What Should we Know?
An Assessment of Urban Forestry Research Needs
in the Pacific Northwest[1]

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ABSTRACT

This project was a process of discovery to explore and understand urban forestry research and technology transfer needs in the Pacific Northwest region of the U.S. using a stakeholder participatory process. A two phase, abbreviated Delphi process was conducted, inviting input from urban forestry professionals, academics, and agency-based managers. Research issues were first identified then prioritized within these themes: urban forest resource, resource management, and human dimensions. The project also assessed outreach messages and audiences for urban forestry technology transfer in the region. The research assessment results are summarized here, providing an urban forestry research framework that can guide science and funding efforts at regional and national levels.

Key Words: urban forestry, research, needs assessment, Pacific Northwest

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INTRODUCTION

Urban forests provide a diverse mix of goods and services that benefit people. Research in urban forestry has generated extensive knowledge about environmental, social and economic benefits of trees and forests for individuals and communities. Research also contributes to evidence-based best management practices.

While much of the research conducted by other USFS Research Stations and scientific cooperators are generalizable to the Pacific Northwest (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. 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).

This project was a process of discovery to explore and understand the urban forestry research and technology transfer needs in the PNW region using a stakeholder participatory process. A two phase abbreviated Delphi process was conducted, inviting input from urban forestry professionals, academics, and agency-based managers. Respondents were asked to identify research issues, then they were asked to prioritize the issues within three themes: urban forest resource, resource management, and human dimensions. The resulting information, summarized here, provides a framework to guide future research and research funding efforts at regional and national levels. Though not presented here, results concerning outreach messages and audiences can be used to guide urban forestry technology transfer in the PNW region.

The University of Washington partnered with the Pacific Northwest Research Station of the US Forest Service on this project. While wildland and production forest research needs have been assessed periodically in the region, this is the first assessment of research needs for forests located where most people live, work, play and learn. It is hoped that the information reported here will launch expanded research to better understand the forest resource and how to manage it, as well as governmental policy and other human dimensions applications.

BACKGROUND

Delphi Themes – Urban Forest Sustainability
A model of urban forestry sustainability, developed by James Clark and colleagues (1997) served as the basis for the Delphi process. A brief overview of the model is provided.

Creation and management of urban forests to achieve sustainability is a long-term goal of an ever-increasing number of communities in the PNW region. The most significant outcomes of a sustainable urban forest are to generate the maximum level of net environmental, ecological, social, and economic benefits over time. In recognition of the higher human population densities associated with city trees, the model considers social and economic factors, as well as aspects of biophysical systems.

The model proposes that sustainable urban forests have requirements based on three major themes:

Forest resource
Vegetation is the essential basis of a citywide ecosystem. The vegetation resource of a sustainable urban forest 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 run-off, and social well-being. The composition, extent, distribution, and health of an urban forest define the limit 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 while trees are planted and removed.

Resource management
This theme addresses the direct management of the resource, as well as the philosophy of management. Specific policy strategies describe how to protect existing trees, manage species selection, train staff, and apply standards of care that focus on the tree resource itself. At a broader scale, acceptance of a comprehensive management plan and program funding by city government and its constituents enables participants to develop a shared vision. Management approaches will vary as a function of the resource and its extent. Similarly, management of the urban forest must be considered within the context of the larger landscape, and across multiple political jurisdictions.

Human dimensions
A sustainable urban forest is one in which all sectors of the community share a vision for their forest and act to realize that vision through specific goals and objectives, and includes neighborhoods, public spaces and private lands. At one level, an attainable vision requires that a community agree on the benefits of trees and act to maximize those benefits. On another level, this cooperation requires that private landowners acknowledge the key role of their trees to community health. Finally, in an era of reduced government service, this means sharing the financial burden of caring for the urban landscape. While the original model termed these dynamics "community framework," we have used the term "human dimensions" in this project.

Delphi Method
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). It is based on well-researched principles, and results in information that is more accurate than that obtained from unstructured groups (Rowe and Wright 1999, 2001).

