Urban Forestry

Courtesy of Sacramento Tree Foundation

The Final Frontier?

E. Gregory McPherson

ABSTRACT

Forestry and urban forestry have more in common than practitioners in either field may think. The two disciplines could each take better advantage of the other's expertise, such as foresters' impressive range of scientific theory and technological sophistication, and urban foresters' experience in working with diverse stakeholders in the public arena. The wildland-urban interface is geographic center of convergence, and the nexus of forest ecology and human ecology will become forestry's next frontier–where forestry and urban forestry join together to construct healthier habitats for humans.

Keywords: silviculture; wildland-urban interface

Although forestry and urban forestry share the word *forestry*, they seem to occupy different worlds. Forestry connotes sylvan environments—timber, streams, wildlife, and a close connection with the land. Urban forestry evokes cognitive dissonance: the image of cities with buildings and pavement seems inimical to forests. Equally bizarre is the idea of forest management in cities. How can silvicultural practices applied in forest stands be adapted for specimen trees in cities? As America's population becomes more urban, answers to questions such as these are important to the future of forestry and urban forestry.

This article describes what forestry and urban forestry share in common. By working together, both professions can become stronger and benefit from a shared sense of purpose. Constructing healthier and safer habitats for humans provides a focus for such collaboration.

Offshoot of Forestry

Compared with forestry, urban forestry is a frontier—"a new or unex-

The health and survival of urban trees may rely more on their social environment than on their physical environment. *Above:* Trained volunteers monitor for Dutch elm disease in Sacramento, California.

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plored area of thought or knowledge." Silvicultural theory and the profession of forest management are hundreds of years old, and forestry is an established institution worldwide. Urban forestry is young in theory but old in practice. Although people have managed trees in cities for eons, academic and scientific interest did not reach critical mass until the 1970s. The nation's first National Urban Forestry Conference (Hopkins 1978) took place in 1978, and now more than 50 universities offer courses in arboriculture and urban forestry within departments of forestry or horticulture.

Interest among professionals in urban forestry is growing. Membership in the International Society of Arboriculture (founded in 1924) is 14,000, only 4,000 less than membership in the Society of American Foresters (founded in 1900). Although urban forestry is a relatively new field, it continues to deepen and broaden its base of human interest, professional participation, and intellectual capital (Bradley 1995).

The urban forest is where most Americans—75 percent of whom live in metropolitan areas—work and play. It is the forest they experience on a daily basis. Urban forests account for about 25 percent of the total tree canopy cover in the United States and contain approximately 75 billion trees (Dwyer et al. 2000). These trees clean the air we breathe and the water we drink, protect us from the elements, and heal us emotionally, spiritually, and psychologically. They are integral to the quality of life in our communities.

Urban forests are important for economic reasons as well. In 1995, for example, California's urban forest contributed $3.8 billion to the state's annual sales, about one-third of the $12.5 billion contributed by the state's forest products industry (Templeton and Goldman 1996). However, California cities also spend $70 million annually on problems created by conflicts between street tree roots and the hardscape (McPherson 2000). That expenditure ($2.68 per capita) is more than half the total average annual amount ($4.36) cities spend on their tree programs (Thompson and Ahern 2000). The green industry is an important part of the economy, but when trees are unwisely selected or mismanaged, they can create costly problems.

During the past decade, there has been a shift in the way many people perceive trees in their communities. Trees have always been viewed as ornamental, but they are now seen as providing social, economic, and environmental benefits as well. This shift has led to new partnerships, such as that between Trees Forever, an Iowa-based nonprofit, and local electric utilities. Since 1990 this partnership has planted more than 1 million landscape-size trees in 400 communities with the help of 120,000 volunteers. These trees are estimated to offset CO_2 emissions by 50,000 tons (45,359 metric tonnes) annually. Based on an Iowa State University study, the survival rate is an amazing 91 percent, indicating a highly trained and committed volunteer force.

