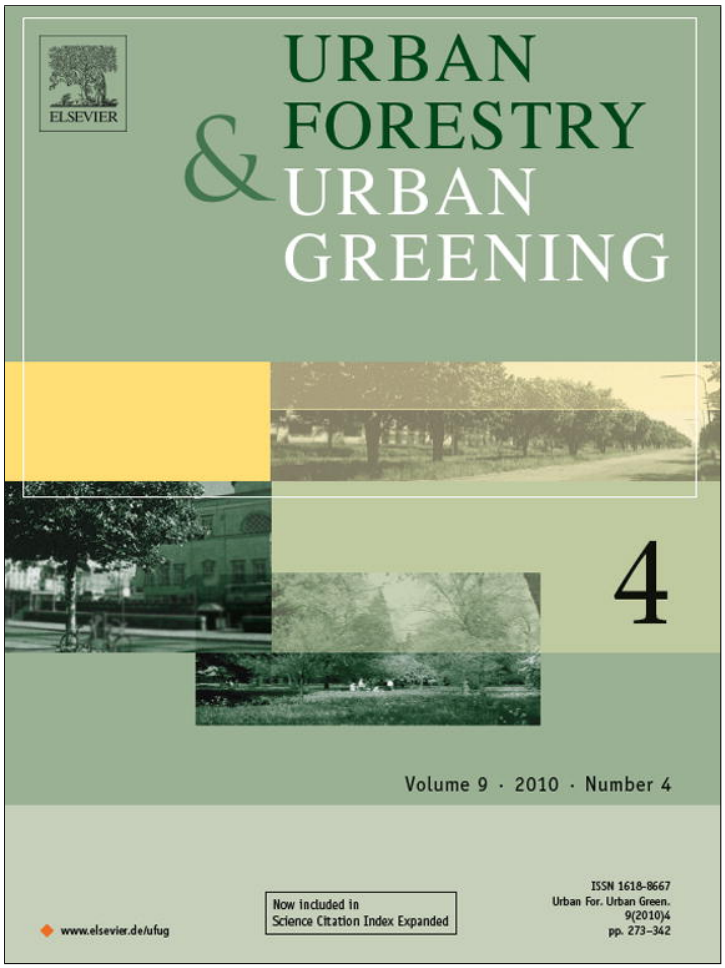

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Managing municipal green space for ecosystem services

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ABSTRACT

Cities are the dominant form of human settlement. As centers of economic growth and population they are focal points of both ecological disturbance (through resource consumption and land conversion) and the provision of public goods. Ecosystem services provided by municipal forests and green space are positioned to address both these arenas. While technical means to mainstreaming this approach have grown, the importance municipal foresters' departments place on pursuing this objective and their department's engagement in actions necessary for its realization is under-researched. I surveyed the membership of the Society for Municipal Arborists to address this gap. I found that municipal foresters perceived the management of municipal green space to enhance ecosystem services to be increasingly significant to the goals and actions of their departments. Survey respondents expected this role to grow in importance, matching or exceeding some traditional objectives of their profession. While most perceived traditional services such as tree planting and maintenance, and social outputs like beautification and enhancing public health to remain high departmental priorities; respondents rated managing municipal green space to produce ecosystem services such as enhanced energy and climate management, water quality and habitat and biodiversity as more important to their department than traditional objectives such as maintenance of property values and protection of power lines. As responsibility for the management of urban green space resides predominantly at the municipal level, the importance municipal foresters' departments place on managing for ecosystem services is fundamental to advancing this strategy for the delivery of public goods in urban centers.

Introduction

Urbanization and environmental decline

The contemporary city's function as a "growth machine" and center of accumulation has resulted in an increasing draw of energy and materials from global hinterlands to metropolitan centers (Logan and Molotch, 1987; Rees and Wackernagel, 1996). The urbanization process supporting these roles currently operates through widespread land conversion and incomplete waste assimilation resulting in increased energy consumption, impermeable surface, disturbance of the hydrological cycle, climate alteration and habitat and biodiversity loss.

These impacts affect environmental patterns and processes from the local to the global scale through climate change (i.e., increasing urban heat island effect and carbon emissions), water management challenges (i.e., increasing run-off and flooding) and biodiversity loss (i.e., increasing habitat alteration and the introduction of non-native species). As a result, cities are hotspots where the concentration of energy and materials (through the demand for and consumption of resources) and the transformation of landscapes (through the urbanization process) contribute significantly to contemporary environmental problems (Odum, 1971, 2007; Foster, 2007).

Concurrent to their role as centers of disturbance, cities are also now home to the majority of humans. This demographic trend in urbanization is expected to continue resulting in over 5 billion humans residing in metropolitan centers by the year 2030 (UN, 1997, 2007). As a result, cities have and will increasingly play a key role the delivery of public services as well as offer a critical arena in which to address a wide range of ecosystem health issues.

