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The Ecological Street Tree: Mainstreaming the Production of Street Tree-based Ecosystem Services in Northern California Cities, 1980-2008

By

Georgia Norma Silvera Seamans

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Landscape Architecture and Environmental Planning

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Randolph T. Hester, Chair

Professor Louise A. Mozingo

Professor Elizabeth Macdonald

Fall 2010

The Ecological Street Tree: Mainstreaming the Production of Street Tree-based Ecosystem Services in Northern California Cities, 1980-2008

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Georgia Norma Silvera Seamans

Abstract

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Doctor of Philosophy in Landscape Architecture and Environmental Planning

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This dissertation examined the role of municipal and nonprofit actors, scientific research, and local geography in the ecological characterization of street trees in the planning and policy arena of three northern California cities between 1980 and 2008. During this time period, the discourse of ecosystem services such as carbon sequestration, stormwater runoff management, criteria air pollutant reduction, avoidance of energy use and energy savings and thus reduction in power plant emissions, and wildlife habitat provision has been applied to street trees. Municipal agencies and nonprofit organizations have engaged in policies, programs, and activities that are increasingly characterizing street trees by the ecosystem functions they can provide; this is what I call the ecological street tree. Since trees have been planted along city streets, they have provided ecosystem services. Yet, over the last 30 years, two actions began occurring more systematically: (1) the ecosystem functions provided by street trees were incorporated into planning documents and activities and (2) researchers began publishing scientific evidence to support policy and advocacy claims about the environmental services provided by street trees.

To measure and analyze the emergence of the ecological street tree, a multiple-case study of three Northern California cities was conducted. One of the strengths of the case study, proposed Yin in 2003, is its "methodological versatility," i.e. multiple methods and sources of evidence can be incorporated into an overall strategy. Furthermore, the dissertation met Yin's criteria for using a case study strategy: (1) the study propositions were framed as "how" and "why" questions; (2) the phenomenon could not be manipulated by me; and (3) the ecological street tree phenomenon are contemporaneous. The study relied on multiple sources of evidence such as municipal and nonprofit reports and plans, nonprofit newsletters, newspaper articles, and interview transcripts. Computer-aided content analysis of nonprofit newsletters and document analysis of municipal and nonprofit reports and plans and newspaper articles were used to track the emergence of the ecological street tree. Transcripts from face-to-face qualitative interviews were also analyzed. Qualitative interviews were used in this project because I required in-depth information from the individuals involved in the

conceptualization of the ecological street tree. Furthermore, there are few studies on how and why this conceptualization has taken place.

This dissertation asked six questions:

1. Has there been a rise in the ecological characterization of the street tree?
2. What is the role of the urban forest nonprofit?
3. Has the concept of the ecological street tree been mainstreamed through the nonprofit's newsletter?
4. How is the production of research evidence implicated in mainstreaming the ecological street tree?
5. If different services are salient to different cities, what factors account for this difference?
6. What strategies are used by different actors, in different cities to capture tree-based ecosystem services?

Based on a cross-case analysis of data from Sacramento, Palo Alto, and San Francisco, the main conclusions of this dissertation are as follows:

- Between 1980 and 2008, there was a rise in the ecological characterization of street trees in all three cities.
- The urban forest nonprofit has played a role in mainstreaming the ecological street tree, but this role varies in strength among the cities. Also, the nonprofit has not acted alone. Municipal agencies are part of the network of actors advancing the ecological value of street trees.
- The newsletter is not the nonprofit's primary mode of communicating the ecosystem benefits of street trees; it is one mode among a "landscape of communications".
- The production and dissemination of urban forest research was critical to legitimizing the ecological street tree.
- Different services were salient to different cities and contributing factors included climate, geography, infrastructure, culture, and the history of urban forestry development in each city.
- Different strategies such as policies and reports, program development and activities, funding streams, and research collaboration were used capture street tree-based ecosystem services.

This dissertation is dedicated to RCSIV and RCSV.

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Chapter 1:: Introduction

1.1 Overview

The central contention of this dissertation is that there has been a conceptual evolution of the street tree, from the provision solely of beautification and ornamentation to the provision of ecosystem services. The tree-based ecosystem services studied in this dissertation were air quality improvement, carbon sequestration and storage, energy conservation and efficiency, stormwater runoff management, and wildlife habitat.

Several propositions were developed. Propositions 1, 1a, and 1a1 address the emergence of the ecological street tree. This study investigates the presence of an upwards trend in the ecological characterization of street trees (Proposition 1), the role the urban forest nonprofit in promulgating the ecological street tree (Proposition 1a), and its corollary that the nonprofit's newsletter is the primary mode of communicating the ecological benefits of street trees (Proposition 1a1). Also, the role of the municipality is examined. Municipal plans and activities are examined alongside those of the urban forest.[1] Proposition 1b of this dissertation states that the ecological street tree phenomenon has been made possible through knowledge sharing of research findings; in the Bay Area, evidence-based planning has been influenced by the work of the Center for Urban Forest Research (CUFR), a U.S.D.A. Forest Service research station. Finally, Propositions 2 and 2a consider the geography of ecosystem services planning. A geography of ecosystem services exists, i.e. particular ecosystem services are salient in particular cities (Proposition 2) and different strategies are used by different actors to capture tree-based ecosystem services (Proposition 2a). The concept of the geography of ecosystem services takes its cue from the evolution of neoliberalism scholarship. In early half of the 2000s, geographers began calling for more nuanced and place-based descriptions of neoliberalism in contrast to the existing generalized body of work. Tom Slater wrote about the concept "geography of gentrification"[2] and Theodore and Brenner wrote about "actually existing neoliberalism".[3] The same can be done with the ecosystem services concept. Although municipal agencies and nonprofit organizations talk about the multiple benefits of street trees – environmental, economic, psychological, health, and social – closer analysis reveals, at least with regards to environmental benefits, that particular services are salient to particular cities. Also, different strategies are used in ecosystem services planning.

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[1] In this study, tree-based plans, policies, activities, and events are considered as sources of evidence. Writing about the role of nonprofits in environmental management, Nikolic and Koontz assert that environmental outcomes include "the tangible policies and activities that promote environmental amelioration, including the development of new management plans or policies as well as site-specific cleanup and restoration efforts." Sara J.S. Nikolic and Tomas M. Koontz, "Nonprofit Organizations in Environmental Management: A Comparative Analysis of Government Impacts," *Journal of Public Administration Research and Theory* 18 (2007):445.

[2] Tom Slater, "North American Gentrification? Revanchist and Emancipatory Perspectives Explored," *Environment and Planning A* 36, no. 7 (2004):1191-1213; Tom Slater, "Comparing Gentrification in South Parkdale, Toronto and Lower Park Slope, New York City: A 'North American' Model of Neighbourhood Reinvestment?" *ESRC Centre for Neighbourhood Research Paper* 11 (2003).

[3] Neil Brenner and Nik Theodore, "Cities and the Geographies of 'Actually Existing Neoliberalism'," *Antipode* 34, no. 3 (2002):349-379.

These propositions were tested with a multiple-case study of three cities in Northern California – Sacramento, Palo Alto, and San Francisco. Several data were used in this dissertation. Urban forest nonprofit newsletters, nonprofit and municipal planning documents, newspaper archives, interview transcripts, and field work and observation were analyzed to track the evolution of the ecological street tree and its context.

Since trees have been planted along city streets, they have provided ecosystem services. Trees provide ecosystem services such as air and water quality improvement, stormwater runoff attenuation, carbon storage and sequestration, wildlife habitat, and energy conservation and efficiency. Yet, beginning in the 1980s, there has been apparent reframing of the ecological role of street trees. The re-conception of the street tree in the early 1980s from a symbol of beautification and refinement to a provider of ecosystem services was part of what Nelles described as "broader cultural reconsiderations of the environment and nature."[4] The refiguring of the city as an ecological space harkens back to the 1970s. McBride pointed to Earth Day 1970 as the watershed moment in shifting perceptions of the environment, arguing that Earth Day 1970 "wrested ecology away from national parks and rural spaces to the city and suburbs."[5]

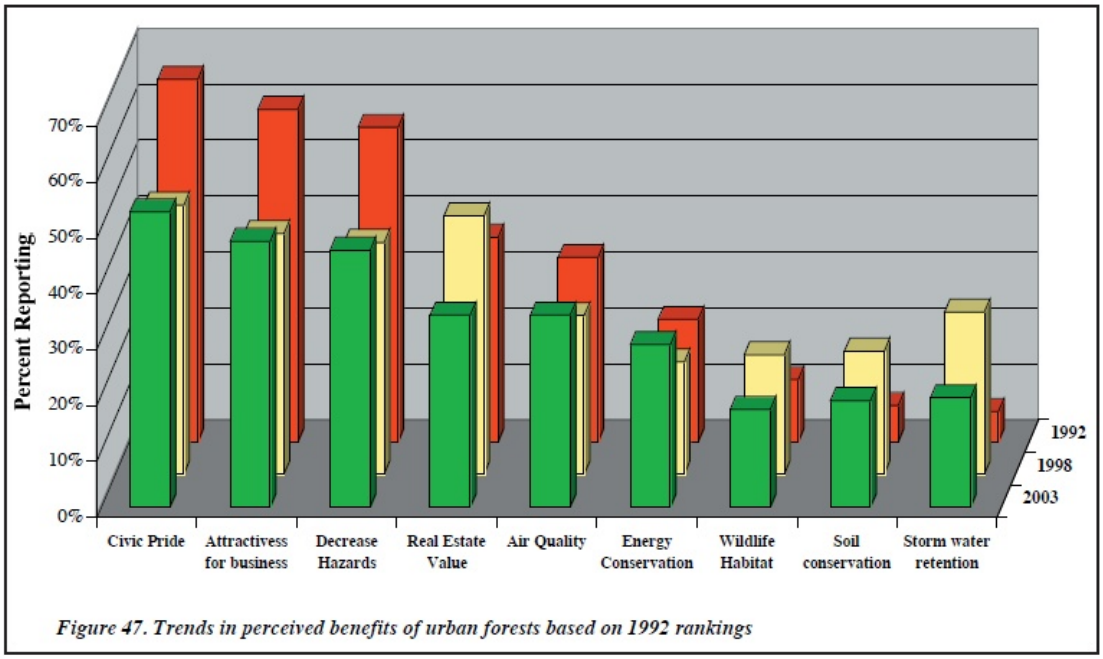

Figure 1.1 The state of urban and community forestry in California – 2003 status and trends since 1988, from *Source*: Richard P. Thompson, The State of Urban and Community Forestry in California – 2003 status and trends since 1988, (San Luis Obispo: Urban Forest Ecosystems Institute), 33.

One of the iterations of this conceptual change can be read in the use of the terms "urban forest" and "urban forestry." Urban forestry was a new concept in the late 1970s referring to

[4] H.V. Nelles, "How Did Calgary Get Its River Parks?" *Urban History Review* 34, no.1 (2005).
[5] Joe R. McBride, personal communication with author, October 8, 2008.

"the management of trees in urban areas based on *ecological and biological premises*."[6] In 1994, Platt pointed to "changing perceptions of nature in cities" in the 1980s.[7] Proof of this in the urban forestry context is apparent in survey work conducted by Thompson and Ahern in 2000 and Thompson in 2006. In their 1997 survey, the authors found that "environmental benefits like storm water and soil retention, and improved wildlife habitat" were ranked higher in 1997 than they were in 1992 (Figure 1.1). By 2003, these benefits had declined in the rankings while the ranking of energy conservation and air quality increased (Figure 1.1). This survey work, however, is not a systematic analysis of the shift towards the ecological conceptualization of the street tree, and the urban forest in general, which was the aim of this study.[8]

Another iteration of the ecological street tree is the numerous "million trees" initiatives launched in cities such as Los Angeles (Million Tree LA), Denver (The Mile High Million), New York (MillionTreesNYC), and Sacramento (Greenprint). This list also includes cities that are not literally planting a million trees or more, like Grow Boston Greener (100,000 by 2020),[9] Portland (83,000 – of which 50,000 will be street trees – by 2013)[10], Seattle (650,000 by 2036),[11] and Chicago (400,000 new trees were planted between 1989 and 2004).[12] While not all the proposed trees will be planted along streets, the catalyst for these initiatives is the ecological street tree. Also, municipal tree planting rarely occurs on private property.

