

Urban Forestry Research Needs: A Participatory Assessment Process

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ABSTRACT

New research initiatives focusing on urban ecology and natural resources are underway. Such programs coincide with increased local government action in urban forest planning and management, activities that are enhanced by scientific knowledge. This project used a participatory stakeholder process to explore and understand urban forestry research and technology transfer needs in the Pacific Northwest region of the United States. The approach can be readily used for any geographic region or metropolitan area. A two-phase, abbreviated Delphi process was conducted, inviting input from urban forestry professionals, academics, and agency-based managers. Research issues were identified and prioritized within three themes: urban forest resource, resource management, and community framework. The results serve as a stakeholder relevant research framework to guide science proposals for funding initiatives at regional and national levels. Notable is major support by respondents for a better understanding of the transactional dynamics of human systems and urban natural resources.

Keywords: urban forestry, urban ecology, research assessment, Delphi method, Pacific Northwest

Recent demographic projections have called out the probable rapid pace of urbanization in the United States and the subsequent need for better science regarding associated landscape changes (Nowak and Walton 2005). The forest science community has expanded from a more traditional focus on wildland and market-oriented forestry scenarios, to knowledge of the entire forest landscape gradient from the downtown core extending to rural areas, and including increasingly populated wildlands. All resource and social systems along the landscape gradient are interconnected; effective forest planning and management must now address the full range of forest conditions and human stakeholders.

Regional and national science initiatives increasingly address urban ecology and natural resources. The most recent US Forest Service strategic plan (USDA 2007) directly targets urban conditions, particularly in goal 3 (conserve open space), and goal 6 (engage urban America with forest service programs). Goal 7 (provide science-based applications and tools for sustainable natural resources management) reinforces the long-term commitment of the US Forest Service to the application of high-quality science in its activities. Such efforts will also need to address urban systems.

There has been variable effort across US regions with regard to urban forest science and investigations. The purpose of this

project was to assess and compile current research needs in the Pacific Northwest (PNW) region of the United States (including Alaska), based on input from professional and management stakeholders. Results are being used to develop a regional research program that emphasizes applied science.

Periodic assessments of knowledge development and needs are used in a variety of professional and scientific disciplines (such as education, medicine and public health, and atmospheric sciences) to guide and consolidate research activity. A research assessment focuses on fundamental questions for knowledge building concerning resource character and dynamics and social transactions associated with the resource. Such inquiries are potentially generalizable across locations or resource units. Periodic assessments highlight stages of progress within a domain of knowledge development, thus summarizing what is understood and recommending orientations of future efforts.

The University of Washington partnered with the PNW Research Station of the US Forest Service in a discovery process to better understand urban forestry research and technology transfer needs. Although wildland and production forest research needs have been assessed periodically in the PNW region, this is the first assessment of

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science needs for urban forest systems. This assessment provides a touchstone for development and conduct of urban natural resource science in a rapidly urbanizing geographic region of the United States.

Project Background

Urban forestry is the art, science, and technology of managing trees, forests, and natural systems in and around cities, suburbs, and towns for the health and well-being of all people (National Urban and Community Forestry Advisory Council 2006). In this project, an urban forest is defined as the inclusive tree canopy across a city or town made up of individual trees, groves, and patch forests located within public or private properties, including streets, parks, open spaces, and residential areas. Such forests are distinguished by culturally framed biological diversity and social complexity.

Within the PNW region and across the continent, there is expanding local government interest in urban forest planning and management, activities that are enhanced by scientific knowledge. With about 80% of America's residents living in urban areas, urban forests and urban forestry are becoming increasingly important. The population distribution in the PNW states, particularly Oregon (79%) and Washington (82%), mirrors this national average, with Alaska showing a slightly less urban population (66%; US Census 2004a). In addition, regional population growth indicators suggest that the urban forest conditions and issues of the PNW are similar to other North American regions. Urban forests are important resources, providing essential social, economic, and environmental functions and benefits in the everyday places where people live, work, learn, and play (McPherson 2006). Better scientific understanding of these resource systems will be transferable to other urbanized landscapes across the continent.