Rapid urbanization and increased affluence are driving the development of our urban forests. Because of urban sprawl, residents experience increased air pollution, more congestion on highways, loss of biodiversity, and occasional shortages of energy, water, and other resources. Fragmentation of habitats and loss of critical natural resources at the wildland-urban interface are chipping away at our natural resource base. Studies by American Forests are quantifying the loss of tree canopy cover as cities expand. In response, some cities have adopted urban growth boundaries and smart-growth initiatives. Integrating green infrastructure into the land-planning process is a smart-growth principle with implications for the future of forestry and urban forestry (Benedict and McMahon 2002).

As the discipline of urban forestry matures, it is approaching convergence with its well-established relative. The concepts of forest structure, function, and value that underpin forest management are finding parallels in urban forestry.

Structure

Most ecological measures used to describe forest structure can be fruitfully applied to urban forests. Forest structure—the species composition, age diversity, and spatial arrangement of trees and associated vegetation in the landscape—is determined largely by such natural factors as climate, soil types, seed sources, and dispersal processes. Just as influential in urban forests, however, are development patterns that create space for trees, and human management that determines what is planted and removed, as well as how vegetation is manipulated. Urban environments are heterogeneous, a complex mix of land cover types and uses. Like some forests, street tree populations are intensively managed, and at the other extreme, forest stands on urban vacant lots develop in ways similar to rural forest stands (Rowntree 1984). Growing conditions for trees are highly variable. Where trees are well adapted and sites are favorable, growth rates of city trees can be twice those of forest trees because of watering, fertilizing, and reduced competition.

Species richness—the number of species in a population—is usually greater in urban forests than in rural forests. In southern California communities, open-grown street tree populations frequently contain more than 200 species. Richness decreases in colder climates, where minimum temperatures reduce the number of broadleaf evergreen species and preclude palms (McPherson and Rowntree 1989). However, species composition is similar in both forests and cities when the distribution of individuals among species is considered. In both cases, a few well-adapted species tend to dominate.

Ecologists have found that forest structures vary along urban-to-rural gradients that extend from city centers, through suburban development, and into the rural hinterlands (McDonnell et al. 1993). Significant variations in climate, soil, flora, and fauna along the gradient reflect the influences of presettlement vegetation, people, development patterns, and natural factors

(McBride and Jacobs 1986). Our urban ecosystem studies in Chicago and Sacramento revealed that tree density, basal area, and canopy cover increased along the urban-rural gradient in Chicago but decreased in Sacramento, where surrounding rural lands were largely grassland communities instead of forests (Nowak 1994; McPherson 1998).

Convergence in Structure

Tree biometrics. Our preliminary research results suggest that the architecture of open-grown trees differs fundamentally from that of forest trees (McPherson and Simpson 1999). Open-grown trees appear to have substantially more above-ground biomass in their foliage and branches, whereas forest trees have more biomass in their boles. Applying forest-derived biomass equations to calculate air pollutant uptake by urban forests could lead to inaccurate findings. Understanding tree growth and the effects of silvicultural treatments on individual trees in sparse stands is one point of biometric convergence. For example, new biometric information on individual trees will help the next generation of physics-based fire models better simulate effects of fuel treatments on fire spread at the wildland-urban interface.

Characterizing the wildland-urban interface. Very little is known about the structure of this frontier between forest and city. We need, for example, information on relationships among population density, building density, and tree density to better assess the cost-effectiveness of fuel management strategies (DeJong and McPherson, submitted). Also important is the use of remote sensing to detect critical and threatened habitats. Field studies would help us understand how the structure of these habitats is affected by such urban processes as development, introduction of exotic species, and management practices.

Canopy change detection. Foresters use the new generation of satellites to obtain hyperspectral, high-resolution data, but this technology has not been applied in cities. We need specific studies to determine the feasibility of using different types of imagery to identify urban tree species, vegetation height, and leaf area.