The catalytic nature of the street tree might lie, in part, in the fact that street trees provide more opportunities for everyday experience of nature. Also, they are in the public domain making them easier to access – at least in the days before wide use of aerial mapping technologies – for research purposes. The "million tree" projects highlight a central contention of this study: street trees have garnered increased ecological validity. The ecological street tree is one pathway of many to greening. Other modes are evident in green roofs (ex: Chicago City Hall; California Academy of Sciences, San Francisco), green streets (ex: SW 12th Avenue Green Street, Portland, Oregon; SEA Streets, Seattle), and green buildings (ex: David L. Lawrence Convention Center, Pittsburgh; San Francisco Municipal Green Building Compliance Guide). The ecological refiguring of the city is also apparent in legislation; for example, the Energy Conservation through Trees Act or H.R. 5867 was

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[6] Ira Bruce Nadel and Cornelia Hahn Oberlander, *Trees in the City* (New York: Pergamon Press, 1977), 7 (emphasis added). Nadel and Oberlander are referring to street trees in their description of urban forestry, but both the concept and management style have evolved to include all trees and other vegetation under public and private ownership.

[7] Rutherford H. Platt, "Crosscutting Themes and Recommendations," in *The Ecological City*, ed. Rutherford H. Platt, Rowan A. Rowntree, and Pamela C. Muick (Amherst: The University of Massachusetts Press, 1994), 277.

[8] The survey was sent to and/or completed by managers of street tree planting programs and not necessarily policy makers. Also, this survey was not completed by municipal staff from Sacramento, Palo Alto, or San Francisco.

[9] Grow Boston Greener website, http://www.growbostongreener.org.

[10] Robin Franzen, "Portland-Area Communities Look to Thicken Tree Canopy," *The Oregonian*, August 19, 2008, http://www.oregonlive.com/environment/index.ssf/2008/08/portlandarea_communities_look.html (July 28, 2010).

[11] City of Seattle, Office of the Mayor, "Mayor Plants Seed to Dramatically Expand Tree Cover in Seattle" press release, http://www.cityofseattle.net/mayor/newsdetail.asp?ID=6463&dept=40 (July 28, 2010).

[12] City of Chicago, Mayor's Office, "Daley Urges Chicagoans: Do Your Part to Protect Environment" press release, http://www.cityofchicago.org/city/en.html.

introduced to Congress in April 2008. The proposed act "would encourage utility companies to partner with local nonprofit tree planting organizations to plant trees to reduce residential energy demand."[13]

Table 1.1 Selected Urban Forest Nonprofits and Years of Establishment

Year of Establishment	Nonprofit	City
1973	TreePeople	Los Angeles
1975	Tree Trust	St. Paul (MN)
1976	Trees New York	New York
1981	Friends of the Urban Forest	San Francisco
1982	Sacramento Tree Foundation	Sacramento
1984	Parks and People*	Baltimore
1985	Trees Atlanta	Atlanta
1989	The Greening of Detroit	Detroit
1989	Friends of Trees	Portland (OR)
1991	TreeKeepers (Openlands program)	Chicago
1992	TREE Davis	Davis
1994	Our City Forest	San Jose
1995	Community Greenspace (Urban Resources Initiative program)	New Haven
1996	Canopy	Palo Alto
1996	Greening Milwaukee	Milwaukee
1998	Urban ReLeaf**	Oakland
2001	Casey Trees	Washington, D.C.
2003	CityRoots (Urban Ecology Institute program)	Boston
2006	Friends of the Pittsburgh Urban Forest	Pittsburgh

* Street tree planting, an element of the Community Greening Stewardship Program, is administered with the Department of Recreation and Parks.
** The organization was founded as Oakland ReLeaf and changed its name when it began urban forestry activities in Richmond, California.

The 1980s marked a coincidence between the shift towards the ecological street tree conception and the shift in mixed provision of street trees, that is, a rise in the establishment of urban forest nonprofits, due in part to declines in municipal budgets (Table 1.1). In addition to providing and planting street trees, the urban forest nonprofit is also an advocate for street trees. As such, its operations should reflect the change in the depiction of the street trees. Newsletters and other nonprofits documents were examined to detect not only the shift in the conception of the street, but also the role of the nonprofit in shaping this shift. For example, Sacramento Tree Foundation (STF) has partnered with the USDA Forest Service Center for Urban Forest Research (CUFR) since 1996. In a 2008 e-newsletter, STF noted that the partnership has allowed both institutions "to study and delineate the values and benefits of trees."[14]

[13] Alice Ewen Walker, "Legislation Promotes Shade Tree Programs," California Trees 17, no. 3 (2008): 1-2.
[14] Sacramento Tree Foundation, Growing Greenprint e-Newsletter (October 2008).

Neither the establishment of urban forest nonprofits nor declines in municipal budgets have meant an abandonment of municipal involvement in street tree provision. Cities like Boston did not host an urban forest nonprofit until recently; CityRoots, a program of the Urban Ecology Institute was founded in 2003 and JP Trees, a front yard tree planting organization based in the Jamaica Plain neighborhood of Boston, was founded in 2007. However, the majority of Boston's street trees continue to be planted by the Parks and Recreation Department. San Francisco's urban forest nonprofit, Friends of the Urban Forest, was established in 1981 but the city's public works department also plants street trees. Furthermore, cities have also influenced the contemporary ecological framing of street trees.

> *The trees will provide shade and save on energy costs, clean the air and help reduce the greenhouse gases that cause global warming, capture polluted urban runoff, improve water quality, and add beauty to our neighborhoods. This approach puts focus on the natural processes that can reduce pollution and transform our city into a sustainable, green city. Our urban forest is a natural utility -- one that improves in value over time* (Million Trees LA).[15]

And from New York City's MillionTreesNYC mission statement:

> *Planting trees is one of the most beneficial and cost-effective ways to help ease these growing pains. Trees help clean our air, and reduce the pollutants that trigger asthma attacks and exacerbate other respiratory diseases. They cool our streets, sidewalks, and homes on hot summer days. Trees increase property value, and encourage neighborhood revitalization. And trees make our City an even more beautiful and comfortable place to live, work, and visit.*[16]

The municipal role in the evolution of the ecological street tree was examined alongside the nonprofit's role. Municipal documents were analyzed along with newspapers, and in the second phase of this study, interviews were conducted with nonprofit and municipal staff. The ecological street tree was examined using case studies of nonprofit and municipal actors based in three Northern California cities: Sacramento, San Francisco, and Palo Alto. Content analysis methods were used to examine nonprofit and municipal documents from 1980 to 2008 to assess the evolution of the ecological street tree. The remainder of this chapter proceeds with a literature review then a description of the significance of this study.

1.2 Related Literature

Research on urban trees and street trees more specifically, has focused on six areas: provision of scenic, commercial, psychological, social, and environmental benefits; tree planting design and technology; urban forest history; urban forestry management; and more recently, the

[15] MillionTreesLA website, About MillionTreesLA, http://www.milliontreesla.org/mtabout.htm (October 31, 2008).
[16] MillionTreesNYC website, About MillionTreesNYC, http://www.milliontreesnyc.org/html/about/about.shtml (October 31, 2008).

political economy and ecology of street trees. However, the literature has not explicitly addressed the characterization of street trees using the discourse of ecosystem services both conceptually and in policy making; this is what I call the ecological street tree.

This study relies on four sets of literature: (1) the scientific evidence for ecosystem services; (2) case studies of street trees and urban forests in the U.S.; (3) the nonprofit as an institution; and (4) city standards and the ecological city. The scientific evidence of ecosystem services is presented because of its role in supporting claims about the ecological street tree. A reading of existing case studies of street trees highlights two gaps in the urban forestry literature: (1) most studies end their narratives in the 1970s and (2) studies that end in the 1990s do not address the conceptualization of the street tree in primarily ecological terms. The potential effect of the ecological street tree on sidewalk standards is highlighted through attention to standards literature. Finally, the scholarship on nonprofits is critical given this study's emphasis on the role of the nonprofit in the framing of the ecological role of street trees.

Scientific evidence of street tree-based ecosystem services

> *Not that many years ago city trees were only valued for their beauty. People didn't think beyond beautiful park trees or wonderful fall color. Now science can show that trees are much more than just beauty: trees improve the quality of life in cities.*[17]

Briefly, street trees sequester carbon, intercept rainfall and attenuate runoff, reduce surface temperatures, filter pollutants and reduce greenhouse gas emissions, and provide habitat and forage for wildlife. There is more than three decades of scientific evidence on the ecosystem services provided by street trees, but the density of publication increased beginning in the 1980s. The seminal volume in the 1980s was Anne Whiston Spirn's *The Granite Garden* published in 1984. Spirn's assertions about the capacity for urban trees to filter air pollutants and to ameliorate urban heat islands were based on scientific evidence published in the 1970s.

The next set of evidence was published beginning in the early 1990s and has continued steadily into the 2000s. Researchers at the USDA Forest Service research stations generated many of these publications. Energy conservation and air quality benefits of Chicago's urban forest and street trees were chronicled in the highly influential 1994 Chicago Urban Forest Climate Project. Researchers found that in 1991, the 50.8 million trees – of which approximately 1.5 million were street trees – in the Chicago area provided "air cleansing valued at $9.2 million" by removing 6.145 tons of pollutants, provided "residential heating and cooling energy savings that, in turn, reduce carbon emissions from power plants by about 12, 600 tons" per year, and stored approximately 155 tons of carbon per year.[18] In terms of ecosystem services, energy conservation and air quality improvements were the dominant

[17] Jim R. Geiger, "San Francisco Trees Poised to Provide Big Benefits," *Western Arborist* 30, no.2 (2004), 31, emphasis added, http://www.fs.fed.us/psw/programs/cufr/products/cufr497.pdf (July 28, 2010).
[18] E. Gregory McPherson, David J. Nowak, and Rowan A. Rowntree, *Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project, NE GTR-186* (Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station, 1994), http://www.nrs.fs.fed.us/pubs/gtr/gtr_ne186.pdf (July 24, 2010).

topics of publications in the 1990s while rainfall interception studies appeared more frequently in the early 2000s.[19]

Studies of urban ecosystem services were not limited to Chicago's urban forest. Nowak et al. studied Brooklyn's urban forest and estimated that its 610,000 trees "store approximately 172,000 metric tons of carbon with an estimated value of $3.5 million…remove about 2,500 tC per year ($51,000/yr) and about 254 metric tons of air pollution per year ($1.3 million/yr)."[20] Nowak et al. also assessed the carbon storage and sequestration and air pollutant removal functions of the urban forests of New York City, Philadelphia, and San Francisco.[21]

Scientific evidence of the energy conservation function of urban tree shade have been published in academic journals, predominantly for California cities including Arcadia, Burbank, Pasadena, Riverside, Sacramento, San Gabriel, Santa Monica, and Santa Rosa.[22]

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[19] Jim R. Geiger, "Is All of Your Rain Going Down the Drain?" *From the Ground Up* 5, no.3 (2004):10-11; E. Gregory McPherson, "Benefits of Trees: Watershed, Energy, and Air," *Arborist News* 13, no. 6 (2004): 29-35.; Qingfu Xiao and E. Gregory McPherson, "Rainfall Interception by Santa Monica's Municipal Urban Forest," *Urban Ecosystems* 6 (2003): 291–302, http://www.fs.fed.us/psw/programs/cufr/products/cufr420_UrbanEosystems_RISMUF.pdf (July 24, 2010); Qingfu Xiao, E. Gregory McPherson, Susan L. Ustin, and Mark E. Grismer, "A New Approach to Modeling Tree Rainfall Interception," *Journal of Geophysical Research* 105, no. D23 (2000): 29,173-29,188, http://www.fs.fed.us/psw/programs/cufr/products/cufr_86_XQ98_54.PDF (July 24, 2010); Qingfu Xiao, E. Gregory McPherson, Susan L. Ustin, Mark E. Grismer, and James R. Simpson, "Winter Rainfall Interception by Two Mature Open Grown Trees in Davis, CA," *Hydrological Processes* 14, no. 4 (2000): 763-784, http://www.fs.fed.us/psw/programs/cufr/products/4/cufr_87.pdf (July 24, 2010).

[20] David J. Nowak, Daniel E. Crane, Jack C. Stevens, and Myriam Ibarra, *Brooklyn's Urban Forest Gen. Tech. Rep. NE-290* (Newtown Square, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, 2002), http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/2002/gtrne290.pdf (July 28, 2010).

[21] David J. Nowak, Robert E. Hoehn III, Daniel E. Crane, Jack C. Stevens, and Jeffrey T. Walton, *Assessing Urban Forest Effects and Values, New York City's Urban Forest*, *Resource Bulletin NRS-9* (Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, 2007), http://nrs.fs.fed.us/pubs/rb/rb_nrs009.pdf (July 23, 2010); David J. Nowak, Robert E. Hoehn III, Daniel E. Crane, Jack C. Stevens, and Jeffrey T. Walton, *Assessing Urban Forest Effects and Values, Philadelphia's Urban Forest*, *Resource Bulletin NRS-7* (Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, 2007), http://nrs.fs.fed.us/pubs/rb/rb_nrs007.pdf (July 23, 2010); David J. Nowak, Robert E. Hoehn III, Daniel E. Crane, Jack C. Stevens, and Jeffrey T. Walton, *Assessing Urban Forest Effects and Values, San Francisco's Urban Forest*, *Resource Bulletin NRS-8* (Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, 2007), http://www.sfenvironment.org/downloads/library/sfuforefinal.pdf (July 23, 2010).