Creation, conservation, and management of urban forests to achieve sustainability is a long-term goal of an ever-increasing number of communities. Clark et al. (1997) described an action model for urban forest sustainability based on three themes: forest resource, resource management, and community framework. The model illustrates how to achieve sustainable urban forests through community cooperation, quality care, continued funding, and personal involvement. It emphasizes the need

for vision and responsibility, direct intervention with the resource, and stewardship programs that are ongoing and responsive. Additional citations regarding the three themes (discussed in the following sections) are available in the source article (Clark et al. 1997).

Forest Resource

Vegetation is the essential foundation of a citywide ecosystem. The vegetation resource can and should provide a continuous high level of net benefits including energy conservation, reduction of atmospheric contaminants, enhanced property values, reduction in storm water runoff, and social well-being. The composition, extent, distribution, and health of an urban forest define the type, quality, and level of benefits provided and costs accrued. As dynamic organisms, urban forests (and the trees that form them) change over time as they grow, mature, and die. Therefore, forests must possess a mix of species, sizes, and ages that allows for continuity of benefits over time.

Resource Management

This theme includes direct management actions, as well as the philosophy of management. Specific policy strategies describe how to protect existing trees, manage species selection, train staff, and apply best management practices (BMP). At a broader scale, acceptance of a comprehensive management plan and program funding by local government and its constituents enable communities to develop and pursue a shared vision. Local management approaches vary as a function of the resource and its extent and must be considered with the context of the larger landscape and across multiple political jurisdictions.

Community Framework

A sustainable urban forest is one in which all sectors of the community share a vision for forests located in neighborhoods, public spaces, and on private lands and work to transform the vision into reality through specific goals and objectives. At one level, an attainable vision requires that a community agree on the potential functions of trees (e.g., water quality) and act to maximize those benefits. On another level, this cooperation requires that private landowners acknowledge the key role of their trees in community health. Finally, in an era of reduced government service, this means sharing the financial burden of caring for the urban landscape.

Although much of the scientific information generated by other US Forest Service

Research Stations and scientific cooperators are generalizable to the PNW, unique local conditions merit study, replication, or expansion to confirm applicability. In addition, the PNW is a rapidly growing region, and study of both urban and urbanizing landscapes can provide valuable knowledge for other locales in the United States.

Coupled Human/Natural Systems

The need to consider human social and biophysical interactions in resource planning and management is called out in many places. More research and outreach is needed to better understand resource issues, improve management approaches, build networks, and create better local government policy concerning city trees (Clark et al. 2005). However, the reality of how and why individuals and human systems would engage with science outcomes on behalf of natural systems is rarely discussed in any greater detail; and there are innumerable instances where policy and planning decisions appear to disregard or be inconsistent with scientific evidence. Science does not become public action without consideration of human motivation.

Derived from theory in environmental psychology, a transactional perspective recognizes the processes through which people shape and are shaped by their environment. Various aspects of human-environment systems serve to define each other (Hartig 1993). People, from elected official to homeowner, initiate actions that generate consequences for resource systems. Ecological change, in turn, influences future decisions and activity. Urban resource planning and management typically involves many stakeholders and political jurisdictions. Recent discussions in urban ecology point to the importance of policy and planning that is informed by science but provide few specifics about the iterative transactions between human systems and landscape outcomes that must take place.

Communities vary in terms of both ecological possibilities and societal expectations. Recognizing this complexity and the higher human population densities associated with city trees, the three-theme model was used for this project, because it incorporates social and economic factors with biophysical systems. Although such a multidimensional approach seems intuitively obvious, recent reviews of urban ecology studies indicate that understandings of the transactional dynamics of coupled human/

natural systems are still formative, with many urban ecology studies conceptualizing human systems as externalized sources of disturbance or impact in relationship to changes of biotic systems (Marzluff et al. 2008). Human action, from individual to institutional scale, is often reported as an external disturbance factor, rather than an integral condition of ecosystems. This project assessed research needs pertaining to a defined resource, as well as potential social and administrative transactions.

