

controlled experiments that examine the effect of trees on an individual house; and (2)

large-scale simulation modeling. For example, Akbari et al. (1997) modeled energy

savings from temperatures at two similar houses in Sacramento, California and estimated

that trees reduced seasonal cooling costs between 26% and 47%. Simpson and

McPherson (1998) modeled the effects of 254 residential properties participating in a

utility sponsored tree planting program in Sacramento. There were an average of 3.1

program trees per property, and the simulation found an average annual cooling savings

of $10.00 per tree from shade. Exploring the building cooling potential of trees in urban

areas across the state of California, McPherson and Simpson (2003) used tree canopy

cover data from aerial photographs and building energy simulations, and estimated that

peak load reduction by existing trees saves utilities 10%, valued at roughly $778.5

million annually, or $4.39/tree.

Modeling and experimental studies such as these make an appealing case for reducing

building energy use and associated GHG emissions through tree planting. Yet, few

studies have measured the direct energy savings of urban trees (Akbari, Pomerantz, and

Taha 2001), and those that have did not use actual electricity billing data (Donovan and

Butry 2009). The first study to analyze electricity billing problematizes this discussion. In

Sacramento, tree cover on the west and south sides of 460 single-family homes were

found to reduce summertime electricity use (ibid). However, trees on the north side of

houses not only failed to generate energy savings, those within 6.1 meters of houses

increased summertime electricity use. The authors hypothesize that trees close to a house

reduce the cooling effect of wind, slow the release of building heat at night, or cause

more lighting to be used inside the house. In this Sacramento study, that may have been

true of trees on all four sides of houses, but on the east side the positive and negative

effects of trees on energy use canceled out, and on the south and west sides the energy

saving effects of trees predominated (ibid, p. 664).

This study demonstrates how critical tree location is upon the magnitude and direction of

house-energy use. It also raises fundamental questions about thermal interactions

between trees and buildings in different climatological zones. Indeed, the biological

mechanisms that influence thermal effects are season-, species-, location-, and

management-dependent (Bush et al. 2008; McCarthy and Pataki 2010; Berry, Livesley,

and Aye 2013). Other important considerations include the color of building walls and

roofs (Rudie, Jr. and Dewers 1984), as well as the material, height, and width of

structures. Providing a synoptic overview, Pataki et al. (2011) describe the potential

magnitude of local cooling by urban vegetation as high, and the level of uncertainty as

moderate (see Figure 5.1). It is worth noting, however, that this characterization did not

account for the findings of Donovan and Butry (2010), which introduces additional

uncertainty and reinforces the need for place-specific research and potential norms.[7]

Pataki et al. (2011) raise other concerns that problematize urban tree planting and greening as a strategy to substantially mitigate GHG emissions and global climate change. First, the management of urban trees requires energy for planting, pruning, watering, fertilizing, repairing sidewalks and road surfaces, and removing debris (Pataki et al. 2006). Second, relative to emissions from natural ecosystems, the emissions of non-CO_2 GHGs such as nitrous oxide can be quite large in common urban land cover types such as lawns and turf grass (Kaye et al. 2004; Groffman et al. 2009). Third, even in largely intact urban forests, modified climate and other disturbances can result in higher emissions and smaller sinks (methane [CH_4] uptake) of non-CO_2 GHGs (Groffman et al. 2006; Groffman and Pouyat 2009). In sum, Pataki et al. (2011) characterize GHG emissions as both an ecosystem service and disservice of urban vegetation, as the impacts of plants or soils can be either positive (net cooling) or negative (net warming) in hot climates (see Figure 6.14).

Also, in an urbanizing world characterized by increasing density and multistory buildings, the capacity of trees to significantly cool tall structures and reduce their energy use and emissions seems questionable. Vegetated roofs and walls, and increasing surface

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[7] In an October 2014 e-mail communication with Dr. Geoffrey Donovan, he was not aware of any other studies that have emerged since the 2009 paper he co-authored which assess links between trees and electricity billing data, revealing an important gap in this literature.

albedo, may hold more potential to cool tall structures in dense urban settings (see

Chapter V).

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CHAPTER VII

Proximal Greening for Multifunctional Urban Landscapes

"If we still believe that cities are the most complicated artifact we have created, if we believe further that they are cumulative, generational artifacts that harbor our values as a community and provide us with the setting where we can learn to live together, then it is our collective responsibility to guide their design."

    - Spiro Kostof (1991, 335), in *The City Shaped: Urban Patterns and Meanings Through History*

Introduction

Municipalities around the world are showing substantial interest in urban greening, defined here as the introduction or conservation of plant material in cities. Encompassing ambitious tree canopy cover goals and a range of innovative policies and designs that are vegetating the urban landscape, this bloom of activity – described by some as a 'frantic greening process'– may be unlike anything since the planting of street trees and creation of large parks transformed the fabric of cities in the 19th century.

This phenomenon is arising amidst two major historical events. First, cities are now the dominant form of human settlement and nearly 70% of people will live in urban areas by 2050. Second, popular culture is awakening to the Anthropocene, wherein humanity's pervasive impact upon the biosphere suggests that humans can improve as well as harm ecosystems and mitigate and adapt to global climate change. This dissertation strives to

make meaning of urban greening at this unprecedented historical inflection point; and suggest norms for greening 21st century cities.

Chapters II and III revealed, in brief, that up to the mid-19th century, trees were not a prominent element in most American cities. In the Colonial period, trees could be found in public squares such as Boston Commons, and street trees were sometimes planted by individuals, exemplified in Albany and New York City. The Early Republican period witnessed an early tide of civic improvement, including a two-decade fad for Lombardy Poplars and emergence of a nascent network of street trees, green squares, public promenades, and private yards and gardens. Individuals were still the primary actors in tree planting. In the Industrial Era, explosive urbanization inspired reform-based urban design interventions, including street tree planting and new types of public parks, park systems, parkways, and residential open spaces that established trees as major elements in the urban fabric. This was especially true in New England, where elm tree planting undergirded the first village improvement societies, and laws were passed first enabling then requiring appointment of public tree wardens. By the end of the 19th century, management of trees was a legitimate arena of municipal responsibility.

Today, trees are substantial elements in the biophysical, sociopolitical, and aesthetic life of cities; and urban areas in the U.S. have, on average, slightly more canopy cover than the conterminous nationwide landscape. Important actors include the federal U.S. Forest

Service, mayors, municipal staff, and national and local nonprofit groups, whose work is

supported by a range of new tools guiding research, planting, and management. A

noteworthy trend from this longitudinal chronicle is that the rationale for urban sylva has

over the past couple of decades undergone a shift from beautification and civic

improvement to ecosystem service provision.

Chapter IV revealed a lack of attention to plant material in American urban planning

journals, as well as noteworthy gaps in the urban ecosystem services (UES) and green

infrastructure (GI) discourse. First, there is a substantial mismatch between UES theory

and municipal greening practice. Second, UES and GI literature frame human health as a

principal outcome, yet there is little reference to public health scholarship, suggesting that

there may be an *a priori* assumption of benefits undergirding contemporary urban

greening. Chapter V assessed peer-reviewed literature on the human health benefits of

urban vegetation and revealed some unexpected findings. In public health scholarship, for

example, mental health and social cohesion are commonly cited benefits of urban

vegetation, and flora is largely framed as a disservice regarding respiratory health.

