The Elements of Sustainability in Urban Forestry

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Preface

This research project was begun in October 1993 with the purpose of identifying and describing cities in California that had achieved a level of sustainable urban forest ecosystem management worthy of emulation. The purpose of this report was to document these cities' course to sustainability, showing the economic benefits of the various programs comprising their efforts, and to design a means of translating their programs to fit most medium-sized cities (roughly 10,000 to 150,000) in California.

As the study progressed, it became evident that a more immediate and pressing need was dominating the minds and activities of urban forestry professionals — survival! In our opinion, no city in California has, nor should they have been expected to have, attained sustainability in these recessionary times. Cities with solid reputations in urban forestry are now striving to survive, and a few well-known programs have been effectively abandoned. According to many, urban forestry is at a critical juncture — just when the field was maturing to a point of noticeable contribution, funding and political support have declined to critical levels.

In light of this situation, this study took on added importance and a somewhat new direction. We have sought to identify program elements that are ecologically, economically and politically sustainable and to connect urban forestry with other basic public services. As you read this report, keep in mind that it represents only one of many early efforts in a comprehensive, long-range program of research to support and establish sustainable objectives and practices in urban forest ecosystem management.

I. Defining Sustainable Urban Forestry

Since World War II, California has experienced a four-fold increase in population — more than any other state. City populations have soared and city boundaries have spread. New communities have formed until many regions of the state are effectively one continuous city. Even with a state as large as California, this population explosion has urbanized most of the available lands in the state. Areas once called rural are now communities of small ownerships where incomes are no longer primarily derived from the land.

As a result of this remarkable growth, landscapes have been irrevocably altered which in turn has heightened people's desire and appreciation for open space and amenity values derived from forested settings. Many cities, mainly medium to large size, responded to this demand by planting trees on public property and by requiring tree planting in private development. The *"two trees per parking space"* adage typified this early era. However, with few exceptions, little attention was given to the fact that urban forests were being created with little planning or foresight as to their sustainability. Now, the effects of those early decisions are being felt in high tree maintenance costs to the point where many medium-sized cities must choose between "basic" services and tree programs.

Arboricultural practices alone cannot solve the complex design, managerial, social, economic and ecological problems affecting urban forest ecosystems (Aslin 1994). As it is known today, urban forestry is viewed as a merging of the science and practice of forestry and arboriculture (Figure 1).

The goal of urban forestry is to design and efficiently manage public and private lands in and adjacent to urban forested landscapes to be ecologically, socially and economically sustainable.

Narrow parkways, small trees and overhead restrictions spell problems for urban foresters.

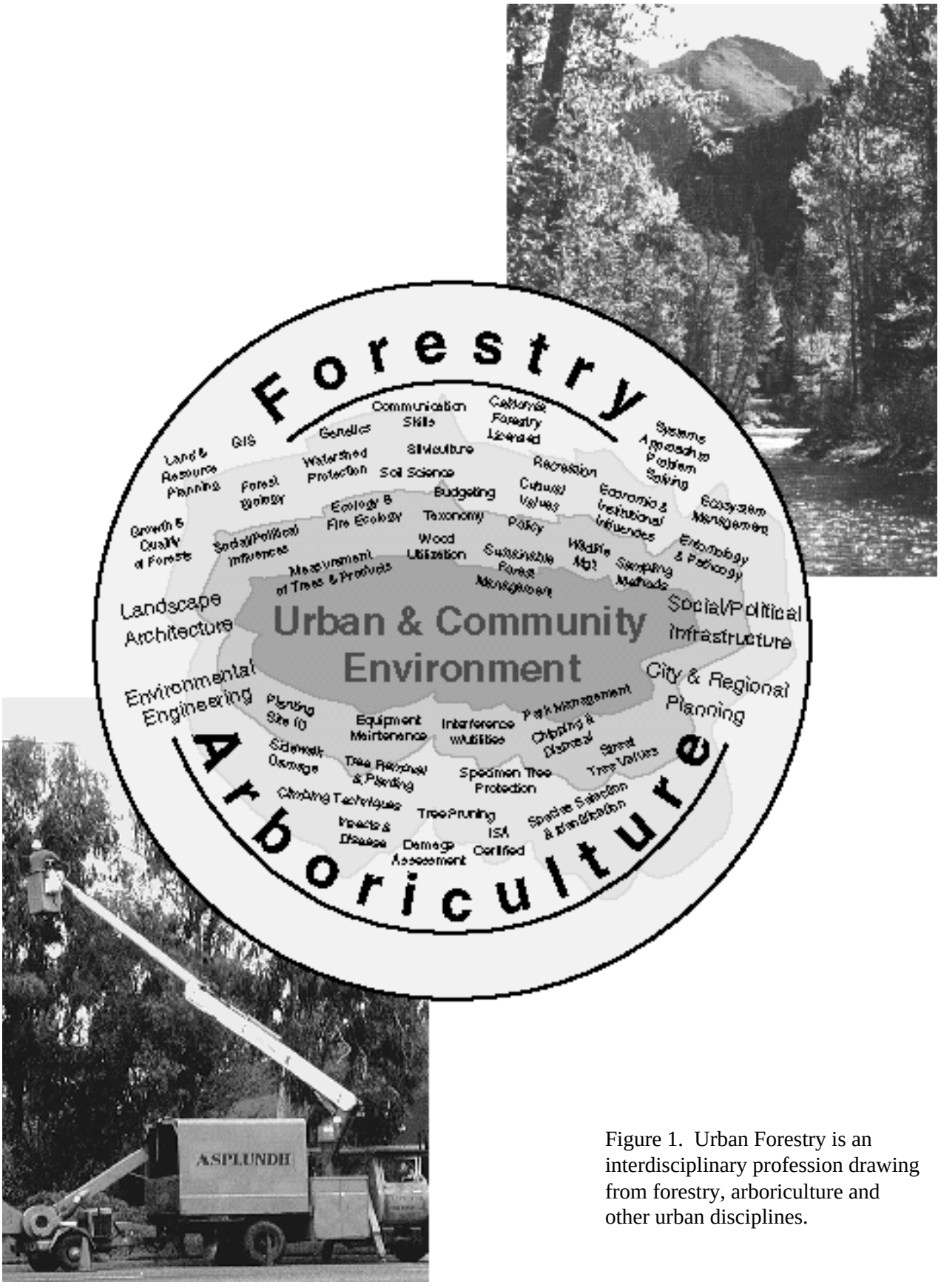


Figure 1. Urban Forestry is an interdisciplinary profession drawing from forestry, arboriculture and other urban disciplines.

The forestry profession provides well-established concepts and models in management, resource economics, and long-term planning of forest ecosystem structure and composition. The ultimate goal is to maintain forest health while sustaining yields of all forest values, both market and non-market.

Arboriculture contributes the science and practice of individual tree care and health. Both professions complement one another in the practice of urban forestry. As urban forestry evolves into a distinct discipline, other basic and applied sciences and technologies in the social sciences, landscape architecture and urban planning must be incorporated (Figure 1).

As with general forestry, the key concept in urban forestry is "sustainability." Cities, and communities, as well as wildland managers, realize that forestry activities must be more self-supporting. Sustainability, in this context, should imply programs that yield desired environmental and economic benefits without inefficient, wasteful design and practices. Gary Mason (1993) described sustainability as "…rather than seeking to maintain a resource (namely street trees), we are striving to create a more sustainable landscape that works with the economic and ecological limitations of the area."

Clearly, sustainability is fundamental to urban forest programs. This takes on added meaning, given the growing fiscal problems of cities. Unfortunately sustainable urban forest ecosystems are not commonplace because the necessary programs require careful, long-term design and planning.

This type of "systems-thinking" demands more time, effort and money in the short-term with the benefits coming in the long-term. For this to occur, elected officials must "buy into" the idea of investing today in order to realize major cost-savings and other benefits in the future. The hope is that this report will assist in providing additional leverage in generating support for your urban forestry programs.

Urban and Community Forester and Forestry Definitions

The Society of American Foresters has developed the following definition of urban forestry: "Urban forestry is a specialized branch of forestry that has as its objective the cultivation and management of trees for their present and potential contribution to the physiological, sociological, and economic well-being of urban society. Inherent in this function is a comprehensive program designed to educate the urban populace on the role of trees and related plants in the urban environment. In its broadest sense, urban forestry embraces a multi-managerial system that includes municipal watersheds, wildlife habitats, outdoor recreation opportunities, landscape design, recycling of municipal wastes, tree care in general, and the future production of wood fiber as raw material."

"Urban forestry encompasses all the typical activities involving trees which occur principally, but not exclusively in urban areas. At its most comprehensive level it involves the management of an entire urban tree population." (Lewis 1991).

"The urban forester juggles people, trees, and money in a cost-efficient manner that increases the quality of life of the community." (Skiera 1986).

Although the focus of this study was on urban forests in medium-sized cities, all communities regardless of size face issues related to urban interface with wildlands. Fire hazard, loss of oak woodlands and wildlife habitat, and the introduction of exotic species are just a few of these issues. The concepts of sustainability presented in this report should contribute to the ecosystem management strategies needed to address urban interface issues, but these lands have unique problems that will not be addressed in this report.

The purpose of this study is to help medium-sized cities and communities adopt urban forest programs without repeating the costly mistakes made by others in the past. Results of four specific objectives in pursuit of sustainable profiles are presented in the following sections:

II. Elements of Sustainability — what are the essential programmatic areas?

III. The Road to Sustainability — A Case Study of Five Cities — what are some of the more recognized California cities doing and what lessons have they learned?

IV. Benefits and Costs of Sustainable Programs — how cost-effective are these urban forestry programs?

V. Basic Regional Models — how should a medium-sized California city structure its basic urban forestry program?

II. Elements of Sustainability

A sustainable urban forest ecosystem can be viewed as a fabric woven by integrating the biological, ecological, economic and socio-political sciences and issues. The strength of the urban forest fabric depends on both the foresight of the planning effort in each area, as well as the method in which they are implemented. The purpose of this report is to provide a vision or concept of urban forestry for planning purposes.

Four core areas capture the state-of-the-art science and technology in designing and managing sustainable urban forest ecosystems:

- ***Species Selection and Diversity***
- ***Inventory and Landscape Planning***
- ***Tree Care and Wood Utilization***
- ***Public Relations and Support.***

Species Selection and Diversity

The importance of proper tree species selection is probably the most easily understood element of sustainability, but historically one that has not been consistently followed. Although a detailed discussion of species selection issues is beyond the scope of this study, an overview of benefits and problems will help underscore the importance of this concept.

Figure 2 illustrates the interrelationships between species selection and other urban forest values and activities. For example, species that are not carefully selected with the planting site and environmental effects in mind, often result in interference with city utilities (e.g., sidewalks, powerlines, lighting and traffic signs), hazardous fire landscapes, high tree maintenance costs, a short life, and even air quality problems (Bernhardt and Swiecki 1993, Cerulean 1986, Corchnoy *et. al.* 1992). In essence, the desired fabric of a sustainable urban forest is jeopardized or even lost. The cost to correct these problems overshadows the many exceptional benefits of the urban forest ecosystem.

These detrimental effects can be avoided through proper selection and diversity. Incorporating these relationships in the species selection process can greatly enhance sustainability. Clearly the entire system, that is the urban forest ecosystem, transcends its parts when functioning properly.

From an even broader perspective, proper species selection must equate to a diversified mix of species. This means that planning for the "best" species for a given site must include ecosystem-level planning to avoid a monoculture-effect on the landscape. A recent survey shows that over 90% of the trees planted in California, in about three-fourths of the responding cities, consisted of just five or fewer species (Bernhardt and Swiecki 1993).

In addition, the same survey reported that California cities are increasingly relying on fast-growing, small-sized trees that do not generate the environmental benefits sought in urban forests. The most commonly cited criteria for selection was (1) available planting space for street trees and (2) aesthetics for park trees.

Table 1 summarizes the views of several California urban forestry professionals on the best and worst street trees (California Trees 1994a). The reasons for liking or disliking a species usually related to root growing space or increased maintenance due to tree structure and growth.

Guidelines and tips for species selection are presented in Section V - Basic Regional Models.

The species selection issues and effects described thus far reflect what is important and ideal but may not address a more urgent and practical problem. Urban foresters are often faced with the difficult decision of whether to chose species that best fit sites that are often inadequate for practically any

preferred species, or to delay planting until an adequate planting site can be provided.

The economically and political expedient choice is to find some species that may fit but this is not sustainable. The basic reason such a choice is not sustainable is that long-term problems are created such as shorter-lived species, higher maintenance cycles, and not fully realized benefits of full-sized trees.

Increasingly, urban foresters are working with planners and other city services in new development and modification of the existing city infrastructure to accommodate urban forestry's needs. This brings us to the next key element in urban forest sustainability — inventory and planning.

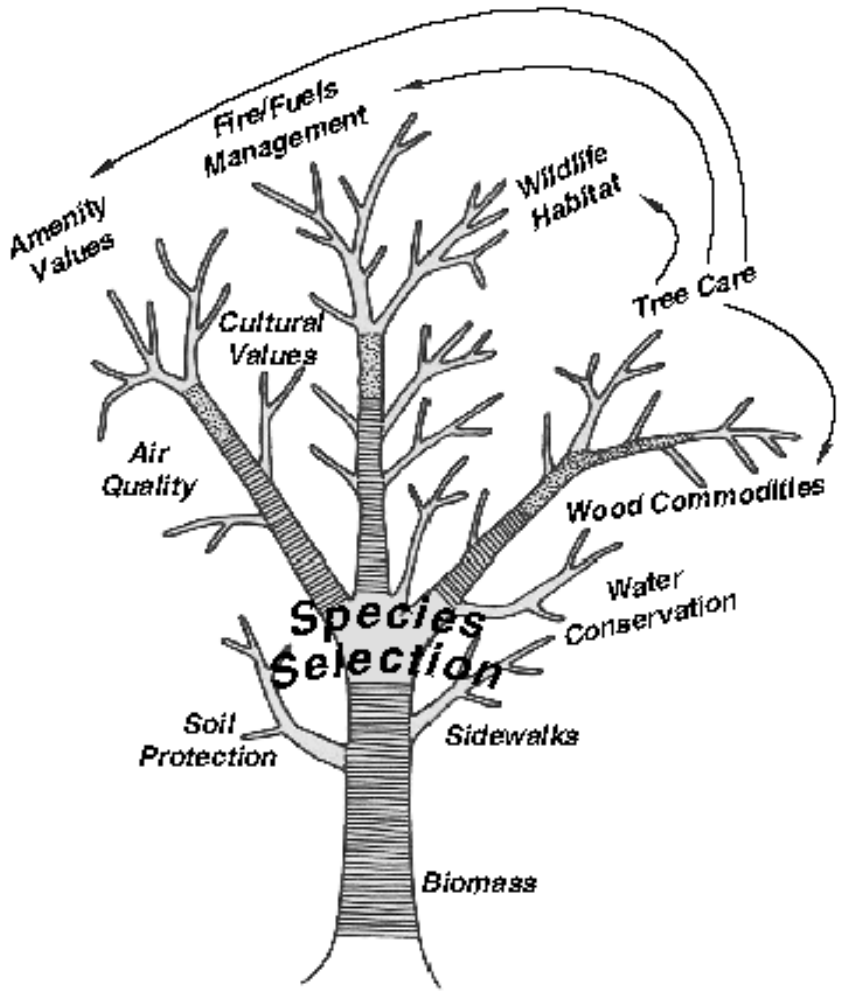


Figure 2. The interrelated effects of species selection and other urban forest values and activities.

Table 1. The best and worst street trees — selected viewpoints

Best	Worst	City
Brisbane Box (*Tristania conferta*)	Carrotwood (*Cupaniopsis anacardioides*)*	San Luis Obispo
Chinese pistache (*Pistacia chinensis*)	Nichol's eucalyptus (*Eucalyptus nicholii*)	Santa Rosa
Chinese pistache (*Pistacia chinensis*)	Liquidambar (*Liquidambar styraciflua*)*	CDF, Santa Rosa
Canary Island pine (*Pinus canariensis*)	Sycamore (*Platanus acerifolia*)	Irvine
Yarwood sycamore (*P. acerifolia* yarwood)	Siberian elm (*Ulmus pumila*)	San Jose
Camphor (*Cinnamomum camphora*)	Black acacia (*Acacia melanoxylon*)	Pasadena

Source: What's your view? Best and worst street-tree species? California Trees, Vol. 5, No. 1, 1994, p.10.
* Cited as potentially major hydrocarbon emitters (Corchnoy *et. al*., 1992).

Inventory and Landscape Planning

The second element of sustainable urban forestry includes inventory, tracking and planning. A recent study indicated that only 38% of the urban foresters knew with any accuracy how many street trees were in their city (Kielbaso 1990). Understanding how the urban forest landscape is composed and distributed (e.g., the condition, age, and distribution of urban trees) will provide important information on

- tree maintenance cycles
- the effects on other city services (e.g., powerlines and streetlights)
- the forest structure and composition for pest/pathogen "spread" models
- strategic planning and budgeting
- the urban forest landscape for public interactions.