Ecosystem services reside at the nexus of these two issues. Defined as the ability of robust ecological systems to provide, directly or indirectly, products and services fundamental to the healthy functioning of human societies, the management of these systems becomes important both for the continued delivery of public goods and improving the ecological health of cities (Costanza et al., 1997; Bolund and Hunhammar, 1999). However, in order to realize this synergy, a key question is whether municipal foresters rate the production of ecosystem services as important to their department's objectives. Understanding the extent to which municipal foresters perceive their departments to be prioritizing such man-

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agement can provide insight into the scope and trajectory of public sector interest in using this strategy to join urban environmental quality with the provision of public goods.

Background

Managing urban forests as an ecological and public goods asset

Urban forestry is one of the earliest professional components of North American municipal green space management (Cook, 1894; Campanella, 2003). From its outset, advocates have identified the urban forest and its associated green space as an important focal point for the delivery of social and environmental goods (Konijnendijk, 1997; Ricard and Bloniarz, 2006). Historically this emphasis was described both in terms of the urban green space's impact on air quality (acting as the "lungs of the city") and its influence on social behavior through amenities such as beautification and shade (Olmsted, 1858; Fernow, 1910; Ricard, 2005).

More recently, public, community and private actors at local, national and international levels are expanding and refining this purpose through recognizing urban forests and green space as a central component of a community's overall "green structure" or "green infrastructure" (Werquin et al., 2005; Benedict and McMahon, 2006; Tratalos et al., 2007; USDA, 2009a). In this role, urban forests and their related green space are identified as fundamental assets in a community's infrastructure, important in addressing a broader range of environmental and societal issues. This importance centers on the environmental, economic and social value of the ecosystem services that urban forests and green space provide (Forrest et al., 1999; Dwyer et al., 2003; James et al., 2009; USDA, 2009b).

As a result, public, private, and non-profit institutions are investing in efforts to increase the capacity of researchers and forest managers and advocates to understand and quantify the value of services urban forests and green infrastructure produce. This effort has yielded a number of studies and proposed research frameworks seeking to refine the comprehension of the economic, environmental and social contribution made by the urban forest and municipal green space. These outputs aim to assist researchers and communities in determining the scope, value and potential of the ecological services provided in urban areas (Dwyer et al., 2002; Konijnendijk et al., 2007; Loram et al., 2007; Tzoulas et al., 2007; James et al., 2009).

Additional capacities advanced by these investments include the development and harnessing of more robust observational tools such as: aerial photography and Landsat imaging that increase the ability to assess the urban forest; computer modeling and traditional field studies that estimate the specific ecological and economic contribution of the services urban forests generate; the creation of accessible, analytical software programs such as UFORE (Urban Forest Effects Model), CITYgreen and i-Tree that can manipulate this data; and the promulgation of new regulatory frameworks such as EPA's expanded storm water management mandates that allow green infrastructure inclusion as a component of municipal best management practices (Dwyer et al., 2002; EPA, 2009; Schwab, 2009a,b).

Complimenting these proposed research frameworks and analytical tools have been a range of studies emphasizing the importance of local knowledge in approaching issues in urban forestry and its associated green space. These studies focus predominantly on citizen and policy makers' perspectives on the importance, maintenance and role of urban forests and green space (e.g. Austin, 2002; Treiman and Gartner, 2004).

While these capacities provide powerful new research methods, insights and quantitative means for municipal foresters to engage municipal green space to produce both public services and improvements in environmental quality through ecosystem services, the priority municipal foresters' departments place on the pursuit of this objective and the actions necessary for its realization becomes increasingly significant. As intellectual understanding and tools supporting this approach have grown more robust, key questions remain. Do municipal foresters rate the production of ecosystem services as important to their department's objectives? Has their perception of its importance changed over time? How do they rate its importance to their departments in comparison to more traditional urban forestry objectives? And what specific actions, if any, are their departments taking to enhance municipal green space to produce ecosystem services?

Researchers have posited that increased understanding of the ecosystem services provided by urban green space has not been adequately integrated into the management process (Yli-Pelkonen and Niemela, 2005). While research frameworks, computerized analytical tools and the perceptions of citizens and public officials have received significant attention, municipal foresters perceptions of their department's objectives remain under-researched (Ricard and McDonough, 2007). Since responsibility for the management of urban green space resides predominantly at the municipal level, examining the importance managing for ecosystem services holds for municipal foresters and their departments is vital to achieving this end (Bolund and Hunhammar, 1999; Niemela, 1999).

Understanding municipal foresters' perspective on the importance of these management issues can give us insight into the priorities and actions influencing the engagement of municipal foresters' departments in the production of ecosystem services. By identifying municipal foresters' perceptions of its importance to their departments' operations, a deeper understanding can be gained of the extent to which municipal foresters are directed to prioritize engagement in the production of ecosystem services as a means to deliver public goods and mitigate environmental problems. In addition it can contribute to more general demands for increased research on urban forest management (Konijnendijk et al., 2007).

Methodology

To answer these questions I performed, in cooperation with the Society of Municipal Arborists (SMA), a survey of North American members of the SMA that asked:

- What is the range of municipal green space managed by SMA members' departments?
- How important, in their management of these assets, do public sector SMA members' departments rate the production of ecosystem services over time?
- What specific actions do their departments take in managing these assets to enhance ecosystem services?