To assess the perception of benefits amongst municipal tree planting organizations and

leaders, Chapter VI summarized the results of a review of web-based documentation and

a survey/interview with 33 participants representing 25 organizations in 13 U.S. cities.

This showed that urban tree planting managers believe that trees play a major role in

reducing air pollution and improving local air quality; and that most urban tree planting managers believe that tree planting is an important strategy to mitigate global climate change.

The implications of these collective findings are discussed below. In particular, gaps and opportunities will be addressed in relationship to three themes: Urban Planning and Design; Urban Ecosystem Services; and Urban Greening in the Anthropocene. Conclusions on the relationship of urban greening to livability and sustainability then follow.

Urban Planning & Design

Public health literature suggests the importance of site, block, and neighborhood scale greening: streetscape vegetation has been shown to be at least as strongly related to self-reported health as green areas (van Dillen et al. 2012); the strongest links between greenness and reduced morbidity were found closest to home: within 1 km or roughly a 10-minute walk (Maas et al. 2009); and physical proximity to nature areas in Seattle did not have a strong effect on neighborhood satisfaction,[1] whereas visual proximity to vegetation did (Kearney 2006).

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[1] Neighborhood satisfaction has been linked with lower risk of stroke (Kim, Park, and Peterson 2013), chronic health impairments, and emotional distress (K. Wilson et al. 2004).

The importance of nearby green space for people's health and well-being highlights the need for greening to be evaluated in terms of visual proximity and how it is experienced from the street and the home (van Herzele and de Vries 2011). This supports calls for nature "at the doorstep" (Kaplan 1985), "along necessary journeys" (Pincetl and Gearin 2005), and maximizing "the total minutes of nature exposure in residents' everyday lives" (Kuo 2013, 178)." This also suggests an urban planning and design norm that might best be described as 'proximal greening' (see Figure 7.1).

Figure 7.1: Vegetated streetscape, from City of Seattle Department of Planning and Development (2013).

A noteworthy consideration is that proximal greening supports contemporary efforts to manage stormwater through GI. The City of Philadelphia, for example, has formally adopted GI as a strategy to manage stormwater and reduce combined sewer overflows

instead of spending billions of dollars on traditional grey infrastructure pipes, tunnels, and treatment systems. This $2.4 billion Long Term Control Plan includes goals to increase the number of 'greened acres,' restore stream corridors, and upgrade wet weather treatment plants. It also includes a Parcel-Based Billing Initiative that is intended to incentivize private landowners to convert impervious surfaces to GI. One of its most noteworthy characteristics is the promotion of a suite of site and block scale design interventions, wherein vegetation is a prominent feature. These treatments include: stormwater tree trenches; downspout planters; green roofs; rain barrels; pervious paving; stormwater planters; and vegetated bump-outs (see Figure 7.2). The net effect is an urban landscape whose horizontal surfaces and interstitial spaces are increasingly clad in plant material (see Figure 7.3) (City of Philadelphia 2011).
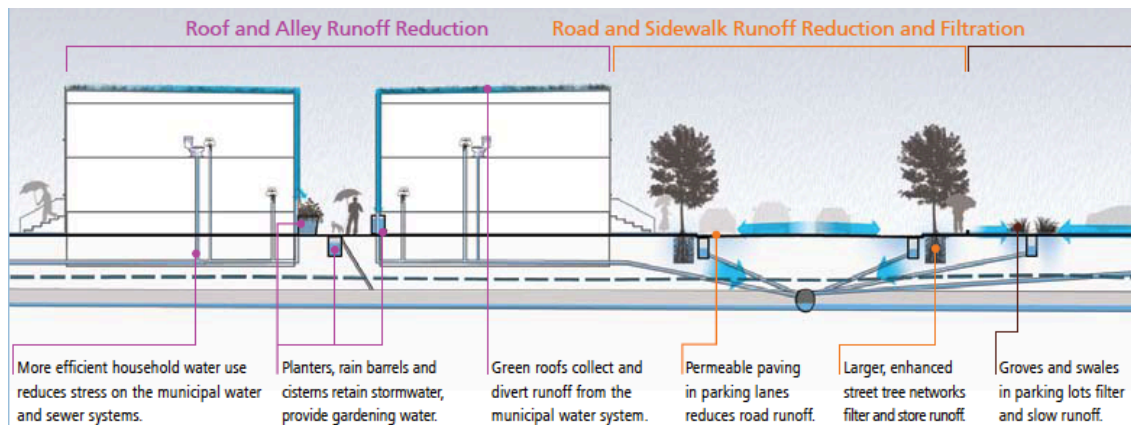
Figure 7.2: Schematic diagram of hydrologic flows via site and street level GI (City of Philadelphia 2011).

Figure 7.3: Speculative rendering of GI implementation in a residential area (City of Philadelphia 2011).

This resonates with calls for an urban design norm where vegetation is "integrated…with infrastructural systems" (Waldheim 2006). Proximal greening also responds to the challenges of increasing urbanization and density. Singapore, for example, has adopted a formal goal "to draw nature closer to people," through: a Streetscape Greenery Master Plan; pedestrian and vehicular bridges veiled with creepers; and vegetated building façades, balconies, and roofs (ULI 2013). Another policy tool that supports the provision of nearby nature is the Green Area Factor. Pioneered in Berlin, this municipal regulation establishes the minimum proportion of a site requiring vegetated features (see Figure

7.4), and it has since been replicated in Malmö, Sweden, and Seattle and Washington, D.C. in the U.S. (District of Columbia 2011; Keeley 2011; Kruuse 2011).

A1 - Landscaped Area <24" Soil Depth
A2 - Landscaped Area >24" Soil Depth
A3 - Rain Garden
B1 - Groundcovers <2' Height
B2 - Plants >2' Height
B3 - Small Tree
B5 - Medium Tree
B6 - Large Tree
B7 - Large Existing Tree
C1 - Green Roof 2-4" Growth Medium
C2 - Green Roof >4" Growth Medium
D - Green Wall
E - Water Feature
F1 - Permeable Paving 6-24" Subgrade
F2 - Permeable Paving >24" Subgrade
G - Structural Soil Systems
H1 - Drought Tolerant/Natives
H2 - Rainwater Cistern
H3 - Public Visibility
H4 - Food Cultivation

Figure 7.4: Composite model depicting Green Factor elements and how they might relate spatially to a building and landscape in a conceptual project (Hirst 2008).