Using Delphi procedures experts are asked to respond to a small number of questions over two or more rounds. Delphi typically includes experts who cannot meet physically, so 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 initial question(s) is/are very broad, and focus on issues, objectives, needs, solutions, or forecasts. The second question set builds on first round responses and may ask for clarification, level of agreement, or requests that respondents 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. While the facilitator knows the identities of respondents and how they have responded, the information reported to the group is not attributed to specific individuals. 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.

The Delphi method recognizes the value of expert opinion, experience and intuition. A Delphi is designed to accommodate emergent and spontaneous response to a broad request for information. It permits an informed dialog when full scientific knowledge is lacking. The anonymous response format avoids the negative affects of face-to-face panel discussions and solves the usual problems of group dynamics. These key characteristics of the Delphi method help participants to focus on core issues, and separate Delphi from other methodologies: 1) structuring of information flow, 2) cycles of relevant feedback, and 3) anonymity of the participants.

For this project two rounds of Delphi method were used. The purpose of the Delphi was to discover a broad array of urban forestry research issues, and then determine priorities. A team made up of representatives from the US Forest Service and University of Washington prepared a participant recruitment list and designed questions. Dr. Kathleen Wolf served as the Delphi facilitator, with questions posed to participants using WebQ, the University of Washington's web-based survey tools.

Participants

Potential participants were selected with two general criteria in mind. First, effort was made to select individuals who, through their employment history and participation in regional professional activities, have demonstrated an interest in planning and development in arboriculture and urban forestry. Second, effort was made to provide a diverse base of professional experience and affiliations.

The project team developed, pretested, and finalized the Delphi questions, then recruited participants. An e-mail invitation provided a link to the online Delphi questions, with a reminder sent a week later. In the first Delphi round there were 42 out of 66 replies, or 64 percent response. After analysis of the first phase the second phase was designed and the recruitment process was repeated with 62 percent responding. Tables 1 and 2 provide more information about the participants.

Employment Affiliation	Participant Pool n=66	Delphi 1 n=42	Delphi 2 n=37
Municipal/city government		26	30
County/regional/borough/metro government	35	2	3
State government	18	21	24
Federal government	7	14	3
Non-profit organization	11	14	14
Business, company or firm	12	12	11
Educational/scientific institution	17	19	16

TABLE 1 Delphi Participants' Employment Affiliation (%)

Community Population	Delphi 1 n=42	Delphi 2 N=37
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
Doesn't apply	10	0

TABLE 2 Delphi Participants' Work Base by Population (%)

DELPHI ONE – EXPLORATION

The first phase of the Delphi process was conducted in November and December 2006. Questions within the three themes of Forest Resource, Resource Management, and Human Dimensions were presented on-line. Each participant was asked for three replies on each theme, provided in an unstructured, open-ended format. At the close of round one responses were electronically downloaded, then prepared as text lists. Content analysis generated summary issue lists for each theme. 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 round.

Forest Resource - Table 3 displays sorted responses to the question, *What are the 3 most pressing issues concerning forests and ecosystems in urbanized places? This question is about the natural resource.* Many of the issues that were identified are about landscape change associated with rapid urbanization in the region, such as forest fragmentation, development impacts, and loss of biodiversity. Other issues 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 address the ecosystem services that are potentially provided by quality urban forests - water quality and carbon dynamics.

Resource Management - Table 4 is a summary of responses to the question, *What are the 3 most pressing issues concerning how forests and ecosystems are managed in urbanized places? This question is about practices and policies.* Several of the issues addressed the practical aspects of tree care, calling for the need to implement best management practices widely and consistently, with adequate staff and budgets, on a routine basis, and based on good inventories so that the results of management actions can be monitored. Several addressed political leadership in management, noting a need for greater vision concerning an essential urban ecosystem, and having comprehensive policy and codes. Finally, several management issues urged broader integration of urban forestry with other governmental services and activities, both within local governments and across regional landscapes, to optimize ecosystem services and green infrastructure throughout the PNW.