The first step in the planning of the urban forest is to understand the status of the current forest. Typical information recorded on urban forest inventories are species, location, age, size, condition and maintenance history. Additional useful items are percent live wood, availability and quality of planting spaces, presence of overhead wires, and reason for pruning (Nighswonger 1986).

Information from a recent street tree inventory will help clarify the objectives and tasks for achieving the goals of the urban forest. In order to optimize management activities over the life of the forest, careful planning and design of the urban forest system is required. The means to achieve ecosystem-level planning has been an important issue in forest management for decades.

One of the major goals in forestry is to manage a forest so that yields of all forest values are sustained over the long-term to create a "regulated" forest. The term "regulation" is not used in the legal sense, but in the sense of determining the predictability and sustainability of the forest's

Advantages of a Computerized Tree Inventory

Either specialized computer software or a general purpose computer database can be used to create tree inventories. Formulas for calculating the dollar values of trees, shading coefficients, or other environmental benefits are also available (Barker 1983, Cooney 1985, McPherson 1993). Computerized tree inventories (Wagar & Smiley, 1990) allow for rapid data retrieval, report generation, maintenance scheduling and evaluation of species performance.

Rapid data retrieval can be a plus when information about a single tree is needed in response to service calls. Data can also be retrieved by themes such as street name, species, date of maintenance, or availability of planting sites.

Computerized tree inventories can also be used to generate a wide variety of reports. Summaries can be used to compile information for quarterly or annual reports, to support budget allocation requests, and to estimate the value of forest resources. When maintenance information is added, the inventory can be used to produce work orders, schedule or document maintenance and predict workloads. Documenting periodic tree inspection is an additional benefit where liability is a concern. Entry of completed work orders is used to keep an established database current and document inspections to reduce hazard liability. In the long term, tree characteristics and maintenance history can be combined to calculate species performance, and to create a locally appropriate species selection database.

outputs. The same must be true in the urban forest if sustainability is to be achieved.

The principles used in designing urban forests to achieve sustainable outputs and values are fairly simple to understand but challenging to implement. These principles are to

- control age class distribution through maximum (rotation) age by species
- control age class and species distribution geographically
- control management practices to maintain forest health and growth

In wildland settings, this is a complicated task due to the diverse structure of the forest and the numerous use-value objectives imposed on the landscape. Similarly, "regulating" the outputs in medium-sized urban settings are equally complex because of (1) the intricate mix of public land and private owners, (2) the natural and human-caused disease, pest and fire interactions, (3) a continually changing social and political climate, and (4) the need for community involvement through volunteers and civic groups.

In wildland management, Geographic Information Systems (GIS) has been a valuable tool in implementing and evaluating efforts to design and manage a sustainable forest ecosystem. The real potential of GIS lies in its capability to compile multiple layers of resource data "overlays" so the user can see the effects of policy and management strategies prior to implementation.

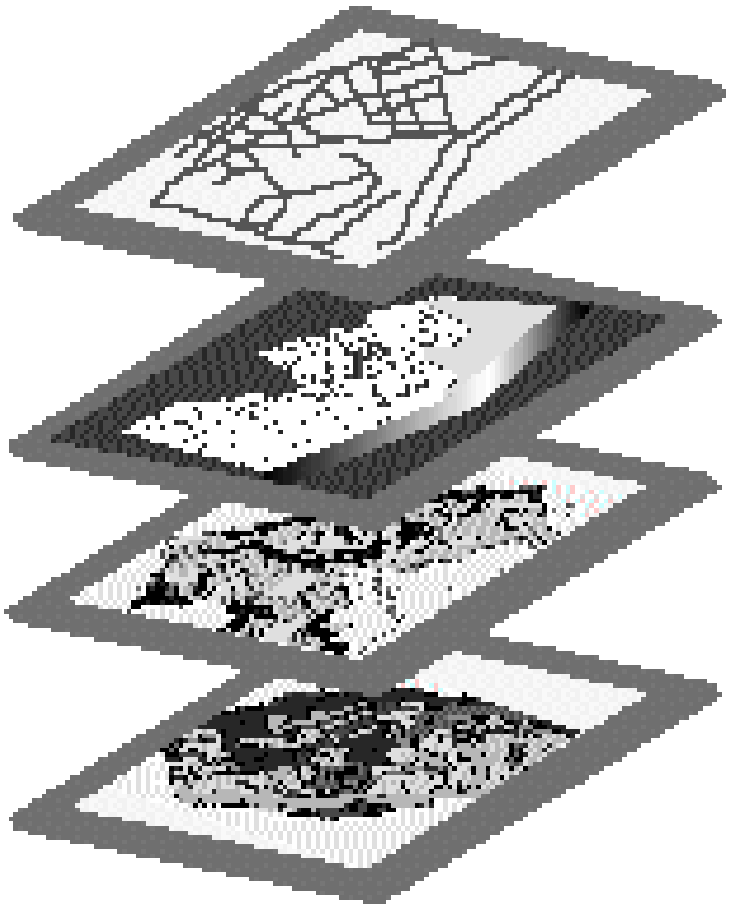


Figure 3. Multiple overlays of geographic information are compiled and accessed in GIS.

Figure 3 illustrates the concept of GIS, where large amounts of information can be synthesized, queried and displayed on one map. Later in this report an entire section is devoted to how cities can quickly acquire this capability at relatively low cost.

With a GIS database, characteristics such as the distribution of species, the clustering of age classes, or the spread of a disease can be displayed graphically making it easier to communicate large quantities of complex information to supervisory committees and public groups.

The urban forestry GIS database can be integrated with engineering information, such as the locations of sidewalks, overhead electrical lines, driveways, and scheduled road improvements.

Street tree inventory data can be directly entered into the GIS, or an existing computer inventory can be imported. In addition, map data can be entered into the GIS by digitizing from existing maps, or , if tree locations are recorded by address, digital street maps can be linked to the street tree inventory.

Regardless of the degree of sophistication, a city's database is crucial for long-term planning, management and rotation of trees on the landscape.

Tree Care and Wood Utilization

Proper care, maintenance, removal, and planting of urban trees, including associated shrubs, is an important milestone on the road to sustainability. As Figure 2 illustrated, care and maintenance are important factors in selecting a species.

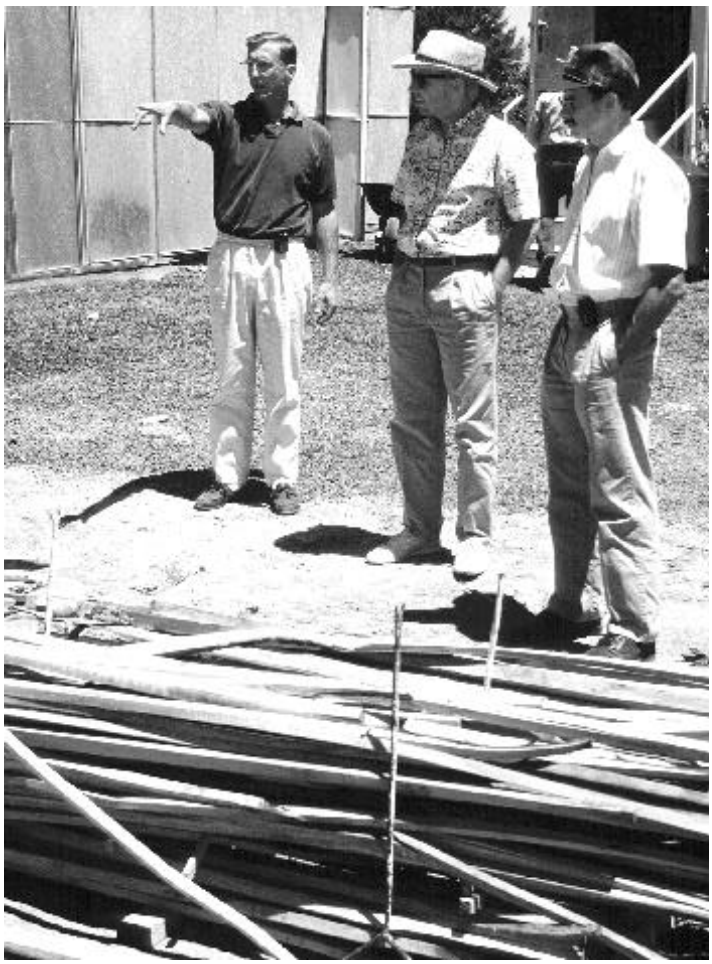
Historically, however, the issue of tree care has dominated urban forestry activities and budgets. This was because of the many ill-conceived efforts in tree selection and planting programs. As a result, tree maintenance and removal work are often seen as a cost-center, creating the image of urban forestry as a "money-pit."

Urban forestry cannot tolerate such costs, nor a "cost-image." Through the use of sustainable species selection and utilization of urban forest residues, tree maintenance operations can be financially sustainable and, in some cases, profitable.

It is encouraging to note that dumping wood waste has declined in recent years — only about half the cities in California now "bury and burn", while 78% recycle some wood residue (Bernhardt and Swiecki 1993). Such solutions are a critical component in creating sustainable urban forests and building a positive image.

Use of prunings as mulch, firewood and other biomass has grown rapidly in recent years. Some of the reasons for this are

- increasing landfill costs (over $20 per cubic yard or about $45 per ton, and rising).
- public awareness of waste issues (the state goal is to reduce solid waste 50% by 2000).
- landfill prohibitions (available landfill space is highly constrained in some cities).



Significant cost-savings can be realized by building upon the potential value of this resource. The City of Hayward saved $75,000 in 1992-93 by recycling 551 tons of wood waste. However, recycling wood waste as mulch or fuel is a low value return to the city compared to its potential in solidwood products (Herr 1993).

Tremendous opportunities in solidwood utilization exist in traditional commodities (e.g., firewood, veneer, lumber) and, more likely, specialty uses. In fact, because of the relatively small supply, specialty uses by local cabinetry and furniture businesses represent the greatest market potential when the species and wood quality is sufficient.

Utilization of removal waste as a solidwood raw material adds value to the urban forest (and revenue to the city), when the species, wood quality and volume are sufficient. Such value-added management is an essential component of sustainability but it requires the infrastructure to handle and market such raw material. Sacramento has started development of such an infrastructure by selling eucalyptus, elm, ash and sycamore logs to a local hardwood mill, thereby turning a disposal problem into an income producer.

The maintenance and removal of urban trees represents a high cost to communities primarily due to the high costs of labor, equipment and disposal. A study in southern California is focussing on the management of urban forests, specifically their potential for use rather than the more traditional practice of disposal (Pillsbury 1994).

The investigators are evaluating the volume and biomass potential of urban forests by sampling and measuring five common urban tree species, and through statistical techniques, developing equations to predict a tree's volume and energy value. By applying volume and energy coefficients to a city's tree database, aggregate estimates of the urban forest resource can be estimated (Pillsbury 1994).

Finding alternatives to costly waste disposal of woody biomass can reduce the cost that communities and cities face on an annual basis.

Plant stakes sawn from urban tree removals.

Public Relations and Support

Sustainability cannot be achieved based on the first three elements alone. It can only be realized when a solid base of support is available from the public and elected officials. Large sums can be spent on elaborate models to design sustainable urban forests. However, it is expense without benefit unless equal effort is spent on building political support in the communities.

For an urban forestry program to survive and grow, program leaders must pursue both city government support (internal line item funding) and citizen/ private sector support ("soft money" from non-city external sources).

It is increasingly clear that citizen support of urban forestry outpaces government support and that government support would be much lower or even nonexistent without citizen advocacy groups (Bernhardt and Swiecki 1993). Organization and funding challenges and initiatives differ according to these two avenues of support.

Internal Organization and Funding

As basic as it sounds, careful attention to the position/level and structure of the urban forestry organization is critical and can pay rich dividends. Urban foresters must recognize the close link between organizational position and budget continuity (i.e., line item status). Bernhardt and Swiecki (1993) identified funding as the number one issue in urban forestry today. As Michal Moore (1993) put it, "…finding protected budget niches must rise high on your priority list." Clearly, an initial goal should be to achieve line item status for urban forest management programs.

Another valuable approach is to educate the urban forestry staff, including the field crew, on the long-term value of high quality, on-going public relations. There is no substitute for developing good public relations in the community.

External Organization and Funding

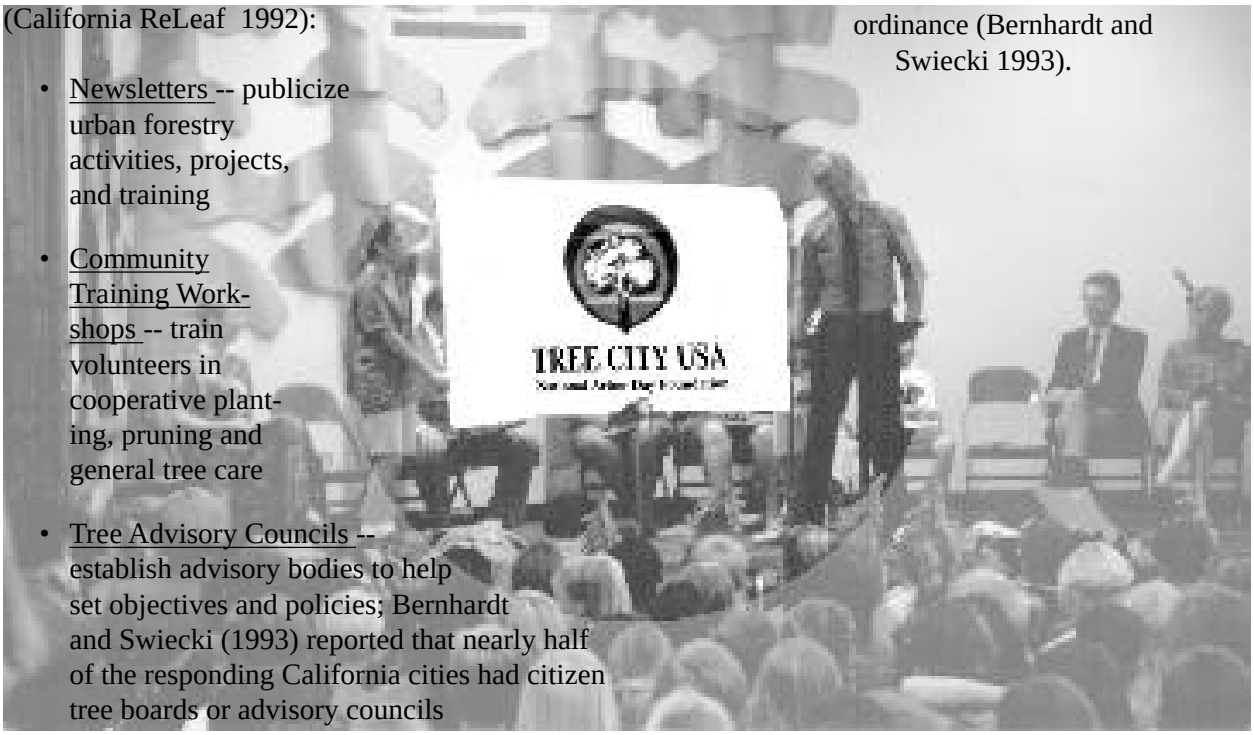
A number of methods for building a political support base in the public have been quite successful. The most common programs and initiatives are perhaps best captured by the funding categories used by California ReLeaf in disseminating community forestry enhancement grants (California ReLeaf 1992):

- Newsletters -- publicize urban forestry activities, projects, and training
- Community Training Workshops -- train volunteers in cooperative planting, pruning and general tree care
- Tree Advisory Councils -- establish advisory bodies to help set objectives and policies; Bernhardt and Swiecki (1993) reported that nearly half of the responding California cities had citizen tree boards or advisory councils
- Volunteer Coordination and Education -- recruit, educate and coordinate volunteers
- Youth/Intergenerational Projects -- promote social and cultural dimensions in urban forestry.

More details on the guidelines for these grants are provided in Section V of this report.

A fairly new approach in building public involvement and support is to channel urban forestry planning and activities through home owner associations (HOAs) and other similar neighborhood entities. Since most of the urban forest is under private care, efforts to involve private citizens and groups will create the greatest leverage in improving conditions.

Once a solid communication link is established in the community, the goals and objectives of urban forestry can be developed in concert with citizens, support groups, and elected officials. This process can be aided by a proactive tree ordinance — one that encourages tree protection and replacement in a positive manner (California Trees 1994b). Community and private sector commitment to and support of urban forestry goals are important contributors to the success of a tree ordinance (Bernhardt and Swiecki 1993).



In this section, we have developed the basic framework for sustainability in urban forestry. The four core elements are:

- species selection and diversity
- inventory and landscape planning
- tree care and wood utilization
- public relations and support.

These elements compare well with the recently adopted goals of National Urban and Community Forestry Advisory Council (USDA-Forest Service 1994).