While there is relatively little research directly linking heat related morbidity and mortality to urban vegetation, the fact that heat-related deaths may be more common at night when people tend to be in their homes (Changnon, Kunkel, and Reinke 1996), suggests that the building surface cooling capacity of vegetated walls (Stec, van Paassen,

and Maziarz 2005), reflective roofs and green roofs (Santamouris 2012), and trees adjacent to houses (Heisler 1986; Akbari et al. 1997) may be preferable to interventions further away such as open green spaces (Mackey, Lee, and Smith 2012) or citywide canopy cover goals. This may be of special significance in communities with older buildings, which can have a lower level of thermal insulation and reduced heat dissipation capacity, leading to high indoor temperatures during heat waves (Haralambopoulos and Paparsenos 1998). Peng and Jim (2013) suggest that vegetated roofs can also cool the air entering street canyons; however, roof greening in a high-rise city may be ineffective for thermal comfort near the ground (Ng et al. 2012). Green walls, on the other hand, may hold considerable street canyon cooling potential (Alexandri and Jones 2008).

Local climate is an important consideration for urban heat island mitigation. In sunny, hot areas, reflective roofs may be preferable, while in moderate and cold climates vegetative roofs seem to present greater benefits (Santamouris 2012). Others suggest that in arid regions, arrays of photovoltaic panels may be preferable to urban forestry because they yield greater thermal reduction during the diurnal cycle while also providing the additional benefit of supporting peak energy demand, conserving water resources, and employing a renewable energy source (Golden et al. 2007). Importantly, a uniform approach to urban heat island mitigation may not be desirable, and efforts to increase tree cover should concentrate on neighborhoods with the least vegetation, where substantial

gains in cooling can be achieved with minimal additional water use (Gober et al. 2010).

Proximal greening may also have relevance in municipalities with a lot of vacant land, which is especially relevant for shrinking cities (IURD 2007) and legacy cities (Mallach 2012). As noted in Chapter IV, Schilling and Logan (2008) provide a broad urban planning perspective on how to leverage green infrastructure (GI) to 'right size' shrinking cities by: instituting GI plans and programs; creating land banks to manage the effort; and building community consensus through collaborative neighborhood planning. At the site and neighborhood scale, Spirn (1991) has identified six types of vacant land: missing teeth; vacant corners; connectors; vacant blocks; Swiss cheese; and multiple contiguous blocks. For each of these, she offers nine potential treatments, many of which contain vegetated features. Figure 7.5 provides an example of potential uses for the missing teeth vacant land type. Combined, these precedents offer urban planning and site design approaches to proximal greening in shrinking cities.

Missing Tooth
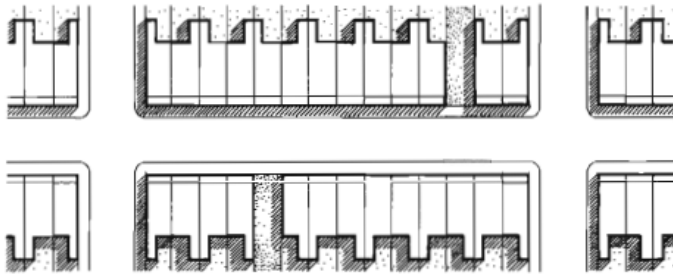
Plan of Missing Tooth
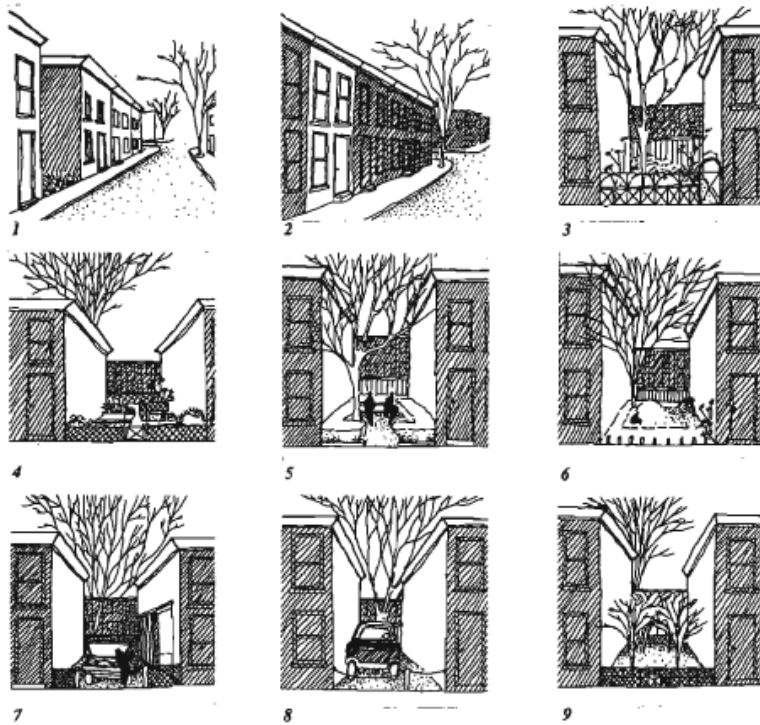
Figure 7.5: Potential uses for the "missing teeth" vacant land type: 1) Missing Tooth; 2) New Building; 3) Private Garden; 4) Community Garden; 5) Meeting Place; 6) Playlot; 7) Outdoor Workshop; 8) Parking; 9) Woodland. See Spirn (1991) for potential uses of five other vacant land types.

Reflecting literature related to crime, urban greening should consider: planting and maintaining large trees that do not obstruct views, especially in barren areas and in public spaces and rights-of-way, in order to maximize "cues to care," public use, and "eyes on the street" (Kuo and Sullivan 2001; Donovan and Prestemon 2012; Troy, Grove, and O'Neil-Dunne 2012). Research also encourages better management of vegetation that may potentially facilitate crime by serving as a screen or storage area for criminals, particularly on abandoned lots or in interface zones around industrial properties (Branas et al. 2011; Donovan and Prestemon 2012; Troy, Grove, and O'Neil-Dunne 2012).

Findings on air quality complicate the picture. Based on deposition modeling, Nowak et al. (2014, 126) argue that, "the greater the tree cover, the greater the pollution removal; and the greater the removal and population density, the greater the value." This would support ambitious tree canopy cover goals and large-scale tree planting initiatives. However, as described earlier, there seems to be little empirical evidence to support this rationale (Pataki et al. 2011), the science may be flawed (Pataki et al. 2013; Whitlow et al. 2014b), and trees along roads and in urban canyons may concentrate air pollution (Gromke and Ruck 2009; Gromke and Ruck 2012; Wania et al. 2012; Vos et al. 2013; Jin et al. 2014). This has led some to question the logic of wholesale goals to increase urban tree canopy (Pugh et al. 2012). In the U.S., it also raises important questions about the role of urban trees in meeting the National Ambient Air Quality Standards (NAAQS) established to fulfill the Clean Air Act Amendments of 1970. Notwithstanding concerns

about the underlying assumptions, methods, and public communication of modeling

studies such as the increasingly popular i-Tree tool (see Chapter III), even if such

modeling is accurate, a 1% reduction in air pollution suggests that trees are at best a

minor strategy to improve urban air quality. By extension, communications that purport

otherwise may confuse municipal leaders and residents (Whitlow et al. 2014b), and

potentially divert attention from the actual source of the problem: fossil fuel emissions

(see Chapter VI). To complicate matters further, public health scholarship frames urban

vegetation as a contributor to asthma and respiratory illness via pollen allergy, described

as "one of the most widespread diseases in urban populations" (Cariñanos and Casares-

Porcel 2011, 205). Further research is required to assess optimal urban greening and tree

planting norms for air quality that are specific to locality (Pataki et al. 2013), account for

urban canyons (Jin et al. 2014), minimize allergy impacts,[2] and address different scales of

intervention. Importantly, even critics acknowledge that trees carry "aesthetical and

emotional value . . . [and] the argument of local air quality does not necessarily need to

be a reason not to plant roadside urban vegetation" (Vos et al. 2013, 119).