[22] James R. Simpson and E. Gregory McPherson, "Tree Planting to Optimize Energy and CO_2 Benefits," in *Proceedings of the 2001 National Urban Forest Conference: Investing in Natural Capital*, 81-84. (Washington, D.C.: American Forests, 2001), http://www.fs.fed.us/psw/programs/cufr/products/cufr_46_JS01_52.PDF (July 24, 2010); E. Gregory McPherson, James R. Simpson, and Klaus I. Scott, "Actualizing Microclimate and Air Quality Benefits with Parking Lot Tree Shade Ordinances," *Wetter und Leben* 4, no. 98 (2001): 353-369, http://gis.fs.fed.us/psw/programs/cufr/products/11/cufr_69.pdf (July 24, 2010); James R. Simpson and E. Gregory McPherson, "Energy and Air Quality Improvements through Urban Tree Planting," in *Proceedings of the 1999 National Urban Forest Conference: Building Cities of Green*, 110-112 (Washington, D.C.: American Forests, 1999), http://www.fs.fed.us/psw/programs/cufr/products/cufr_44_JS00_47.PDF (July 24, 2010); James R. Simpson and E. Gregory McPherson, "Effects of Urban Trees on Regional Energy Use and Avoided Carbon," in *Preprints of the 3rd Symposium on the Urban Environment 2000*, 143-144 (Washington, DC: American

Beginning in the second half of the 1990s, studies began to link the shade and energy conservation function of urban trees with reductions in greenhouse gas (GHG) emissions and improvements in air quality.[23] Scientific evidence of reductions in energy use via the energy conservation function of trees and subsequent reductions in GHG emissions are seen as important elements in carbon and emissions trading markets.[24]

The Center for Urban Forest Research (CUFR) has assessed urban tree ecosystem functions in several California (Davis, Los Angeles, Modesto, Oakland, Sacramento, San Diego, and Santa Monica) and Southwest (Tucson) cities. Different ecosystem functions have been studied in these different cities: energy conservation in Tucson and Davis;[25] rainfall interception in

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Meteorological Society, 2000), http://www.fs.fed.us/psw/programs/cufr/products/cufr_17_JS00_46.PDF (July 24, 2010); Klaus I. Scott, James R. Simpson, and E. Gregory McPherson, "Effects of Tree Cover on Parking Lot Microclimate and Vehicle Emissions," *Journal of Arboriculture* 25, no. 3 (1999): 129-142, http://www.treelink.org/joa/1999/may/03scott.pdf (July 24, 2010); Klaus I. Scott, James R. Simpson, and E. Gregory McPherson, "Green Parking Lots: Can Trees Improve Air Quality?", in *Proceedings of the Best of the West Summit 1999*, 86-87, UC Davis College of Agricultural and Environmental Sciences, http://www.fs.fed.us/psw/programs/cufr/products/cufr_7_KS99_76.PDF (July 24, 2010); James R. Simpson and E. Gregory McPherson, "Simulation of Tree Shade Impacts on Residential Energy Use for Space Conditioning in Sacrament," *Atmospheric Environment: Part B - Urban Atmospheres* 32, no. 1 (1998):69-74, http://www.fs.fed.us/psw/programs/cufr/products/cufr_30_JS98_50.PDF (July 24, 2010); E. Gregory McPherson, "The Impact of Shade Trees in Reducing Heat Island Effect in Parking Lots, *Arid Zone Times* February (1998): 1-2; James R. Simpson and E. Gregory McPherson, "Estimating Urban Forest Impacts on Climate-Mediated Residential Energy Use," in *Proceedings of the 12th Conference on Biometeorology and Aerobiology 1996*, 462-465 (Boston: American Meteorological Society), http://www.fs.fed.us/psw/programs/cufr/products/cufr_34_JS96_48.PDF (July 24, 2010); James R. Simpson and E. Gregory McPherson, "Potential of Tree Shade for Reducing Residential Energy Use in California," *Journal of Arboriculture* 22, no.1 (1996): 10-18, http://www.fs.fed.us/psw/programs/cufr/products/cufr_35_JS96_49.PDF (July 24, 2010); E. Gregory McPherson, David Nowak, Greg Heisler, S. Grimmond, C. Souch, R. Grant, and Rowan Rowntree, *Results of the Chicago Urban Forest Climate Project*, Paper presented at the 7th National Urban Forest Conference, American Forests, New York, September 12-16, 1995, http://www.nrs.fs.fed.us/pubs/gtr/gtr_ne186.pdf (July 24, 2010); E. Gregory McPherson and James R. Simpson, "Shade Trees as a Demand-Side Resource, *Home Energy* March/April (1995): 11-17, http://www.fs.fed.us/psw/programs/cufr/products/cufr498.pdf (July 31, 2010); D. G. Levitt, James R. Simpson, C. S. Grimmond, E. Gregory McPherson, and Rowan Rowntree, "Neighborhood-Scale Temperature Variation Related to Canopy Cover Differences in Southern California," Paper presented at the 11th Conference on Biometeorology and Aerobiology, American Meteorological Society, San Diego, California, March 7-10, 1994, http://www.fs.fed.us/psw/programs/cufr/products/cufr_513_neighborhood-scale.pdf (July 24, 2010).

[23] Simpson and McPherson, "Tree Planting to Optimize Energy and CO_2 Benefits"; McPherson et al. "Actualizing Microclimate and Air Quality Benefits with Parking Lot Tree Shade Ordinances"; Simpson and McPherson, "Effects of Urban Trees on Regional Energy Use and Avoided Carbon"; Scott et al., "Effects of Tree Cover on Parking Lot Microclimate and Vehicle Emissions"; Scott et al., "Green Parking Lots: Can Trees Improve Air Quality?".

[24] Center for Urban Forest Research, *Urban Forest Greenhouse Gas Reporting Protocol, August 12, 2008* (Davis, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, 2008), http://www.fs.fed.us/psw/programs/cufr/products/12/psw_cufr742_UrbanForestProtocol.pdf (July 20, 2010); Melissa R. McHale, E. Gregory McPherson, and Ingrid C. Burke, "The Potential of Urban Tree Plantings to be Cost Effective in Carbon Credit Markets," *Urban Forestry & Urban Greening* 6 (2007): 49-60, http://www.fs.fed.us/ecosystemservices/pdf/urban-tree-planting.pdf (July 24, 2010).

[25] McPherson et al., "Actualizing Microclimate and Air Quality Benefits with Parking Lot Tree Shade Ordinances."

Santa Monica and Oakland;[26] energy savings, sequestration, atmospheric CO_2 reduction, air quality benefits, and stormwater runoff reduction in Modesto;[27] stormwater runoff reduction, energy use reduction, atmospheric CO_2 reduction, and air quality improvement in Los Angeles;[28] and atmospheric CO_2 reduction, air pollutant uptake, and cooling in Sacramento.[29] An assessment of San Francisco's street tree cover was made by the Northern Research Station and focused on carbon storage and sequestration and pollution removal.[30] While these studies provide scientific evidence of the ecological value of street and urban trees, they do not address the contextual factors that make particular ecosystem benefits more salient to particular cities.[31]

Case studies of street trees and urban forests

In addition to natural science research on street trees, there are numerous social science publications about street trees, specifically on the development of street tree planting in different cities. Street tree planting in colonial U.S. states and two of our case cities – Sacramento and San Francisco – has been documented in other studies.[32] This study will not compare street tree planting among cities, nor will it compare street tree planting strategies

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[26] Qingfu Xiao and E. Gregory McPherson, "Rainfall Interception by Santa Monica's Municipal Urban Forest," *Urban Ecosystems* 6 (2003): 291–302, http://www.fs.fed.us/psw/programs/cufr/products/cufr420_UrbanEosystems_RISMUF.pdf (July 24, 2010).

[27] E. Gregory McPherson, "A Benefit-Cost Analysis of Ten Street Tree Species in Modesto, California, U.S.", *Journal of Arboriculture* 29, no. 1 (2003): 1-8, http://www.fs.fed.us/psw/programs/cufr/products/cufr_162.pdf (July 31, 2010).

[28] McPherson and Simpson, "*Effects of California's Urban Forests on Energy Use and Potential Savings from Large-Scale Tree Planting*"; Leavitt et al., "Neighborhood-Scale Temperature Variation Related to Canopy Cover Differences in Southern California"; Geiger, "Is All of Your Rain Going Down the Drain?".

[29] E. Gregory McPherson, "Benefits of Trees: Watershed, Energy, and Air," *Arborist News* 13, no. 6 (2004): 29-35.

[30] David J. Nowak, Robert E. Hoehn III, Daniel E. Crane, Jack C. Stevens, and Jeffrey T. Walton, *Assessing Urban Forest Effects and Values, San Francisco's Urban Forest, Resource Bulletin NRS-8* (Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, 2007), http://www.sfenvironment.org/downloads/library/sfuforefinal.pdf (July 23, 2010).

[31] McBride and Jacobs studied the role of pre-settlement vegetation in contemporary urban forest development and found that tree planting in a previously non-treed area increases tree density while tree planting in a previously treed area is complicated by tree removal for development purposes (Joe R. McBride and D. Jacobs, "Presettlement Forest Structure as a Factor in Urban Forest Development," *Urban Ecology* 10 (1986):26-52.) McPherson and Simpson "estimated annual benefits 15 years after planting for a medium-statured *residential yard tree* in three California regions" which illustrates an estimated science-based geography of tree benefits but does not reflect policy-based geography of tree benefits (E. Gregory McPherson and James R. Simpson, "Effects of California's Urban Forests on Energy Use and Potential Savings from Large-Scale Tree Planting," Davis CA: USDA Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research, 2001, http://www.fs.fed.us/psw/programs/cufr/products/cufr_78_EM01_68.PDF.)

[32] Thomas Campanella, *Republic of Shade: New England and the American Elm* (New Haven: Yale University Press, 2005). Evelyn Herwitz, *Trees at Risk: Reclaiming an Urban Forest* (Worcester, Massachusetts: Chandler House Press, 2001). Henry W. Lawrence, *City Trees: A Historical Geography from the Renaissance through the Nineteenth Century* (Charlottesville: University of Virginia Press, 2006). E. Gregory McPherson and Nina Luttinger, "From Nature to Nurture: The History of Sacramento's Urban Forest," *Journal of Arboriculture* 24, no. 2 (1998):72-88. Richard D. Schein, *Street Trees: A Manual for Municipalities* (State College, Pennsylvania: TreeWorks, 1993).

among California cities. However, a review of case histories of street tree planting reveals a gap in the literature – the ecological framing of the street tree – which was the focus of this dissertation. There are two exceptions: McPherson and Luttinger's history of urban forestry in Sacramento[33] and Cranz and Boland's typology of parks.[34] In their 1998 history of Sacramento's urban forest, McPherson and Luttinger wrote,

> *Today, as the region grows and its population becomes more diverse, the urban forest is expected to produce more benefits. Multiple managers are interested in nurturing "their" trees to clean the air and water, conserve energy, increase employment, produce food, restore riparian habitats, reduce skin cancer, and enhance biodiversity.*[35]

McPherson and Luttinger considered all trees – street and park trees – within the public domain and enumerated the multiple benefits of urban trees. In a different context, that of the urban park, Cranz and Boland discussed the role of "ecological performance" in their discussion of contemporary park design, or the Sustainable Park.[36] Unlike previous park designs outlined by Cranz,[37] designers, beginning in the 1990s, placed greater emphasis on ecological and sustainability principles.