These elements will vary city by city depending upon current forest condition, budget realities, political climate and site specific influences.

The remainder of this report is devoted to providing examples of cities that are employing these concepts in sustainable urban forestry, along with a preliminary benefit-cost analysis of the individual program elements. The last section of the report is a preliminary guide to help cities structure their urban forestry programs.

Notice where the sidewalk was narrowed to make room for growing trunk and root systems.

III. Profile of Five Cities -- The Road to Sustainability

In this section, we examine five cities that have committed to long-term urban forest development and are on the path to sustainability. This cursory survey of city urban forest programs is by no means exhaustive; numerous other cities and communities in California are making significant progress in urban forestry.

The purpose in this section is to document their status, and the issues and conditions that are shaping each city's urban forestry programs. At the end of this section, a summary of the progress toward each sustainability element is shown.

Looking ahead to Section IV, an economic analysis of the sustainability elements discussed in Section III will be presented. And finally, in Section V, a basic guide that summarizes some of the lessons learned will be presented.

Cities studied for urban forestry sustainability: Irvine, Lompoc, Monterey, Modesto and Sacramento.

Before going further, it should be emphasized that although these cities were chosen, they have not yet achieved a status that ensures a sustainable urban forest ecosystem. However, they are, in our opinion, well on their way toward their goal of sustainability. Unfortunately, some cities that we planned to profile, based on their reputation for progressive urban forestry, were dropped from the study as their political support suddenly eroded, losing years of progress. In our opinion, this rapid change in support is one of the most significant findings, and warning signals, in this study. Hopefully, the principles and practices referenced in this study will help others avoid this outcome.

Three major regions in California where urbanization has been pronounced were investigated:

- The coastal region between greater Los Angeles and the San Francisco Bay Area.
- The Southland — from greater Los Angeles to San Diego
- The Central Valley

Within these regions, at least one "medium-sized" city was identified that was active in urban forest ecosystem management and trying innovative ideas. The issue of city size is important for two reasons. First, medium-sized cities (defined here as roughly 10,000 to 150,000 population) generally have very limited budgets and suffer from size-related economic problems. Second, the purpose of this study is to help medium-sized cities and communities adopt urban forest programs without repeating the costly mistakes made earlier by larger cities.

The five cities selected are: Irvine, Lompoc, Modesto, Monterey, and Sacramento. Although

Sacramento is not medium-sized, it has many progressive programs worthy of discussion.

In addition to a description of the basic elements of each city's urban forestry program, the people that are making it happen will be introduced. It is the energy and vision of people and organizations that create progress. Their experiences will be shared.

Each city's urban forestry program will be described using the following format:

- *Background* — a brief introduction to the city and its environment
- *Organization* — a short description of the urban forestry staff and its organization
- *Highlights* — a summary of several priority issues and programs from each urban forester
- *Urban Forest* — a short description of the current urban forest and its condition
- *Budget & Operations* — a summary of the funding, programs and operations

Monterey

Background

Monterey is a medium-sized city, population 29,000, but situated in a highly developed region that attracts tourist worldwide. The unique environment of the Monterey Peninsula creates some of the highest land values in the nation. The role of urban forestry in the city of Monterey and the surrounding area is to maintain the aesthetic that residents and tourists have come to expect.

Organization

Robert Reid holds a B.S. degree in natural resources management, is an ISA Certified Arborist with eight years experience as Monterey's urban forester. Urban forestry is a section within the Parks Division (Figure 4). Staff responsibilities include tree maintenance, greenbelt maintenance, nursery operations, and parks maintenance and operation of Veteran's Park, including the city campground facility.

Highlights

Public relations & education. Robert strives to promote the public's awareness of urban forest issues through Neighborhood Incentive Programs which receive 16% of the city budget by city ordinance. He believes that a sense of ownership in the goals of the urban forestry program is firmly established in such neighborhood groups.

Education of public and staff. Monterey has committed to educating and training urban forest workers — city crews will be ISA certified this year, followed shortly by contract crews.

City uniqueness and landscape diversity. He also believes that continued research into sustainability concepts and practices and conservation of the native Monterey pine forest are a necessary investment. Given that urban forestry is a relatively new field, much is still to be learned and implemented.

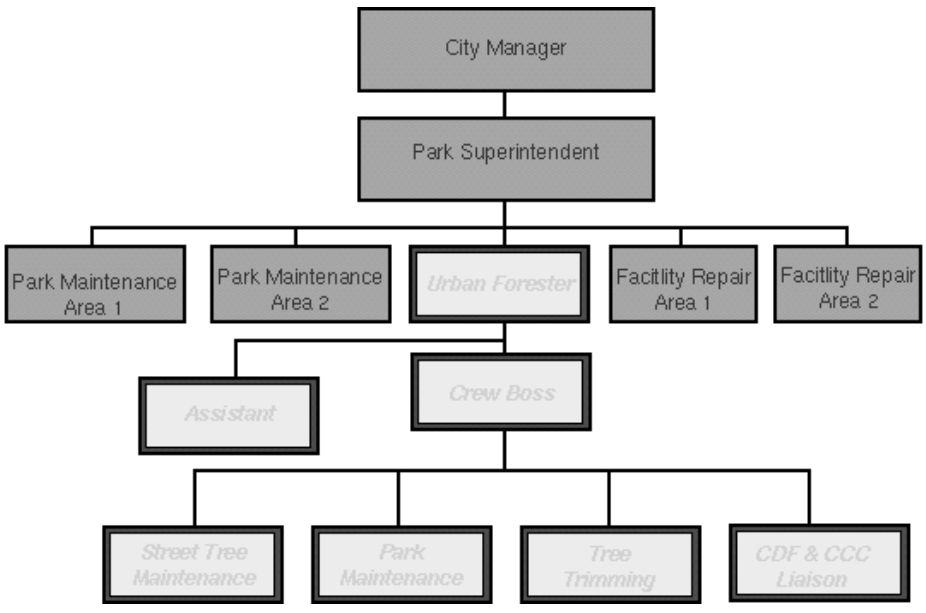


Figure 4. Organizational chart of Monterey's Parks Division

Urban Forest

Monterey's urban forest is stratified into native and ornamental stands. The most prominent stratum is the native Monterey pine stands for which the region is widely known. The second strata is streets and parks, with a large diversity of species being planted.

The Monterey pine forest is the largest remaining native stand in the world (3,000 out of original 15,000 acres). Regeneration of the original lands containing Monterey pine are planned using native seed sources. There are 23 Monterey pine greenbelts covering 300 acres (one includes campsites in-town). Rob is working towards age class diversity in an effort to create a higher level of sustainability. Finally, creating and improving wildlife habitat is a major objective in the management of the native Monterey pine stands.

Non-native species. An aggressive program to eradicate invasive non-native vegetation (e.g., genista and pampas grass) is underway. Weed control is needed to reduce fire hazard due to proximity to wildlands. California Dept. of Forestry (CDF) crews are used for most of this work (13,000 man-hours in 1993).

Tree Ordinance. Monterey enacted its tree ordinance in 1991, emphasizing tree preservation, removal of dying or diseased trees and replacement of trees removed on both public and private property.

Budget & Operations

Monterey's urban forestry budget is currently $550,000 — nearly $19 per resident. Robert considers this budget level adequate to achieve the program's goals. In general, the budget has remained steady during the past decade, however, it has declined in the recent lean fiscal times. These budget cuts have been distributed equally between maintenance of street trees and native forest by: (1) reducing contract greenbelt maintenance, (2) reducing street tree maintenance, and (3) extending tree maintenance cycle from 5 to 8 years. About 50% of tree care and removal work is done by contract crews ($122,000 FY 1993). City crews are used for planting in addition to other arboricultural work. In FY 1993, 4,200 trees were planted.

Sources of External Funds. "Eco-core" and "Friends of the Forest" — both are local support groups.

Pursuit of operational efficiency. A strong emphasis has been placed on reducing operating costs. Prunings and removals are chipped and used to supply all of the urban forest mulch and the remainder (about 20%) is piled for free public use. Tree removal and maintenance work on the 300 acres of greenbelts is completed by contract with local arborists. A GIS inventory and database is currently under development. Also, a street tree conversion program, about 80% complete, to replace species with low tolerance to frost is underway. The total replacement cost is about $120,000.

Why Rank Cities by Dollars per Resident?

Dividing urban forestry budgets by the resident population is apparently the most common approach to measuring the adequacy of funding. It is certainly the easiest relative measure and one used to assign, in part, Tree City USA status. Another common measure is to report expenditures on a per tree basis.

However, these measures do not express (1) current urban forest condition and needs, (2) efficiency improvements, and (3) investment in long-term sustainable programs.

To promote sustainability, a new measure is needed, perhaps, one that divides the total cost of the urban forestry program by an index of program activities would be better — a type of price index (e.g., Producer Price Index).

An example of a mature stand of the world famous Monterey pine; the largest Monterey pine native forest in California, and gene source of the dominant commercial species in the Southern Hemisphere.

Lompoc

Background

Lompoc is a city of about 40,000 people, located adjacent to Vandenberg Air Force Base. Vandenberg is the dominant economic influence and Lompoc is the primary residence of base personnel. Lompoc is somewhat remotely located on Pt. Arguello between Santa Maria and Santa Barbara. Tourism is a fairly important industry due in large part to the coastal aesthetics and periodic festivals.

Organization

Urban forester Cindy McCall holds a B.S. in Biology, has 23 years experience in urban forestry and related fields, and is an ISA Certified Arborist. Recently, Cindy received additional education and training in California land use and planning and believes this is an important element to the education of an urban forester in California.

The Urban Forestry Department has 13 full-time staff and is an equal branch with other basic city services (Figure 5). Cindy believes that it is critical that urban forestry be a division on par with other public works divisions, in order to compete effectively for funding. Because staff and field workers are in constant contact with the public, she promotes both staff development and public relations training — important elements of urban forestry sustainability.

Highlights

Public and political involvement key to sustainability. The urban forester must be first and foremost a politically-oriented, people-skilled professional working behind-the-scenes to direct intensive media work. Cindy and staff interact frequently and in differing venues with citizen groups, usually via Home Owner Associations (HOAs) and other neighborhood groups in order to connect with public needs and sentiment. Cindy has facilitated workshops to involve the public and enlist support for their extensive tree replacement program (see *Urban Forest*). She also views staff development as important to sustainability given that field personnel have a high public profile.

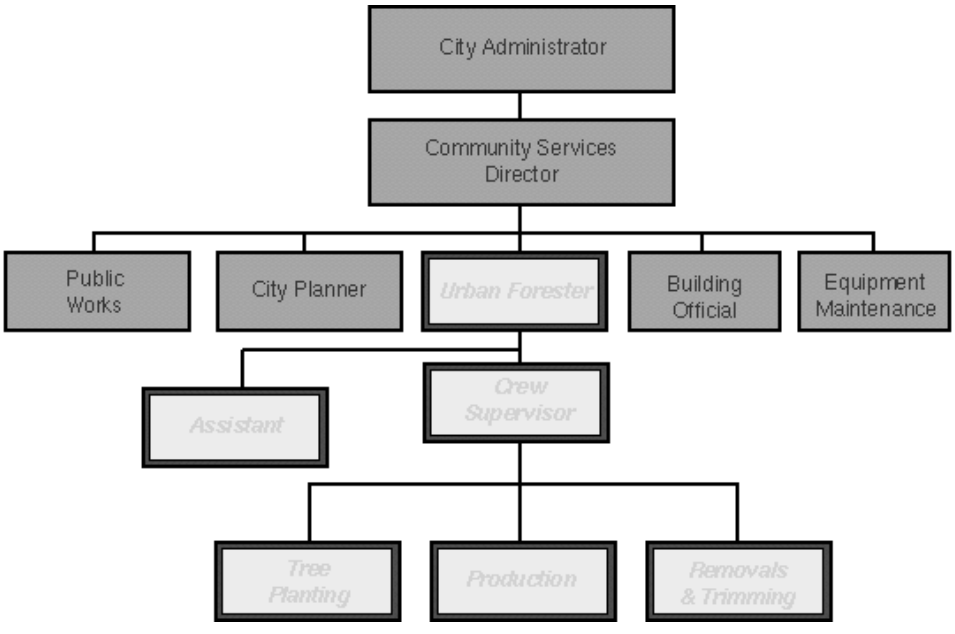


Figure 5. Organizational chart for Lompoc's Community Services Division

Organizational position and structure. The urban forester and the department must have stature within city government to create weighted competition for funding. Cindy's experience has taught her that status within a city's public works organization reduces the problem of receiving lower priority and in turn reduced and/or inconsistent budgets. This matter was one of Cindy's highest priorities upon arrival in Lompoc.

Geographic Information Systems. Lompoc has invested $2 million on a city-wide computer with GIS capability (InterGraph). Of the total GIS investment, $150,000 was allocated for urban forestry activities -- landscape diversity, urban forestry management, planning and public relations work. Cindy is a strong supporter of utilizing GIS in inventory and planning efforts. Her experience demonstrates the value of GIS in helping city administrators and the public to visualize impacts from urban forestry decisions.

Urban Forest

Urban forest diversity. Species and age class diversity are a high priority in Cindy's efforts to achieve sustainability. It is anticipated that about 67% of current urban forest will require replacement in the next 5 years due to a lack of diversity when planted about 30 years ago. Lompoc's Urban Forestry Master Plan states that the urban forest will be limited to 5% of any one species. Tree plantings range between 1500 to 3500 per year but will increase significantly as the urban forest conversion begins.

A prominent urban forest feature is the avenue of Italian Stone pines (*Pinus pinea)*. This area of the city has a unique aesthetic quality that generates considerable local business value.

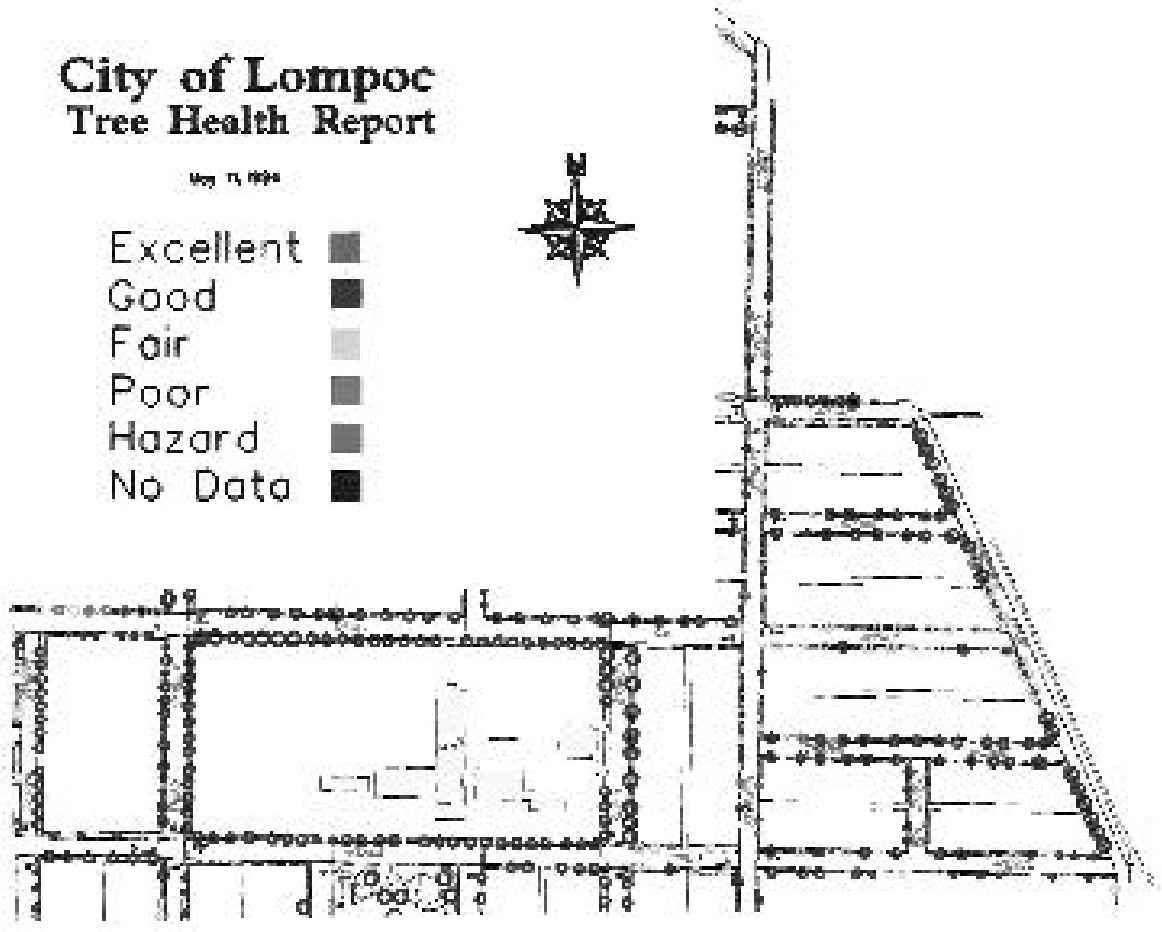
Tree ordinance. Species selection in the initial planting efforts, some 30 years ago, are now causing major problems such as more intensive tree care and early death, and extensive planning for its replacement. This, in addition to Cindy's experience in Atlanta, served to raise the importance of enacting a tough, comprehensive tree ordinance shortly after her arrival in 1989. Lompoc's tree ordinance was passed in 1991. The ordinance focuses on preservation and replacement of trees on public and private property with emphasis on proper species selection when planting.