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[2] Guidelines to design green spaces with low-allergy impact include: a) Increase plant biodiversity; (b) Ensure moderate, controlled introduction of exotic flora; (c) Control of invasive species; (d) Avoid massive use of male individuals of dioecious species (avoid botanical sexism); (e) Choose species with low-to-moderate pollen production; (f) Adopt appropriate management, maintenance and gardening strategies to ensure removal of opportunist and spontaneous species; (g) Avoid forming large focal pollen sources and screens by respecting planting distances; (h) Obtain expert advice when selecting suitable species for each green area, and avoid fostering cross-reactivity between panallergens; (i) Establish specific local authority by-laws ensuring that sufficient time is available for the design and planning of urban green spaces (Cariñanos and Casares-Porcel 2011).

A proximal greening norm need not be seen in isolation from a larger network of city, metropolitan, and regional green space, such as the system of urban parks and parkways advanced by Frederick Law Olmsted, Sr. in the 19th century (Schuyler 1986; Kowsky 1987), the hubs and links GI framework advocated by Benedict and McMahon (2006), and the conversion of existing land uses to parks in 'built out' cities (Harnik 2010). Tim Beatley and Tanya Denckla-Cobb, for example, have proposed the idea of a four-scaled Nature Pyramid, wherein neighborhood greenery provides "the bulk of our nature diet" (2012) (see Figure 7.6). Building on Beatley's work to advance the idea of *biophilic cities* (2011),[3] this conceptual framework is based upon the popular food pyramid that guides nutritional eating habits, except here it refers to the frequency, intensity, and duration of optimal nature exposure.

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[3] Biophilia theory posits that because human beings coexisted in close relationship with the natural environment for millions of years, we have an affinity for life and life-like processes (E. O. Wilson 1984).
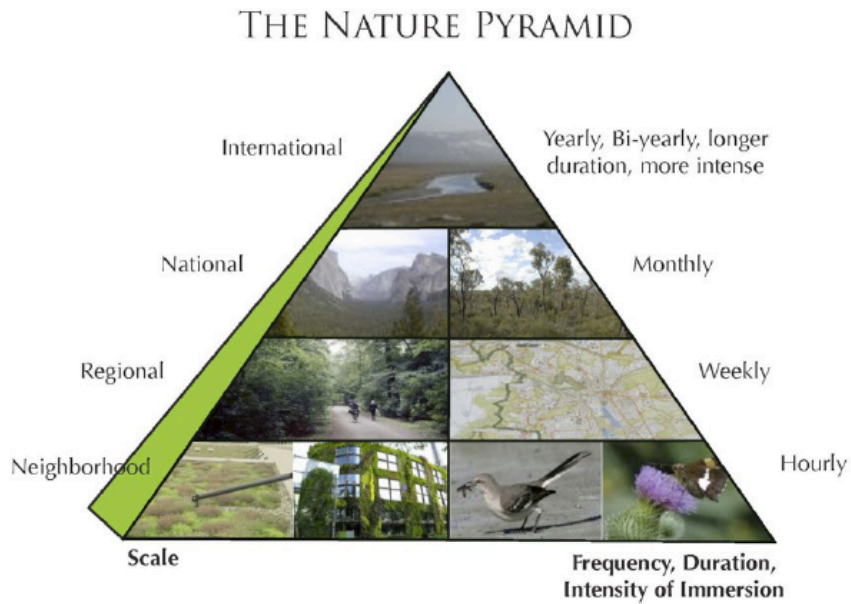
Figure 7.6: Hypothetical depiction of The Nature Pyramid. Graphic by Tim Beatley. Concept by Tanya Denckla-Cobb (2012).

The Nature Pyramid is noteworthy for its reinterpretation of a well-established public health construct, and for how it emphasizes the mental health benefits of nearby nature described in Chapter V. In advancing a rhetorical discussion about nature 'servings' and 'nutrients,' this framework also reflects some of the latest thinking amongst public health scholars who are investigating the benefits of urban vegetation. Drawing upon standards of practice in epidemiology, Howard Frumkin (2013, 196), Dean at the University of Washington School of Public Health, has framed the following questions as an approach to future research: "What is a 'dose of nature'? Do people need to view leafy trees, or does a wintertime look at denuded trees do the trick? Are trees necessary, or do shrubs

suffice? What density of trees is needed? How close to trees do people need to be? How long a view is needed?"

Ultimately, the introduction and conservation of vegetation in cities should aspire to serve a range of human, environmental, and wildlife needs. Urban areas, for example, are important for plant and animal habitat,[4] and there are various landscape design approaches to enhance native biodiversity (Müller et al. 2013). Of note, a review on links between biodiversity and human health found that "relationships were most evident at a local scale, following immediate encounters or through presumed repeated exposures" (Lovell et al. 2014, 13).

As urban designers and planners navigate this interdisciplinary terrain, Naveh's (2001) theory of 'multifunctional landscapes' provides an intellectual scaffolding that seems appropriate for the highly altered biome of cities.[5] Drawing upon decades of research in

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[4] Across 76 ecoregions in North America, urban cover is positively correlated with both species richness and endemism amongst eight major plant and animal taxa comprising over 20,000 species (Ricketts and Imhoff 2003). Urban-rural gradient studies show the greatest avian and mammalian species richness and diversity in moderate (suburban) levels of urbanization (Blair 1996; Blair and Johnson 2008; Riem et al. 2012).

[5] Zev Naveh was a pioneer in landscape and restoration ecology. Based in Israel, Naveh disagreed with his North American colleagues' aspiration for a 'pre-Columbian' landscape, and he emphasized the prominent role of humans in the dynamics of most ecosystems (Allen, Olsvig-Whittaker, and Aronson 2011). His proposition of multifunctional landscapes is embedded within an overarching theory of The Total Human

the anthropogenically modified regions of the Mediterranean and East Africa, Naveh

proposes multifunctional landscapes as a transdisciplinary orientation "to overcome the

great epistemological barriers erected between . . . the natural and humanistic scientific

'cultures'" (p. 279). Multifunctional landscapes, he argues, are "treated simultaneously as

products of material, natural biogeophysical systems and as mental, cognitive noospheric

systems" (p. 269).[6]

Rooting Ecosystem Services in Urban Greening Practice

Ecosystem services is now one of – if not the – dominant rationales for street trees, urban

forestry, municipal greening, and urban environmental management writ large. The

underpinnings of ecosystem services emerged in biological literature in the 1970s

(Norgaard 2013), and according to Costanza and Kubiszewski (2012), Ehrlich and

Mooney published the first scholarly paper to use the term 'ecosystem services' in 1983.