Now turning to case studies of tree planting, ecosystem benefits are not explicitly addressed in tree case histories by Schein,[38] Herwitz,[39] Campanella,[40] and Lawrence.[41] As the title of his book suggests, Lawrence looked at the evolution of tree planting – along city streets and in parks and other open spaces – traditions between the Renaissance and the nineteenth century in western European and colonial U.S. cities. He discussed the planting of trees within these cities as displays of power and aesthetic values. Street trees along city streets receive more attention in his article about the precedents of the "tree-lined boulevard," a design form popularized by Napoleon III and Baron Haussmann.[42]

Schein provided a U.S.-centric history of street trees; in *Street Trees: A Manual for Municipalities*, he devoted a chapter to the development of street tree planting from the colonial era to 1970.[43] The site of Schein's history is the East Coast. Before the Revolution, trees along (town and village) streets were remnants of existing pre-colonial forests and woodlands. The period that followed, between 1790 and 1850, is characterized by the

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[33] McPherson and Luttinger, "From Nature to Nurture," 72-88.
[34] Galen Cranz and Michael Boland, "Defining the Sustainable Park: A Fifth Model for Urban Parks," *Landscape Journal* 23, no.2 (2004):102-120.
[35] McPherson and Luttinger, "From Nature to Nurture," 86.
[36] Cranz and Boland, "Defining the Sustainable Park," 102.
[37] Cranz identified four eras of urban park design: the Pleasure Ground, the Reform Park, the Recreational Facility, and the Open Space System (Galen Cranz, *The Politics of Park Design: A History of Urban Parks in America* (Cambridge, Mass.: The MIT Press, 1982).)
[38] Schein, *Street Trees.*
[39] Herwitz, *Trees at Risk.*
[40] Campanella, *Republic of Shade*.
[41] Lawrence, *City Trees*.
[42] Henry W. Lawrence, "Origins of the Tree-Lined Boulevard," *The Geographical Review* 78, no. 4 (1988): 355-374.
[43] Schein, *Street Trees*.

"purposeful planting" of street trees in cities on the East Coast and west of the Mississippi. Street tree planting, argued Schein, was firmly established between 1850 and 1900, a period marked by "improvement" impulses. Trees were planted by improvement societies, municipal governments, and suburban developers. While the City Beautiful Movement of the early twentieth century "easily incorporated tree planting," changes in communications (telephone lines), power (overhead utility wires), and transportation (road widening) infrastructure "came into direct conflict" with tree-lined streets between 1900 and 1940.[44] Schein described the period after World War II "'development' …unfettered, ruining town and countryside"[45] but was encouraged by the "new tree movement" of the 1990s to preserve existing trees and to plant replacements.[46]

Schein's narrative of tree planting history in the U.S. is echoed in Campanella's 2005 *Republic of Shade: New England and the American elm*. Like Schein, Campanella described the beautification and improvement impulses in New England, the various initiators of tree planting such as private individuals and municipal governments, and the infrastructural changes that "begun to weaken New England's curbside elms,"[47] though he placed these changes in the mid-nineteenth to early twentieth century, earlier than in Schein's timeline. Where Campanella's narrative differs significantly from Schein is in scope; Campanella focused on the planting of a single species of street tree (the America elm) in a smaller region (New England).

Campanella's narrative about the development of New England street tree planting, specifically the American elm, is reiterated in Herwitz's 2001 *Trees at Risk: Reclaiming an Urban Forest*. Herwitz, writing about Worcester, Massachusetts, documented extensive deforestation by English settlers followed by the planting of trees along streets and in parks by the same "public spirited individuals" described by Campanella.[48] This period of planting is followed by a period of decline in both planting and maintenance. Herwitz's history ended with the current period of burgeoning reclamation spearheaded by "concerned individuals."[49]

Nonprofit service provision

Both Campanella and Herwitz's histories ended with the involvement of non-governmental groups and individuals in restoring tree-lined streets. The authors also pointed to the role of municipalities in this effort. The emergence of the urban forest nonprofit in the late 1970s and early 1980s was primarily in response to municipal fiscal constraints. Providing an overview of the fiscal environment in the 1980s, Ladd wrote that

> *In 1978…federal aid to state and local governments began to decline, and two years later the economy slid into recession. After a brief economic recovery, the economy deteriorated again in 1981 as the country entered its worst recession since the Great*

[44] Schein, *Street Trees*, 25-26.
[45] Schein, *Street Trees*, 10.
[46] Schein, *Street Trees*, 29.
[47] Campanella, *Republic of Shade*, 144.
[48] Herwitz, *Trees at Risk*.
[49] Herwitz, *Trees at Risk*, 189.

> *Depression. Simultaneously, cities faced significant additional cutbacks in federal aid at the hands of the Reagan administration and, in many states, a revolt against local and state taxes. By the end of 1982, the economy began to recover, but federal assistance to cities continued to fall. The recession, high interest rates, and loss of federal aid in the early 1980s presented major new fiscal challenges for city governments and caused many observers to worry about how the cities would cope.*[50]

The nonprofits' modus operandi has matured since the 1980s. Like other contemporary nonprofits, urban forest nonprofits "are playing increasingly important and complex roles in American cities and local communities."[51] Furthermore, local governments are relying on nonprofits to deliver services. LeRoux argued that government might be interested in nonprofit development because government "is able to capitalize on the nonprofit resources like voluntary labor, flexibility, and creative programs that are often difficult to implement in rule-bound public bureaucracies."[52]

Pincetl examined the role of the nonprofit in park provision in Los Angeles in the decades following the disinvestment described by Ladd.[53] She also addressed the broad category of the environmental nonprofit – which could include the urban forestry nonprofit – as well as geographic areas beyond Los Angeles in her analysis. Pincetl wrote,

> *Environmental nonprofits have effectively become partners in the local urban regime and in local governance arrangements. Although there remains a great deal of empirical research to be done to fully trace the rise of power of environmental nonprofits in the local politics of land-use allocation generally, and in Los Angeles specifically, sufficient evidence exists to point to the emergence of environmental nonprofits as important players in the governance of the Los Angeles metropolitan area and to believe that Los Angeles is not an isolated case.*[54]

Pincetl's contention about "the emergence of environmental nonprofits as important players in [urban] governance" is echoed by LeRoux's observation that urban nonprofits have assumed "increasingly important and complex roles."[55] This dissertation asserts that the urban forest nonprofit has been critical in disseminating scientific evidence of the ecosystem benefits of street trees. Writing about discursive strategies, Fortmann argued that "if the story tellers are strategically placed, their stories will diffuse into a wider societal discourse which will strengthen their hand in waging their struggle."[56] Nonprofits are "strategically placed." They are visible as tree planters, provide information via their Web sites and newsletters, and

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[50] Helen F. Ladd, "Big-City Finance," in *Big-City Politics, Governance, and Fiscal Constraints*, ed. George E. Peterson (Washington, D.C.: The Urban Institute Press, 1996), 214.
[51] Kelly LeRoux, "Nonprofits as Civic Intermediaries: The Role of Community-Based Organizations in Promoting Political Participation," *Urban Affairs Review* 42, no. 3(2007): 410.
[52] LeRoux, "Nonprofits as Civic Intermediaries," 413.
[53] Ladd, "Big-City Finance," 1994. Stephanie Pincetl, "Nonprofits and Park Provision in Los Angeles: An Exploration of the Rise of Governance Approaches to the Provision of Local Service," *Social Science Quarterly* 84, no. 4 (2003): 979-1001.
[54] Pincetl, "Nonprofits and Park Provision in Los Angeles," 981.
[55] LeRoux, "Nonprofits as Civic Intermediaries," 410.
[56] Louise Fortmann, "Talking Claims: Discursive Strategies in Contesting Property," *World Development* 23, no. 6 (1995): 1061.

sponsor events. Also, local governments often direct citizens toward nonprofit providers. For example, the San Francisco Department of Public Works directs users to the Friends of the Urban Forest website with a link titled "Non-Profit Assistance for Tree Planting."[57]

The urban forest nonprofit's "struggle" is the promotion of the ecological validity of street trees. Pulido developed the concept of ecological legitimacy in her work on New Mexican Hispano claims to rangeland. She wrote that not only is ecological legitimacy assigned to "a group when it is seen as a valid environmental actor, when its commitment to preserving the environment is not regarded as suspect," it is "associated with environmental stewardship or the practice of caring for the land in a sustainable manner."[58] Certainly ecological legitimacy attaches to the urban forest nonprofit, but more importantly, it attaches to the street tree, which has been predominantly conceptualized as "ornamental or cultivated additions to a cityscape" as late as the 1970s.[59]

Trees were recognized for their ecological value before the 1980s. For example, writing in 1817, Solotaroff mentioned the role street trees play in purifying the air and modifying temperatures. Specifically, he describes air purification as the absorption of "the carbonic-acid gas that is exhaled by man."[60] Air temperatures are modified vis-à-vis the evaporation of "large quantities of water from [the trees'] surfaces."[61] Given that the ecosystem functions of urban trees were recognized in the early twentieth-century, why wasn't the street tree framed as an ecological element of the city earlier than the 1980s? Although the ecosystem benefits provided by street and urban trees have been known for some time, it was not until the later part of the 20th century that scientific evidence was generated to support these claims. (Of course, evidence from studies of rural forests was often used in early discussions about the potential benefits of urban forests.) Technological advances in tree mapping and geographic information systems have allowed not only scientists but municipalities and nonprofits to evaluate and quantify the functions of street and urban tree canopies.[62]

Nonprofits and municipalities were able to refigure the role of the street tree using the growing body of research on the ecological value of urban trees. In a 2007 paper, Evans critically observed the role of science in sustainability arguments. Based on scholarship generated in the mid-1990s, Evan argued that "claims to ecological authority are proliferating under the science-driven rubric of sustainable development, and particularly the notion of evidence-based policy."[63] In the seminal volume of the 1990s about the ecological city, Platt

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[57] San Francisco Department of Public Works website, Street Tree Planting Permitting Process, http://38.106.4.205/index.aspx?page=649, July 26, 2010.
[58] Laura Pulido, "Ecological Legitimacy and Cultural Essentialism: Hispano Grazing in the Southwest," *Capitalism, Nature, Socialism* 7, no. 4 (1996): 37.
[59] Ira Bruce Nadel and Cornelia Hahn Oberlander, *Trees in the City* (New York: Pergamon Press, 1977), 7.
[60] William Solotaroff, *Shade Trees in Towns and Cities* (New York: John Wiley & Sons, 1912), 3.
[61] Solotaroff, *Shade Trees in Towns and Cities*, 4.
[62] See Nancy Lee Peluso, "Whose Woods Are These? Counter-Mapping Forest Territories in Kalimantan, Indonesia," in *The Anthropology of Development and Globalization: From Classical Political Economy to Contemporary Neoliberalism*, ed. Marc Edelman and Angelique Haugerud (Wiley-Blackwell, 2005), 273-281, http://books.google.com/books?id=gSAtk2zamNUC&lpg=PP1&pg=PR5#v=onepage&q=&f=false (September 8, 2009).
[63] James P. Evans, "Wildlife Corridors: An Urban Political Ecology," *Local Environment* 12, no. 2 (2007), 134.

underscored the role of scientific evidence "in the design and redesign of urban communities" by noting among other applications, Greg McPherson's use of climate data in generating urban forestry designs to mitigate urban heat islands.[64] Scientific data also plays a role in developing "green" laws and ordinances that support sustainable landscapes.[65] In an article about the use of legal strategies to achieve sustainability, Wolf argued that scientific evidence was responsible for the transition in green laws towards an active engagement with urban ecology.

> *While early efforts at green law focused on the amenity value of plants in the urban setting, many ordinances alluded to environmental benefits. Increasing concern in the late 1970s and 1980s about the quality of the environment prompted more serious study of urban ecological processes. In the past two decades, urban forest and urban ecology research has provided information that broadens the purposes of green law….*[66]

City standards and the ecological city

Whereas municipal ordinances for tree planting, maintenance, and protection (from removal and construction damage) have existed in U.S. cities since Pennsylvania's Shade Tree Law of 1700, municipal tree planting standards drafted explicitly to capture ecosystem benefits are relatively new. Although formal standards are new, there are scores of guidelines for species selection and planting arrangements ("strategic planting") to reduce wind speed and to conserve energy, in particular (Figure 1.2). Much of the research that led to the development of "strategic planting" guidelines has been conducted by scientists at the USDA Forest Service research stations or by scientists funded by the USDA Forest Service Urban & Community Forestry Program. In its 2008 draft Urban Forest Project Reporting Protocol, the California Climate Action Registry task force listed "strategic planting" as essential to reducing "greenhouse gas emissions at the power plant."[67] Two examples of standard setting follow.

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[64] Rutherford H. Platt, "Crosscutting Themes and Recommendations," in *The Ecological City*, ed. Rutherford H. Platt, Rowan A. Rowntree, and Pamela C. Muick (Amherst: The University of Massachusetts Press, 1994), 283-284.

[65] Kathleen L. Wolf, "Trees, Parking and Green Law: Strategies for Sustainability," (University of Washington, Seattle, Washington: College of Forest Resources, 2004), http://www.naturewithin.info/Roadside/Trees_Parking.pdf 2004 (July 24, 2010).

[66] Wolf, "Trees, Parking and Green Law: Strategies for Sustainability," 18.