Selection of survey population

I selected the membership of the SMA as the survey population to investigate these questions. The SMA is the largest professional organization representing municipal foresters in the United States. Founded in 1964, the SMA's members also include consultants, commercial firms and citizens who "actively practice or support some facet of municipal forestry".

The SMA's membership is predominantly based in North America and is a professional affiliate of the International Society of Arboriculture. As such it is the leading professional organization of municipal foresters in North America. The SMA identifies its mission as: "Leading the world in building the confidence, competence,

and camaraderie of the family of professionals who create and sustain community forests" (SMA, 2010). In surveying the public sector members of the SMA, I sought to gain insight into the extent to which these members felt their departments were prioritizing and engaging the production of ecosystem services in the management of municipal green space.

Definition of terms

Municipal foresters

Researchers and professionals use a broad range of terms to define the individuals who manage urban forests and their associated green spaces (Konijnendijk et al., 2006). Historically and in contemporary usage, forestry professionals managing green space assets at the municipal level have variously been labeled: city forester, town forester, shade tree commissioner, tree warden, city arborist, municipal arborist, and municipal forester (Kinney, 1972; Jorgensen, 1986; Miller, 1997; Harris et al., 2004; Ricard, 2005). I have selected to use the term "municipal forester" in this paper to represent this population. I selected the term "municipal" because as members of the SMA, the survey population has self-identified its interest in the municipal-level management of these assets. I chose the term "forester" in recognition of the historical and growing role urban forestry professionals have and are playing beyond single-tree management in the supervision of green space assets.

Municipal forester's department

Throughout the paper I use this term "department" to refer to the immediate department or agency to which the respondents report.

Municipal green space and ecosystem services

For the purposes of this study I defined municipal green space as publicly managed natural resource assets in a city or town including street trees, parks, "natural areas", cemeteries, utility rights-of-way, and the grounds of public buildings (Swanwick et al., 2003; Randrup et al., 2005; Konijnendijk et al., 2007). Not included in this study (although still falling within the general definition of green space) were privately held and managed land such as individual residences, private parks, corporate campuses and commercial and industrial areas.

Using the categories set out in the Millennium Ecosystem Assessment (2005) I defined ecosystem services as the functions of natural assets to provide:

- *provisioning services*: (e.g. fuel and materials)
- *regulating services*: (e.g. carbon sequestration, climate regulation and water quality management) and
- *support services*: (e.g. preserving habitat and species diversity)

Research objectives

Specifically I wanted to learn how SMA members:

- rated the importance to their department of environmental management and natural resource conservation to enhance ecosystem services along side "traditional" municipal green space management objectives such as tree maintenance, beautification, property value enhancement, public health and recreation;
- viewed the trajectory, over time, of the importance of such management objectives to their department;
- and rated the importance of actions addressing energy and climate, water quality and biodiversity issues in their department's management of municipal green spaces.

Elaborating on the latter question I further investigated SMA members' perception of the importance their departments place on natural resource management strategies to produce specific ecosystem services affecting:

- energy and climate through:
  - reducing urban heat island effect,
  - sequestering carbon/providing carbon-neutral fuel;
- water quality, through:
  - reducing run-off and flooding, and;
- non-human species, through:
  - improving habitat and
  - supporting biodiversity.

Study execution and response rate

The directorship of the SMA agreed to the study and the online survey was emailed to the membership and announced on the SMA web site. In accordance with Dillman (2007), outreach for the survey included two pre-survey notifications and two reminder notices from the SMA's executive director emailed prior to and following the survey's distribution to the SMA membership.

The survey instrument was divided into eight sections. The first queried municipal foresters about the portfolio of green space assets their department managed. This section also covered municipal foresters' perceptions of their department's current and past goals related to the environmental management and natural resource conservation of these assets. The next three sections of the survey asked municipal foresters to rate the importance to their department of a series of municipal green space management actions related to energy and climate, water resources, and biodiversity and habitat. The fifth section sought municipal foresters perceptions regarding the engagement of their department's current operations in managing municipal green space to produce ecosystem services. The sixth section of the study asked respondents for their perceptions about sources of current support or constraint of their department's managing municipal green space to produce ecosystem services. Section seven and eight queried respondents for their expectations regarding the extent to which, in the future, their department would be involved in managing municipal green space to produce ecosystem services and the future sources of support or constraint of such actions.

This survey of SMA members garnered a 51% response rate (599 respondents out of a possible 1175). The respondents were categorized by their employment sector: public, private, education, and non-profit. The largest subgroup of respondents were members of public sector organizations where $n = 480$ (or 80% of total respondents). I reported results in terms of percentages of public sector members of the SMA. I used the data to identify respondents' perception of the importance of a range of objectives and specific methods to their departments' work both currently and over time. In addition, I used cross-tabulations to determine what percentage of respondents who ranked objectives related to environmental services (climate, water quality and habitat and biodiversity management) as very important to their department also ranked specific methods as very important to their department's effort. The analysis, frequencies, and tables in this paper are limited to this subgroup: public sector members of the SMA. Future papers will incorporate the entirety of the dataset.