Invasive plants and restoration. Foresters and ecologists study disturbance in forests and natural communities, but we know very little about disturbance and restoration in urban environments. Cultivated landscapes are the dispersion points for many exotic invasive plant species, but methods for assessing and predicting their invasiveness are lacking. Similarly, there are few guidelines for urban tree selection to prevent the introduction of invasive species to surrounding ecosystems. Ecologists are just beginning to develop a taxonomy of urban disturbances by disturbance agent and community type. Understanding the impacts of disturbances on vegetation structure is the first step toward developing restoration strategies. There are no better laboratories for studying disturbance ecology than our cities.

Function and Value

Function, the dynamic operation of the forest, includes biogeochemical cycles, gas exchange, primary productivity, competition, succession, and regeneration. In forests, these functions are largely natural processes; intervention is usually limited to silvicultural practices. In urban environments, forest functions are frequently related to the human environment. Trees are usually selected, planted, trimmed, and nurtured by people, often with specific intentions, as when a tree is planted in a front yard to shade the driveway and frame the residence. The functional benefits provided by this tree depend on structural attributes, such as species and location, as well as management activities that influence its growth, crown dimensions, and health. The value of these benefits is highly personal and may be quantifiable (e.g., cooling savings) or intangible (e.g., increased satisfaction). Urban forest functions are thus often oriented toward human outcomes, such as shade, beauty, and privacy.

Perhaps the most fundamental difference between forestry and urban forestry is the way trees are valued. Most people believe that city trees are more valuable alive than dead, whereas trees in forests obtain their greatest market value after they are cut (see sidebar). Trees in cities are imbued with meaning; some are landmarks, others are memorials. People develop emotional attachments to trees that give them special status and value. Removing hazardous trees can be difficult when it means severing the connection between residents and the trees they love. For many, feelings of attachment to trees in cities influences feelings for preservation of trees in forests.

Convergence in Function and Value

Waste-wood utilization. Model waste-wood utilization programs exist in some cities. Lompoc, California, for example, uses a portable mill to make lumber for picnic tables, benches, and tables from urban sawlogs. Nevertheless, most urban waste wood is chipped for mulch or taken to landfills. Foresters with expertise in wood science, forest products, and economics could assist urban foresters in developing new products from this resource, identifying new markets, and building a substantial consumer base.

Urban wildlife. Wildlife connects people with nature. Because people enjoy seeing wildlife in cities, urban forest landscapes need to be designed and managed to nurture desirable urban wildlife and prevent certain species from becoming a nuisance. In the Pacific Northwest, the streams that salmon species inhabit link urban and rural environments. Foresters who manage forestlands with salmon in mind can help urban foresters develop management plans for wooded riparian areas near cities. And they can assist in developing realistic guidelines for landscape design and management that will restore fish to an area's streams.

Tree improvement. Foresters who specialize in tree improvement could work with local growers and other members of the green industry to develop improved trees for urban environments. Traditionally, nurseries have selected new introductions for their ornamental or aesthetic attributes, such as flower color, fall leaf color, and crown shape or size. There are other attributes, however, that might reduce the costs associated with maintaining trees in cities. For example, deep-rooting patterns could reduce conflicts with sidewalks. Increased tolerance to drought-related stressors could improve survival rates where climates are becoming hotter and drier.

Forest Management

Forestry has a rich tradition of theory and practice related to forest ecosystem management. Managers view a forest as a collection of stands to be treated as an integrated unit. In the forest, stands are relatively easy to identify because of their distinctive structure and species composition. They are more difficult to discern in cities because the boundaries between plant communities are vague, seldom following environmental gradients. Urban forest stands may coincide with neighborhood development—trees in the same neighborhood are usually planted at approximately the same time and tend to reflect the horticultural preferences of that era (Whitney and Adams 1980). Nevertheless, much like foresters, urban foresters manipulate the composition of species, stand density, and structure to achieve management objectives. They strive to obtain optimal stocking levels for each stand, recognizing that conditions can change from site to site within an urban forest stand.