[67] Center for Urban Forest Research, *Urban Forest Greenhouse Gas Reporting Protocol*, (Davis, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, August 12, 2008), http://www.fs.fed.us/psw/programs/cufr/products/12/psw_cufr742_UrbanForestProtocol.pdf (July 20, 2010).

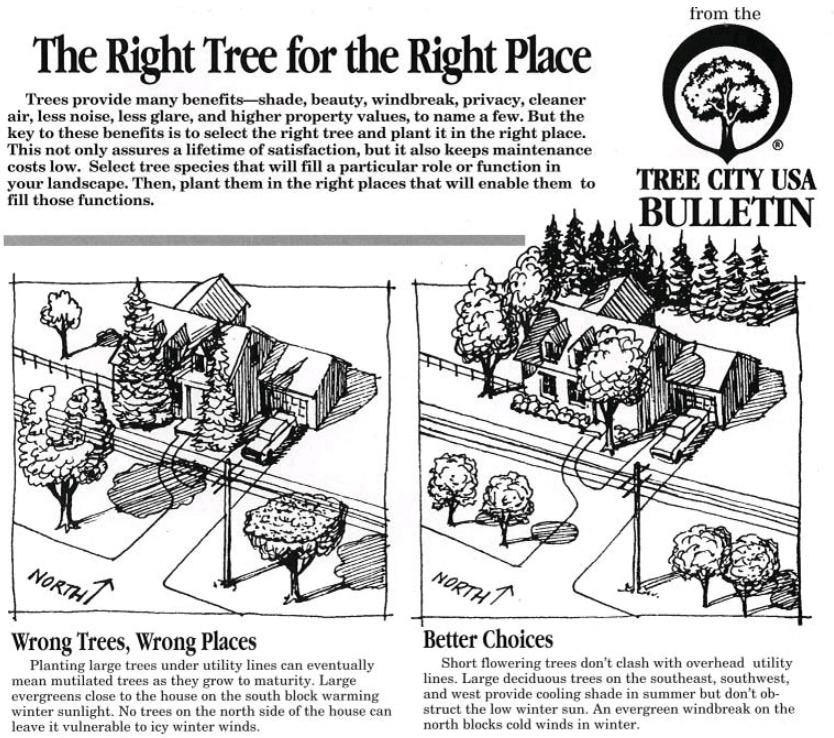

Figure 1.2 Tree species and geometries for summer shading and winter irradiance. *Source*: Tree City USA Bulletin No. 4.

One, on April 30, 2008, the New York City Council amended the Zoning Resolution, requiring "planting of street trees in all zoning districts for all new developments, major enlargements (20% or more increase in floor area on the zoning lot), and certain conversions (where 20% or more of the building floor area is changed in use between commercial, residential, community facility, or manufacturing uses)."[68] These street tree standards are part of the City's PlaNYC initiative. The standards themselves were designed to meet tree canopy, air quality, and stormwater runoff management goals.

The second example of formal standards setting at the municipal level occurred later in 2008. On November 19, 2008, the findings of the "Stormwater Management with trees and structural soils" research project were released.[69] The explicit goal of the project was to manage stormwater in urban areas. The team developed a stormwater best management practice (BMP) that incorporated the rainfall interception function of trees, the tree development and pavement support qualities of structural soil, and the infiltration and drainage qualities of subsoil.[70] The lead scientists on the team were Susan D. Day (also

[68] New York City Department of City Planning website, Street Tree Planting Text Amendment, http://www.nyc.gov/html/dcp/html/street_tree_planting/index.shtml (November 29, 2008).
[69] American Society of Agronomy, "Urban Trees Enhance Water Infiltration," *ScienceDaily* November 28, 2008, http://www.sciencedaily.com /releases/2008/11/081119120153.htm (July 26, 2010); Susan Downing Day and Sarah Beth Dickinson, *Managing Stormwater for Urban Sustainability using Trees and Structural Soils* (Blacksburg, VA: Virginia Polytechnic Institute and State University, 2008), http://www.cnr.vt.edu/urbanforestry/stormwater/Resources/TreesAndStructuralSoilsManual.pdf (July 20, 2010).
[70] Day and Dickinson, *Managing Stormwater for Urban Sustainability using Trees and Structural Soils*.

project lead) of the Urban Forestry and Urban Horticulture programs at Virginia Tech, Nina Bassuk of the Urban Horticulture Institute at Cornell University, and Qingfu Xiao of the Department of Land and Water Resources at the University of California at Davis. The project was partly funded by the USDA Forest Service Urban & Community Forestry Program.

These two events are significant in the discussion of city standards. As Day and Dickinson acknowledged in their report, structural soil has been in existence since the mid-1990s, with the development of CU-Soil by Nina Bassuk of Cornell University. Structural soil directly addresses the need for expanded soil volumes for the street tree growth and longevity. The most famous example of the role of expanded soil volume in vigorous tree growth is the double allee of willow oaks on Pennsylvania Avenue in Washington, D.C. The trees in traditional tree pits are smaller in height in and in width than the trees growing in the lawn. The ability to meet engineering load-bearing standards under sidewalks, parking lots, plazas, and wherever it was installed, was critical in the use of structural soil in urban projects. Day and Dickinson made an explicit connection between the provision of ecosystem services, in this case, stormwater management, and planting technology.

The implications of formal standards – and to some extent popular guidelines and practices – are underscored in *Regulating Place*. Standards, wrote Ben-Joseph, "shape and affect physical space."[71] On one hand standards can negatively impact place. An example of this is provided by Macdonald et al.'s study of street trees and intersection safety. The authors argued that the wide spacing of trees (defined by the authors as greater than 25 feet) as well as the lack of trees near intersections has decreased "pedestrian comfort and environmental legibility."[72] An empirical study of standards regulating the (non-) planting of trees near intersections in San Francisco revealed that cars parked near intersections, in particular tall and bulky cars, and newspaper racks constitute the primary visibility hazards at intersections.[73] On the other hand, standards can have positive outcomes. In the case of New York City's new street tree standards, environmental planning goals are supported, specifically enabling streets to "operate and function in natural ways."[74]

1.3 Significance of this Dissertation

This study makes several contributions to the street tree literature. One, the focus of the study is the street tree and not the urban forest as a whole. The urban forest is defined as street trees and all other vegetation both public and private within the city limits.[75] Although street trees

[71] Eran Ben-Joseph, "Introduction: Standards and Rules in Shaping Place," in *Regulating Place: Standards and the Shaping of Urban America*, ed. Eran Ben-Joseph and Terry S. Szold (New York: Routledge, 2005), 1.
[72] Elizabeth Macdonald, Alethea Harper, Jeff Williams, and Jason A. Hayter, "Street Trees and Intersection Safety," *IURD Working Paper Series* 11 (2006): 9, http://www.uctc.net/research/papers/768.pdf (July 23, 2010).
[73] Macdonald et al., "Street Trees and Intersection Safety."
[74] Timothy Beatley, *Green Urbanism: Lessons from European Cities*, (Washington, D.C.: Island Press, 2000), 197.
[75] David J. Nowak, "Urban Forest Development and Structure: Analysis of Oakland, California," PhD diss. (University of California, Berkeley, 1991).

typically comprise only 10 to 20 percent of the urban forest,[76] these trees are in the public domain and thus more easily regulated and accessed.[77] In addition, their location in the public domain has made them preferred elements for experimentation, the results of which are then more broadly applied. For example, two of the demonstration sites for the Stormwater Management with trees and structural soils project are city-owned parking lots.[78]

Two, the study extends the narrative of the street tree; Lawrence's history is limited to the period between the Renaissance and the nineteenth century, and Schein's and Campanella's are limited to the period between Anglo-European settlement and the 1970s. This study narrates the street tree from the 1980s to the present.

Three, the context of this study is California which broadens our geographical understanding of street trees, whereas the existing literature on street trees and urban forests has an Eastern bias. The McPherson and Luttinger (1998) article on the history of urban forestry in Sacramento is an exception, whereas this study examines the ecological street tree in several cities in California.

Four, although Herwitz's book on Worcester's urban forest ends in the 1990s, it did not address the framing of the street tree in primarily ecological terms.

1.4 Organization of the Dissertation

Chapter 1 (Introduction) provided the purpose of the dissertation as well as a literature review. Chapter 2 (Methodology) presents the research design and methods. Chapters 3 to 5 present findings for Sacramento, Palo Alto, and San Francisco, respectively, and are organized around the study's main propositions which are repeated below.

Propositions 1, 1a and 1a1 address the emergence of the ecological street tree. This study investigates the presence of an upwards trend in the ecological characterization of street trees (Proposition 1), the role the urban forest nonprofit in promulgating the ecological street tree (Proposition 1a), and its corollary that the nonprofit's newsletter is the primary mode of communicating the ecological benefits of street trees (Proposition 1a1). Also, the role of the municipality is examined. Municipal plans and activities are examined alongside those of the urban forest. The ecological street tree has been made possible through the production and

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[76] Ibid.

[77] Street and park trees account for approximately 25% or 35,814 of Palo Alto's total urban forest (PA3, personal interview, June 16, 2009; Palo Alto, Department of Planning and Community Environment, "Tree City USA Application 2009," Palo Alto: Planning Department, 2009.). Street (estimated 110,000) and park (100,000) trees account for 30% of San Francisco's total urban forest (San Francisco, Department of the Environment, Urban Forestry Council, *Annual Report September 2008* (San Francisco: SFEnvironment, 2008); San Francisco, Department of the Environment, Urban Forestry Council. *Annual Report September 2009* (San Francisco: SFEnvironment, 2009), http://www.sfenvironment.org/downloads/library/sfe_urban_forest_annual_report_2009.pdf (July 20, 2010).). Sacramento has 71,463 trees including "17,205 trees that are in front yards and the ROW" and 23,765 park trees (SAC1 follow-up, email communication, May 13, 2010).

[78] Day and Dickinson, *Managing Stormwater for Urban Sustainability using Trees and Structural Soils*.

dissemination of research findings (Proposition 1b). In the Bay Area, evidence-based planning has been influenced by the work of the Center for Urban Forest Research (CUFR), a U.S.D.A. Forest Service research station. Finally, Propositions 2 and 2a consider the geography of ecosystem services planning. Particular ecosystem services are salient to particular cities (Proposition 2) and different strategies are used by different actors to capture tree-based ecosystem services (Proposition 2a). Chapter 6 (Conclusions) concludes the dissertation with a cross-case comparison, implications, and future research directions.

Chapter 2:: Methodology

2.1 Overview

This dissertation used a multiple-case study of three cities in Northern California to analyze the evolution in the framing of the street tree (Table 2.1). One of the strengths of the case study is its "methodological versatility," i.e. multiple methods and sources of evidence can be incorporated into an overall strategy.[79] The use of multiple data sources allows the researcher to triangulate and corroborate the study's findings and conclusions.[80] This study used the following sources of evidence: nonprofit newsletters; newspaper articles; nonprofit and municipal planning documents; interview transcripts with nonprofit and municipal staff; and field work and observation.

Table 2.1 Research Propositions

Proposition	Definition
1	The presence of an upwards trend in the ecological characterization of street trees
1a	The urban forest nonprofit plays a significant role in promulgating the ecological street tree
1a1	The nonprofit's newsletter is the primary mode of communicating the ecological benefits of street trees
1a2	The municipality (city) also plays a role in mainstreaming the ecological street tree
1b	The ecological street tree has been legitimated vis-à-vis the production of scientific research
2	Particular ecosystem services are salient in particular cities
2a	Different strategies are used by different actors to capture tree-based ecosystem services

Another reason for selecting the case study approach was its use in and recommendation by scholars of design and landscape architecture. In *Inquiry by Design*, Zeisel wrote that the case study is appropriate for an in-depth examination of a single phenomenon and its context.[81] Francis goes beyond this; he recommends the case study approach for its "systematic examination of the process, decision-making, and outcomes of a landscape issue."[82]

A multiple-case study with cross-case synthesis was used in this study. The cross-case synthesis is a comparative analysis recommended by Yin and Miles and Huberman.[83] In this type of analysis, each case is studied separately and compared and contrasted to generate "strong, plausible, and fair arguments that are supported by the data."[84] Each nonprofit – city pair (ex: Friends of the Urban Forest – San Francisco) was studied individually followed by a comparative analysis of the three cases. The research design fits Yin's definition of a case study strategy: (1) the study propositions can be framed as "how" and "why" questions; (2)

[79] Robert K. Yin, *Case Study Research: Design and Methods* (Thousand Oaks, CA: Sage Publications, 2002), 106.
[80] Robert K. Yin, *Case Study Research: Design and Methods* (Thousand Oaks, CA: Sage Publications, 2009).
[81] John Zeisel, *Inquiry by Design*: *Environment/Behavior/Neuroscience in Architecture, Interiors, Landscape, and Planning* (New York City: W. W. Norton, 2006).
[82] Zeisel, *Inquiry by Design*, 8.
[83] Matthew B. Miles and A. Michael Huberman, *Qualitative Data Analysis* (Thousand Oaks, CA: Sage Publications, 1994); Yin, *Case Study Research*, 2009.
[84] Yin, *Case Study Research*, 2009, 160.

the phenomena under investigation cannot be manipulated; and (3) the phenomena are contemporary in nature. This study examined the evolution of the ecological street tree beginning in the 1980s; this time period can be considered contemporaneous in contrast to the "'dead' past."[85]

A primary concern of this study was the emergence of the ecological street tree and the role of the urban forest nonprofit in mainstreaming the ecological function of street trees. As such, the primary source of evidence was nonprofit documents including newsletters, annual reports, and planning documents. In the first phase of data analysis, this dissertation used document content analysis to examine both nonprofit and municipal documents. Face-to-face qualitative interviews were conducted with nonprofit and municipal staff in the second phase. The interview schedule was driven by the results of the document content analysis.