Budget & Operations

Budget currently $575,000 — over $23 per resident. Lompoc utilizes contract services only to a minor extent and then only for tree removals, mainly due to its somewhat isolated location (the nearest certified services are located in Santa Barbara). The current prune/inspection cycle is a maximum of 5 years; however, Chinese Elm requires more frequent maintenance, on the order of a 1.5 year cycle.

Sources of external funds. The primary source of funding for urban forestry operations is Measure D Highway Improvement funds, representing about 80% of the current operating budget. The balance of the funds comes from SBA grants, Prop. 70 grants and the city electrical utility.

Biomass utilization. Currently Lompoc uses tree care and removal residues for mulch and firewood sales. This program will expand in the near term as the massive tree replacement program gets underway. It will create both a difficult scheduling task as well as undermine the publics image of having a sustainable and cost effective urban forestry program. This further demonstrates the lasting and complex effects from inadequate attention to species selection.



The City of Lompoc uses GIS to locate and map street trees, and to plan for general urban forest management.

Irvine

Background

Irvine has a population of 118,000, with a work force of 240,000. Irvine is a part of greater Los Angeles but is not considered a bedroom community for Los Angeles given the current workforce and the influx of new businesses. The primary economic base is technology, followed by agriculture. Irvine is the largest planned community in North America, providing a greater likelihood for the role of urban forestry.

Organization

Henry Canales, Landscape Supervisor of Tree Services is an ISA Certified Arborist and has 26 years experience (nine in Irvine). Clay Martin, Urban Forester, has a B.S. and M.S. in Forestry, is an ISA Certified Arborist, and recently completed the city's Urban Forest Management Plan. The entire Public Works division has 20 ISA Certified Arborists and was recently restructured to streamline services (Figure 6). Contracts are administered within the related Landscape Services department.

Highlights

Education and training of city and contract crews. All city and contract crews are ISA certified. Henry attributes most of the recent tree care efficiency gains to the education and training provided through ISA certification. For example, one city crew is devoted to care of juvenile trees which has significantly reduced the cost of planting and maintenance.

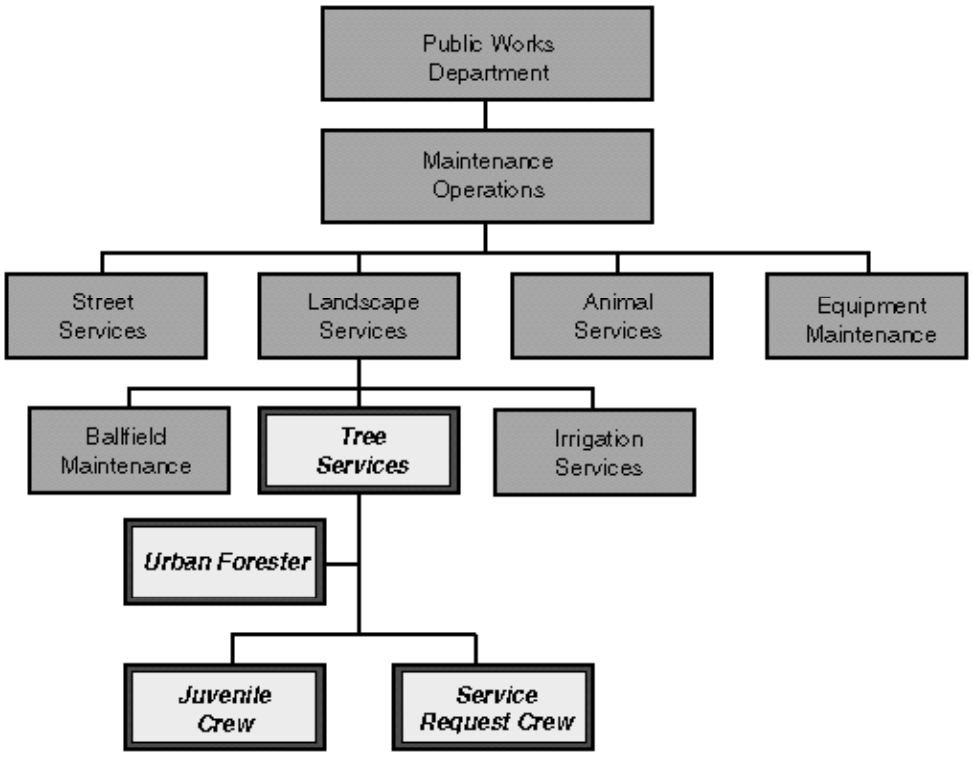


Figure 6. Provisional organizational chart for Irvine's Public Works Department

Planning and management information systems. Recent efforts to inventory the urban forest and track maintenance and inspection work have paid large dividends. Reduction in hazard tree liability and planned maintenance have generated considerable cost-savings.

Public relations and support. Cooperative action through planned Home Owner Associations (HOAs) has helped to promote volunteerism and reduce costly, lower priority, maintenance work. Such activities also contribute to consistency in maintenance, design, and planning between city and private services.

Urban Forest

Irvine's has two forest types. Irvine's inventory consists of 27,000 street trees and 6,000 eucalyptus shelterbelt trees. Eucalyptus shelterbelts are a major part of the local landscape and are favored for windbreak, wildlife habitat and shade. A fairly maintenance intensive species group, eucalyptus groves are further in need of restoration work due to pre-urban forestry "topping" practices. In addition, efforts are underway to introduce prescribed burning in the urban-wildland interface in response to recent wildfires in Southland.

Tree ordinance. The City of Irvine is currently considering enacting a tree ordinance. The prevailing view is that the city wants to pass control over to HOAs. Such an action would be an innovative approach to instilling citizen involvement, to improving enforceability, and to increasing volunteerism.

Budget & Operations

Budget currently $780,000 — over $7 per resident. One two-person city crew is designated as the "Juvenile Crew" devoted to tree planting and care of trees through age 5, while the other two-person crew works on pruning and related post-juvenile tree care. The current maintenance cycle is 3 to 5 years, but increasing to 4 to 6 years due to recent improvements in tree care practices. About 30% of pruning and removal residues are utilized through firewood sales and mulch.

Sources of external funds. Landscape and Lighting assessments, SBA grants, Prop. 70 (for tree plantings), and other state and federal grants.

Utilization of contract services. About half of the tree pruning, planting and removals are met by contract services. Planting costs (and supporting budget) have declined due, in large part, to cost-savings realized by increased planting knowledge

and tree care practice conducted by the ISA certified city and contract crews. Henry places great importance on all urban forestry staff and especially field workers being ISA certified after realizing these efficiency gains.

New management plan. A new urban forest management plan has already created significant benefits such as improved projections of nursery stock, and public involvement and support. The sustainability and efficiency of Irvine's urban forest has been greatly enhanced by having a reliable supply of planting stock available and by adhering to high planting stock standards prior to planting.

Modesto

Background

Modesto has grown rapidly in the last 20 years, tripling in population to over 174,000. In recognition of Modesto's progress in urban forestry, it has received the Tree City U.S.A. award 12 years consecutively.

Organization

Chuck Gilstrap, Urban Forestry Superintendent, is an ISA Certified Arborist with 20 years experience in tree care work. He has worked for the City of Modesto since 1981. Allen Lagarbo, Arborist, holds a B.S. in Ornamental Horticulture and is an ISA Certified Arborist. The recently reorganized urban forestry division is a large operation with 35 staff and crew members and is located in the Parks and Recreation Administration Division (Figure 7).

Highlights

Staff productivity incentive program. Modesto is one of three cities in California to receive the National Arbor Day Growth Award for tree planting and maintenance. The urban forestry division also received the 1992 National Productivity Award from Rutgers University for its innovative approaches to organizational efficiency and staff motivation, surpassing even its private sector counterparts. Each crew assesses weekly cost effectiveness and work schedules. The Self Achievement Training Program is a six step program, encouraging significant contributions from all employees. A recent article in California Trees described in more detail the efforts of Chuck in "Empowering City Tree Crews." (Gilstrap 1994).

Programmed Pruning. A planned and systematic pruning system is organized by grid location rather than on request. Chuck sees such planning as imperative to efficiency gains in urban forestry operations. As a result, productivity has increased by more than 300% since beginning the program.

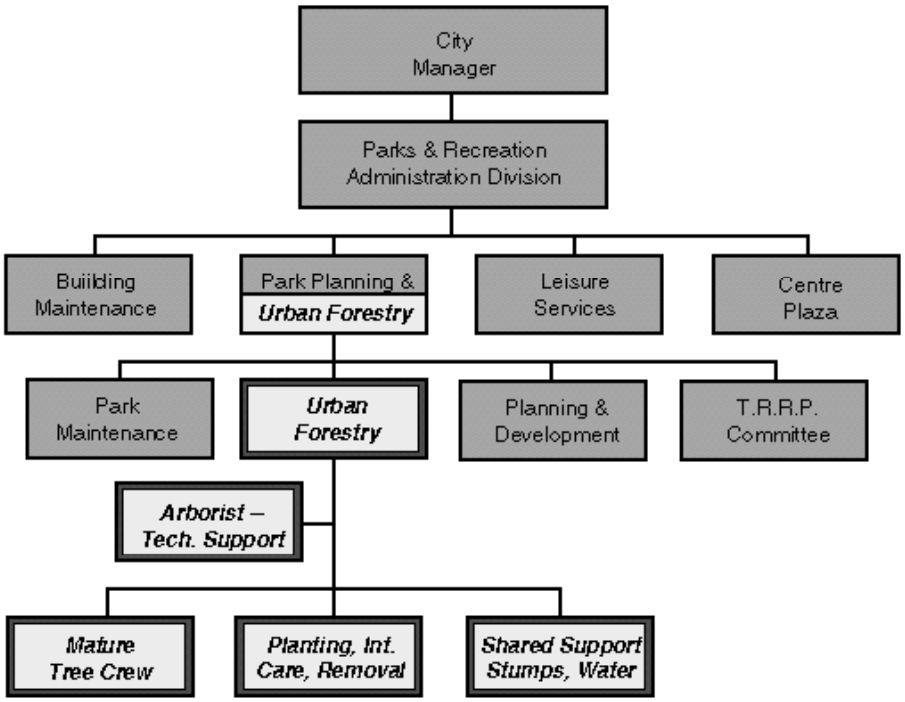


Figure 7. Organizational chart of Modesto's Parks and Recreation Administration Division.

Citizens first program. Citizen-customer satisfaction requests are distributed after maintenance has been completed. This in turn informs staff and managers of the strengths and weaknesses of the operational strategies and practices.

Urban Forest

Modesto's forest. The current public inventory is 96,000 street & park trees. Management emphasis is placed on fall color trees located along main feeder streets. Modesto is the home of the Modesto Ash — a "pride in native species" tree.

Tree ordinance. Modesto has had a tree ordinance in place since 1960. It was enacted largely because of the public's concern over intense and improper tree pruning (i.e., topping) for utility line clearance. The ordinance established the urban forestry program and emphasizes methods to preserve and enhance values arising from urban forests.

Budget & Operations

Current budget $ 2,188,346.00 — over $13 per resident. Fiscal 1993 activities included 3,000 trees planted (25% provided by city nursery), 1,000 removals, and 32,000 pruned. Modesto annually quantifies the costs and cost-savings on an individual crew member basis. Recently Modesto received a contract with a local utilitiy for line clearance which promises to be a significant source of revenue. In addition, reliance on inmate crews has resulted in large cost-savings.

Sources of external funds. A local gas tax and SBA grants ($220,000 over 4 years).

Three year maintenance cycle. Modesto strives for a very high maintenance-inspection frequency. This results in less harmful pruning on each maintenance visit. Currently an inventory system, designed for another city service, was adapted for tracking and planning urban forestry work.

Operation efficiency analysis. The urban forest program recognizes the human resource as the most important resource. The last three years of individual work were analyzed by cost per task, time per task, and equipment breakdowns to identify areas for improvement. A computerized inventory and record keeping system, operated for 11 years, has enabled managers to track maintenance trends, project management activities, and assess staff and crew productivity. Modesto's program was rated more efficient than the private sector. Given this impressive "in-house" efficiency, contract services are not used.

Sacramento

Background

For years, Sacramento has been recognized for its efforts to create and maintain an attractive urban forest landscape. It has been a Tree City U.S.A award recipient for many years, a difficult task for large cities. Because Sacramento is considerably larger than the other cities in this study, some organizational aspects of its urban forest program may not fit the purposes of this study. However, the goals and experiences in the urban forestry operation are relevant and important.

Organization

Martin Fitch, Superintendent of Tree Services, holds a B.S. in Ornamental Horticulture and an M.S. in Public Policy, has 15 years experience in Sacramento parks division, and is an ISA Certified Arborist. The Tree Services department, with 60 staff and crew members, is part of the Parks and Recreation Division under Neighborhood Services. Figure 8 illustrates Sacramento's organizational structure of Neighborhood Services.

Highlights

Reduce inspection/maintenance cycle. Like other cities, one of Sacramento's urban forestry goals is to reduce the inspection cycle. In spite of the large size of the city, they have been able to reduce the inspection cycle to 5 to 7 years — a remarkable achievement. Their service/trim cycle is about 12-14 years.

Private sector support and involvement. Sacramento has undertaken a massive volunteer program by cooperating with neighborhood groups to assist in caring for residential street trees and most especially private tree planting and care. However, Martin warns that cities must carefully address safety issues when involving the public in volunteer activities due to liability concerns.

Value of greenbelts. Martin stressed the contribution made by Sacramento's open spaces and greenbelts. The American River Bikeway, downtown pedestrian openspace and the Del Paso park

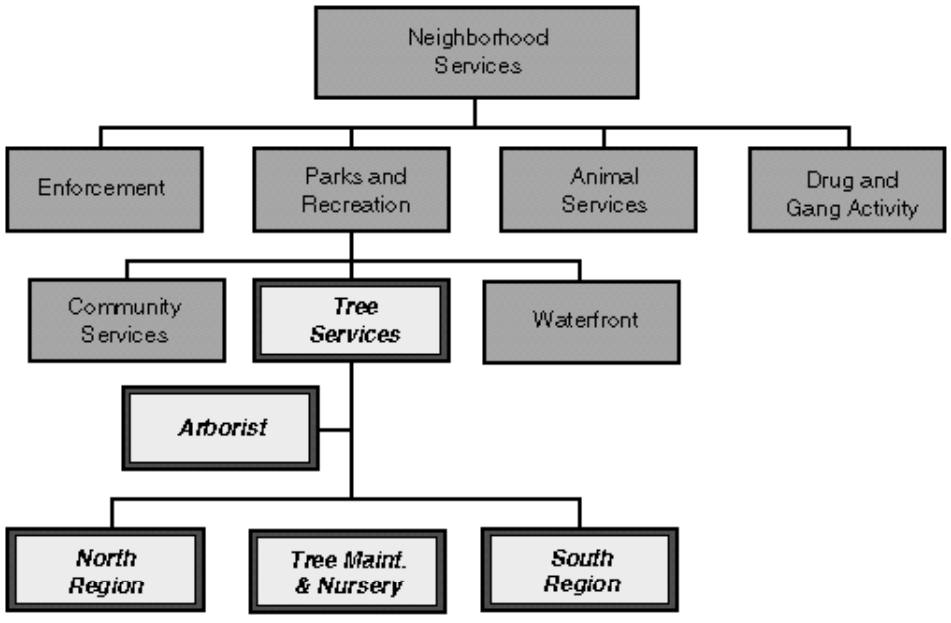


Figure 8. Organizational chart of Sacramento's Neighborhood Services

establish an urban aesthetic that influences many other elements of Sacramento's urban forestry program. The American River Bikeway is California's largest urban open space. Old Town Sacramento and associated areas contain over 12 miles of canals. And Del Paso park possesses 269 acres of attractive open space.

Urban Forest

Sacramento's urban forest. The urban forest is comprised of about 92,500 public trees on 2,000 acres of parks, 360 acres of greenbelts and maintenance strips, and special "pocket" areas such as the downtown mall-walk. The current forest is old (currently at 78% of average life expectancy) and is insufficiently diverse, but plantings now outnumber removals. About 50% of trees removed is for Dutch Elm disease control.

There is concern over past industrial development which made little allowance for planting space. Goals for species and age diversity have been designed and established to reduce the dominance of ash and elm. Sacramento sees its river greenbelts as a major environmental and business asset. The urban forest could benefit greatly from the elimination of residential designs that create "dead zones too small for planting."