One forest management concept that has not been very useful for urban foresters is economic rotation. The urban forestry analog is "useful lifespan," the idea that after a species reaches a certain age, the annual cost of its maintenance will exceed the value of its benefits. Urban forest plans have recommended planting tree species with different useful lifespans to promote age diversity. However, this notion has failed in practice because the public seldom allows managers to remove healthy trees solely because they have reached the end of a predetermined useful lifespan.

Managing costs is particularly important in urban forests because of the many potential conflicts between trees and the surrounding infrastructure. In California, municipal programs spend, on average, $19 per tree each year to plant, trim, protect, and remove public

What Is the Value of a Tree?

To answer this question, the net present values (NPV) of a forest tree (Douglas-fir, *Pseudotsuga menziesii*) and a street tree (red oak, *Quercus rubra*) in Oregon were calculated for 40 years after planting using a 4.5% discount rate (*table 1*).

Costs for planting and managing the street tree are about 60 times greater than for the forest tree (present value, PV, of $463 for red oak and $7 for Douglas-fir). However, the present value of benefits for the city tree is 110 times greater than the forest tree (PV of $1,101 for red oak and $10 for Douglas-fir). Forty years after planting, the NPV of a Douglas-fir is $3, substantially less than the red oak's estimated $638.

Table 1. 40-year stream of benefits and costs discounted (4.5%) to their present values (PV) for a typical Douglas-fir in managed forestland and a red oak street tree in Oregon.

Present value costs	Dollars per tree	Present value benefits	Dollars per tree
Forest tree (Douglas-fir)			
Site preparation	$ 0.39	Timber harvest	$ 10.39
Planting	0.93		
Brush control	0.34		
Precommercial thinning	0.23		
Timber harvest	5.08		
Annual administration	0.49		
Total	$ 7.46		$ 10.39
Net present value	$ 2.93		
City street tree (red oak)			
Planting	122.00	Energy savings	93.09
Pruning	187.03	CO_2 reduction	49.15
Removal and disposal	37.50	Air pollutant uptake	36.20
Infrastructure and cleanup	58.58	Stormwater runoff	187.98
Administration and other	58.23	Aesthetics and other	734.88
Total	$ 463.33		$ 1,101.30
Net present value	$ 637.98		

This analysis suggests that the value of a city tree is considerably greater than that of a similar-aged forest tree. However, it does not account for other benefits produced by the forest tree prior to harvest, such as wildlife habitat and watershed protection. The value of benefits for the city tree are implied, since trees are not paid directly for the ecological and social services they provide. Prices are based on regional electricity and natural gas prices and control costs that reflect society's willingness to pay for air quality and stormwater runoff improvements.

Note: The forestland scenario was modeled by FPS, a forest planning tool designed by Jim Arney (Oregon Department of Forestry). Pam Overhulser, resource analyst with the Oregon Department of Forestry, provided assistance. The city tree scenario relied on data from the Western Washington and Oregon Community Tree Guide: Benefits, Costs, and Strategic Planting *(McPherson et al. 2002). Findings were based on growth curves developed from a sample of 75 red oak street trees in Longview, Washington, computer modeling of benefits, and a regional survey of municipal tree care costs.*

trees (Thompson and Ahern 2000). However, annual benefits from a large tree can exceed $100 (McPherson et al. 2002). Like foresters, urban forest managers face tradeoffs between short-term economic interests and long-term ecological issues. Short-term interests frequently involve election or budget cycles, but net benefits from trees increase as they live 30 to 50 years or more.

The concept of sustained yield of benefits from the urban forest has theoretical application but is difficult to measure (Clark et al. 1997). Yield of benefits, measured as board feet of timber harvested, watershed values, or wildlife habitat, has been more successfully quantified in forests than in cities.

Convergence in Management

Small-stand management. Many communities have been sculpted from a forest matrix and have, as a result, scores of small, relict forest stands. Frequently, people and the development process have had heavy impacts on these stands. Foresters need to develop principles and practices of silviculture for application to small stands. The often-linear shape of these small stands and their roles as connectors, recreational assets, and refugia for native plants and animals will influence management prescriptions.