Following Crewe, individual, long interviews were used in the second phase of the study.[86] Crewe interviewed designers about the effects of citizen participation on the development of Boston's Southwest Corridor Parkway. Her qualitative interview approach was an excellent model for the interview phase of this dissertation for two reasons. One, in-depth information is better collected from qualitative interviews. Two, in-depth information was necessary for this dissertation because the ecological framing of the street tree is understudied.

2.2 The Cases

The case study methodology requires the researcher to distinguish between "the object of study" and "the case."[87] The object of study or the phenomenon being studied is the ecological framing of the street tree. The cases, defined by Orum and Feagin as "empirical instances" [88] are the urban forest nonprofits and the municipalities in which they are located. Three cases were selected to study the role of nonprofit and municipal actors in mainstreaming the ecological valuation of street trees. The nonprofits studied were Friends of the Urban Forest, San Francisco; Sacramento Tree Foundation, Sacramento; and Canopy, Palo Alto. The urban forest nonprofit does not operate in a vacuum. It functions in the context of a city with its own greening agenda, in which the nonprofit plays a role. In each city, municipal agencies responsible for street trees and the urban forest were studied in conjunction with the urban forest nonprofit. The selected cities, all located in the Northern California/San Francisco Bay Area, were selected for the following reasons: (1) presence of an urban forest nonprofit (with good record keeping); (2) heterogeneity of city type; (3) heterogeneity of age of the nonprofit; (4) geographic accessibility; and (5) environmental legacy of the region. Regarding the latter, in his chronicle of open space battles in the region, Richard Walker highlighted the early advocacy of environmental issues by Bay Area

[85] Yin, *Case Study Research*, 2009, 9.
[86] Katherine Crewe, "The Quality of Participatory Design: The Effects of Citizen Input on the Design of the Boston Southwest Corridor," *Journal of the American Planning Association* 67, no. 4 (2001): 437-455.
[87] Yin, *Case Study Research*, 2002.
[88] Anthony M. Orum and Joe R. Feagin, "A Tale of Two Cases," in *A Case for Case Study*, ed. Joe R. Feagin, Anthony M. Orum, and Gideon Sjoberg (Chapel Hill, NC: University of North Carolina Press, 1991), 123.

residents, organizations, and governments.[89] Given this legacy, the ecological street tree was expected to be present in this region and its cities.

The evolution in the framing of the street tree was diagnosed by comparing the three nonprofits which were founded in different years (Figure 2.1). Canopy was founded more than a decade after Friends of the Urban Forest and the Sacramento Tree Foundation. The variance in year of establishment allowed an examination of the synergy between nonprofit provision of street trees and the ecological framing of the street tree. Also, the variance in the age of the organization highlighted differences between recent and more established urban forest nonprofits.

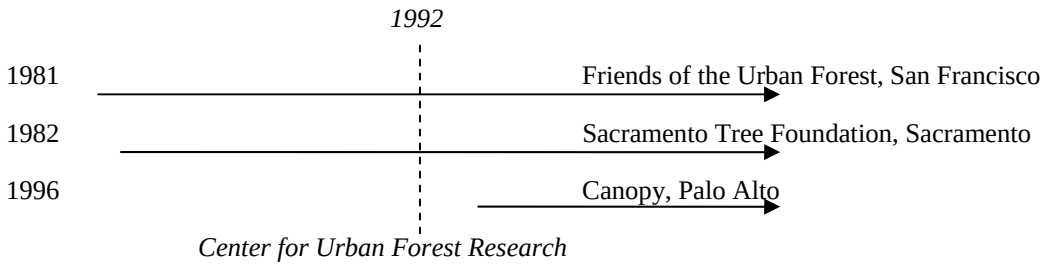

Figure 2.1 Temporal comparison of the cases (not to scale).

Finally, the region is home to one of the major urban forest research stations in the U.S., the Center for Urban Forest Research (CUFR) in Davis, California.[90] CUFR was founded in 1992, a decade after the establishment of Friends of the Urban Forest (FUF) and Sacramento Tree Foundation (STF) and a few years before Canopy. This dissertation examined differences in the framing of street trees before and after CUFR's founding. It was expected that CUFR would have a significant impact on the ecological street tree for the following reasons: (1) the Center is a major source of scientific evidence about the ecosystem benefits of street trees and (2) the Center is located in close proximity to the cities studied.

Sacramento Tree Foundation and the City of Sacramento

Sacramento experiences hot, dry summers and is located within a federal nonattainment area for air quality. More specifically, the city has a Mediterranean climate with an "average of 74.5 days over 90°F."[91] Sacramento is a valley and experiences thermal inversion which not only keeps warm air at ground level, but also traps pollutants at ground level. [92]

[89] Richard Walker, *The Country in the City: The Greening of the San Francisco Bay Area*, (Seattle: University of Washington Press, 2007).
[90] CUFR is a branch of the USDA Forest Service Pacific Southwest Research Station (http://www.fs.fed.us/psw/).
[91] SAC1 follow-up, email communication, December 8, 2009. (See Table 2.3 and Table 2.4 for more details about the interviews.)
[92] Sacramento Tree Foundation, *State of the Trees Report: A Call to Action for the Sacramento Region, Fall 2000* (Sacramento: STF, 2000), 5; Klaus I. Scott, E. Gregory McPherson, and James R. Simpson, **"**Air Pollutant Uptake by Sacramento's Urban Forest," *Journal of Arboriculture* 24, no.4 (1998): 224, http://www.fs.fed.us/psw/programs/cufr/products/cufr_27_KS98_43.PDF (October 4, 2009).

The local form of government is mayor-city council while the county form is a board of supervisors. To promote citizen participation in urban forestry, the Mayor of Sacramento and the County Board of Supervisors called for the formation of an urban forest nonprofit.[93] The Sacramento Tree Foundation (STF) was founded in 1982. STF partners with the city to maintain and to replace diseased elms. STF also partners with the Sacramento Municipal Utility District to provide trees for private yard plantings and public areas including street trees. In addition to STF, the Department of Transportation Urban Forest Services (formerly part of the Department of Parks and Recreation), plants street trees.
A 2009 inventory found approximately "71,463 trees, including 17,205 trees that are in front yards and the ROW. (In some cases the ROW extends beyond the actual street and in to front yards). Maintenance easement trees were not inventoried."[94] The same 2009 inventory found 23,765 park trees. These numbers are lower than the 1993 estimates of "92,500 public trees (parks and streets) 57,000 maintenance easement trees and 500,000 or more trees on private land outside the maintenance strips" in the 1993 Urban Forest Management Plan by Wolfe Mason Associates.[95] At the county level, the city's Urban Forest Enhancement Program staff estimated one million trees in 2005.[96] Within the six-county region (El Dorado, Placer, Sacramento, Sutter, Yolo and Yuba), McPherson calculated a population of six million trees in 1998.[97]

Canopy and the City of Palo Alto

Palo Alto is located on the San Francisco peninsula with a coastal climate "85% - 98% of the time" and an inland climate "for the remainder."[98] The city experiences "cool, moist winters and moderate dry summers, often with high morning fog" and an annual average rainfall of 15.25 inches.[99] The city is underlain by three types of soil – clay near San Francisquito Creek; fertile, heavy clays in the south; and gravelly clays west of El Camino Real[100].

The local form of government – council-manager – was established by charter in 1968. The Palo Alto City Council commissioned a Tree Task Force in 1993 in response to public concern about declines in tree health. Canopy was founded 1996 to implement the task force's recommendations.[101] The organization became an independent nonprofit in 2002. .

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[93] McPherson and Luttinger, "From Nature to Nurture."
[94] SAC1 follow-up, email communication, May 13, 2010.
[95] Robert L. Tate Associates, Inc., *Sacramento Tree Services: Best Management Practices: Review and Report* (Sacramento: City of Sacramento Parks and Community Services, 2003), 3.
[96] SAC1 follow-up, email communication, July 6, 2009.
[97] E. Gregory McPherson, "Atmospheric Carbon Dioxide Reduction by Sacramento's Urban Forest," *Journal of Arboriculture* 24, no. 4 (1998b): 215-223.
http://www.fs.fed.us/psw/programs/cufr/products/cufr_26_EM98_9.pdf (October 4, 2009).
[98] Palo Alto, Department of Public Works, Parks & Open Space Division, *The Palo Alto Street Tree Management Plan 1982* (Palo Alto: Public Works, 1982).
[99] Palo Alto, *The Palo Alto Street Tree Management Plan 1982.*
[100] Palo Alto, *The Palo Alto Street Tree Management Plan 1982.*
[101] Canopy website, Organization History, http://www.canopy.org/pages/about-canopy/history.php (July 26, 2010).

The City of Palo Alto provides 34% of Canopy's annual revenue.[102] As part of its partnership with the city, Canopy "perform[s] a number of tasks" such as administering public education programs, providing young tree planting and care, and fielding calls regarding tree removal permits approved by the Planning Department.[103]

The Public Works Department is responsible for 25% of the city's total urban canopy.[104] Palo Alto's publicly owned tree population (street and park trees) in 2009 was 36,814.[105] In 2008, Canopy planted 352 trees.[106] The city plants, prunes, and removes trees while watering of young trees is the responsibility of the homeowner.[107] The city partners with Canopy for planting and young tree care.[108]

Friends of the Urban Forest and the City of San Francisco

San Francisco has a diversity of microclimates, ranging from cold and foggy in the Sunset District to warm and sunny in the Mission, the latter as a result of the influence of Twin Peaks, Mount Sutro and Mount Davidson,[109] the overall climate is cool, even in summer. It is a coastal city whose historical landscape was sand dunes covered with "low-growing shrubs, grasses, and ground covers" and stands of coast live oak, willows, and California buckeye.[110]

The local form of government is city-county with mayor-board of supervisors under the 1856 Charter. The city's municipal tree division was established in 1955 by the Board of Supervisors. San Francisco's Friends of the Urban Forest (FUF) is one of the first modern urban forestry nonprofit providers in California and is the primary urban forestry nonprofit in San Francisco. FUF was founded in 1981 after the municipal planting program was cancelled in the late 1970s.[111] The organization plants approximately 1,000 trees each year, provides tree care, and sponsors community and youth education.[112] FUF operates independently of the city's urban forestry agency, the Bureau of Urban Forestry (BUF) in the Department of Public Works. Residents are responsible for the maintenance of the trees planted with FUF

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[102] PA1, personal interview, June 16, 2009; PA2, personal interview, June 16, 2009; (See Table 2.3 and Table 2.4 for more details about the interviews.); Canopy, *Annual Report November 2008* (Palo Alto: Canopy, 2008). http://www.canopy.org/Canopy_Report_2008.pdf (November 9, 2009).
[103] PA1, personal interview, June 16, 2009; PA2, personal interview, June 16, 2009.
[104] PA3, personal interview, June 16, 2009.
[105] Palo Alto, "Tree City USA Application 2009."
[106] Canopy, *Annual Report November 2008.*
[107] PA1, personal interview, June 16, 2009.
[108] PA4, personal interview, June 16, 2009.
[109] Harold Gilliam, "Weather as Varied as the People: Land and Fog Build Summer Microclimates," *San Francisco Chronicle*, Monday, July 9, 2001. http://www.sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2001/07/09/MN139536.DTL (July 15, 2010).
[110] SFEnvironment website, History of San Francisco's Urban Forest, http://www.sfenvironment.org/our_programs/interests.html?ssi=4&ti=8&ii=65 (July 26, 2010).
[111] Patricia Yollin, "Group Brings City under the Canopy: For 25 Years, the Friends of the Urban Forest Has Planted Trees and United San Franciscans to Green What was Once Largely Sand Dunes," *San Francisco Chronicle*, Sunday, November 19, 2006. http://www.sfgate.com/cgi-bin/article/article?f=/c/a/2006/11/19/BAGFSMG1B41.DTL (July 15, 2010).
[112] Friends of the Urban Forest website, About FUF, http://fuf.net/about/index.html (July 26, 2010).

while BUF has maintenance responsibility for trees on streets with "DPW-Maintained Trees."[113]

The city's canopy has changed significantly since European settlement. The street tree population was estimated at 110,000 in the 2009 Urban Forest Council Annual Report[114] while the total urban forest population was estimated at 669,000 in 2007.[115]

2.3 Content Analysis

This dissertation applied content analysis (computer-aided and qualitative) to nonprofit and municipal documents, newspaper articles, and interview transcripts. Content analysis is the classification of written (ex: newspaper article), graphic (ex: print advertisement), or aural (ex: television commercial) materials using a coding scheme. Document content analysis, wrote Chadwick et al., "is an insightful means to study social change, for the writings of a people—the printed communications as well as their private ones—reflect changes in values, beliefs, and behaviors.[116] Furthermore, the authors noted that the method "is useful in studying trends over time, particularly in trying to reconstruct events in the past."[117] Document content was used to examine changes in the depiction of the street trees between 1980 and 2008.