Assessment Methods

Delphi Method Overview

The Delphi method is a systematic interactive technique for obtaining information from a panel of independent experts without the need to meet face-to-face. It is used to help identify issues, set goals and priorities, clarify positions and differences across groups, and identify solutions (Delbecq et al. 1986, Rowe and Wright 2001).

The Delphi approach is iterative, as experts are asked to respond to a small number of questions over two or more rounds. Delphi typically includes experts who can not meet physically, so it is conducted by mail or e-mail. In each round, a facilitator sends out a set of questions (or one broad question) that is the focus of the Delphi effort, and if the panel of experts accept, they follow instructions and present their understanding and perspectives. The second question set builds on first-round responses and may ask for clarification, level of agreement, or urges respondents to rank or prioritize items that have been submitted in previous rounds.

After each round, the facilitator provides a generalized summary of the responses that have been received. The process stops when submissions have changed little between rounds, consensus is approached, or sufficient information is obtained to satisfy the needs of the effort (Delbecq et al. 1986). Final round responses are combined, summarized, and reported back to participants. From that, a framework or timetable of future activity can be derived.

This research assessment invited input from diverse stakeholders using a two-phase abbreviated Delphi process. The research team (University of Washington social scientist, US Forest Service social scientist, and US Forest Service regional urban forestry program manager) recruited participants and designed questions. Questions were

posed to participants using WebQ, the University of Washington's web-based survey tool. The two Delphi rounds were administered over a 7-month time span. Using an online programmed response format, respondents identified research issues (and priorities) within three themes: urban forest resource, resource management, and community framework.

Delphi One—Issue Discovery

Questions within the three themes of forest resource, resource management, and community framework were presented in the first phase. Participants were given an explanation of the three themes and online access to the source article. In an unstructured, open-ended format, each participant was asked to list the three most pressing issues within each theme.

At the close of round 1, responses were electronically downloaded, and then prepared as text lists. Summary issue lists for each theme were generated using content analysis. Analysis was first done by one project team member (University of Washington social scientist), with the other two project team members reviewing and revising the preliminary results. Content sorting and thematic interpretations were finalized with consensus of the project team. No formal cross-checks on reliability or validity, such as intercoder reliability, were conducted. Resulting issues do have face validity because they are consistent with topics presented by Clark et al. and with regional dialogue about urban landscape change.

Counts of text items were used to prepare percent distributions for each issue. Draft issues were reviewed and refined, and then final versions were used to design the second phase.

Delphi Two—Issue Importance

An online instrument was used in phase 2. In response to issues within each urban forestry theme, participants were asked to respond to the question, "How important are each of these issues concerning forests and ecosystems in urbanized places?" by rating each issue statement on a scale of 1–5, with 1 being "low importance" and 5 being "high importance." Mean responses were calculated for each issue.

Participants

Engaging resource professionals and managers in the processes of research design and implementation may assure the rele-

vance of the knowledge for practical application and enhance managers' translation of scientific studies to practices, from planning to management. Managers may also draw on their broad experiential understanding of the resource to help develop insightful, innovative research questions. Managers are sometimes regarded as consumers of research, but astute and "reflective" practitioners probably have enough scientific background to recognize not only key questions, but also to envision how professionally framed research can be integrated readily into local planning and policy. Using a Delphi process provided an opportunity to engage resource professionals and managers in identifying key questions and research needs.

Potential participants were listed based on professional membership and activity networks (such as conferences). A subset was strategically selected with two general criteria in mind. First, effort was made to select individuals who, through their employment history and participation in regional activities, had shown an interest in planning and landscape scale issues (versus emphasis in arboriculture). Second, effort was made to provide a diverse base of professional experience and affiliations by participants. More than 60 stakeholders representing nonprofit; industry; academia; and local, state, and federal agencies were recruited for the assessment.

The project team developed, pretested, and finalized the Delphi questions and then recruited participants. An e-mail invitation provided a link to the online Delphi questions. A reminder was sent a week later. All responses were anonymous. In the first Delphi phase, there were 42 of 66 replies (64%) response. The team analyzed results from the first phase, set up the second phase, and repeated the recruitment process with 37 of 62 (62%) responding.