Results

Public sector SMA members responding to the survey indicated a broad portfolio of green space assets under their department's supervision. Over 95% identified the maintenance and replacement of street trees as a part of their management responsibilities. In

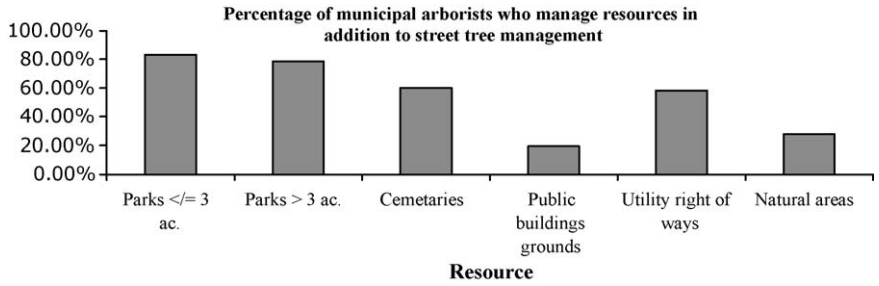


Fig. 1. Public SMA members whose organizations manage other green space assets in addition to street trees (% of public sector respondents).

addition to street trees, many identified additional municipal green space assets including large (greater than 3 acres) and small (3 acres or less) parks, cemeteries, public buildings grounds, utilities rights-of-way, and natural areas (see Fig. 1) under their management.

Public sector respondents responsible for street tree maintenance also managed large parks (83.4%) and small parks (78.7%) while approximately 60% were responsible for cemeteries (60.1%) and utility rights-of-way (58.1%). Natural areas and public building grounds were also included in the management portfolios of 27.8% and 19.4% of public sector respondents respectively.

In assessing the importance of various objectives to their departments, SMA members ranked both *traditional services*, such as maintaining and replacing street trees, beautification, protecting power lines and enhancing public health, recreation, and property values; and *environmental services* such as energy and climate management and water quality, habitat and biodiversity enhancement (see Table 1).

Maintaining and replacing street trees ranked very high in departmental objectives (with 83.5% of public sector respondents ranking it "very important" and 95.3% ranking it "very" or "moderately" important). Traditional services that produced social outputs were ranked very important included beautification (52.8%), public health (50.1%) and recreation (38.6%). Traditional services that produced capital outputs were identified less frequently as very important objectives: maintaining property value (25.1%) and protecting power lines (21.2%).

The production of environmental services was ranked more highly as a departmental objective than traditional services that maintained capital infrastructure and property value. Energy and climate management, enhancing water quality, and habitat and biodiversity were ranked as very important objectives (41.1%, 45.2% and 37.4% respectively) above the rankings for maintaining property value and protecting power lines but below the social objectives of beautification and public health.

Public sector SMA members further ranked the change in importance of these objectives (decreased, remained the same, or increased) over the past 5 years. Nearly 60% (59.6%) reported an increase in the importance of planting and maintaining street trees while approximately one third reported an increase in the importance of traditional services that produced social outputs: beautification (38.3%), enhanced public health (37.8%) and enhanced recreation (31.9%). Traditional services that produced capital outputs were less likely to be identified as gaining in importance: enhancing property values increasing as an departmental objective for 17.5% of respondents and protecting power lines for 15.4% of respondents.

Ecosystem services were strongly identified as increasing in importance as departmental objectives over the past 5 years. Scoring below only the increased importance of planting street trees, public sector respondents saw enhancing water quality (50.7%), enhancing habitat and biodiversity (48.4%) and energy and climate management (41.1%) as increasingly important departmental objectives above the rate of increase of all traditional services (see Table 2).

Public sector SMA members were also asked to identify the extent to which their departments were presently *engaged* in the management of municipal green space to produce ecosystem services (versus its importance as an objective). Over a third identified their department as very engaged (36.6%) and over a third (36.9%) as moderately engaged in managing municipal green space for the production of ecosystem services. Approximately a quarter (24.2%) reported their department as only slightly engaged and 2.3% reported no engagement at all.

Public sector SMA members were further asked about their future expectations regarding the extent of their department's engagement in the management of municipal green space to produce ecosystem services 5 years from now. Over two thirds of respondents (69.1%) reported their expectation that their department would be very engaged in pursuing this management objective and nearly a quarter (23.3%) reported an expecta-

Table 1
Importance of departmental management objectives as rated by SMA public sector respondents.

Objective	Importance (% public sector respondents)			
	Very	Moderately	Slightly	Not
Traditional services				
Maintaining and replacing street trees	83.5	11.8	3.9	0.9
Beautification	52.8	38.6	7.5	1.1
Enhancing public health	50.1	33.4	13.1	3.4
Enhancing recreation	38.6	37.7	17.0	6.7
Enhancing property value	25.1	40.4	25.5	9.1
Protecting power lines	21.2	27.4	29.9	21.5
Environmental services				
Water quality enhancement	45.2	32.0	16.6	6.2
Energy and climate management	41.1	36.0	17.6	5.4
Habitat and biodiversity enhancement	37.4	39.1	19.6	3.9

Table 2
Change in engagement: change (over the past 5 years) in importance of management objectives as rated by SMA public sector respondents (% of public sector respondents).