Human Dimensions - Table 5 is a summary of responses to the question, *What are the 3 most pressing issues concerning how people interact with forests and ecosystems in urbanized places? This question is about governments, organizations and individuals.* Extensive research demonstrates and confirms the functions and benefits that city trees provide. Participants pointed

Forest Resource Issues	128 text items	Response Examples
Invasive Species Detection & Management	21.1%	Introduction of non-native species Invasive species proliferation and dominance in degraded natural areas Invasive species (plants and animals) decimating urban open spaces
Habitat Loss & Fragmentation	13.3	Maintaining forests and ecosystems in pieces large enough to support a variety of ecosystem services Fragmentation and clearing that results in loss of habitat, wildlife corridors, and biodiversity, and disruption of other natural processes Pressure on remnant stands as marginal lands become economically viable for development and natural area corridors are further fragmented
UF Health Conservation & Retention	12.5	Declining urban forest health (disease, ecological and mechanical stresses) Declining tree cover and tree longevity Cultural practices to maximize the health and vitality of urban ecosystems
Aquatic Resource Quality & Stormwater Management	11.7	The role of urban forests and vegetation in protecting aquatic resources, including stormwater mitigation and riparian/shoreline edges Effects of urbanization on streams, watersheds and overall ecosystem health Increased runoff from impervious - eutrophication, scouring, temp changes
Urbanization & Development Impacts	10.9	Preserving significant trees during expanding roadways and rapid development Loss of urban forestry canopy Impacts due to development and the continual expansion of transportation systems
Loss of Biodiversity & Ecological Complexity	10.2	Loss of native species/PNW character and mature trees being replaced with young, deciduous trees all of similar age Flora diversity is not considered when development is planned Limited diversity in areas can jeopardize entire canopy in the event of major disease, insects, weather conditions
Climate Change & Carbon Dynamics	8.6	The effects of climate change and ecosystem response; i.e. invasive species, drought, forest regeneration, etc. Role of urban forests and green space in climate protection. How might vegetation help to mitigate climate change? Climate change - disruption of average rainfall amount resulting in increased pest outbreaks (Leaf miner, archnips rosana, spruce bark beetle)
Adequate Tree Spaces	7.0 (9)	Poor conditions for tree survival in urban settings (small root wells, poor soils, cutting roots for utility lines, compaction issues, etc) Understanding tree protection as it relates to soils, critical root zone, species, and groups vs. individuals Establishing better planting spaces to minimize infrastructure conflicts, allow for large tree species, increase individual tree longevity, and improve urban canopy coverage

TABLE 3 Delphi I, Forest Resource Issues

Resource Management Issues	149 text items	Response Examples
Develop/Implement Best Practices	18.8%	Increased awareness on maintaining the root health of trees both in public and private situations (preserving trees in development) Inconsistent implementation of industry standards and specifications relative to tree and vegetation plantings Ensuring that city staff have the skills, knowledge, and desire to implement practices and policies
Adequate Funding & Staff	16.1	Lack of urban forestry and ecosystem funding at local, state and federal levels Maintaining adequate funding levels, but can be based on building/land use fees, municipal stormwater revenue, exactions, etc. Inadequate funding to protect and acquire open spaces
Integrate Forests with Other City Systems	12.8	How to most effectively implement green infrastructure practices within city systems Few centralized and coordinated municipal policies, regulations and enforcement to encourage more trees and protect existing stands The importance for cities to manage and coordinate their various municipal programs that bridge urban forestry
Inadequate Vision/Awareness & Knowledge	10.7	The urban forests and ecosystem need to be at the forefront of the planning process, not as an afterthought or a luxury Lack of public info/awareness and prioritization of urban forests Staff knowledge of forest/natural systems ecology and the ability to develop and implement site specific prescriptions to achieve and maintain healthy ecosystems in urban natural area sites
Conduct Consistent & Routine Management	10.7	Poor, inadequate or non-existent on-going maintenance Lack of proactive management of urban natural areas to achieve the environmental values and benefits for which they were set aside There is a lack of investment via the maintenance of existing trees and ecosystems, or the "native areas take care of themselves" mindset
Comprehensive Programs at Regional/Landscape Scale	9.4	No cohesive regional management strategies (ordinances, canopy cover goals, etc) Multiple agencies have staff for natural resource care that don't communicate with each other. Agency policy and practices are not tied together in a comprehensive way Balancing development pressure and urban growth with forest preservation and enhancement across the landscape gradient
Adequate Policy, Code & Regulations	9.4	Need development of similar ordinances throughout a region as municipalities have quite varied [regulatory] approaches to how to achieve desired outcomes Lack of policies and incentives that require and motivate developers to leave native forest remnants on developing sites
Implement Ecosystem Services/Green Infrastructure	7.4	Public does not see the urban forest infrastructure as an important utility that provides storm water relief/water quality, energy conservation/cooling, carbon sequestration/air quality Dissemination of green infrastructure case studies, documenting challenges and successes in other cities, national and international Need quantification of the functions trees provide in PNW urban areas
Conduct Inventory, Assessment & Monitoring	4.7	Need resource inventory and assessment-we don't know what we have Urban forest health monitoring is needed to see changes in canopy cover, forest health, etc. Young tree survival -- little data on mortality rates, why trees die, and how to improve survival