Tables 1, 2, and 3 provide information about the participants. Participant representation by state for Delphi 1 was 20% from Alaska, 25% from Oregon, and 55% from Washington; representation in Delphi 2 was 22, 33, and 45%, respectively. Approximately one-third of participants were affiliated with the largest cities in the region (greater than 100,000 population). Smaller towns were represented by a small percentage of respondents, as well as professionals that serve multiple jurisdictions. High representation of large cities was desired because projections indicate rapid expansion of population centers in the next few decades

Table 1. Delphi participants' employment affiliation.

Employment affiliation	Participant pool (n = 66) (%) ^a	Delphi 1 (n = 42) (%) ^a	Delphi 2 (n = 37) (%) ^a
Municipal/city government	35	26	30
County/regional/borough/metro government		2	3
State government	18	21	24
Federal government	7	14	3
Nonprofit organization	11	14	14
Business, company, or firm	12	12	11
Educational/scientific institution	17	19	16

^a Delphi column totals may include multiple responses

Table 2. Delphi participants' work base by population.

Community population	Delphi 1 (n = 42) (%) ^a	Delphi 2 (n = 37) (%) ^a
More than 100,000	29	35
From 50,000 to 100,000	12	5
From 30,000 up to 50,000	5	11
From 10,000 up to 30,000	5	0
Less than 10,000	5	0
Work in multiple communities	36	16
Does not apply	10	0

^a Column totals include multiple or no response.

Table 3. Professional memberships of Delphi participants.

Professional affiliation	Delphi 1 (n = 42) (%) ^a
International Society of Arboriculture	62
Society of Municipal Arborists	29
American Society of Landscape Architects	12
American Planning Association	10
Society of American Foresters	7
American Society of Consulting Arborists	5
Other (ecology, restoration, recreation, public works, and local government)	31

^a Column percentages reflect multiple responses.

(US Census 2004b); respondents provided insights for emerging needs as new urban centers expand or emerge.

The Delphi process also pursued information about potential partners in future research and outreach efforts. Participants were asked about their professional membership (Table 3). The results indicate orga-

nizations that could be recruited and might be interested in collaborating on future outreach and technology transfer projects. These partners may also be particularly helpful in the distribution of urban forestry knowledge to local staff and professionals.

Results

Delphi One—Designation

Table 4 displays issues resulting from both Delphi phases. Open-ended responses were solicited on the first phase based on the following questions.

- What are the three most pressing issues concerning forests and ecosystems in urbanized places?
- What are the three most pressing issues concerning how forests and ecosystems are managed in urbanized places?
- What are the three most pressing issues concerning how people interact with forests and ecosystems in urbanized places?

Considering the natural resource, many of the issues identified by participants related to landscape change associated with rapid urbanization in the region, including forest fragmentation, development impacts, and loss of biodiversity. Other issue topics are concerns that apply to both established city trees and remnant forests associated with recent development, such as invasive species, forest health, and adequate tree space. Finally, two issues focus on ecosystem services provided by quality urban forests—water quality and carbon dynamics.

The second question was about practices and policies. Several of the issues that participants identified address the practical aspects of arboricultural tree care, calling for the need to implement BMPs widely and consistently, with adequate staff and budgets, on a routine basis, and based on quality inventories so that the results of management actions can be monitored. Several responses address political leadership in management, noting a need for greater vision concerning an essential urban ecosystem and comprehensive policy and codes. Finally, several identified issues that entail broader integration of urban forestry with other government services and activities, both within local governments and across regional landscapes, to optimize ecosystem services and green infrastructure throughout the PNW.

The final question was about governments, organizations, and individuals. Extensive research has identified and established the functions and benefits that city

trees provide. Participants pointed out the widespread lack of knowledge and understanding concerning such benefits among citizens and public leaders. They also observed that communications and action about urban forests is not shared within and among the resource agencies whose programs have impacts across landscape systems. Concerning citizens and private property owners, there are tensions between appropriate uses for diverse human populations (particularly property rights) and the integrity of the forest resource. Finally, respondents noted that citizen volunteers conduct a certain level of forest management and asked how host organizations can better support citizen stewardship programs and themselves.