In the 1990s, ecosystem services gained considerable traction as a way to demonstrate

humanity's dependence – often in quantitative and monetary terms – on the biosphere for

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Ecosystem, where landscapes "have to be studied and managed in their own right at different functional and spatial scales and dimensions" (Naveh 2000, 358).

[6] The noosphere refers to the "psychosocial layer of evolution" (McIntosh 2007, 173), or "the world of thought, to mark the growing role played by mankind's brainpower and technological talents in shaping its own future and environment" (Crutzen and Stoermer 2000, 17). The term was developed in the early 20th century by Russian geologist Vladimir Vernadsky, French philosopher and mathematician Édouard Le Roy, and French paleontologist Pierre Teilhard de Chardin, whose pioneering work laid the groundwork for the concept of the Anthropocene (ibid).

its survival (Costanza et al. 1997; Daily 1997). The idea was later popularized through the Millennium Ecosystem Assessment (MEA), which describes ecosystem services as "the benefits people obtain from ecosystems" (2005a, v). As of January 2011, over 2,400 scholarly papers written by more than 2,000 authors had been published on this topic since the 1990s (Costanza and Kubiszewski 2012).[7] Yet, the application of ecosystem services to urban settings has lagged. Between 1995 and 2012, roughly 8% of articles referring to ecosystem services specifically dealt with the urban context (Hubacek and Kronenberg 2013), which has been described as "an open frontier in ecosystem service research" (Gómez-Baggethun and Barton 2013, 235).

The ecosystem services construct has been criticized for commoditizing nature and prioritizing utilitarian values (Rees 1998; Soma 2008; Spash 2008; Kosoy and Corbera 2010). In cities, the ascendance of ecosystem services as the dominant rationale for greening has also generated concern. Some posit that large-scale tree planting based on ecosystem services is often framed as a 'sustainability fix' for municipalities (Silvera Seamans 2013);[8] and this type of 'panacea' might obscure the actual causes of poor environmental quality while inhibiting more substantive solutions to problems such as fossil fuel emissions (Cohen 2004). Framing trees as a biotechnology may diminish the

[7] Others identify 5,557 publications referring to "ecosystem services" between 1995 and October 8, 2012 (Hubacek and Kronenberg 2013).

[8] This draws upon the work of While et al. (2004), who describe a 'sustainability fix' as the selective incorporation of environmental goals in the greening of urban governance.

urban design and aesthetic value of trees, as well as cultural ecosystem services (Konijnendijk van den Bosch 2014). Municipalities are mainstreaming ecosystem services at the policy level but delegating tree management to residents, "where the latter could negate the former" (Silvera Seamans 2013, 9). Indeed, tree mortality studies suggest that many trees will not survive to provide the ecosystem services that motivate planting campaigns (Roman 2014).

The IPCC has also issued a cautionary note, suggesting that in cities there is a false assumption that ecosystem service-based climate change adaptation measures are an easy alternative to the constraints that limit the implementation and effectiveness of 'hard engineering' solutions (Revi et al. 2014). Indeed, citywide introduction of green infrastructure generates costs, management, and urban design challenges that raise important questions about municipal governance (Pincetl 2010), a topic that has been neglected in UES research (Ernstson et al. 2010).[19] Urban trees do not merely generate benefits; they also create health problems (Cariñanos and Casares-Porcel 2011) and disservices (Lyytimäki et al. 2008; Escobedo, Kroeger, and Wagner 2011). Most importantly, perhaps, is that scientific claims underlying ecosystem service arguments for urban tree planting/greening may be flawed, and this may lead to less-than expected outcomes (Pataki et al. 2011; Pincetl et al. 2013; Whitlow et al. 2014b).

In addition to these targeted critiques in existing literature, this dissertation unearthed

noteworthy gaps in UES conceptualization and discourse:

1) <u>Definition:</u> Some assess the functions and services provided by vegetation and

ecosystems *in* cities and urban areas (Bolund and Hunhammar 1999; Pataki et al.

2006; Nowak et al. 2013). Others study the ecosystem functions and services

provided *to* cities and urban areas; and sometimes those generated in cities and urban

areas (Hirsch 2008; Breuste, Haase, and Elmqvist 2013; Gómez-Baggethun et al.

2013; Jansson 2013). The latter narrative focuses largely on "the process of

urbanization, rather than [on] an assessment of cities per se" (Elmqvist et al. 2013, x),

framing cities primarily as consumers and degraders of ecosystem services. The

substantial difference between these definitions and approaches muddles scholarly

discourse on UES and weakens the capacity to inform municipal greening practice.[9]

2) <u>Terminology:</u> Reflecting ecosystem services writ large, there is a lack of clarity

between ecosystem functions, ecosystem services, and ecosystem benefits (Boyd and

Banzhaf 2007; Fisher and Turner 2008). Moreover, assessment of ecosystem

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[9] For example: Preservation of the eight-county Catskill/Delaware and Croton watershed some 140 miles north of Manhattan is a groundbreaking precedent in regional water quality protection. However, this initiative extends far beyond the biophysical and sociopolitical scope of urban greening as exemplified by the MillionTreesNYC program, whose goal is "to plant and care for one million new trees across the City's five boroughs" (2014).

functions and services depends on geographic location, societal choices, and values

(Haines-Young and Potschin 2010), as well as the question being asked by the

investigator (Grove, Hinson, and Northrop 1999). Indeed, the air quality discrepancy

described previously suggests the need to incorporate direct human health outcomes

in any conceptualization, definition, and assessment of UES. This was recently

reinforced at the December 2014 conference proceedings of A Community on

Ecosystem Services, which made the following one of its three most important goals

to address prior to the next gathering: "Explicitly and formally link ecosystem

services with human health and well-being" (ACES 2014).

3) <u>Scale:</u> Urban greening usually occurs at nested scales within the jurisdictional limit

of cities.[10] Yet, the accepted conceptual framework guiding UES research is the one

developed by the MEA in 2005, which encompasses the global and sub-global

ecosystems that support human life (see Figure 7.7). In other words, the relationship,

direction, and strength of services provided by ecosystems in urban areas – highly

altered biomes that occupy .5% of the Earth's land area (Schneider, Friedl, and Potere

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[10] Tree Pittsburgh (2010) describes its urban forest as "all of the trees within the city boundaries." Green Area Factor policies apply to sites within the jurisdictional limit of the authorizing municipality (e.g. City of Seattle 2012; District of Columbia 2014). Green roof policies are usually undertaken by municipal authorities for application within the city's jurisdiction (Eisenman 2007; Carter and Fowler 2008).