TABLE 4 Delphi I, Resource Management Issues

Human Dimensions Issues	118 text items	Response Examples
Improve Public Appreciation & Understanding	22.9%	We need to reposition. Trees need to more align with politically important issues such economic development, alleviation of crime, reduction of health care costs, etc. Lack of understanding by the general public about the values of urban trees and forests for environmental, social, and economic benefits Most citizens and elected officials do not understand how natural processes work and how our actions impact them
Enable Appropriate Uses & Interactions	20.3	Changing ethnic demographics are changing the levels of appreciation for remnant forests and city trees How can urban forests and green spaces serve multiple populations and purposes: social space, the homeless, and ecological services? We need to do research to understand children's critical interactions with plants
Understand & Recognize Human & Economic Benefits	16.9	[Should be] easier to access and utilize tools that measure, quantify and track forests benefits across time and location To preserve trees or to be able to plant more, we need to show they have functions that people would otherwise pay for Health impacts of the UF -- air quality, active living, mental health
Lack of Public & Elected Leadership	16.1	The need to engage in a meaningful dialogue with urban residents about urban AND rural forestry, and choices they can make to benefit both themselves, forests, and ecosystem functions Policy makers continually view trees and forests as "nice to have" amenities, without truly recognizing the services provided Lack of elected decision-makers at the state or local levels who are willing to be champions for community livability through urban forestry
Integration Across Institutions & Agencies	10.2	[Is now] no communication amongst myriad organizations responsible for managing a single resource Need for cross-jurisdictional approaches (integration of local, state and fed) to address forests across the entire landscape gradient - urban core, urban neighborhoods, suburbs, rural communities, wildlands A major focus on transportation system improvements without adequate mitigation for the impacts it has on natural systems and quality of life.
Private Property Action & Conflicts	6.8	Balancing urban forest preservation and enhancement with private property rights Incentive programs to stimulate private behavior in the public interest In PNW viewsheds are precious leading to canopy loss as trees obscure view and thus lower property values
Volunteers & Citizen Stewards	4.2	Awareness of importance of locally-based citizen initiatives Local stewardship groups [now] need to compete with each other for funding What drives people to grassroots nonprofits or voluntary service involving trees? How to increase service for trees/tree planting?

TABLE 5 Delphi I, Human Dimensions Issues

out the widespread lack of knowledge and understanding concerning such benefits held by citizens and public leaders. They also observed that communications and action about urban forests, a resource that is a landscape-wide system, is not shared within and among resource agencies. Considering citizens and private property owners, there are tensions between uses that were appropriate for diverse human populations (some with property rights) and the integrity of the forest resource. Finally, respondents noted that citizen volunteers conduct a certain level of forest management; how can host organizations better support citizen stewardship programs and themselves.

DELPHI TWO – IMPORTANCE & PRIORITY

The second round of the Delphi process was conducted in July 2007. An on-line instrument was again used. In response to the issues representing each urban forestry theme (Forest Resource, Resource Management, and Human Dimensions), participants were asked to indicate *How important are each of these issues concerning forests and ecosystems in urbanized places?* by rating each issue on a 1 to 5 scale, with 1 being "low importance" and 5 being "high importance." Mean responses were calculated for each issue. Results ranged from the high of 4.68 for *improve public appreciation & understanding* to the low of 3.51 for *enable appropriate forest uses & interactions*. Mean importance ratings for all items are displayed in Table 6.