Objective	Increase	No change	Decrease
Traditional services			
Maintaining and replacing street trees	59.6	33.6	4.4
Beautification	38.3	52.6	5.7
Enhancing public health	37.8	56.4	2.3
Enhancing recreation	31.9	61.7	3.4
Enhancing property value	17.5	74.2	4.7
Protecting power lines	15.4	73.4	5.7
Environmental services			
Water quality enhancement	50.7	43.6	2.1
Energy and climate management	41.1	36.0	17.6
Wildlife, biodiversity and habitat enhancement	48.4	45.2	3.0

Table 3
Current and future engagement: current and expected (over the next 5 years) engagement in managing municipal green space to produce ecosystem services.

	Level of engagement (% of public sector respondents)			
	Very	Moderately	Slightly	Not
Current engagement	36.6	36.9	24.2	2.3
Expected engagement (over next 5 years)	69.1	23.3	6.8	0.8

tion of moderate involvement. Less than a tenth (6.8%) reported an expectation that their department would be only slightly engaged and 0.8% reported an expectation of no engagement at all (see Table 3).

The percentage of respondents who identified their departments as presently very engaged in the management of municipal green space to produce ecosystem services were most highly concentrated in the South Central region of the United States and the least in the Northern Great Plains and trans-Mississippi regions. The greatest numeric concentrations (though not percentage-wise) were located in the Southern Atlantic, West Coast and Great Lakes regions (see Map A).

The percentage of respondents who expected their departments to be very engaged in managing municipal green space to produce ecosystem services in the future (5 years from now) showed the highest concentration in the Northern Great Plains region of the United States and the lowest concentration in the Great Lakes region of the United States. The greatest numeric concentrations (though, again, not percentage-wise) were located in the West Coast and Southern Atlantic regions of the United States (see Map B).

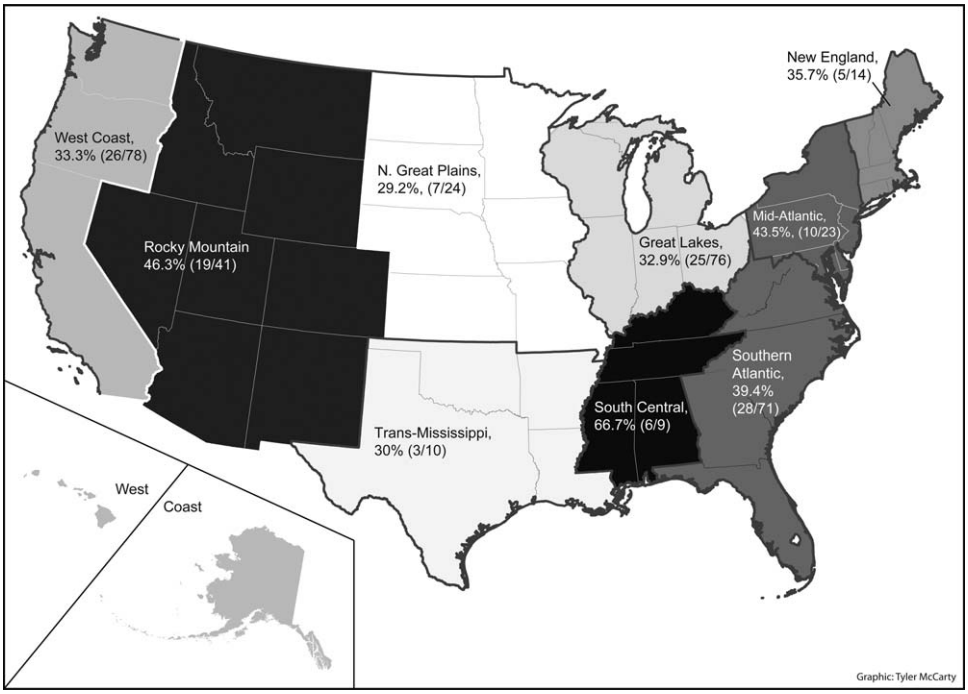
Public sector SMA members also reported on *actions* their departments were taking to produce ecosystem services. In doing so they rated the importance of specific methods in their department's work affecting climate, water quality and habitat and biodiversity. As noted above, in addition to identifying respondents ranking of the importance of these methods to their department's work, I used cross-tabulations to determine what percentage of respondents who ranked these objectives (climate, water quality and habitat and biodiversity management) very important to their department also ranked specific methods as very important to their department's efforts.

In rating the importance of methods affecting local climate over half of the public sector respondents (51.8%) identified shading impervious surfaces through planting trees or other vegetation as a very important action in their department's efforts to mitigate the urban heat island effect. One third (33.1%) identified the use of plantings to shade buildings as very important while one fifth (20%) reported using vegetation to shade water bodies as very important. These numbers rose to 71.4%, 47.0% and 30.3% respectively for public sector respondents who ranked climate management as a very important objective in their department's management of municipal green space.