2009; Angel et al. 2011)[11] – are likely to be dramatically different from global

ecosystem services. Indeed, the findings of this dissertation support claims that as one

moves from wildland and rural areas to urban landscapes, cultural ecosystem services

become more important (Haines-Young and Potschin 2008; Wolf 2012). These

distinctions illuminate a substantial gap between ecosystem services theory and urban

greening practice, and highlight the need for an UES framework that responds to the

sociopolitical and biophysical reality of municipal greening practice. To the best of

this author's knowledge, no such conceptual framework currently exists.[12]
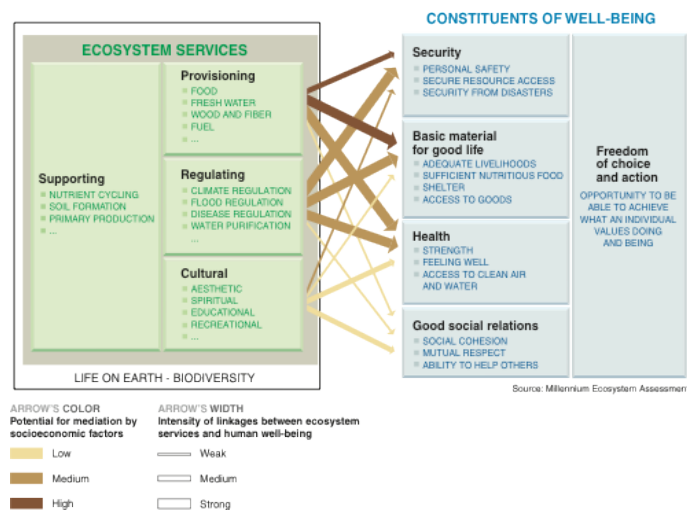
Figure 7.7: Linkages between ecosystem services and human well-being (MEA 2005a, VI) [Courtesy of World Resources Institute].

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[11] The MEA (2005b, 18) places this figure at "less than 3% of the total land area of Earth." Of note, urban areas worldwide are expanding on average twice as fast as their populations (Angel et al. 2011; Seto et al. 2011).

[12] Radford and James (2013) have developed a new analytical tool for the non-economic valuation of ecosystem services across a rural-urban gradient; but this is not the same as a conceptual framework such as that developed by the MEA (2005).

4) <u>Disciplinary Scope</u>: As noted in Chapter IV, the MEA (2005c, 14) describes human health as "the central aspect" of ecosystem services, and the American Planning Association describes public health as the principle outcome of green infrastructure (APA 2013, 16) – the biophysical artifact that generates ecosystem services. Yet, public health expertise is virtually absent from UES and GI discourse. A review of 463 articles addressing ecosystem services in an urban context organized this literature in five categories, and human health is absent from this classification. Likewise, of 18 journals that have published at least five articles on UES, none represent public heath (Hubacek and Kronenberg 2013).

This inattention to public health literature is, perhaps, not surprising given that the ecosystem services discourse has been driven primarily from within ecological economics, environmental science, and conservation biology (Roy, Byrne, and Pickering 2012; Keune et al. 2013). Yet, the lack of interdisciplinary discourse may be one of the contributing factors to the science-practice gap on the effect of trees upon local air quality described in Chapters V and VI. As mentioned, deposition modeling of air pollution removal by trees has been strongly critiqued, primarily in the pages of natural science journals such *Environmental Pollution, Frontiers in Ecology and the Environment,* and

Nature.[13] One of the most direct exchanges emerged in the first of these journals, where

Whitlow et al. (2014a; 2014a) questioned the assumptions, methods, and extrapolation of

results by Nowak et al. (Nowak et al. 2013). At the risk of oversimplification, the

following distills the essentials:

- Nowak et al. (2013) modeled $PM_{2.5}$ in 10 U.S. cities and concluded that trees

reduce mortality by an average of 1 person/city/year with an average value per

mortality incidence of $7.8 million.

- Whitlow et al. (2014a, 256) submitted a Letter to the Editor stating that: "Given

the error associated with the model . . . it is very likely that predicted mortality

might actually be negative when the typical reduction in mortality is 1 person per

year." Moreover, deriving large monetary values has the net effect of "distracting

attention from the marginal impact that urban tree canopy may have on air

quality."

- Nowak et al. (2014, 257) responded: "Marginal impact on air quality is not the

same as having a marginal impact on human health and value . . . And trees can

produce substantial health improvements and values in cities."

[13] Scientists exploring other mechanisms mediating air pollution via trees have published in *Atmospheric Environment, Boundary-Layer Meteorology, Journal of Environmental Management,* and *Environmental Science & Technology.*

- Whitlow et al. (2014b, 259) replied: "The conclusion of this paper concerns us because readers who are not familiar with the underlying science will likely reach the erroneous conclusion that planting trees will improve air quality and cardiopulmonary health. Furthermore, catch phrases like 'substantial health improvements' are prone to be repeated in the popular media, policy statements and unfortunately even in scientific papers without nuance or qualification."

Notwithstanding the technical details, a noteworthy characteristic of this disagreement is that it has now arrived at a standoff over the definition of 'substantial health improvement.' Yet, of the twelve co-authors contributing to this conversation, none are public health scholars. From both an epistemological and practical standpoint, this is problematic. Moreover, public health research tends to addresses a different air quality mechanism that frames urban trees/vegetation as a respiratory health problem due to pollen allergy – described as one of the most widespread diseases in urban populations (D'amato 2000; Dales et al. 2008; Cariñanos and Casares-Porcel 2011; Jariwala et al. 2011; Jariwala et al. 2014). More broadly, this example suggests that the ecosystem services and urban greening discourse is prone to a narrative that is potentially skewed by overreliance upon natural science. This assumes heightened relevance in light of the fact that cities are, "most fundamentally . . . socioecological systems that are built by and for humans" (Groffman et al. 2014, 74).

As the relationship between urban greening practice and UES research evolves,

interdisciplinary engagement should clearly be a priority. This needs to include greater

engagement with scholars in the social sciences and humanities, public health,

psychology, and landscape architecture and urban planning (Colding 2011), whose

facility with physical design, municipal governance, and community outreach bridges the

research-practice divide.[14] The findings of this dissertation also support arguments that

ecosystem services do not merely reflect an objective biophysical reality; they must also

be understood and studied as a social phenomenon (Ernstson and Sörlin 2013). As urban

environmental research blurs boundaries between science, practice, and advocacy, "it

matters who gets to experiment, and how" (Evans 2011, 233). And "any attempt to forge

more viable relations between city and nature will be as much a politics of knowledge as

a politics of urban space" (Lachmund 2013, 236).

Finally, UES research should consider both the universal and place-specific

characteristics of cities and urban areas. For example, Groffman et al. (2014) are pursuing

research on "urban homogenization," exploring how urbanization may be a key macro-

scale driver of local and regional ecology that largely overrides natural climate and

ecology. Outcomes of this type of research may facilitate the development of

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[14] Signs of this integration are emerging. The American Public Health Association (APHA) has adopted a
new policy entitled Improving Health and Wellness through Access to Nature (Chawla and Litt 2013).
Sullivan et al. (2014) have called for the meeting of Gaia (the Greek goddess who personified Earth) and
Asclepius (the god of medicine, healing, and rejuvenation) in the pages of *Landscape and Urban Planning*.

generalizable claims regarding UES. With that said, the vegetative composition of

Albuquerque, New Mexico is vastly different from that of Portland, Oregon or Charlotte,

North Carolina. This complicates generic tree canopy cover and greening norms. Indeed,

the "identification and ranking of ecosystem services critical to the particular city or

region," is an important priority when using ecosystem services as a basis for urban

design (Windhager et al. 2010, 120). Moreover, if cultural (psychosocial) outcomes are

principal ecosystem service benefits in cities, research and practice should emphasize the

aesthetic, experiential, socioecological, and urban design dimensions of urban flora.