Tree ordinance. Sacramento's tree ordinance promotes (1) education on the intrinsic value of trees, (2) tree planting and preservation, and (3) protection of "Heritage Trees" (large natives). The heritage tree ordinance enhancement was established based on recommendations from a lengthy strategic planning process. Finally, the ordinance requires that certified arborists prune any trees that are not maintained by the city.

Budget & Operations

Current budget $3.2 million — $11 per resident. Only about 4% of the budget goes to contract services.

Solidwood utilization. Sacramento has made several attempts at city-run solidwood utilization over the last five years but none were very successful. Now, Sacramento sells ash, elm, sycamore and eucalyptus logs from removals to D.P. Hardwood Inc., Auburn, CA, for lumber, flooring, furniture, and craft stock. The remaining volume is sold as firewood for about $150 per cord. Utilization of this solidwood comes at no extra cost to Sacramento; however, volumes are still small (about 3 to 6 dumptruck loads per weekend or about 15 to 20 tons per month) and therefore provide minor fiscal benefit. Terms of payment are from D.P. Hardwood's sales of products — currently about $7.50 per ton. D.P. Hardwood's average cost for processing hardwood logs is around $100 per cord.

Sources of external funds. Landscape and Lighting assessments, construction fees, and SBA grants.

Concentration yard for logs merchandized from tree removals adjacent to D. P. Hardwood's facility in Sacramento.

To summarize, the results of investigating these progressive urban forestry programs, Table 2 is offered as our assessment of the degree of progress toward the sustainability elements established in this report.

Table 2. Rating of five cities progress in key areas of sustainability

Elements/Programs	Monterey	Lompoc	Irvine	Modesto	Sacramento
Current Age & Species Diversity	3	2	3	3	2
Inventory & Planning Systems	2	4	2	2	3
Tree Care	4	4	4	4	4
Wood and Residue Utilization	2	2	2	2	3
Importance of Certification	3	3	4	2	1
Public Relations Programs	4	4	4	4	4

Note: Rating scale is 1 to 5 with 5 being maximum level.

Even though none of these cities has yet achieved the maximum level in any of the sustainable program areas, we believe that sustainability is achievable given current funding, efficiency improvements and time.

IV. Benefits and Costs of Sustainable Programs

In the preceding sections of this report, we introduced the basic elements of sustainable urban forestry and five California cities that are progressing toward sustainability. This background is important for understanding the guidance and recommendations presented in Section V. Before moving to those topics, it is important that the costs and benefits associated with each element be incorporated in the concept and thinking of sustainability.

This section describes the costs and benefits associated with sustainable urban forestry programs. It is generally a straight forward procedure to quantify the costs of urban forestry programs; however, to quantify benefits generally is a more complex process. Program benefits that are more easily quantified are:

- operational cost-savings
- operational flexibility and efficiency
- new sources of revenues

In situations where quantifiable benefits and costs dominate, benefit-cost analysis can be conducted. Net present value (NPV) or rate of return (ROR) on dollars invested in these programs are typical measures used in benefit-cost analysis. Program benefits (and/or costs) that are not easily quantified include:

- improved planning efficiencies
- enhanced social and political support
- organizational improvements
- reduced worker and public liability
- and the many environmental enhancements such as wildlife habitat or amenity values.

The program areas analyzed and discussed in this section fit in the four areas of sustainability. They are shown in the chart below.

Element of Sustainability	***Topic to be Analyzed***
Species Selection and Diversity	Proper species selection Age diversity
Inventory and Landscape Planning	Inventory and planning systems
Tree Care and Wood Utilization	Certification of workers Wood utilization Contract services
Public Relations and Support	Public Relations and Support

Species Selection and Diversity

Proper Species Selection

The net benefits of properly selecting species generally arise from the long-term economic and environmental effects (recall Figure 2):

- energy-savings from shade and cooling from evapotranspiration
- water and soil conservation
- fire prevention and management
- wildlife habitat
- wood biomass and commodity value (net of tree maintenance costs)
- air quality, especially hydrocarbon emissions from trees
- mitigation of effects on other public services (e.g., utility lines, sidewalks, street signs)

The cost of urban tree planting and establishment, maintenance and removal is highly dependent upon the suitability of selected species and tree care. City budgets for urban forest operations are heavily impacted by past mistakes.

Several studies have been conducted recently to quantify the values accruing from proper species selection (Dwyer 1991, Kollin 1991, McPherson 1991). Table 3 summarizes the benefit and cost estimates from these studies.

Table 3. Summary of approximate benefits and costs over a hypothetical tree's 40 year life.

Costs[1]		
Planting, 15 gal. tree	$120	per tree ± $20 by stock
Training prune @ ages 3, 6 and 10	$100	per tree (total)
Annual irrigation, < 6 years (mulch, water & labor)	$50	per tree per year for 6 years
Structural prunings (2 @ $75)	$150	per tree ± $80 by tree size
Tree & stump removal, age 40	$700	per tree ± $500 by tree size
Average costs annualized over 40 year life[3]	**$35**	**per tree per year** (approx.)
Disposal costs[1]	$25	per ton
Potential Benefits		
Energy-savings[2]	$20	per tree per year
Soil & water conservation[1]	$75	per tree per year
Air quality enhancement[1]	$50	per tree per year
Property value enhancement[1]		
private	$85	per tree per year
public	$25	per tree per year
Average benefits annualized over 40 year life	**$255**	**per tree per year**
Wood value (firewood only)	$75	± $25 per cord
Mulch value	$20	± $5 per yard

Note: These values are averages; costs vary by species and benefits vary by species and over a tree's life.

1. Kollin (1991) estimated costs and benefits for various tree sizes and conditions based on studies in San Jose and Tucson. San Jose urban forester, Mark Beaudoin (1994), has developed a matrix of costs and returns over the life cycle of the tree.
2. Dwyer (1991) estimated energy cost-savings by summarizing several studies. In the "Trees of Home Series" in American Forest, Davis (1994) reported potential energy-savings from increased plantings ranging from 1.6% in open-lands to 12.7% in residential areas.
3. McPherson (1991) estimated an annualized cost of about $10 per mesquite tree over a 40 year life in Tucson. Estimated annualized benefits were about $25 per tree (only includes energy-savings, water conservation, & air quality enhancement).

Note: Deviations in costs are not standard deviations and only express a typical range of cost variation in each type of operation as reported by Kollin, McPherson, Dwyer and urban forester interviewees. Energy-savings accrue by reducing city temperature and therefore cooling costs by nearly 20%; air quality benefits accrue by reduced inspection and maintenance costs to control pollutants; water and soil benefits accrue by conserving stormwater runoff and dust interception. Other costs that could become significant if the species is not well-adapted include pest control @ $0.44 per tree and sidewalk repair from root damage @ $150 per tree. Other operational costs can include site preparation (e.g., concrete-cutting and soil aeration), liability and litigation, recreational value, wildlife habitat, and various human (hedonic) values.

Annualizing the benefits and costs, shown in Table 3, does not reveal their timing. Generally, costs tend to dominate in the early years and benefits accrue in the latter years. Therefore, the ideal tree would be one that grows fast and lives long, however, nature tends to force a tradeoff.

Unfortunately, the trend in urban forestry is to favor fast-growing, short-lived species (Bernhardt and Swiecki 1993). Such practice may be cheaper but does not promote a sustainable forest. Longer-lived trees will clearly provide the aesthetics demanded and allow for extended maintenance cycles.

From a strictly financial perspective, the potential net benefits over a tree's 40 year life span generates a competitive rate of return of 15%. McPherson's analysis (based on fewer benefits) indicated that rates of return vary between 2% and 14%, the highest rates being yard trees since they receive better sites and more care.

Age Diversity

The purpose of diversifying age classes in the urban forest is to create a sustained flow of the maximum net benefits attributed to a single tree (summarized in Table 3). To do this requires "regulating" (proportionally distributing) the ages of the species mix to obtain an uneven-aged forest (see side bar, next page), while considering constraints such as expected maintenance budgets, city utilities, and aesthetics.

For example, the approximate number of trees to plant per year should be determined by dividing the total number of trees expected, when the urban forest is fully planted, by the maximum age at removal. This would be calculated for each species. When a grant for planting is awarded, it is tempting to ignore this rule and over-plant. Once age class distributions are regulated (i.e., balanced among age classes), net benefits from urban forestry (based on data in Table 3) can appropriately be annualized (Figure 9).

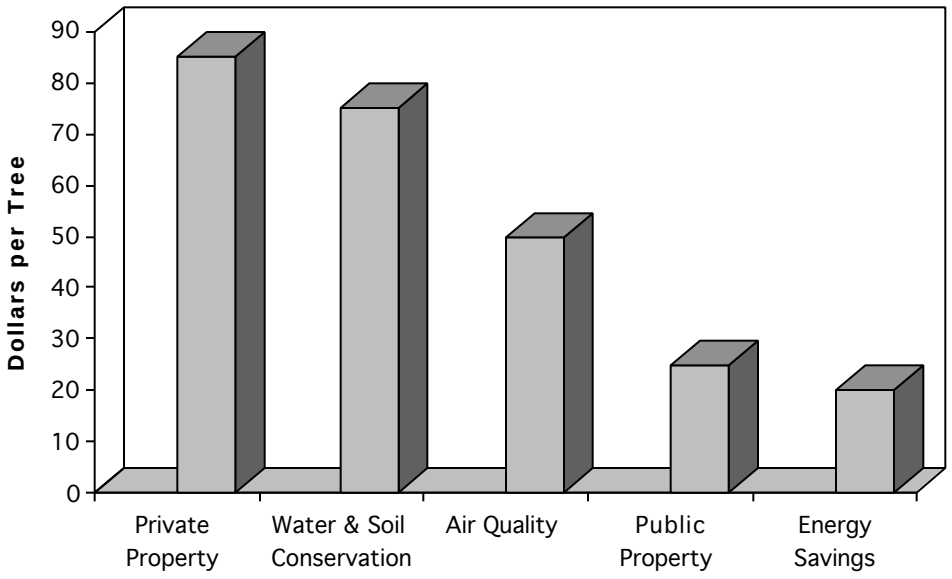


Figure 9. Annualized benefits of an individual tree over a 40 year life (benefits vary over life of tree).

Note: Estimated annualized costs per tree is $35. Annualized net benefits are based on studies by Kollin (1991), Dwyer (1991) and McPherson (1991).

Inventory and Landscape Planning

Inventory and Planning Systems

Evaluating rates of return on investments in a computerized tree inventory and mapping systems is a challenging task. This is because needs and operating costs vary according to a wide variety of current and expected forest conditions and related city characteristics.

The benefits of computerized inventories include more efficient scheduling, budgeting, and reporting of management activities. Systematic scheduling can produce savings of nearly 30% for pruning and 50% for tree removals (de Vries 1993). Howard and Hudson (1984) reported the cost of crisis tree pruning at 2.38 hours per tree, while the cost of planned maintenance was 1.03 hours per tree. Wager and Smiley (1990) cited cost-savings of up to $1500 for report generation with computerized inventories. Table 4 below summarizes the developmental costs and long-term cost-savings from investing in GIS.

Table 4. Costs and cost-savings from investment in a computerized inventory and planning system

Development Costs		
ARC/INFO License (GIS)	$6,000	
dBase System	$600	
Data Entry	$900	
State Data	$150	
	$7,600	
Cost Savings		
Pruning	$60	per tree
Tree Removal	$585	per tree
Report Generation	$1,500	per year

Note: Cost-savings on pruning are based on de Vries' 30% savings rate applied to Kollin's average clearance and structural pruning cost of roughly $200 per tree (see Table 3). Cost-savings would rise rapidly as emergency pruning declines through planning. Similarly, tree removal cost-savings are derived using de Vries' estimate applied to average tree removal costs reported in Table 3.

Management by Different Age Structures

Uneven-age implies a forest structure in which there are several age classes represented in a given management area.

Even-age implies a structure wherein all trees in the management area are one age.

All-aged infers a structure wherein every age class up to the maximum planned age is represented in the management area.

Computerized tree inventories make it feasible for managers to calculate the benefits and costs of an urban forest. Two examples follow. Indices which reflect a species adaptability to local environmental conditions can be developed. Inventory reporting procedures can be supplemented with formulas which have been developed to estimate biomass by size class, and the dollar value of the urban forest in terms of improved air quality, energy-savings, and reduced storm runoff.

Tree Care and Wood Utilization

Certification of Workers

Proper species selection and tree care go hand-in-hand. Poorly selected species, disregarding the long-term effects, can force the city to spend large sums on regular and emergency pruning. Alternatively, improper tree care (e.g., topping or ill-timed pruning) can ruin a good tree and require frequent pruning in the future. Again, sustainable urban forestry is a systems notion — a management approach in which one cannot single-out one idea/program.

Practices to enhance the health, vigor and appearance of trees have been greatly improved through the study of arboriculture. The International Society of Arboriculture (ISA) has established a

certification program to promote sound tree care practices. Careful tree selection, planting, and timing of the training-prune can result in a high likelihood that no extraordinary maintenance work will be necessary during the remainder of a tree's life.

Most of the cities that we worked with during this study, paid, or are planning to pay, for all city tree workers to be ISA certified. Many have also required contract workers to be certified. The benefits of certified workers are provided through:

- reduced worker hazard and liability
- reduced public liability
- improved maintenance efficiency
- and an extended maintenance cycle.

The cost of certifying, and continuing education of a tree care worker is relatively small when compared to the benefits derived. Cost for certification includes $400 for books, registration and test, annual continuing education, time lost and per diem (Steve Holcomb, ISA Western Chapter Certification Board, see Section V). Of course, these costs will vary by city depending on location, mix of city and contract workforce, and time lost.

The net benefits per tree over time will vary primarily in accordance with the size and existing condition of the city's tree inventory. For more details on ISA certification and related services, see Section V of this report for the address and phone numbers of ISA Western Chapter contacts.

A benefit-cost analysis of certification was conducted, based in part, on data obtained from Irvine's efforts to ensure that all tree care was done by certified workers. Figure 10 illustrates the costs and benefits over a 25 year period resulting from worker certification. The experience of Irvine and other similar cities indicate that they could potentially realize a return of over 100% on

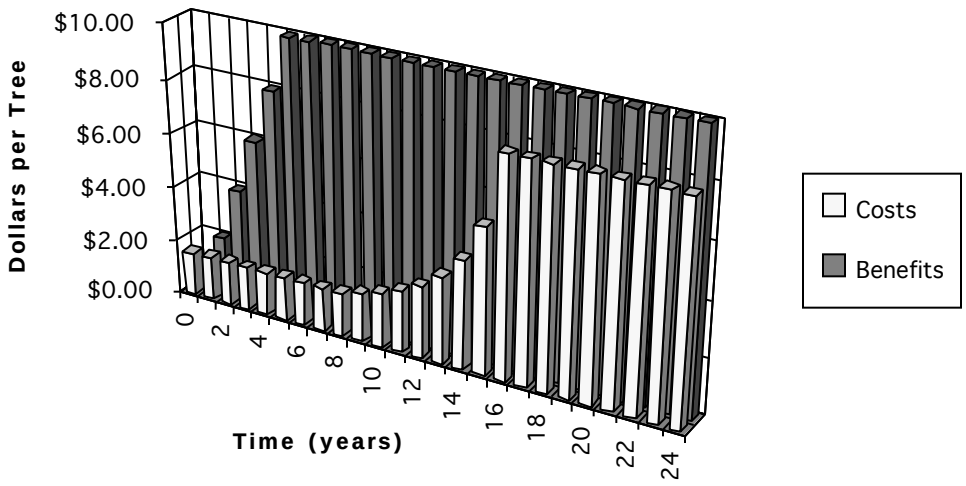


Figure 10. Benefits and costs per tree using ISA certified field crews over a 25 year investment period

Note: An all city workforce was assumed (increasing cost/tree). Benefits from observed contract cost-savings due to improved worker efficiency and reduced tree care problems accrued over 9 years. Costs per tree were derived by amortizing the certification costs of a hypothetical 8-person city crew over 2,000 trees treated each year using Irvine's approximate 16,000 street tree inventory. Increasing costs per tree reflect the annual decline in emergency prunings and similar effects thereby spreading costs over fewer trees.

worker certification, all other things being equal. From another perspective, this is equivalent to reducing the present value of maintenance expenditures by about $60 for every tree in the city's street tree inventory (at a 6% discount rate).

Not included in this benefit-cost analysis is reduced worker and public hazard liabilities which can be quite significant considering the frequency of litigation. This preliminary analysis should serve to reinforce the influence of proper tree care in sustainable urban forestry.

Measures to ensure high quality tree care are one important element in the education and training of staff and workers in urban forestry. Similar high standards should be met in the other areas comprising urban forestry: forest landscape structure and composition, inventory and planning modeling and analysis, and urban forest ecology and silviculture to name a few.