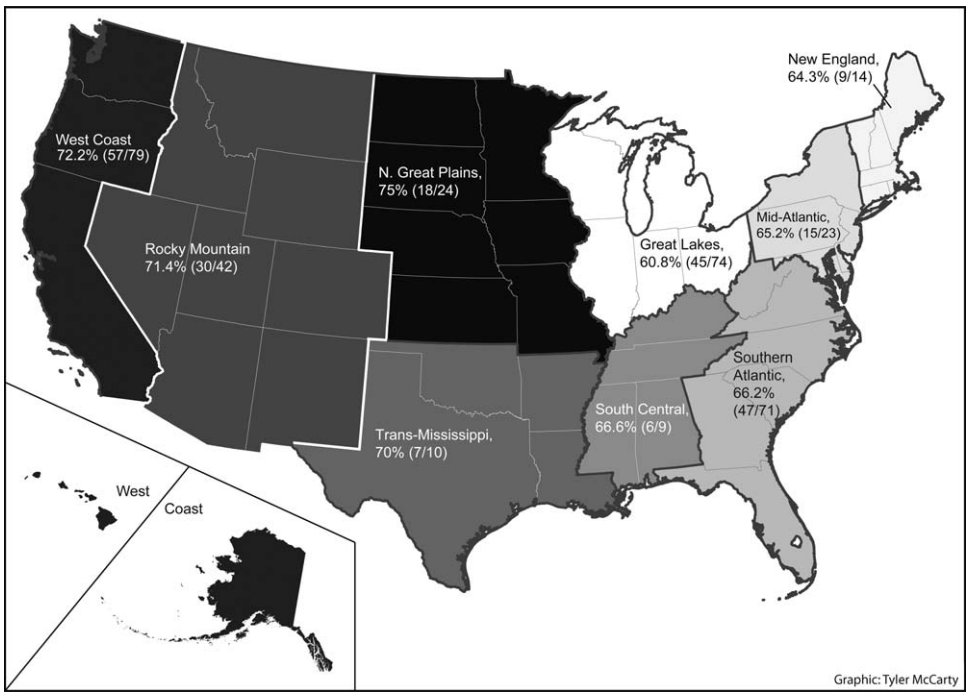
In rating the importance of methods affecting global climate, approximately 40% (39.9%) of public sector SMA members identified planting long-lived species as a carbon sink as very important in their department's actions while other methods such as planting fast growing species or the use of municipal trees for forest-related products (e.g., building materials) to sequester carbon or provide carbon-neutral fuel were rated very important by less than one tenth of respondents (6.1%, 4.3% and 4.8% respectively – see Table 4).

Correspondingly, for public sector respondents who ranked climate management as a very important objective for their department these values increased to 60.3%, 11.6%. 7.2% and 6.1% respectively (see Table 5).

Public sector SMA members also rated the importance of specific methods in their department's work affecting water quality. Over half (51.1%) rated maintaining wetlands as very important to their department's actions in reducing water quality degradation, run-off and the risk of flooding. Reducing these impacts through planting vegetated cover strips and increasing canopy cover were ranked very important less than half the time (43% and 45.9% respectively) while over a third of public sector respondents (36.4%) identified increasing permeable surfaces as very important (see Table 6).



Map A. Geographic distribution of public sector respondents who identified their departments as presently very engaged in the management of municipal green space to produce ecosystem services.



Map B. Geographic distribution of public sector respondents who expected their departments to be very engaged in managing municipal green space to produce ecosystem services in the future (5 years from now).

Table 4
Importance to public sector SMA members' departments of methods producing ecosystem services affecting local and global climate (% of public sector respondents).

Objective	Method	Very	Moderately	Slightly	Not
Climate management		41.1	36.0	17.6	5.4
Urban heat island effect	Planting trees or vegetation to shade impervious surfaces	51.8	28.8	13.5	5.9
	Planting trees or vegetation to shade buildings	33.1	40.4	20.6	5.9
	Planting trees or vegetation to shade water bodies	20.0	28.2	31.8	20.0
	Green roof plantings	6.2	13.7	27.0	53.1
Carbon neutrality/sequestration	Using wood from municipal trees for fuel	4.8	12.3	21.9	61.0
	Using wood from municipal trees for construction	4.3	11.8	22.3	61.5
	Planting fast growing species as a carbon/air pollution sink	6.1	14.8	35.9	43.2
	Planting long-lived species as a carbon/air pollution sink	39.9	33.3	14.2	12.6

Table 5
Percentage of respondents ranking climate management methods very important (all public sector respondents v. only public sector respondents identifying climate and energy management as department priorities).

Objective	Method	Department priority (%)	Department priority (%)
Climate management		41.1	100
Urban heat island effect	Planting trees or vegetation to shade impervious surfaces	51.8	71.4
	Planting trees or vegetation to shade buildings	33.1	47.0
	Planting trees or vegetation to shade water bodies	20.0	30.3
	Green roof plantings	6.2	10.4
Carbon neutrality/sequestration	Using wood from municipal trees for fuel	4.8	6.1
	Using wood from municipal trees for construction	4.3	7.2
	Planting fast growing species as a carbon/air pollution sink	6.1	11.6
	Planting long-lived species as a carbon/air pollution sink	39.9	60.3

Table 6
Importance to public SMA members' departments of methods producing ecosystem services affecting water quality (% of public sector respondents).