Urban Greening in the Anthropocene

Here in the early 21st century, a strong majority of Americans, 83%, have expressed

concern about the environment and believe that at least some (if not immediate and

drastic) action must be taken to address environmental problems (Winter and Koger

2004).[15] In Europe, over two-thirds of people consider themselves environmentalists

(Castells 2010). This mainstreaming of ecological values can be seen as a half-century

progression that blossomed in the 1960s, gained federal U.S. protections in the 1970s,

and over the past few decades has evolved to an expanding concern for the global

biosphere, abetted by the emergence of sustainability in the 1980s and 1990s. The

proposition in the early 2000s that humanity's impact on the planet is so extensive that

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[15] According to a recent poll, two-thirds of Americans said they were more likely to vote for political candidates who campaign on fighting climate change (Davenport and Connelly 2015).

the Earth has entered a new geological epoch known is the Anthropocene, is now moving
to the center of popular awareness.

National Public Radio has featured the Anthropocene in multiple segments (2008; 2013;
2014), and dedicates a webpage to the subject (2014). *National Geographic* ran a special
feature on the Anthropocene (2011). Reaching #4 on the New York Times bestseller list
for nonfiction (2014), *The Sixth Extinction: An Unnatural History* (2014) highlights the
Anthropocene as the overarching context for massive species decline. Even establishment
financial magazines such as *Forbes* (2014a; 2014b) and *The Economist* (2011) have
featured the subject.

The geologic span and planetary scope implicit in the Anthropocene is, perhaps, unlike
anything that humans have previously recognized. And it is no hyperbole to suggest that
the epochal environmental challenges presented by anthropogenic species extinction and
climate change is unprecedented. As the 21st century mind now internalizes the
implications of this socio-environmental phenomenon, making meaning of urban
greening assumes heightened significance.

This dissertation suggests that urban tree planting is motivated in part by concern about
global environmental decline. In a series of Likert scale questions: 64% of respondents
Strongly Agree or Agree with the statement: "Conserving and planting trees in my city is

an important strategy to mitigate global climate change;" 79% of respondents Strongly

Agree or Agree with the statement: "Thinking globally and acting locally accurately

depicts my approach to tree planting;" and 82% of respondent Strongly Agree or Agree

with the statement: "Urban tree planting is an important strategy to protect the global

biosphere."

When asked to expand upon this, some participants spoke directly to an emotional

response to environmental decline.

– "People recognize that things are out of whack, and they want to take

responsibility. I can't tell you how many times I've heard people say, 'I recognize

that the global environmental is suffering, and I wanted to do something to make

a positive change.'"

– "Planting trees is something concrete. You can see what you've done at the end

of the day and it might make you feel connected to the greater world. It's a baby

step."

– "I'm so frustrated by how much energy we put into planting smaller and fewer

trees – this year alone 800 trees in [our city] – when a fracking site is going to

take down so many more mature trees. Our urban tree planting efforts are a drop

in the bucket compared to what's being lost regionally and globally."[16]

While sincere in motive, these sentiments substantiate critiques of tree planting and ecological restoration more broadly. Some argue that restoration activity is misguided in that it aspires to fulfill an Edenic impulse for a bygone world that never existed and for which there is no baseline threshold (Merchant 1996; Eisenberg 1998; Marris 2011). Cohen (2004, 165) contends that planting trees to soothe human guilt about environmental degradation serves as an emotional analgesic that ultimately lulls people into complacency by distracting attention from root causes to mere symptoms. Stated more sharply, it "allows[s] the public to engage in parasitic relationships with nature (which shows signs of growing crisis), all the while believing they are changing the world for the better."

One respondent spoke about the way that a local tree planting initiative was employed for political purposes. In this case, a mayor vying for statewide executive office publicly announced an initiative to plant one million trees, but provided no funding or resources to pursue the project. Said the participant:

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[16] In the Foreword to Ellen Stroud's *Nature Next Door: Cities and Trees in the American Northeast* (2012, x), environmental historian William Cronon concludes: "Rather astonishingly, a landscape that was more than three-fourths forested when the Pilgrims landed at Plymouth in 1620, and that was more than three-fourths deforested when Henry David Thoreau made his retreat to Walden in the late 1840s, is today more than three-fourths forested once again."

– "The initiative was started by a mayor and who had – I'm trying to say this

without making it sound pejorative – it was largely politically motivated. The

mayor basically said, '[That city] is doing it. And [that city] is doing it. By God,

we're going to do it! Oh, by the way, [nonprofit group] please do this because we

don't have the money.' To plant a million trees is going to cost X, but to maintain

and water trees is going to be X squared. And so what happens is the politicians

say, 'Well, I don't care, because planting 300,000 trees plus watering doesn't get

me the legs I need. So, I'm going to plant a million trees."

Other participants spoke about the role that tree planting may play in cultivating greater
environmental and global consciousness:

– "If you use trees, which are very approachable, as a way to talk about natural

resources, that leads to a conversation about sustainability. And so it's maybe a

consciousness raising issue."

– "The trees themselves provide some benefits at a city level, but the main benefit

is the shift in attitude towards more environmentally sensitive politics and

behaviors."

– "People are egocentric, and if they see their own sphere in the world including a

greater concern for environmental sustainability, then it has ripple out effects

across the planet."

– "I work with students in K-12 and when you talk about rainforests being cut down or polar bears losing habitat, they can't relate to that. But when you talk about planting trees in your backyard, it's something tangible that they can relate to. And it instills environmental values that may lead to them one day working to save the rainforest."

These qualitative statements are supported by the survey results reported in Chapter VI, where 91% of respondents Strongly Agree or Agree that "conserving and planting trees in my city will increase residents' environmental stewardship." Research supports the idea that municipal tree planting can increase ecological awareness, and that this may in turn build support for efforts to protect the environment (Summit and Sommer 1998; Connolly et al. 2013; Falxa-Raymond, Svendsen, and Campbell 2013).[17] Yet, the causal pathway from grassroots urban tree planting to increased ecological consciousness to global environmental protection seems fairly remote.[18] Moreover, 'ecological stewardship through tree planting' is a narrative generated primarily by tree planting

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[17] Research also suggests that tree planting can increase community engagement and satisfaction (Dwyer et al. 1992; Sommer et al. 1994; Westphal 2003), which may lead to more livable communities.

[18] This author has made the anecdotal observation that in other countries such as Sweden, citizen-based tree planting and stewardship is not a common social practice; yet that nation is generally regarded as having enlightened environmental policy.

advocates; not necessarily by residents, who are the "recipients or consumers" of this messaging (L. K. Campbell 2014, 255); and whose relationship to trees may be different from those of advocates.

For example, in post-survey interviews with tree planting leaders, a consistent theme that emerged was a perceived need to rationalize tree planting differently to two principle audiences: 1) municipal leaders, foundations, and corporations; and 2) residents.