Decision support for planning. Foresters have developed sophisticated decision support tools, such as GIS mapping, stand growth models, visual assessment simulations, and economic analysis programs. Although some urban foresters use tree inventory and management systems, these programs lack the decision support technology and visualization capabilities needed to project the future impacts of alternative management strategies.

Forest health monitoring. Urban trees are susceptible to threats from pests and diseases and are subject to a variety of abiotic disorders. Although the USDA Forest Service and partnering states spend millions of dollars annually to monitor forest health, they spend very little monitoring urban forests. Protection efforts are mounted in reaction to local crises, and remedies are often too late to curb the damage. Many of the concepts developed to monitor forest health apply to trees in cities, but in cities people may be more critical to tree health than the physical environment, in ways both positive and negative. Foresters and urban foresters can develop more holistic approaches for health monitoring.

Hazard tree reporting is relevant to foresters in high-use recreational areas as well as in cities. California has a tree failure report program, in which data from tree failures are recorded in a central database (Costello and Berry 1991). Species profiles are developed that describe how, where, when, and why each species is likely to fail. This volunteer-based program deserves greater support from both the forestry and the urban forestry communities.

Watershed restoration. Watersheds link the city with the surrounding forests and provide a definable organizing structure for studying a region's ecosystem. Foresters and urban foresters could work side by side to determine how the quality of water, air, soil, vegetation, and wildlife habitat changes from the headwaters of rivers to their confluence with downstream waterbodies. To address this issue, we need to understand the individual and cumulative effects of urbanization and land management practices on land, air, and water resources along the urban-rural gradient. A second issue is determining the best management practices for sustaining healthy watersheds in urban, suburban, and rural lands.

Conclusions

As Americans become increasingly urban, urban forests become increasingly important. These forests provide local, regional, and even global benefits. Stewardship of urban forests connects people to nature and to each other. If a new land ethic is going to emerge during the 21st century, it will spring from our cities.

The wildland-urban interface is the geographic center of convergence for forestry and urban forestry, but in subtle ways the disciplines are finding common interests along the entire urban-rural gradient. Because forest management will continue to be influenced by the changing attitudes, perceptions, and lifestyles of urban residents, convergence offers mutual benefits to forestry and urban forestry.

Forestry can benefit from

- Working with an urban public that is more accepting of management.
- Connecting urban residents with nearby nature as a pathway for reinvestment in forest management.
- Sharing expertise that urban foresters have acquired by working with diverse stakeholders in the public arena.
- Creating more livable cities, reducing sprawl, and conserving forestland and the natural resource base it supports.

Urban forestry can benefit from

- Including more forest management theory in urban forestry.
- Extending the impressive range of scientific expertise and technological sophistication developed in forestry.
- Increasing support by the forest products industry and the academic community.

During the past century we have learned how to manage forests for spotted owls and songbirds. We can design zoos that approximate natural habitats for giraffes and chimpanzees. Yet we have not succeeded in protecting green space near cities or creating environments that make people happy. The next frontier is where forestry and urban forestry join together to construct healthier habitats for humans.