Means were also calculated for each theme, across all component issues:

4.26 (0.49 sd) for Forest Resource
4.35 (0.39 sd) for Resource Management
4.12 (0.42 sd) for Human Dimensions

Generally, the Delphi participants indicated that all of the issues, within and across the themes, are quite important as research needs. Reviewing each of the theme columns, with mean issue ratings proceeding from high to low, there are no items at the midpoint of the scale or lower. No issue items received ratings below 3.5.

DISCUSSION & RECOMMENDATIONS

To return to the model that served as a foundation for the Delphi process, Clark and his colleagues (1997) described how to achieve sustainable urban forests through community cooperation, quality care, continued funding, and personal involvement. Sustainable urban forests are created and maintained through shared purpose and cooperation, with maximizing benefits and minimizing costs being constant pursuits. The model identifies the need for vision and responsibility, for direct intervention with the resource, and for programs of care that are on-going and responsive. Such vision and activity extends a traditional orientation of urban forest management from municipal trees alone to the mix of public and private trees.

This document reports the outcomes of a brief exploratory process to assess and understand urban forestry research needs in the Pacific Northwest region. The urban forest is a natural resource of great biological and social complexity, thus a process to solicit expert stakeholder input was devised. A two phase, abbreviated Delphi process revealed a wide range of research issues, and emphasized that most are of high priority. This report presents a concise package of need statements organized within the themes of urban forest resource, resource management, and human dimensions.

The responses of PNW stakeholders align closely with the principles of the sustainable urban forests model, but amplify challenges and needs that are particular to the political and landscape contexts of the region. Respondents provided a broad array of insights about how

Forest Resource			Resource Management			Human Dimensions		
Issue	**Mean**	**SD**	**Issue**	**Mean**	**SD**	**Issue**	**Mean**	**SD**
urbanization & development impacts	4.62	0.72	adequate funding & staff	4.59	0.60	improve public appreciation & understanding	**4.68 (high)**	0.63
health conservation & retention	4.59	0.69	integrate forests with other city systems	4.51	0.65	lack of public & elected leadership	4.32	0.75
aquatic resource quality & stormwater management	4.41	0.73	develop/implement best practices	4.49	0.73	understand & recognize human & economic benefits	4.19	0.85
habitat loss & fragmentation	4.32	0.71	adequate policy, code & regulations	4.43	0.77	integration across institutions & agencies	4.19	0.74
invasive species detection & management	4.24	0.86	inadequate vision/awareness & knowledge	4.32	0.85	volunteers & citizen stewards	4.11	0.83
climate change & carbon dynamics	4.08	1.04	implement ecosystem services/green infrastructure	4.32	0.78	private property action & user conflicts	3.81	0.85
adequate tree spaces	3.95	1.00	conduct consistent & routine management	4.25	0.69	enable appropriate uses & interactions	**3.51 (low)**	0.387
loss of biodiversity & ecological complexity	3.84	1.01	conduct inventory, assessment & monitoring	4.19	0.78			
			comprehensive programs at regional/landscape scale	4.00	0.85			

TABLE 6 Delphi II Issues-Issue Means by Themes
(1=low importance and 5=high importance)

arboricultural, ecological, and social sciences could provide better knowledge and guidance for sustaining urban trees in Alaska, Oregon and Washington.

Within and between the three themes of Forest Resource, Management, and Human Dimensions most issues were judged to be of highest priority for scientific action. Knowledge building needs range from the scale of visioning across multiple large governmental agencies, to practical tree and forest care by small property owners. Recommendations for study of the resource itself range from biodiversity of interconnected green spaces across the region, to how to provide positive growing conditions for individual trees in the most hardscaped environments.

This document can be used to guide research and funding proposals at state, regional, national levels. For instance, the issues align with national research concerns for forests. For instance the US Forest Service has identified these four major science areas: Resource Valuation and Use; Science Policy, Planning, Inventory and Information; Vegetation Management and Protection; Wildlife, Fish, Water, and Air. The issues emerging from this assessment are similar, with respondents noting the need for research that addresses diverse populations and governmental entities, and that spans the region and landscape.

The range and scope of need that was expressed provides great opportunity for building a research program. As funding initiatives are announced this collection can serve as a pool from which several issues can be integrated to prepare research proposals. The needs are so great that science start-ups can include any number of scientific disciplines, and generate much needed contributions.

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