Objective	Method	Very	Moderately	Slightly	Not
Water quality management		45.2	32.0	16.6	6.2
	Increasing permeable surfaces	36.4	36.4	18.2	9.0
	Planting vegetated buffer strips	43.0	35.5	14.4	7.1
	Maintaining wetlands	51.1	26.8	10.9	11.2
	Increasing canopy cover for rain interception	45.9	31.5	14.8	7.8
	Engaging in watershed planning	28.3	29.3	26.6	15.8

Table 7
Percentage of respondents ranking water quality management methods very important (all public sector respondents v. only public sector respondents identifying water quality management as department priorities).

Objective	Method	Department priority (%)	Department priority (%)
Water quality management		45.2	100
	Increasing permeable surfaces	36.4	53.4
	Planting vegetated buffer strips	43.0	63.9
	Maintaining wetlands	51.1	69.8
	Increasing canopy cover for rain interception	45.9	68.1
	Engaging in watershed planning	28.3	44.4

Table 8
Importance to public SMA members' departments of methods producing ecosystem services affecting habitat and biodiversity (% of public sector respondents).

Objective	Method	Very	Moderately	Slightly	Not
Biodiversity and habitat management		37.4	39.1	19.6	3.9
Habitat	Constructing non-vegetative habitat (i.e. rock outcroppings)	9.4	18.3	36.8	35.6
	Maintaining and expanding wild areas	38.2	31.0	18.5	12.3
	Enhancing migratory habitat	19.4	26.9	33.6	20.1
	Planting species that provide food and/or shelter	25.2	37.0	27.2	10.5
Biodiversity	Planting native species	51.0	33.2	13.2	2.7
	Minimizing invasive species	52.3	29.1	13.8	4.7
	Using integrated pest management	53.9	27.9	12.7	5.4

These percentages grew to 69.8 (maintaining wetlands), 63.9 (planting vegetative cover strips), 68.1 (increasing canopy cover) and 53.4 (increasing permeable surfaces) for public sector respondents who perceived water quality enhancement to be a very important objective in the work their department does in managing municipal green space (see Table 7).

In addition to actions concerning local and global climate and water quality management, public sector SMA members were also asked to rate the importance to their departments of methods affecting biodiversity and habitat. Less than 10% (9.4%) rated constructing non-vegetative habitat (i.e. bird boxes or rock outcroppings) as very important to their department's actions while over a third (38.2%) identified maintaining and expanding wild areas. Nearly one fifth (19.4%) perceived enhancing migratory habitat and approximately a quarter (25.2%) planting species that provide food and/or shelter as very important to their department's efforts to enhance habitat. Over half of the public sector respondents rated as very important the support of biodiversity through planting native species, reducing invasive species, and employing integrated pest management methods (51%, 52.3% and 53.9% respectively – see Table 8).

Public sector respondents who ranked enhancing biodiversity and habitat as very important to their department's municipal green space management objectives had a higher incidence of identifying specific methods of enhancing biodiversity and habitat as very important to their department's work. For habitat these numbers increased to 18.1% (constructing non-vegetative habitat), 60% (maintaining and expanding wild areas), 35.5% (enhancing migratory habitat) and 48.1% (planting species that provide food and/or shelter). In regard to biodiversity, public sector respondents who identified planting native species, reducing the incidence of invasive species and employing integrated pest management as very important departmental actions expanded to 70.7%, 68.4% and 69.7% respectively (see Table 9).

Discussion

Public sector members of the SMA report that managing municipal green space to produce public benefit and environmental quality through ecosystem services is currently a significant objective of their departments. They further report that they expect it to become increasingly important and in doing so join (or exceed) more traditional objectives of their profession.

While most perceive traditional services such as tree planting and maintenance, and social outputs like beautification and enhancing public health, to remain priorities for their departments; managing municipal green space to produce ecosystem services such as enhanced energy and climate management, water quality and habitat and biodiversity was rated well above services that produce traditional capital outputs such as maintenance of property values and protection of power lines.

These groupings suggest that managing green space to produce ecosystem services aligns with the more general objective of municipal foresters' departments: to set objectives and engage in activities that are perceived to support the public good. Such alignment further suggests that expanding municipal foresters' understanding of and engagement in the production of ecosystem services to mitigate environmental issues and deliver public goods would find support within their organizational culture of reducing public risk and supporting public health (Ricard and Bloniarz, 2006). Indeed, except for the fundamental priority of planting trees, respondents reported that the importance of enhancing ecosystem

Table 9
Percentage of respondents ranking habitat and biodiversity management methods very important (all public sector respondents v. only public sector respondents identifying habitat and biodiversity management as department priorities).