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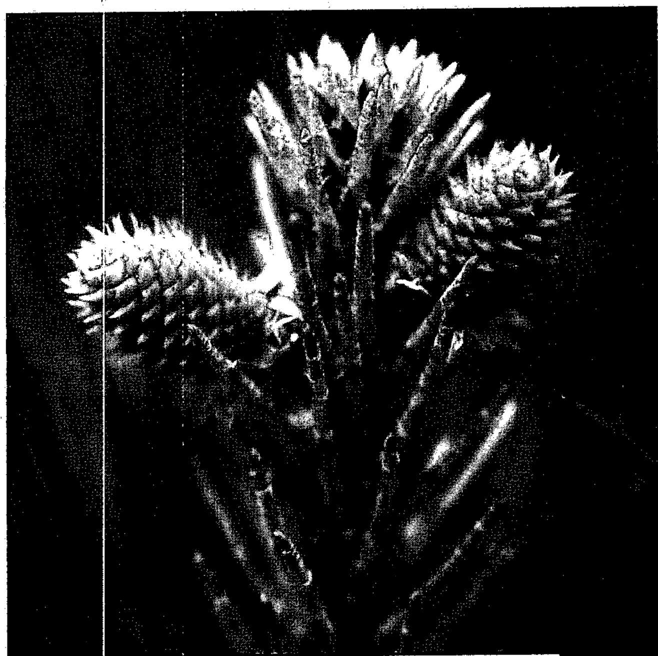
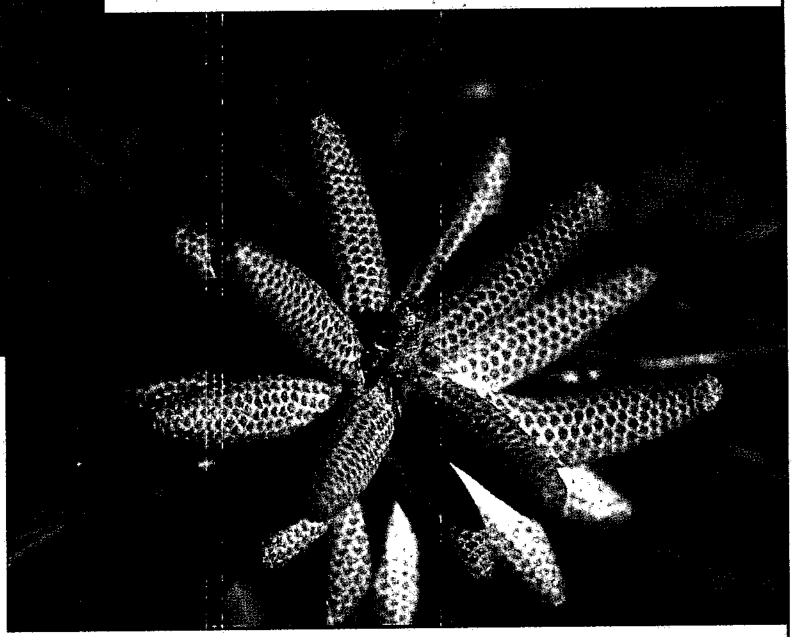
Productivity of Southern Pine Plantations





Where Are We and How Did We Get Here?

Photos by Erich G. Vallery, USDA Forest Service, www.forestryimages.org

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ABSTRACT

The productivity and extensiveness of southern forests in general, and pine plantations in particular, has placed the South at the forefront of production forestry in the United States. That industrial loblolly pine plantations are very productive is a result of researchers and managers developing and applying increasingly intensive silvicultural practices. Our estimates of the percentage of productivity gains attributable to improvements made in individual management practices are based on our collective experience, anecdotal information, and discussions with knowledgeable colleagues. Such informed judgments are based on potential productivity revealed by designed experiments coupled with estimates of how well technology has been implemented.

Keywords: economics; plantations; silviculture; timber markets

A distinctive feature of forestry in the South is the extensive area of intensively managed loblolly pine (*Pinus taeda* L.) plantations along the Atlantic and Gulf coasts. Plantations of all types occupy 17 percent of southern timberland (Guldin and Wigley 1998; Conner and Hartsell 2002) and most are privately owned by forest industry or other corporations (Guldin and Wigley 1998). Nonindustrial private forestland (NIPF) owners hold only 10 percent of their land in plantations, although that amounts to 13.8 million acres (Guldin and Wigley 1998; Conner and Hartsell 2002). The scope of plantation management in the South was summarized by Guldin and Wigley:

- One of six acres of timberland is a plantation.
- Of every 100 acres of plantations in the South, 94 are privately owned (54 acres by industry, 40 acres by NIPF owners).
- Of the six acres out of 100 acres that are publicly owned, four are in national forests and two are owned by

Above: **Female cones (left) and male flowers (right) of loblolly pine (*Pinus taeda* L.).**