Delphi Two—Importance

Following content analysis, the issues lists were turned back to stakeholders and they were asked to indicate relative importance. Within each theme, participants were asked to respond to the question, "How important are each of these issues concerning forests and ecosystems in urbanized places?" by rating each issue statement on a scale of 1–5. Mean responses were calculated for each issue (Table 4). Results ranged from the high of 4.68 for "improve public appreciation and understanding" to the low of 3.51 for "enable appropriate forest uses and interactions."

Means were also calculated for each theme, across all component issues: 4.26 (SD, 0.49) for forest resource, 4.35 (SD, 0.39) for resource management, and 4.12 (SD, 0.42) for community framework. Theme means were compared to determine if workplace or affiliation had any influence on stakeholders' opinions. No differences were found based on participant employment affiliation. A significant difference was found associated with community size, with participants working with communities smaller than 100,000 populations responding that community framework issues were of less importance (one-way analysis of variance [ANOVA], $F = 7.744$, $df = 34$, and $P = 0.002$), rating them at 3.62 (SD, 0.50), whereas those from larger communities rated them at 4.32 (SD, 0.29). Participants from Alaska rated resource management issues as being more important (4.65; SD, 0.38) than participants from Oregon (4.25; SD, 0.28) and Washington (4.30; SD, 0.41), based on one-way ANOVA analysis ($F = 3.295$, $df = 35$, and $P = 0.05$).

Table 4. Delphi issues: Themes and relative importance.

Forest resource				Resource management				Community framework			
Issues	Delphi 1	Delphi 2		Issues	Delphi 1	Delphi 2		Issues	Delphi 1	Delphi 2	
	Percent of 128 responses	Mean	SD		Percent of 149 responses	Mean	SD		Percent of 118 responses	Mean	SD
Urbanization and development impacts	10.9	4.62	0.72	Adequate funding and staff	16.1	4.59	0.60	Improve public appreciation and understanding	22.9	4.68 (high)	0.63
Forest health conservation and retention	12.5	4.59	0.69	Integrate forests with other city systems	12.8	4.51	0.65	Lack of public and elected leadership	16.1	4.32	0.75
Aquatic resource quality and stormwater management	11.7	4.41	0.73	Develop/implement best practices	18.8	4.49	0.73	Understand and recognize human and economic benefits	16.9	4.19	0.85
Habitat loss and fragmentation	13.3	4.32	0.71	Adequate policy, code, and regulations	9.4	4.43	0.77	Integration across institutions and agencies	10.2	4.19	0.74
Invasive species detection and management	21.1	4.24	0.86	Inadequate vision/awareness and knowledge	10.7	4.32	0.85	Volunteers and citizen stewards	4.2	4.11	0.83
Climate change and carbon dynamics	8.6	4.08	1.04	Implement ecosystem services/green infrastructure	7.4	4.32	0.78	Private property action and user conflicts	6.8	3.81	0.85
Adequate tree spaces	7.0	3.95	1.00	Conduct consistent and routine management	10.7	4.25	0.69	Enable appropriate uses and interactions	20.3	3.51 (low)	0.38
Loss of biodiversity and ecological complexity	10.2	3.84	1.01	Conduct inventory, assessment, and monitoring	4.7	4.19	0.78				
				Comprehensive programs at regional/landscape scale	9.4	4.00	0.85				

Issues sorted high to low by Delphi 2 response means 1 = low importance to 5 = high importance. Percent response: column may exceed 100% because of multiple responses.

Generally, the Delphi participants rated all of the issues, within and across the themes, as important research needs. The ratings are not entirely consistent with the percent response ordering of the first Delphi, confirming the importance of an iterative participatory method. For instance, the issue of invasive species detection and management was most mentioned in Delphi 1, but came in at midrange in Delphi 2.

Reviewing each of the theme columns, with mean issue ratings proceeding from high to low, one sees no items at the midpoint of the scale or lower. No issue items received ratings below 3.5 (on a scale of 1–5).