Currently, Registered Professional Foresters (RPF) are legally accountable for (1) management recommendations, and (2) all commercial forestry activities, for which they are qualified, on private forestlands in California. The education and experience required for the RPF license is rigorous (B.S. in forestry, plus 3 years of experience and passing a day-long comprehensive examination). Certification for range management specialists was recently approved by the Board of Forestry for woodlands managed for range purposes.

The Society of American Foresters recently adopted a position statement expressing the need for educational standards in urban forestry. Also, in recognition of the increasing urbanization of California forestlands, the California Board of Forestry is investigating the possibility of a certification program in urban forestry. The need for such a certification will undoubtedly grow as forest management activities occur in a increasingly urbanized landscape.

Wood Utilization

Urban forests that were composed of the "wrong" species, or were improperly pruned, often generating a large residue problem. Landfilling or burning are not a sustainable option (see Table 3 for costs). Even under sustainable conditions (e.g., proper selection and care), residues will continue to be generated. What are the sustainable options for wood waste?

Most cities in California are seeking ways to utilize urban wood waste (Bernhardt and Swiecki 1993). Typically, utilization methods include use of prunings as mulch in urban tree care, free mulch or firewood for the public, or in some cases, use in landfill operations as a cover material. Future uses may include focus on wood commodities and as a cogeneration fuel.

A benefit-cost analysis was used to demonstrate that sound utilization practices are economically efficient. Figure 11 illustrates the benefits and costs over time that result from city investment in a portable chipper, substituting prunings for purchased mulch, and avoiding landfill charges. Clearly, this would represent a comparison between a reasonable use of residues and the worse-case scenario, that is, bury-or-burn and purchase mulch.

Investing about $15,000 in a portable chipper (10 year useful life) will return about $27,000 at 7%, or roughly a 20% return on investment (based on results in Irvine).

But this approach does not have to be the only option available to a community. Wood is an amazingly versatile and valuable raw material. The fact that it was grown on urban lands rather than on timber lands makes it no less useful and valuable. It is an "environmental-friendly" raw material compared to metal, brick or concrete, the least energy intensive, and the only renewable material of all types for use in construction and furniture (Salwasser et.al. 1993).

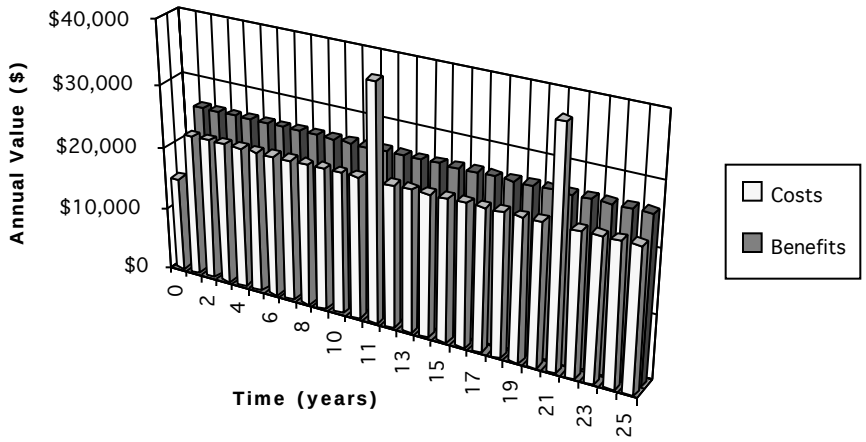


Figure 11. Benefits and costs per tree of biomass utilization from investing in a portable chipper over a 25 year useful life

Note: Expected useful life was estimated to be 10 years. Therefore, cost peaks in years 10 and 20 reflect replacement cost in addition to annual labor costs in support of biomass utilization.

Once the age classes of the targeted species have been properly distributed, annual tree removals will reach a low but steady-state level. Viewing wood residues from these removals as waste is wasteful in itself. As George Hessenthaler, owner/operator of Urban Forest Woodworkers in Utah, a leader in urban solidwood utilization (Herr 1993), is quoted, "I believe it's a crime against nature, and a sacrilege for woodworkers, to dump any hardwood tree, or even to turn a blind eye to the act."

As illustrated in Figure 2, one of the considerations in species selection should be its potential value as a commodity, or specialty use, like woodworking. Pruning operations could also be conducted to enhance ultimate wood values while still being consistent with ISA standards.

Hessenthaler has been operating essentially on a break-even basis for five years selling specialty wood products. In California, David Faison, owner of Into the Woods in Petaluma, processes over 50,000 board feet each year into specialty items like butcher blocks and furniture (Herr 1993). D.P. Hardwood Inc., Auburn, CA, receives approximately 15 percent of its annual supplies from Sacramento's city tree removals (averaging about 15-20 tons per month). In return, Sacramento receives about $7.50 per ton. Many species listed as desirable urban tree species also possess wood characteristics that are easily substituted for traditional species, and some exotic species, used in woodworking shops. This is an area needing further research and promotion work.

The photos on this and the next page illustrate the utilization process for urban tree removal.

Though currently a break-even operation at best, the future seems to offer greater rewards, not just to woodworking businesses, but to

the cities that sell the wood and the public that buys the products. Although the primary reason for species selection should focus on aesthetics and management costs, wood values should and will influence choices.

Contract Services

The role and benefit of utilizing contract services is highly variable but generally on the rise. Bernhardt and Swiecki (1993) report that 83% of responding California cities utilize contract services, compared to 62% in 1988.

Many cities like Irvine and Monterey have realized significant operational cost-savings and flexibility by contracting certain work, primarily tree removals and large tree plantings. However, the degree of cost-effectiveness of contract services is closely linked to the city's adoption of sustainable practices. Simply "farming-out" some work can actually cost the city more if the contract services are not state-of-the-art. Moreover, contract services may not be available due to a community's small size and or remote location (e.g., Lompoc).

Because of the highly unique nature of city-contractor roles and forest conditions, benefits of contract services are difficult to quantify. Nevertheless, the cost-effectiveness of contract services can be quite large through

- reduced fixed costs of urban forest operations
- increased operational flexibility and response
- performance accountability
- reduced city liabilities (Kennedy 1990).

Certainly, a major obstacle to the adoption of an urban forestry program by smaller cities is the fixed costs associated with adding personnel to the city payrolls. Small towns have difficulty in providing even basic services such as police protection and schooling. However, contractors could afford to locate operations in areas dominated by small towns and communities if cities would organize as a cooperative, thereby offering an economical volume of annual work. Thus, small city cooperatives could proxy a medium-sized city and enjoy the benefits of urban forestry through economies-of-scale. In addition, such cooperatives would promote communication between cities and sharing of ideas.

Public Relations and Support

Like all natural resources professionals, urban foresters ultimately work for the resource owner not the resource. Public relations must therefore be the dominant concern of an urban forester and must not be viewed as "something that has to be done." Public relations should be viewed as constituency development since a satisfied public is a supportive public. This support should evidence itself in the form of consistent city funding.

A benefit-cost analysis of investment in public relations is quite simple. The costs are unquestionably significant — time spent and personal stress in public interaction. Even GIS, which can be a very powerful and illustrative tool in public relations work, is expensive to establish and maintain. However, the potential benefits of sincere and relevant public relations effort are, in essence, the whole of the benefits of urban forestry in itself. For without public support, the goals of a city's urban forestry program cannot be sustained. The essential nature of public relations work, results in a return on investment that is many orders of magnitude greater than the other three elements.

Some of the many direct benefits from investments in public relations include:

- means to increase volunteerism
- support for controversial or costly decisions
- reduced need for overly restrictive tree ordinances
- more involved, energetic staff and field crews.

Nearly all urban foresters interviewed indicated that public relations was their dominant and most rewarding activity. Public relations cannot be treated as something successfully done once and forgotten. In these difficult economic times for cities, public sentiment can shift rapidly to more immediate and pressing concerns. For example, in a recent statewide poll, 90% of the respondents ranked jobs and crime as very important, while only 53% ranked urban forestry as very important (Mark 1994a). More importantly, elected officials come and go, and new ones may not be as supportive of urban forestry as their predecessors. Public relations work must be aggressive and ceaseless for urban forestry to survive the ups-and-downs of social and political tides.

One of the first goals of an urban forester should be to design and establish an organization that maintains high social-political visibility and responsiveness, not being dependent on the "boss's" personal energy and enthusiasm. As Cindy McCall described it, "staff and crews are the most visible element of Lompoc's urban forest operations and I work to help them understand their critical role in public relations."

One of the most significant and depressing observations in this study was that a few cities that had established a solid reputation for its urban forestry programs, had lost it almost overnight because of a change in the political climate. Urban foresters must work continuously at heightening the visibility of urban forest goals and activities. The public must be constantly reminded of the value-added benefits of their investments in a sustainable urban forest. Never assume that the public, and most especially elected officials, have the same awareness and enthusiasm for urban forestry as you.

Contours of Coast Live Oak in Sacramento

V. Basic Regional Models

One of the early thoughts of this project was to help translate or "scale" the results from these cities to a new city of different size, style of government and urban forest condition. From numerous interviews with urban foresters around the state, we have concluded that it would be highly difficult, if not inappropriate, to create a "cookbook" for designing your urban forestry program. Nevertheless, as you have seen already, there are certain key elements to any urban forestry program that must be in place in order for it to meet its community goals and be sustainable. The following summarization is provided to give you information sources and general, conceptual direction in designing your programs.

Table 5. Irvine's top one-third target tree species

Species	Target Percentage
Sugar Gum, *Eucalyptus cladocalyx*	6.36
Jacaranda, *Jacaranda mimosifolia*	4.77
Eucaplyptus maculata	4.35
Gum Myrtle, *Angophora constata*	3.96
Canary Island Pine, *Pinus canariensis*	3.93
Carrotwood, *Cupaniopsis anacardioides**	3.86
Brisbane Box, *Tristania conferta*	3.64
Sweet Gum, *Liquidambar styraciflua**	3.43

(* Corchnoy et.al. (1992) study indicates potential hydrocarbon emission problem)

Species Lists by California Region

The same principles that guide wildland species selection equally pertain to the urban landscape. The primary concern is to match species characteristics to the native ecosystem in the context of an urban and community environment.

The following tables are provided as a general guide to designing the mix of species for the three California regions designated in this study.

The Southland

Irvine has developed a Master Species List that consists of over 150 tree species. Table 5 lists species in the top third Irvine used for establishing their urban forest.

Central Coast

Robert Reid has categorized Monterey's preferred list of trees by size, and leaf habit (evergreen or deciduous), shown in Table 6 (see next page). He also has similar lists for special purpose and further consideration.

In Lompoc, Cindy McCall developed a Master Species List of nearly 250 tree species. Table 7 lists the species used on public property and recommended for private property in Lompoc. Each tree is described by height, spread, right-of-way need, growth rate, maintenance problems, root structure, wind resistance and form. A code is

Table 6. Monterey's primary target tree species by size.

Small Trees (15'-25')

Evergreen	Deciduous
Mayten, *Maytenus boaria*	Japanese Maple, *Acer palmatum*
Victorian Box, *Pittosporum undulatum*	Purple-leaf Flowering Plum, *Prunus blireana*
New Zealand Christmas Tree *Metrosideros excelsus*	Aristocratpear, *Pyrus calleryana*
	Chinese Flame Tree, *Koelreuteria bipinnata*
Italian Buckthorn, *Rhamnus alaternus*	
Camphor Tree, *Cinnamonum camphora*	
Tristana laurina	
Strawberry Tree, *Arbutus unedo*	
Arbutus marina	

Medium Size Trees (25'-35')

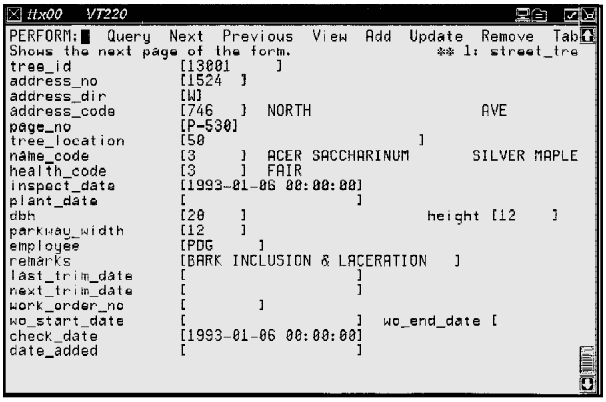
Carob, *Ceratonia siliqua* podless	Chinese Elm, *Ulmus parvifolia*
Magnolia, *Magnolia grandiflora*	

Large Trees (>35')

Evergreen	Deciduous
Monterey Pine, *Pinus radiata*	London Plane, *Plantanus acerifolia*
Coast Live Oak, *Quercus agrifolia*	Tulip Tree, *Liriodendron tulipifera*
Monterey Cypress, *Cupressus macrocarpa*	Maidenhair, *Ginkgo biloba*
Canary Island Pine, *Pinus caneriensis*	American Sweetgum, *Liquidamber styraciflua*
Italian Stone Pine, *Pinus pinea*	Idaho Locust
Coast Redwood, *Sequoia sempervirens*	Honey Locust, *Gleditsia triacanthos*
Red-Flowering Gum, *Eucalyptus ficifolia*	Southern Magnolia, *Magnolia grandiflora*
Sierra Redwood, *Sequoia giganteum*	

used to describe the level of preference assigned to each species:

1. Strongly recommended
2. Recommended
3. Recommended with restrictions
4. Restricted — requires approval prior to planting
5. Not in use at this time
6. Experimental — may be used with prior approval



Example of Monterey's Street Tree Database.

Table 7. Lompoc's list of recommended tree species

Strongly Recommended
- Incense Cedar, *Calocedrus decurrens*
- Western Redbud, *Cercis occidentalis*

Recommended
- Strawberry Tree, *Arbutus unedo*
- Lemon Bottlebrush, *Callistemon citrinus*
- Weeping Bottlebrush, *Callistemon rigidus*
- Leyland Cypress, *Cupressocyparis leylandii*
- Maindenhair, *Ginkgo bilboba*
- Honey Locust, *Gleditsia triacanthos*
- Chinese Flame Tree, *Koelreuteria bipinnata*
- Goldenrain Tree, *Koelreuteria paniculata*
- Sweet Gum, *Liquidambar styraciflua* *****
- Majestic Beauty, *Magnolia grandiflora*
- Mayten Tree, *Maytenus boaria*
- Chinese Pistache, *Pistacia chinensis*
- Coast Live Oak, *Quercus agrifolia*
- Holly Oak, *Quercus ilex*

(***** Corchnoy *et.al.* (1992) study indicates potential hydrocarbon emission problem)

Central Valley

An interdisciplinary team approach is probably the best way to develop the target tree (and shrub) species menu. All team members must agree with and work toward the overall urban forest goals and realize the effects of their preferences on the management of the urban forest ecosystem.

Table 8 summarizes the species preferred for planting on city property in Modesto.

Table 8. Modesto's list of preferred tree species

- Patmore Ash, (cultivar)
- Camphor Tree, *Cinnamonum camphora*
- Chinese Pistache, *Pistacia chinensis*
- Goldenrain Tree, *Koelreuteria paniculata*
- Maidenhair Tree, *Gingko biloba* (autumngold)
- Hesse Ash, *Fraxinus excelsior* (single leaf)
- Zelkova "Village Green", *Zelkova serrata*

Species Selection — Related Annotated Publications

Clark, J. R. and N. P. Matheny. 1991. Management concepts for "natural" urban forests. Proceedings of the Fifth National Urban Forest Conference, Los Angeles, CA, p. 22- 25.

Urban forests require active management, whether they originate as planted landscapes or as fragments of natural forests. The latter are seen as somehow being "natural" and as such not requiring active management. This is a false and misleading concept, for small fragments of forest are subject to a range of external influences which degrade their function.

Gilman, E. F., D. G. Watson, M. L. Cilley, H. W. Beck, P. Fowler and N. R. Morgan. 1993. Computer applications to assist tree selection,. Proceedings of the Sixth National Urban Forest Conference, Minneapolis, MN, p. 208- 211.

Southern Trees is an interactive multimedia CD-ROM program developed to help select the right species or cultivar for the right place. The Tree Expert System of the program selects a list of trees that satisfies the site conditions that the user specifies. The program is designed for trees in USDA hardiness zones 6-11. There are 681 data records, illustrating trees through text, color photos, and line drawings.

Larson, T. A. 1991. Proper selection of quality ornamental trees. Proceedings of the Fifth National Urban Forest Conference, Los Angeles, CA, p. 167-168.

There are three types of tree buyers: 1) the price hunter, 2) the size hunter, and 3) the value hunter. Strive to be the value hunter. Seek the following characteristics in your supplier: good reputation; customer oriented; knowledgeable sales force willing to supply necessary cultural and care information; plant material grown true to name; application of quality horticultural practices; and proper deliver and handling services.

Planning and Inventory Systems

Many cities have adopted computerized inventories for tracking street and park tree work. When tree locations are recorded by street address, a geographic information system can be used to create street and tree maps from inventory data.