Objective	Method	Department priority (%)	Department priority (%)
Biodiversity and habitat management		37.4	100
Habitat	Constructing non-vegetative habitat (i.e. rock outcroppings)	9.4	18.1
	Maintaining and expanding wild areas	38.2	60.0
	Enhancing migratory habitat	19.4	35.5
	Planting species that provide food and/or shelter	25.2	48.1
Biodiversity	Planting native species	51.0	70.7
	Minimizing invasive species	52.3	68.4
	Using integrated pest management	53.9	69.7

services had risen more rapidly than any other of their organization's objectives.

This rising focus on the importance of managing municipal green space to enhance ecosystem services appears to be taking effect in members' departments' actions. Over a third of public sector respondents identified their department as very engaged in such management practices and nearly twice as many reported their expectation that their department would become more so over the next 5 years. In contrast, less than 1% felt that their department would not be engaged at all in such management activities.

While these trends may well reflect significant and growing engagement by public sector SMA members in managing green space to produce ecosystem services, the specific actions that members identified as important to their department's methods add detail. In regards to climate management, public sector respondents ranked highly the planting of long-lived tree species to shade impervious surfaces and buildings and sequester carbon while strategies less traditional to the core mission of planting and maintaining tree stocks, such as planting green roofs and the use of wood from the urban forest as fuel and building materials to reduce heat island effect and atmospheric carbon were ranked lower in importance. The planting of fast growing species as a method of sequestering carbon was the one exception, scoring low in importance despite its potential connection to tree stock maintenance. While research indicating existing urban forests have little impact on urban carbon emissions may support respondents' low ratings for methods that reduce atmospheric carbon (Nowak et al., 1994), new emphases on net-zero urban development suggests there may be a greater future role for active urban forestry carbon management in metropolitan climate change strategies (Oregon State Board of Education et al., 2009).

Actions pertaining to water quality management reflect a similar pattern. While increasing canopy cover, maintaining wetlands and planting vegetative buffer strips are viewed as important methods in reducing run-off and flooding, more recently introduced methods with a broader focus beyond the management of vegetation, such as reducing impermeable surfaces and engaging in watershed planning efforts, received lower ratings.

Methods involving the enhancement of biodiversity and habitat also reflect distinct characteristics. While actions pertaining to supporting vegetative biodiversity such as planting native species, minimizing invasive species and the use of integrated pest management are reported as important departmental methods, the enhancement of biodiversity through the use of green space to create habitat for endemic and migratory wildlife species was perceived as less so.

Despite this understandable focus on the production of ecosystem services through methods closest to their core mission of maintaining tree stocks, public sector SMA member responses reflect an interest in some new strategies. Methods such as increasing permeable surfaces (36.4%), engaging in watershed planning (28.3%) and enhancing migratory habitat (19.4%) were identified as very important objectives by significant percentages (36.4%, 28.3% and 19.4% respectively) of the public sector respondents indicating their interest in expanding their tool set through a broader range of methods. While other actions such as planting green roofs and the harvesting of municipal trees to supply carbon-neutral building materials and fuel were ranked very low by public sector respondents, the near consensus that the objective of managing green space for the production of ecosystem services will become a fundamental part of their department's mission suggests that opportunities may arise to educate and empower municipal foresters to broaden their mandate and methods.

The importance of educating municipal foresters on the value of ecosystem services in municipal green space management is further underscored by the analysis. In each incident where municipal foresters identified objectives such as energy and climate management, water quality management and enhancing biodiversity and habitat as very important to their department, there was a significant rise in the perceived importance of methods producing ecosystem services in their support. These increases were particularly pronounced in planting fast and long-lived species for carbon sequestration, planting trees and vegetation to shade water bodies, planting green roofs and increasing permeable surfaces.

These data indicate that municipal foresters' statements about the perceived importance of ecosystem services to their departments' overall objectives are supported by on-the-ground methods. In short, they appear to be "walking the talk". Municipal foresters who identified enhancing climate, water quality, biodiversity and habitat as very important departmental outputs were more likely than the respondent pool as a whole to identify actions related to ecosystem service production as very important to their department's activities. This suggests that investments in educating municipal foresters and their departments about the value and techniques associated with producing ecosystem services could contribute to their more widespread adoption as a means of producing public goods.

Lastly, while it is not surprising that 83.5% of municipal foresters would rank the maintenance and replacement of street trees as very important (and 95.3% as very or moderately important) to their department, what is of greater interest is that nearly two thirds (59.6%) noted that this fundamental aspect of their department's objectives had increased in importance (and less than 5% reported a decrease in importance) over the past 5 years.

This may reflect the success of efforts to increase focus on the decline of urban green space and urban forest canopy covers in the United States, signaling a new commitment of attention and resources toward the recovery and expansion of urban green infrastructure (Moll, 1989; Glickman, 1999; McPherson, 2006). This renewed focus combined with respondents reported expectations about future management objectives suggests that administering these expanding resources to produce ecosystem services is becoming and can become a fundamental part of the future management of municipal green space. It further suggests a growing role for municipal foresters to deliver both environmental quality and a broader portfolio of public goods to an increasingly urbanized population.

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