Discussion and Recommendations

The outcomes of a comprehensive, participatory process to assess and understand urban forestry research needs in the PNW region are reported here. The urban forest is a natural resource of great biological and social complexity. Thus, a process to solicit expert stakeholder input was devised and could be used for assessments in other locales. The responses of PNW stakeholders align closely with the principles of a sustainable urban forests model, but amplify chal-

lenges and needs that are particular to the political and landscape contexts of the region. Respondents provided a broad array of insights about how integrated arboricultural, ecological, and social studies could provide better knowledge and guidance for sustaining urban trees in Alaska, Oregon, and Washington.

Respondents readily identified the resource threats and challenges itemized in numerous studies of urban natural resources and urban ecology, such as landscape fragmentation and invasive species. Responding to prompts about resource management and community framework, the respondents provided additional insights about community-based actions to address resource changes, showing a keen interest in a science-based approach to initiating human systems change, with subsequent evaluation and outcomes monitoring. All of the named issues fundamentally address the transaction potential of urban resources and human populations, such as the degree to which a community desires to conserve and steward its natural resource foundation.

Urban ecology research authors typically assume that scientific understandings should inform regional (or larger scale) policy and planning. It is also assumed that a

rational actor model will prevail and that decisionmakers (elected and professional) will respond to science outcomes with reasoned action. Rather than leaving this presumed transfer to chance, the respondents identified research activities that would integrate science and local government action. Respondents specifically identified transactional research efforts that pursue a better understanding of policies, programs, and messages by engaging key urban populations on behalf of declining forest resources at micro- to macroscales.

Such a science program could be framed as adaptive management that includes human dimensions. Our cohort of managers and professionals first designated and then assigned importance to both resource understanding and human transactions. This science platform begs for integrated and/or coupled human/natural systems approaches, research that can only be done by multidisciplinary teams of biophysical and social scientists. Combined questions concerning resource and human systems could be framed as interventions that are then monitored and evaluated using scientific methodologies. Resulting knowledge would simultaneously ascertain urban resource systems

effects and social outcomes from individual attitudes and behavior to institutional change.

Here are potential integrated research programs, based on issues called out by the participants (Table 4):

- Historic studies that conduct inventory, assessment, and monitoring of urbanization and development impacts, using remote sensing, could be used to evaluate forest health conservation and retention, in the face of current and proposed trajectories of landscape change. Studies of interventions to change trajectories could explore how to integrate forests with other city systems and introduce strategies to increase integration across institutions and agencies. Public communications of potential trajectories could be used to study changes in public appreciation and understanding.

- A policy study focus would explore adequate policy, code, and regulations that could encourage comprehensive programs at a regional/landscape scale, rather than localized government responses, and analyze lack of public and elected leadership, by positing policy strategies that focus on key public concerns, such as aquatic resource quality and stormwater management or climate change and carbon dynamics.

- Technology transfer development could introduce materials (that are in turn evaluated) so that the public can understand and recognize human and economic benefits, to improve public appreciation and understanding. Visualization tools, based on inventory, assessment, and monitoring, could display urbanization and development impacts, including loss of biodiversity and ecological complexity. Solution-based education tools would address concerns about inadequate vision/awareness and knowledge of forest resources and illustrate how to develop/implement best practices

through comprehensive programs at regional/landscape scale.

Recent research policy is pointing to the need for large-scale, long-term, and interdisciplinary science to build comprehensive knowledge about landscape and resources, rather than piecemeal efforts (Marzluff et al. 2008). Important revisions to ecological theory are needed to better include human activity (Collins et al. 2000). Such approaches are especially relevant in urban contexts. The complex interplay of natural and human or cultural systems associated with urbanized landscapes and ecosystems have only recently become an acknowledged focus of scientific study. This body of science merits greater effort as human populations of nations and the planet continue to be increasingly concentrated in urban areas.

Respondents reinforced these observations at a regional scale, indicating a need for research that addresses diverse populations and government entities across the landscape. The US Forest Service, the National Science Foundation, and other agencies are expanding their investments in urban-based science, encouraged in part by recently proclaimed urban policies of the Obama administration. As funding initiatives are announced, this assessment can serve as a source pool from which issues and collaborators can be integrated to prepare research proposals. The needs are so great that science startups can include any number of scientific pursuits and make important contributions to the ecological and social health of cities in the PNW and beyond.

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