Computerized Tree Inventories

General purpose databases typically cost from $200 to $600 (see sidebar for specific companies, cost and products). The advantage of a general purpose database is that it can be set up to meet the specific needs of the users. Many cities are using databases used for other agency functions, which eliminates the cost of purchasing software and hardware (Warrick and Williams 1993). It may be preferable to adopt a software program that is already in use in the organization, so experienced users can provide on-site advice.

There are a number of specialized databases for urban forestry applications (Cooney 1985; Smiley 1986). Specialized databases range in cost from $200 to $3500. The advantage of specialized databases is that templates for data entry and report generation are often provided for the user. In addition, some specialized databases allow the user to calculate the economic value of the urban forest (Table 9).

Geographic Information Systems (GIS)

General information on hardware and software requirements and costs are provided here, as well as a brief description of Lompoc and Monterey's GIS efforts.

Software. A database software program is needed to develop a computerized inventory. dBase IV software was selected because it is widely used and can be customized by the user. Any database software that can export data in text format could be used. ARC/INFO GIS software was selected because it is the most widely used GIS program. Other packages could be used, as long as it is vector based (tree locations can be represented by x-y coordinates) and includes utilities for importing the street network data files described below. Both ARC/INFO and dBaseIV include utilities for importing pre-existing computerized inventories.

Hardware. The minimum hardware configuration to run ARC/INFO is a PC-386 compatible computer, with 8 MB of RAM, one floppy disk drive, 300 MB hard drive, math coprocessor, one parallel port for a hardware key, and a SCSI card. Total hardware cost is about $2,500. Data is normally input using both keyboard and a map size digitizer ($3,000-5,000), although a considerable amount of data is available through public and private organizations and vendors.

The City of Lompoc has integrated urban street tree data with a city-wide GIS, which includes roads and utilities. The street tree database includes information on species, location, diameter, height, inspection date and prune interval. The database is being used to document tree maintenance and to assess the urban forest history with respect to age distribution and health. This urban forest capability was acquired at a cost of about $150,000.

A pilot project was initiated for the City of Monterey to determine the effort required to produce a GIS database. The pilot project covers a one square mile of Monterey. Activities and costs specific to the pilot study are included here.

The inventory data, which included tree address, common and scientific name, diameter, and date inspected was collected by the City of Monterey Parks Department. There were a total of 973 street trees sampled in the study area. It required 120 hours to record the field data, and 30 hours to enter this information into the database. Forty hours were required to process the street tree data, and to link the map to the inventory data. Unique patterns were created to represent the seven most common species in map form.

A short list of inventory database, GIS and setup services in provided in Table 9.

Development of a GIS database presents a challenge because manually entering the addresses of

Table 9. Computer Software and Services

Product	Price Range	Vendor and Address	Contact & Phone Number
Inventory Databases			
dBase IV	$300	(Most computer stores)	
TreeKeeper	$3,500-5,000	Davey Tree Expert Company 1500 North Mantua Street Canton, OH 44240	Ward Peterson 800-447-1667 x255
Quanta Tree (valuation model)	Unknown		To be distributed through ISA
TreeKeeper Jr.	$100	National Arbor Day Foundation Conferences and Training 211 North 12th, Suite 501 Lincoln, NE 68508	Vicki Saulnier 402-474-5655
TreeMaster	$2500-5000	Tom Pehrson 4980 Appian Way El Sobrante, CA 94803	Tom Pehrson 510-222-6278
GIS/Mapping Software and Systems			
PC ARC/INFO	$6,000	ESRI 380 New York St. Redlands, CA 92373	General Marketing 909-793-2853 x1375
Intergraph	$750 -$17,000+	Intergraph Mailstop LR24B3 Huntsville, AL 35894	Larry Warnick Ian Nixon 205-730-7205
Street Network Files	$1,000-2,500	ETAK, Inc 1430 O'Brien Drive Menlo Park, CA 94025-1432	Kathy McCaw 415-617-0129
TIGER Files	$250 per CD-ROM	U.S. Census Bureau DUSD Washington Plaza, #1, Room 404 Washington, D.C. 20233-8300	David Shaw 301-763-1384
GIS Training and Setup Services			
Vendor	**Services**	**Address**	**Contact & Phone**
Forest Data	Services range from individual training in GIS and mapping to contract analysis to installing "turn-key" inventory and GIS systems.	Forest Data 68 Castle Rock Court Walnut Creek, CA 94598	Dr. Philip Langley 510-935-0735
Geographic Resource Solutions		Geographic Resource Solutions 1125 Sixteenth Street, Suite 213 Arcata, CA 95521	John Koltun 707-822-8005
Pacific Meridian Services		Pacific Meridian Services 5915 Hollis Street, Bldg. B Emeryville, CA 94608	Ruth Askevold 510-654-6980

city streets and the position of trees would be time consuming. To avoid this step, specialized street network files, TIGER files, were obtained from the U.S. Bureau of Census (Table 9). Each file contains roads by county, and street address ranges for each road segment in areas with populations large enough to be designated as small metropolitan areas. TIGER files are inexpensive ($250 for most states on CD-ROM) if purchased from the Bureau of Census, but are only sold by county units. These tend to be large files and special processing is required to clip the information to the city boundaries. Preprocessed files are available from alternative sources for around $500.

Once both inventory and GIS databases are completed, they are linked to provide descriptive information for GIS queries such as tree location.

Planning and Inventory — Related Annotated Publications

Grove M. and M. Hohmann. Social forestry and GIS, Journal of Forestry 90 (12):10-15.

Geographic information systems help foresters meet the challenge of integrating biophysical and sociocultural information and identifying the complex interactions between people and their environment. . . . It [GIS] does present the danger of too much information. Common sense must be used to determine when a GIS has become an all-consuming quest (a goal) rather than a tool.

Moll, G. and C. Kollin. 1993. A new way to see our city forests. American Forests, Sept./Oct., p. 29-32.

From eyes in the sky to well-grounded databases, innovative mapping tools are helping give our cities a new image. Microcomputer-based Geographic Information Systems allow even average-sized communities access to powerful images of their urban forest resource.

Sample, V. A. 1991. Urban forest measurements that help policy-makers. Proceedings of the Fifth National Urban Forest Conference, Los Angeles, p. 143-147.

Beyond the day to day requirements of tree managers, inventories need to provide policy makers with the information to make important decisions. New inventories must give us a three dimensional view of the city's tree canopy; they need to tell much more than how many trees.

Wen-Quan Sun and Nina L. Bassuk. 1991. Approach to determine effective sampling size for urban street tree survey. Landscape and Urban Planning, Elsevier Science Publishers B.V. Amsterdam 20 (1991) pp. 277-283.

The collection of data on the current condition of street trees is the first step in developing an urban street tree planning and maintenance program. The objective of this study was to establish a recommendation of sampling size to facilitate street tree surveys. Sections of study include Sampling Simulation Method, Sampling Sizes and Sample to Sample Variation with a case study and recommendation.

Organization and Funding

From interviews with urban foresters in the surveyed cities, we found that the organizational position of the urban forestry department (or division) is highly important. To better ensure reliable funding and public visibility of urban forestry, the urban forester must strive to elevate departmental status as high as possible in city government. To accomplish this, the urban forester should undertake strategies that will enable the community to see that a well-managed urban forest is equally valuable to the community as are other basic services.

Figure 12 illustrates a generic organizational chart for the urban forestry department for a medium-sized city, based on minimal use of contract services. Inventory, planning and reporting should be a separate function under Urban Forestry. The assistant urban forester would be involved in contract administration, support in proposal development, species selection and public relations work. In small towns, it is clear that urban forestry operations should not expect to enjoy unique status given the overall size of small town government.

The direct result of the status and stature of the urban forestry department is the size and consistency of its budgets. We have already discussed the problems of shrinking city budgets and how this impacts urban forest management. Strategies to overcome these problems begin with organizational position and progress toward increasing external funding (Table 9).

Once organizational status is achieved, what size budget should a medium-sized city strive for? The award for Tree City USA was partly established to recognize those cities that committed sufficient resources to managing its urban forests. The basic standards include:

- a tree ordinance
- an official tree board
- an Arbor Day proclamation and observance
- spending a minimum of $2 per resident on urban forestry activities (Ries 1993).

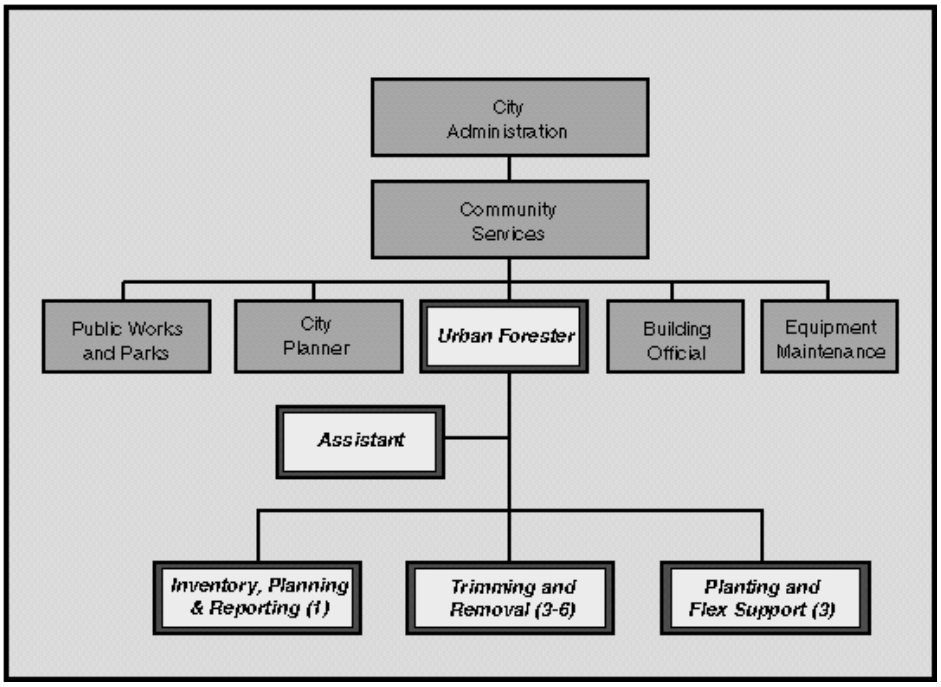


Figure 12. Recommended urban forestry organizational chart for medium-sized cities.

Note: Numbers in parentheses are the size of staff associated with each function. The range in staff numbers is based on city population differences (between 50,000 and 100,000).

Sufficient and stable funding has been historically the toughest and most consuming concern of urban foresters. The budgets of our profiled cities ranged from $7 to $23 per resident — a typical measure of expenditures on urban forests reflecting city size effects. Figure 13 illustrates that urban forestry budgets per resident generally decline as city size increases, a result of economies-of-city size.

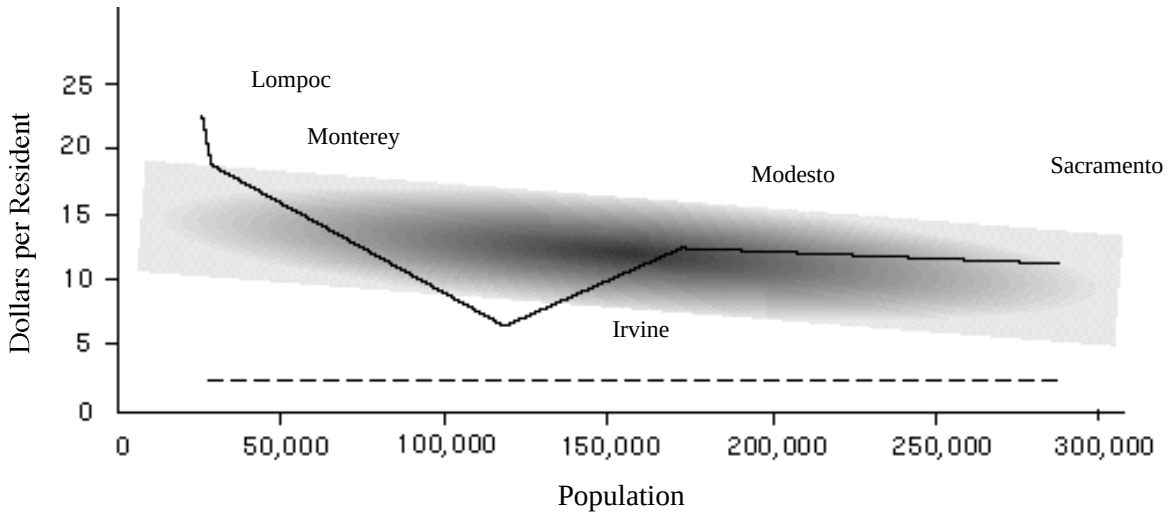


Figure 13. Plot of urban forestry budget per city resident by city population for medium-sized cities.

Note: Irvine is below the shaded trend band. This is partly due to cost-savings (about $1/resident) from efficiency gains, plus recent serious budget cuts. The dashed line is the $2/resident minimum value used by Tree City USA.

Based on analysis of these budgets and discussions with urban foresters, some general recommendations can be made regarding budgets for the start-up phase. Figure 13 shows a shaded band that follows along the downward trend in budgets per resident as city size increases. In general, your city's budget target should fit within this band based on population and adjusted for current forest conditions or problems. The Tree City USA minimum is essentially irrelevant for small to medium-sized cities since it was set sufficiently low to allow very large cities to qualify. As your urban forestry program matures, cost-savings should result as work transitions from expensive emergency tree care to sustainable management conditions. To provide further tips on setting budgets, Table 10 describes a sufficient budget for a hypothetical city of 50,000 under generalized start-up conditions.

Table 10. Generic urban forestry budget for hypothetical city with 50,000 residents.

Income	
50,000 residents @ $13	$650,000
Budget	
Staff (see Figure 13)	
Urban Forester	$45,000
Assistant	$40,000
Staff(1)	$35,000
Crew(6 @ $30,000)	$180,000
	$300,000
Operating & Equipment	
Planting Stock (2000 @ $50)	$100,000
Inventory, Planning & Reporting	$30,000
Prunings and Removals*	$150,000
Planting and Flex-support*	$65,000
	$345,000
Discretionary	$20,000

* Includes contract services

External Funding Sources

Several funding sources for urban forestry and related activities in 1994 are summarized below.

Table 11. Urban forestry funding opportunities, 1994.

Funding Source	Program	Available Funds	Application Deadline	Min / Max Award	Eligibles & Description	Contact
California						
Proposition 70	California Wildlife, Coastal & Park-land Conservation Bond Act	$633,000	May 23	$1,000 to $30,000	Public agencies, & non-profits; Tree Planting	Eric Oldar, CDF 909-782-4140
Proposition 111	Environmental Enhancement & Mitigation	$10,000,000	November	Up to $500,000	501(c)(3); Impact Mitigation	Resources Agency 916-653-5656
California Horticultural Society	CHS Grants	$4,000	June 15th	$500 to $1,250	Education & Research for Orn. Hort.	Parker Sonderson 510-839-7746
USDA-Forest Service	National Urban Forestry Grant (old America the Beautiful program)	$80,000	October 18th	$500 to $5,000	Non-profits; Volunteer development, advisory boards, tree care programs	California ReLeaf 714-557-2575
National						
Horticulture Research Institute	HRI Grant	About $125,000	November 15th	$500 to $6,000	No restrictions	HRI 202-789-2900
USDA-Forest Service	National Urban & Community Advisory Council (Challenge cost-share)	$1,000,000	January 31	5 to 9 grants	No restrictions; Info, training, volunteerism, advisory bodies	USFS-Urban & Community Forestry 202-205-1689
Environmental Protection Agency	Environmental Education	$2,800,000	October	Up to $250,000	Non-profit; Media	EPA 415-744-1581
Intermodel Surface Transportation Efficiency Act	ISTEA Enhancement Activities	$50,000,000	August 1995 (biennial)	n/a	Public agencies; Transportation research & enhancement	CALTRANS 916-654-5275
International Society of Arboriculture Research Trust	ISAR Trust Grant	$25,000	November 1	All grants are $2,500	Individuals researching urban trees	ISA 217-355-9411
Small Business Administration	Tree Planting	$1,700,000	March 10th	Up to $100,000	Public agencies; Tree planting	Allen Robertson 916-657-0300

Source: California ReLeaf, The Trust for Public Land, 116 New Montgomery St., 3rd Fl., San Francisco, CA. 94105. (415) 495-5660.

Note: For more information, see Fazio, J. R. How to fund Community Forestry. The National Arbor Day Foundation, Tree City USA Bulletin No. 34, 8 pp.

Organization and Funding — Related Annotated Publications

(The recent national conference in Minneapolis placed a major emphasis on the subject of funding urban forestry. The reader should review the contributors to the conference. The following list contains just a few contributions from the excellent conference series on this subject.)