 – "If I'm talking to a home-owners association, I'm talking about real-estate values and aesthetics. But if I'm talking to municipal and elected officials to pass a tree planting program or a new landscaping ordinance, I have to reference the ecosystem service benefits."

 – "When I'm fighting for policy and dollars – especially in cities that are stretched in their budgets – you have to be able to show a return on investment. You have to be able to show it in dollar terms. This is especially true for corporations. We give them a nice certificate with the return on investment . . . using the UFORE i-ECO modeling program."

 – "I think if you play up the aesthetic and mental health benefit of trees, it's a huge argument because we have a lot of mental health issues in this country today. The challenge here is that we are funded by the Bureau of Environmental

Services and they want us to highlight environmental benefits like air quality and stormwater. But when talking with homeowners, I usually find that they don't care about these benefits. They don't see those benefits. But they do get an immediate benefit from seeing flowers on trees in spring. That's what it ultimately comes down to: the beauty and good feelings that trees generate. I don't want to down to play down the benefit that the bureau of environmental services provides: without their funding, we couldn't do the kind of work we're doing in our city."

These statements illustrate a fundamental tension. On the one hand, managers feel compelled to make quantitative and monetary arguments to rationalize public policy and funding for tree planting. On the other hand, managers believe that residents value the aesthetic and emotional benefit of trees. This supports arguments by scholars that ecosystem services discourse gives undue primacy to utilitarian values (Chee 2004; Kumar and Kumar 2008; Chan, Satterfield, and Goldstein 2012; Daniel et al. 2012). In cities, Ernstson and Sörlin (2013) also argue that the rhetorical and practical aspects of a utilitarian ecosystem services narrative depoliticizes the urban environment through a number of universalizing attributes (see Figure 7.8).

- De-historicization—the decoupling of objects of analysis (ecosystems, parks, cities, neighborhoods, etc.) from real world actors, events, and processes.
- De-contextualization—disregarding social realities, conflicts, interest driven contestations and actual use of ecosystems on the ground.
- De-ecologization—focusing on the measurable services of individual species or single systemic effects, paradoxically disregarding traditional holistic and interactive dimensions of ecology (Norgaard, 2010).
- Silencing—privileging particular strands of expertise (Bocking, 2004; Sörlin, in press), marginalizing voices that are local, including those that represent traditional ecological knowledge (Howitt and Suchet-Pearson, 2003; von Heland and Sörlin, 2012).

Figure 7.8: Depoliticizing elements of ecosystem services discourse. Ernstson and Sörlin (2013, 281). Highlighted text by author to increase legibility.

Interviews with tree planting leaders support this critique:

– "In speaking with residents, I think they value beauty. I don't think I included that because as important and wonderful a benefit as that is, I'm so practical . . . and the technical benefits rise above."

– "Citizens respond positively to trees that are beautiful and flower; which may not be a forester's preference."

– "Most people don't realize all of the work that trees do. Unless you have a strong connection to urban forestry and science, you're not aware of these benefits. Citizens don't have the long-term perspective to understand the benefits of trees. They're more concerned with immediate gratification."

– "A community member came in and asked about her Cherry Tree and Dwarf Japanese Maple, wondering why they weren't thriving. I think she was overwatering. I tried to persuade her to replace them with a large shade tree, but she talked about how much she loves these trees. As an urban forester, I prefer trees that have a larger canopy because they have greater environmental performance. Plus, our city now has a 40% canopy goal, and we're never going to make it planting ornamentals."

In sum, these findings suggests that contemporary urban tree planting – and possibly urban greening writ large – is motivated in part by a response to man-made global environmental degradation; and that utilitarian ecosystem service arguments are being employed as a solution to this problem. It also suggests that on some level – consciously or not – we may be trying to vegetate cities in an attempt to reverse negative human impacts on the biosphere, i.e. the Anthropocene.

Closing Thoughts

This inquiry into the historical and contemporary bases of urban greening suggests a need for greater discernment and integration between two important concepts animating the discourse on cities today – namely, *livability* and *sustainability*. As noted by Silvera Seamans (2013, 3), "the application of tree-based environmental services to problems of

environmental quality is intimately related to sustainability." This term originated out of concern for the interrelationship between population growth, resource use, and pressure on the environment (Kidd 1992). Sustainability has since evolved to include social variables such as equity and economics, described by Campbell (1996) as "the planners triangle" and by Elkington (1998) as the "triple bottom line." However, sustainability still has a strong environmental and natural science orientation, all the more so with growing concern about anthropogenic climate change and species decline. The environmental sustainability discourse is, by extension, prone to anti-urban (Light 2001) and misanthropic rhetoric (Bookchin 1991; Watson 1992).

Livability, on the other hand, is an anthropocentric and mostly urban notion. Merriam-Webster (2014) defines the term as "suitability for human living," and it is often used in conjunction with "livable communities" (Wagner and Caves 2012) or "livable cities;" described as a movement "to enhance the well-being of inhabitants of cities and towns, strengthen community, improve social and physical health, and increase civic engagement by reshaping the built environment of our cities, suburbs and towns" (IMCL 2012).

Both livability and sustainability are important aspirations for cities, and urban greening may be a strategy to advance both of these goals. But as ecosystem services is adopted as a rhetorical frame for urban greening, the discourse must move beyond its utilitarian bias

and embrace the full range of benefits, as well as disservices, that people may derive from vegetation in cities. In particular, this will require greater attention to cultural ecosystem services and increased engagement with disciplines whose expertise resides in this domain, including but not limited to: social science; community psychology; public health; public policy; landscape architecture; civil engineering; and urban planning and design.

Creating livable, desirable, and lovable cities could actually be one of the most important strategies to pursue in the name of global sustainability, as urban residents may have a lower per capita physical and ecological footprint than non-urban residents (Light 2001; Owen 2009; Gaston 2010; Jones and Kammen 2014; Maclean 2014). Towards this goal, scholars highlight the importance of aesthetics, beauty, and urban greening (Hosey 2012; Montgomery 2013; Benfield 2014). Others emphasize that in an urbanizing world, nature contact becomes essential (Sullivan 2005; Louv 2008; Beatley 2011; Kellert 2012). This is especially true if one ascribes to the maxim: "We shape the city. Then it shapes us" (Reader 2005, 1). While some contest city living as a normative strategy for global environmental sustainability,[19] the inescapable fact is that the world is urbanizing and in a

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[19] William Rees (2012) argues that, "high-income consumer cities are concentrated nodes of material consumption and waste production that parasitize large areas of productive ecosystems and waste sinks lying far outside the cities. The latter constitute the cities' true 'ecological footprints . . . To achieve sustainability, global society must rebalance production and consumption, abandon the growth ethic, relocalize our economies and increase urban-regional self-reliance, all of which fly in the face of prevailing

few decades the vast majority of people will be residing in cities. It is clearly in our

interest to make the dominant form of human habitation as livable and sustainable as

possible (Girardet 2007). This dissertation suggests that urban greening may contribute

more to the former than the latter.

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global development ideology." Others point to 'decentralized concentration' as an urban planning norm (Holden 2004).

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