Content analysis, and specifically document content analysis, has been used in the field of landscape architecture. Gobster examined transcripts of focus and workshop groups as well as notes of public meetings to theorize four "visions of nature" that emerged during the Montrose Point (Chicago) restoration project.[118] Cranz and Boland defined a fifth era in park design using articles about parks published in five landscape journals over the course of a twenty year period.[119] In contrast to written materials used by Gobster and Cranz and Boland, Larsen and Swanbrow used graphic materials, specifically postcards, in a content analysis.[120] Significantly for this study, Larsen and Swanbrow used content analysis to determine a change in conception over time. The authors' hypothesis that "the image of Phoenix shifted toward a tropical oasis" during the course of World War II was confirmed by their analysis of postcards before and after the war.

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[113] San Francisco Department of Public Works website, Streets with DPW-Maintained Trees, http://38.106.4.205/index.aspx?page=650 (July 26, 2010).
[114] San Francisco, Department of the Environment, Urban Forestry Council, *Urban Forestry Council Annual Report 2009* (San Francisco: SFEnvironment, 2009).
[115] Nowak et al., "*Assessing Urban Forest Effects and Values, San Francisco's Urban Forest.*"
[116] Bruce A. Chadwick, Howard M. Bahr, and Stan L. Albrecht, *Social Science Research Methods* (New Jersey: Prentice-Hall, 1984), 241, after Sanders, 1974.
[117] Chadwick et al., *Social Science Research Methods*, 245.
[118] Paul H. Gobster, "Visions of Nature: Conflict and Compatibility in Urban Park Restoration," *Landscape and Urban Planning* 56 (2001): 35-51.
[119] Cranz and Boland, "Defining the Sustainable Park."
[120] Laura Larsen and Lily Swanbrow, "Postcards of Phoenix: Images of Desert Ambivalence and Homogeneity," *Landscape Journal* 25, no.2 (2006): 205-217.

The emphasis in this dissertation on the analysis of nonprofit documents, such as newsletters, is supported by the literature. The multiple roles of newsletters – recruitment, organizing, and communication – make them "important for neighborhood associations."[121] King used the newsletters of neighborhood associations to examine the associations' support for citywide goals in Albuquerque, New Mexico. In her argument for the use of newsletter content analysis, King critically noted that as internal documents, without "external editorial oversight," the substance of the newsletters "can suggest what issues, both inside and outside their boundaries, are genuinely important to the neighborhoods themselves."[122]

Martin made a similar argument using organizational newspapers and other written documents to theorize the action frames used by community development nonprofits in St. Paul, Minnesota.[123] The written documents produced by the St. Paul nonprofits were "representations of residents' daily life and perspectives."[124] Similarly, the discourses present in the newsletters of Canopy, Friends of the Urban Forest, and Sacramento Tree Foundation are representations the respective urban forest advocates.

The newsletter can also be considered as the "formal knowledge base" of the urban forest nonprofit.[125] Gannon et al. coined the term in a study of the "medicalization of women." An analysis of the content from three major journals in the field of obstetrics and gynecology was used to examine the authors' contention that the topics chosen for inclusion reflect a "hierarchy of importance" about women's health issues.[126] Applied to this study, the contents of newsletters can be seen as expressing the claims of urban forestry professionals and advocates, or specialists "devoted" to trees.[127]

Closer afield, Reid et al. discussed the "mainstreaming" of Asia-Pacific fisheries and aquaculture, where to mainstream is defined as "integrating a sector into every stage of the national policy process."[128] Reid et al. conducted a content analysis of development plans and strategy papers from several Asia-Pacific countries to examine the extent of mainstreaming.[129] Borrowing Reid et al.'s framework, the work of the urban forest nonprofit can be framed as mainstreaming the ecological framing of street trees, though not necessarily to the same scale as in the fisheries and aquaculture context. The concept of mainstreaming environmental principles in organizational documents is addressed by Leary who examined environmental

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[121] Karen N. King, "Neighborhood Associations and Urban Decision Making in Albuquerque," *Nonprofit Management & Leadership* 14, no. 4(2004): 397.
[122] King, "Neighborhood Associations and Urban Decision Making in Albuquerque," 398.
[123] Martin 2003 Deborah G. Martin, "'Place-Framing' as Place-Making: Constituting a Neighborhood for Organizing and Activism," *Annals of the Association of American Geographers* 93, no. 3 (2003): 730-750.
[124] Martin, "'Place-Framing' as Place-Making," 736.
[125] Linda Gannon, Jill Stevens, and Tracy Stecker, "A Content Analysis of Obstetrics and Gynecology Scholarship: Implications for Women's Health," *Women & Health* 26, no.2 (1997): 43.
[126] Gannon et al., "A Content Analysis of Obstetrics and Gynecology Scholarship: Implications for Women's Health," 44.
[127] After Gannon et al., "A Content Analysis of Obstetrics and Gynecology Scholarship: Implications for Women's Health," 43.
[128] Chris Reid, Andy Thorpe, and Simon Funge Smith, "Mainstreaming Fisheries in Development and Poverty Reduction Strategies in the Asia-Pacific Region," *Journal of the Asia Pacific Economy* 13, no. 4 (2008): 518.
[129] Reid et al., "Mainstreaming Fisheries in Development and Poverty Reduction Strategies in the Asia-Pacific Region," 518.

policy documents in Manchester, England to determine the extent to which Manchester might be shifting away from sustainable development goals.[130]

Mechanics of content analysis

Based on a review of the content analysis literature, five steps were identified in the conduct of a successful analysis: (1) selecting the coding unit; (2) creating coding categories; (3) developing a coding scheme (categories and coding rules); (4) administering the coding rules to the entire dataset; and (5) testing validity.[131]

Coding unit, categories, and a dictionary

This dissertation used the keyword as the coding unit. Moodie and Catchpole defined the coding unit as "the specific segment of text that can be placed into a category."[132] The keywords used in this study reflect the major themes identified in the ecosystem services literature.

Categories can be developed using an inductive or deductive approach.[133] The inductive approach tends to be more iterative. The researcher, according to Kondracki et al., "frequently shifts directions and reanalyzes sections of text as merging results provide new insights."[134] By contrast, the deductive approach relies on a priori themes generated vis-à-vis the literature.[135] The inductive appears to be more amenable to studying latent (intended) content, while the deductive approach is more appropriate for analyzing manifest (actually written) content. This study used a deductive approach to analyze the manifest content in nonprofit newsletters.

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[130] Michael E. Leary, "Gin and Tonic or Oil and Water: The Entrepreneurial City and Sustainable Managerial Regeneration in Manchester," *Local Economy* 23, no. 3 (2008): 222-233.
[131] Sima Hamadeh and Marie Marquis, "Food Motivation: Content Analysis of Châtelaine Women's Magazine," *Nutrition & Food Science* 38, no.1 (2008): 52 – 60; Kaohsiung Hsieh and Sarah E. Shannon, "Three Approaches to Qualitative Content Analysis," *Qualitative Health Research* 15, no. 9 (2005): 1277-1288; Martin Hand and Elizabeth Shove, "Orchestrating Concepts: Kitchen Dynamics and Regime Change in *Good Housekeeping* and *Ideal Home*, 1922-2002," *Home Cultures* 1, no.3 (2004): 235-256; King, "Neighborhood Associations and Urban Decision Making in Albuquerque"; N. L. Kondracki, N.S. Wellman, and D.R. Amundson, "Content Analysis: Review of Methods and Their Applications in Nutrition Education," *Journal of Nutrition Education and Behavior* 34, no. 4 (2002): 224-230; Gannon et al., "A Content Analysis of Obstetrics and Gynecology Scholarship: Implications for Women's Health"; Chadwick et al., *Social Science Research Methods*; D. W. Moodie Allan J. W. Catchpole, "Environmental Data from Historical Documents by Content Analysis: Freeze-Up and Break-Up of Estuaries on Hudson Bay 1714-1871," in *Environmental Data from Historical Documents by Content Analysis: Freeze-Up and Break-Up of Estuaries on Hudson Bay 1714-1871*, ed. D. W. Moodie and Allan J. W. Catchpole (Winnipeg: Dept. of Geography, University of Manitoba, 1975).
[132] Moodie and Catchpole, "Environmental Data from Historical Documents by Content Analysis," 56.
[133] Kondracki et al., "Content Analysis: Review of Methods and Their Applications in Nutrition Education."
[134] Kondracki et al., "Content Analysis: Review of Methods and Their Applications in Nutrition Education," 225.
[135] Kondracki et al., "Content Analysis: Review of Methods and Their Applications in Nutrition Education."

The thematic categories for this study were generated by asking the question: which ecosystem services are significant for California? Bolund and Hunhammar identified six "locally generated ecosystem services" for Stockholm by asking a similar question.[136] Five themes were used to direct the computer-aided content analysis of the newsletter database: air quality improvement, carbon sequestration and storage,[137] energy conservation and efficiency,[138] stormwater runoff management,[139] and wildlife habitat. These benefits are consistently identified in the ecosystem services literature[140] and were enumerated by McPherson in "Trees with benefits."[141] These five thematic categories were the basis of the study's dictionary and were used to code the data sources. Adobe Acrobat software was used to code the newsletter dataset of the three case nonprofits.[142] At least half of the total number of Friends of the Urban Forest and Sacramento Tree Foundation newsletters was available in PDF format. The remaining newsletters were scanned to PDF format. All of the Canopy newsletters were available in PDF format. Non newsletter documents (newspapers, planning documents, and interview transcripts) were qualitatively coded using the five thematic categories developed for computer-aided analysis.

Tests of validity and reliability

[136] Per Bolund and Sven Hunhammar, "Ecosystem Services in Urban Areas," *Ecological Economics* 29, no. 2 (1999): 295.

[137] This theme mirrors one ("greenhouse gas benefits") in E. Gregory McPherson, "Trees with Benefits," *American Nurseryman* 201, no. 7 (2005): 34-40.

[138] This theme mirrors one ("energy benefits") in McPherson, "Trees with Benefits." There are two types of energy benefits: energy conservation and energy efficiency. The two are often used interchangeably but the Sacramento Municipal Utility District made a distinction between the two noting that its Sacramento Shade program is an energy efficiency, not a conservation, program (SAC2, personal interview, October 15, 2009).

[139] McPherson ("Trees with Benefits") discussed the "watershed benefits" of trees which was defined by the ability of trees to reduce stormwater runoff. As such, this dissertation analyzed mentions of stormwater runoff management in nonprofit and municipal documents. There are two sides to runoff management. One is runoff quantity/volume which was mentioned most often in San Francisco and Palo Alto while runoff quality was mentioned most often in Sacramento and Palo Alto. Avoided water use by selecting drought-tolerant trees was identified as important in Palo Alto and Sacramento.

[140] See published reports at the USDA Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research website (http://www.fs.fed.us/psw/programs/cufr/) and David Nowak's publications at the USDA Forest Service, Northern Research Station website (http://www.nrs.fs.fed.us/).

[141] McPherson, "Trees with Benefits." The thematic categories used in this dissertation were reviewed by Joe R. McBride, PhD, Professor of Forest Ecology (Environmental Science, Policy, and Management) and Professor of Ecology (Landscape Architecture & Environmental Planning) at UC Berkeley.