Macie, E. 1993. The urban forest component of public infrastructure. Proceedings of the Sixth National Urban Forestry Conference, Minneapolis, MN, p. 30-33.

Studies have shown that America's urban forests are in a state of decline. In order to reverse this trend and give increased priority to the improvement, protection, and maintenance of the urban forest, we need to promote the urban forest as part of the public infrastructure and emphasize that the overall survival of the city is dependent on this resource's well-being.

Moore, M. C. 1993. Financing strategies for the 90's. Proceedings of the Sixth National Urban Forestry Conference, Minneapolis, MN, p. 18-20.

Municipal financing strategies for urban forestry services are changing as budget priorities and urban demographics change. As a result, there is less money and more competition from other general fund public services. This author presents future financing strategies for urban forestry that focus on reducing general funds, replacing them with dedicated funding and linking tree care with other municipal services and budgets.

Morrow, R. 1994. Creative solutions to budget woes. Western Chapter News - ISA, 19(4): 8-11.

No abstract available.

Ramsay, S. 1993. Special approaches for communities under 5,000. Proceedings of the Sixth National Urban Forestry Conference, Minneapolis, MN, p. 61-63.

Trees Forever exemplifies a state-wide community reforestation effort for primarily small towns of less than 5,000 people. They rely on civic leaders, who have a variety of roles, and on citizens. Their formula for success is key leadership, good organization, funding sources and focused projects. The program process is discussed through a case study of Belmond, Iowa

Tree Care and Wood Utilization

Wood Utilization

Even though current disposal costs may be acceptable in some communities, disposal of tree prunings and removals is not a sustainable management practice. The question of how to achieve sustainable management of biomass waste disposal and utilization primarily depends on the availability of waste-use markets. Markets for biomass uses that are fairly well established in California include firewood, mulch, landfill substrates, and fuel for cogeneration in some areas. Markets that are growing include cogeneration, and solidwood uses such as veneers and furniture stock (e.g., Sacramento, Petaluma and in greater Los Angeles).

The following recommendations are offered regarding wood utilization:

- In-house investment in utilization equipment provides significant cost-savings for medium-sized cities (see Section IV).
- Contracting wood utilization is probably the most efficient approach for small cities considering the high fixed costs of their small volumes. A reduced cost per unit can be obtained from large volumes.
- Solidwood utilization should feature significantly in the longer term for cities of all sizes. Markets will develop as more and more cities realize these benefits.

Tree Care and Wood Utilization — Companies and Related Annotated Publications

Companies to Contact

David Parmenter D.P. Hardwood 1980 Grass Valley Hwy. Auburn, CA 95603 916-888-8191	George Hessenthaler 585 West, 3900 South, Suite 6 Murry, Utah 801-272-3884	David Faison Into the Wood 300 N. Water Street Petaluma, CA 94952 707-763-0159	Tom Larson Integrated Urban Forestry 23441 S. Pointe Dr., Suite 150 Laguna Hills, CA 92653 714-837-5692

Related Annotated Publications

Coder, K. D. 1991. Planting: The foundation of healthy tree life. Proceedings of the Fifth National Urban Forest Conference, Los Angeles, CA, p. 160-163.

Proper planting is one of the first steps of ensuring quick establishment and low maintenance over both the short- and long-run. The best management procedures for rooting space size, planting hole size and shape, tree placement, soil problem correction, and follow-up tree care are discussed. The focus is on containerized and balled-and-burlapped trees.

Davis, N. D. 1994. The trees of home: the green spires of Frederick. American Forests, 100(7 & 8): 36-39.

First in a series of articles, this paper reported potential energy-savings from increased plantings. Savings ranged from 1.6% in open lands to over 12% in residential areas.

Dyke, R. 1990. Recycling the urban forest. American Forests, Jan.-Feb. 96(1-2): 61-65.

Products of the urban forest such as tree limbs and grass clippings are too infrequently viewed as resources for soil enrichment. As landfill space becomes more limited, yard wastes are being composted by municipalities.

Geiger, J. R. Utilizing urban tree debris an analysis of alternatives for Chicago, Illinois. USDA Forest Service State and Private Forestry, Chicago Bureau of Forestry.

This report addresses the issue of urban tree debris and alternative uses because too often these prunings and cuttings are needlessly filling our landfills and are an inefficient use of a natural energy resource.

- Contact local cabinetry/woodworking shops to explore their raw material needs.
- Research is proposed to identify the potential of urban trees (once removed) as substitutes for common furniture stock and veneer (Mark 1994b).

Certified Contract Services

The following information describes the requirements and steps in obtaining ISA certification for either an Arborist or Worker:

The requirements for Certified Arborist are:

Education/Experience: (1) no degree and 3 years experience in tree care, or, (2) any 4-year degree and 1 year experience, or (3) any 2-year degree and 2 years experience.

Exam: pass a written exam that covers 10 subject areas (cost $100 for ISA member, $150 for non-member, preparation materials run about $300). Recertification fee is $75.

Continuing Education: there are many options but the basic requirement is 30 C.E. Units (including seminars) over a 3 year period.

The requirements for Certified Tree Worker are:

Experience: 18 months experience

Exam: pass the practical skills tests and an oral exam (offered in both English and Spanish) covering tree anatomy, structure, planting, and climbing.

Continuing Education: 12 hours of C.E. Units over 3 years.

For more information regarding ISA certification for city and contract crews contact:

Steve Holcomb
ISA Western Chapter Certification Board
18008 Sky Park Circle, Suite 265
Irvine, CA 92714
714-474-9230

International Society of Arboriculture
3610 North 44th, Suite 240
Phoenix, AZ 85018
602-955-5315

Many individuals in ISA offer workshops to prepare people for taking the certification exam.

Contract Services — Two Related Publications

Dages, W. 1986. Technology transfer: a contractor's perspective. Proceedings of the Third National Urban Forestry Conference, Orlando, FL, p. 53-654.

(No abstract available)

Kennedy, R. W. 1990. Contracting municipal tree maintenance. Journal of Arboriculture 16(11): 300-303.

The City of Los Angeles, with an urban forest of 680,000 trees, has found that developing a partnership with private industry has provided its citizens with a cost effective and flexible tool to provide a high level of quality service. To make this partnership work definitive specifications and contracts must be prepared, executed and enforced. City staff provides support to and inspection of the contractor to ensure that the specified quality and level of service is achieved.

Public Relations and Support

The following ideas are offered as ways for the city urban forester to encourage sustained community support:

- hold regular meetings with Home Owner Associations or similar neighborhood groups
- create a public relations-oriented urban forest organization such as Monterey's Neighborhood Incentive Program. Once formed they become eligible for various grants.
- conduct facilitated public workshops on controversial urban forestry issues or concerns
- arrange media coverage of highly visible activities (e.g., Arbor Day)
- publicize testimonials from businesses that cooperate and assist
- serve on influential city committees.

Community-based programs and services offered by California ReLeaf include:

- a 40 member urban forest stewardship network for exchanging information
- administration of the National Urban Forestry Grant Program for California
- publisher of *California Trees*, a quarterly 12-page newsletter with a circulation of over 2,800
- information assistance and referrals for communities seeking to further urban forestry
- cooperator with landscapers and nurserymen to improve tree stock, planting and care practices
- monitors state and federal legislative action affecting urban forestry policy

Contact: Genni Cross, Director, California ReLeaf, 3001 Redhill Ave., Bldg. 4, Suite 224, Costa Mesa, CA 92626, (714) 557-2575.

Administered by California ReLeaf, the U.S.D.A. Forest Service and California Department of Forestry and Fire Protection provide about $90,000 each year for program development in the area of community relations and support. These grants are awarded to private sector groups (community or nonprofit) and cannot be used by public institutions. The grant period is one year with a $500 minimum and $5000 maximum. All grants must be matched with non-federal dollars.

For further information and an application package, direct your enquiry to:

Grant Coordinator
California ReLeaf
3001 Redhill Avenue, Bldg. 4, Suite 224
Costa Mesa, CA 92626
714-557-2575

Another issue directly related to public relations is the role and design of a city tree ordinance. Here the purpose is primarily to promote education and conservation standards that ensure basic resource protection without undermining public support. In fact, some cities, such as Irvine, are transferring enforcement of their tree ordinances to Home Owner Associations to foster volunteerism and enhance enforceability. CDF published a manual to assist in writing or revising tree ordinances (Bernhardt and Swiecki 1991).

Public Relations and Support -- Related Annotated Publications

Elmendorf, W. 1993. Using ordinances to protect urban trees. Proceedings of the Sixth National Urban Forestry Conference, Minneapolis, MN, p. 111-113.

Many communities are taking aggressive steps to protect trees in response to increasing developmental pressures. In many cases, following public outcry and support communities are using municipal ordinances to preserve and enhance native and landmark trees on both public and private property. Ordinances have proven to be successful in tree preservation as well as in improving community image, and the quality of development.

Giedratis, J. 1993. City foresters and their customers. Proceedings of the Sixth National Urban Forestry Conference, Minneapolis, MN, p. 40-43.

Achieving a healthy urban forest begins with customer service. The City of Austin's Tree Program bases its success on such a management philosophy. A City Tree Manager who can provide leadership will teach and empower his or her customers/citizens to get involved directly with their urban forest. They will, in turn, provide the political and funding support needed to build a strong program.

Miller, R. D. 1993. How can we get the community involved? Proceedings of the Sixth National Urban Forestry Conference, Minneapolis, MN, p. 38-39.

To identify and address neighborhood priorities, Minneapolis developed a Neighborhood Revitalization Program (NRP). NRP's goals are to build neighborhood capacity, redesign public service delivery systems, increase intergovernmental cooperation and create a sense of community.

VI. Concluding Remarks

This study was undertaken in the midst of what many in the state believe is a "crisis in urban forestry." This crisis arises almost entirely from the severe budgetary problems facing California at a time when urban forestry is just starting to be recognized for its valuable contribution to a community's quality of life. Most of the urban foresters interviewed indicated that they are in a "survival mode" — searching for support and the means to justify their value and existence. Learning from each other through direct contact, meetings, and reports such as this are ways to document urban forestry's contributions and to learn from the successes and failures of others. It is essential that the urban forestry professionals share and support one another in trying economic times.

By focusing on programs that reduce current operational costs (e.g., cooperation with the private sector, wood utilization) and build public support, fiscal pressures should be reduced. The real need is to fund the investments in long-term programs that restructures the urban forest to be more sustainable. Any program that aspires to achieve the long-term goals of urban forestry should possess the following key elements:

1. Careful selection of tree species that are adapted to your area and that meet aesthetic, city infrastructural and environmental standards (for example, one could work toward redesign of city sidewalks, prior to planting). ***Element 1 — Species Selection and Diversity.***

2. Investment in inventory and planning systems to aid in scheduling, budgeting, reporting and displaying activities and plans. ***Element 2 — Inventory and Landscape Planning.***

3. Careful consideration and effort in designing and positioning the urban forestry department within city government organization so as to achieve status for political and fiscal support. ***Element 2 — Inventory and Landscape Planning.***

4. Investment in urban tree wood recycling/ utilization technology and marketing. ***Element 3 — Tree Care and Wood Utilization.***

5. Consideration of qualified private sector services that offer the potential of flexibility and reduced liability generating potentially significant cost-savings. ***Element 3 — Tree Care and Wood Utilization.***

6. Staff interaction and involvement with the public that communicates how your goals will meet their demands and to recruit support, especially people and finances. ***Element 4 — Public Relations and Support.***

The National Urban and Community Forestry Advisory Council has recently completed an Action Plan to help achieve its vision of "sustainable urban forests for all communities, and improved ecosystems." (USDA Forest Service 1994). This report details specific outcomes and target dates under six broad goals:

1. Expand and enhance appreciation of the value of urban forests

2. Foster self-sustaining volunteer programs

3. Develop multicultural training and education programs for urban forestry disciplines

4. Stimulate funding from traditional and non-traditional sources

5. Increase urban forestry research

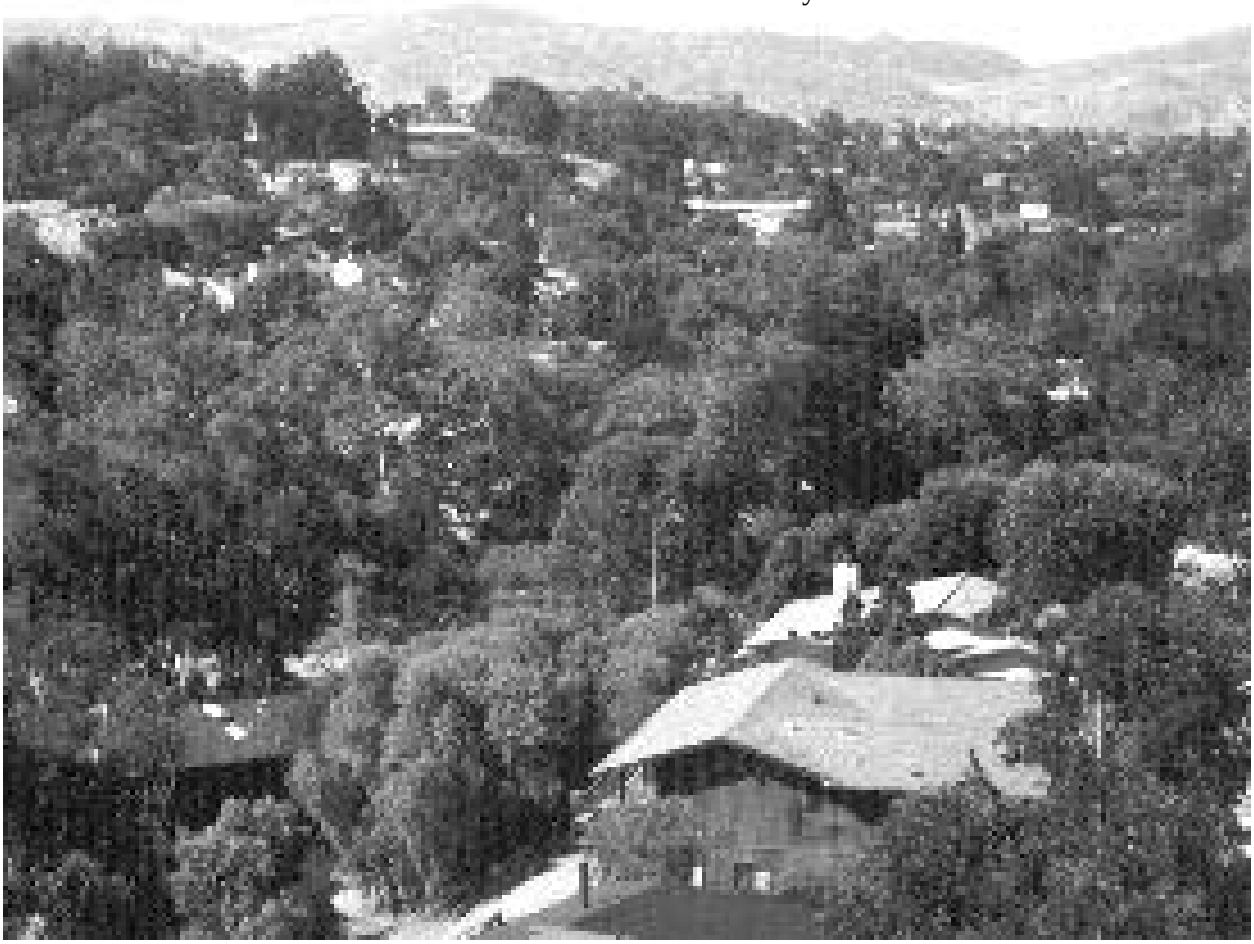
6. Promote partnerships with the private sector

The elements of sustainability developed in this report correspond well with NUCFAC's vision, but so much needs to be done to better understand both the programs and interrelationships that comprise an integrated urban forest ecosystem management plan. Many of these needs were

identified in this study. They include:

- systems modeling — bioeconomic and ecosystem modeling for urbanized forests
- interdisciplinary landscape design, especially regarding fire hazard mitigation
- education of and assistance to private landowners on forest landscaping
- wood utilization — biomass estimation, solidwood utilization technology & marketing and distribution, wood product quality description
- affordable inventory and GIS mapping approaches to assist in management
- more prescriptive research — identify a city that is considering a major move into urban forestry and assist in program design and development
- research into private & public sector partnerships, future role of neighborhood associations, and further integration with other city services, new funding strategies

As we learn more about how to manage urban forest ecosystems, the elements of sustainability will become more refined and more detailed than those presented in this report. However, the prioritization of the basic elements of urban forest sustainability will always be unique to every city and community. These unique community and forest attributes should be capitalized upon in seeking to establish urban forest resource management as a basic service. The methods undertaken toward sustainability must be chosen with the public in mind as much as the resource, in fact they should be viewed as central to urban forest ecosystem management. By building public support, you will be creating a constituency that will continue to support and fulfill the goals of urban forestry.



The urban forest: not merely a collection of trees, but an ecosystem to enrich our environment and our lives.

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