[142] Several other proprietary programs were considered including NVivo 8 (previously NUD*IST), ATLAS.ti, and SPSS Text Analysis for Surveys as well as several freeware programs. Adobe Acrobat offers several functionalities useful in context analysis including: (1) sophisticated full-text search enabling use of the coding scheme/ dictionary; (2) keywords can be "persistently highlighted" in context; (3) bookmark selected text; and (4) comments can be added to files enabling coding. [142] Another consideration is ease of use. I am familiar with the Adobe Acrobat interface and thus the acquisition of additional skills should be relatively easy. Yet another consideration is pricing. The academic price for a full license of the latest professional version of Adobe Acrobat, Acrobat 9, is $159 compared to $595 for NVivo 8 (a 12-month, student license can be purchased for $240; a semester-long student license can be purchased for $125).

This dissertation was designed to achieve reliability and three measures of validity (construct, internal, and external).[143] Construct validity was achieved by sending a draft of the dissertation to interview participants for review.[144] Another test of construct validity is the use of multiple sources of evidence which this dissertation took advantage of. A time series analysis of trends in newsletters and other documents, a cross-case synthesis (the primary mode of analysis), a mix of qualitative and quantitative data as well as the use of theory were used to achieve internal validity. External validity was accomplished by making generalizations about the findings of the dissertation. Finally, reliability was achieved by developing a case study protocol and database.

2.4 Datasets

This study relied on four dataset: (1) nonprofit newsletters; (2) newspaper articles; (3) planning documents (a) nonprofit, (b) municipal; (4) interview transcripts (a) with nonprofit staff, (b) with municipal staff.

Table 2.2 Newsletter Dataset

Nonprofit	Year Nonprofit Founded	Newsletter Title	First and Last Issues included in Dataset	No. of Issues in the Dataset /Est. Tot. No. of Issues (no. of pages in the dataset) [145]
Friends of the Urban Forest (San Francisco)	1981	Treescapes	1984 (summer) – 2008 (fall)	70/ 96
Sacramento Tree Foundation (Sacramento)	1982	Urban Forest Monitor	1983 (fall) – 2008 (winter)	56/100
Canopy (Palo Alto)	1996	Canopy	1998 (summer) – 2008 (winter)	27/27

The newsletters in this study were "Canopy" published by Canopy (Palo Alto), "Treescapes" published by Friends of the Urban Forest (San Francisco), and "Urban Forest Monitor" published by Sacramento Tree Foundation (Sacramento) (Table 2.2). The first Treescapes newsletter was published in spring 1984, three years after the Friends of the Urban Forest nonprofit was founded. The Treescapes dataset included newsletters published from summer 1984 to fall 2008. The Canopy nonprofit was founded in 1996 and published its first newsletter in summer 1998. The dataset included newsletters published from summer 1998 to summer 2008. Sacramento Tree Foundation was founded in 1982 and published its first newsletter in spring 1983. The newsletter was then named "Sacramento Trees." By 1995, it was called "Trees for Tomorrow." It was renamed "Urban Forest Monitor" in 2004.

[143] Yin, *"Case Study Research: Design and Methods,"* 2009.
[144] Six participants -- two from each city -- were sent relevant chapters from the first draft of the dissertation. Three responses were received -- one from Palo Alto and two from Sacramento).
[145] The estimated total number of issues (up to December 2008) for "Treescapes" and "Urban Forest Monitor" is based on a quarterly publication rate.

The newspaper dataset was composed of articles from major newspapers in the region: Sacramento *Bee* (Sacramento); San Francisco *Chronicle* (San Francisco); San Jose *Mercury News* (Palo Alto). Articles were retrieved from two news databases – LexisNexis and Access World News – and Google searches. The search terms for the articles included a series of combinations of each nonprofit's full name and abbreviated name as well as terms such as "street tree" and "urban forest." The third dataset is composed of nonprofit and municipal documents such as annual reports, management plans, and state of the urban forest reports.

Newsletter analyses

Two numerical measures were used to analyze the mainstreaming of the ecological street tree concept in nonprofit newsletters. The first analysis was a graphing of the number of times each ecosystem service was mentioned in each issue for each year which resulted in graphs titled *Number of mentions of each ecosystem service per issue weighted by the number of pages per issue* (see Figures 3.3, 4.3, and 5.4). The second analysis was a statistical regression. First, for each ecosystem service category, the number of issues in which a code word in that category appeared was recorded. Second, these values were summed across all categories and divided by the total number of issues in a given year. The regression produced graphs titled *Trend in the overall ecological characterization of street trees* (see Figures 3.4, 4.4, and 5.5). These analyses were used in different ways. The first graph illustrates peaks in or concentrations of particular ecosystem service benefits over time while the statistical regression supports the hypothesis that there has been a rise in the ecological characterization of street trees between 1980 and 2008.

Interviews and interview transcripts

A total of 14 interviews were conducted between June 9 and November 2, 2009. Of these, 12 were conducted face to face and two were conducted by phone. Interviews ranged in length from approximately 45 minutes to 2 hours. Interviews were conducted primarily with staff from municipal agencies and nonprofits familiar with urban forestry programs and policies in each city (Table 2.3, Table 2.4). Interview participants were formally recruited via a letter sent by email and a follow-up email and/or phone call. Additional participants were recruited via a peer or snowball method.

Table 2.3 Interview Participants

	Palo Alto (PA)	Sacramento (SAC)	San Francisco (SF)
Nonprofit staff	2	2	1
Government staff	2	1	3
Other participant	-	1	2
Total:	4	4	6

Each interview was digitally recorded, transcribed, and coded using a data display matrix organized by fit with the study's propositions.[146] During the course of the interview, each participant was shown two figures and one map. The map was a neighborhood map of the participant's city; each participant was asked to identify areas of high and low canopy cover and to provide explanations for tree cover percents. The figures were graphic results of two analyses conducted on the nonprofit newsletter dataset for each city. One graph showed the number of mentions of ecosystem services provided by street trees in newsletters per year and the other graph showed a trend line for the ecological characterization of street trees between the date of the first newsletter in the dataset and 2008 (or the last newsletter in the dataset).

Table 2.4 Original Interview Dates (2009)

	1	2	3	4	5	6	7
Palo Alto (PA)	June 16	June 16	June 16	June 16			
Sacramento (SAC)	Oct.15	Oct.15	Oct.16	Oct. 22	Nov. 2		
San Francisco (SF)	June 9	June 10	June 10	June 10	June 18	June 30	July 24

2.5 Limitations

There were two primary limiting factors for this dissertation. The first factor was the variables in interview length and access to participants for follow-up. The qualitative interview was selected in order to gather in-depth information about the framing of the street tree in the Northern California cities. However, time constraints prevented the proper execution of such interviews with all participants. Some participants granted more time for the interviews than others. Also, some participants did not respond to repeated attempts to get answers to follow-up questions. The second factor was the availability of documents, or lack thereof. Some newsletter issues were not located despite extensive searches in nonprofit files and library holdings. This was also the case for planning document produced by municipal agencies.

[146] Miles and Huberman, *Qualitative Data Analysis*.

Chapter 3:: Sacramento is the "city of trees"

> *[Now if we travel a hundred miles in a straight line, we come to see the eternal summer of Sacramento. One never sees summer-clothing or mosquitoes in San Francisco—but they can be found in Sacramento. Not always and unvaryingly, but about one hundred and forty-three months out of twelve years perhaps. Flowers bloom there, always, the reader can easily believe—] people suffer and sweat, and swear, morning, noon, and night, and wear out their staunchest energies fanning themselves. [It gets hot there…].*[147]

3.1 Overview

A history of street tree characterization based on city plans and interview transcripts is presented first. For example, Section *1850-1990* shows the use of tree planting to ameliorate poor environmental conditions such as stagnant water in the late 1800s and urban heat islands in the 1980s. Section *1990-2000* looks at municipal efforts at developing a management plan while Section *2000-2009* describes adjustments to the 1990s management plans and the formulation of the sustainability and general plans. A discussion of the role of the Sacramento Tree Foundation is presented next, then that of the Center for Urban Forest Research. This chapter ends with a description of the geography of ecosystem services in Sacramento and conclusions based on an analysis of the Sacramento-based data sources.

3.2 Municipally-led mainstreaming of the ecological street tree, 1850-1990

Sacramento is California's "City of Trees," at least according to the sign on its water tower.[148] Sacramento is the oldest of the three cities studied; it was incorporated on February 27, 1850 (San Francisco was incorporated on April 16, 1850 and Palo Alto in 1894) and has the oldest municipal tree planting program, established with the founding of the city (San Francisco's municipal program was not established until 1955, over a hundred years later). The City of Sacramento has a long history of providing street and park trees within city limits.[149] (The County of Sacramento has jurisdiction over public trees located outside the city boundaries but within the county limits.) This history includes the drafting of tree planting laws such as the Willow Tree Planting Ordinance of 1853 and Article 17 of the 1911 City Charter which mandated tree planting on streets and in other public areas.[150] Sacramento's summers are notoriously hot. A primary goal of tree plans and activities from the time of incorporation through the first half of the twentieth century remained planting trees for shade (human

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[147] Mark Twain, *Roughing It* (Hartford, CT: The American Publishing Company, 1901), 153 (quoted in Sacramento Tree Foundation, *State of the Trees Report: A Call to Action for the Sacramento Region, Fall 2000* (Sacramento: STF, 2000), 5, http://books.google.com (December 2, 2009).

[148] Image of Sacramento's water tower (Welcome to Sacramento City of Trees) can be viewed at http://img.groundspeak.com/waymarking/large/85d4b154-829a-40a8-9174-3f610274ccae.jpg (July 3, 2010).

[149] For a detailed discussion of this history, see McPherson and Luttinger, "From Nature to Nurture."

[150] McPherson and Luttinger, "From Nature to Nurture."

comfort).[151] During the same time period, the goal of tree planting for "civic pride" and beauty was a close second, if not a tied goal. In the first half of the twentieth century, Sacramento's street tree cover was described in royal terms:

> *The crowning glory that is Sacramento's—her glorious shade trees, are glorious because the city looks out for them with as much care and anxiety as a fond parent does for her offspring.*[152]

Tree planting to achieve urban design goals is still a relevant aspect of tree-related planning in Sacramento.[153]

By 1955, with a population of 100,000 street and park trees, Sacramento boasted a "ratio of approximately one tree for every two residents" which "easily bettered Paris, whose world-renowned street trees amounted to a mere one tree for every 10 residents."[154] In the second half of the twentieth century, tree plans and activities focused on combating tree diseases and pests such as the elm leaf beetle (Dutch elm disease was not discovered in Sacramento until 1990), fostering greater citizen participation in urban forestry (to be discussed in the section about the Sacramento Tree Foundation), and developing an urban forest management plan.[155]

Prior to the adoption of the management plan in the 1990s, the City passed the Parking Lot Shade Tree Ordinance in 1983. Parking lot shading ordinances developed in California cities around the same time as the Sacramento ordinance were in response to the energy crisis of the 1970s.[156] The ordinance was one of the first tree-related laws in the city to acknowledge the ecosystem functions of urban trees. It ordinance mandated that new or nonconforming parking lots must be planted with trees that will shade at least 50% of the entire facility within 15 years of construction.[157] An unshaded parking lot contributes to (1) the urban heat island effect through heat gain and subsequent transfer of heat to its surroundings and (2) high energy usage via air conditioning of surrounding structures.[158]

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[151] McPherson and Luttinger, "From Nature to Nurture."
[152] McPherson and Luttinger, "From Nature to Nurture" (quoting *Sacramento Bee*, August 31, 1939).
[153] In the Urban Design Guidelines of the General Plan 2030, "consistent patterns of street trees providing shade and enhancing character and identity" are recommended (Sacramento, City of Sacramento, *Sacramento General Plan 2030* (Sacramento: City of Sacramento, 2009), 2-42, 2-50. http://www.sacgp.org (July 20, 2010).
[154] Sacramento Tree Foundation, *State of the Trees Report*, 2.
[155] McPherson and Luttinger, "From Nature to Nurture." The management plan was prepared by Wolfe Mason Associates for the Parks and Community Services Department and adopted by City Council in 1992.
[156] E. Gregory McPherson, "Sacramento's Parking Lot Shading Ordinance: Environmental and Economic Costs of Compliance," *Landscape and Urban Planning* 57 (2001): 105-123. http://www.fs.fed.us/ccrc/topics/urban-forests/docs/parklotarticle.pdf (July 24, 2010); Vanessa Hua, "Parking-Lot Trees May Trim Pollution." *The Sacramento Bee* July 19, 1997, Metro Final, Metro: B1 (*NewsBank*, October 27, 2009).
[157] City Code § 17.68.040 Tree shading requirements for parking lots: A nonconforming parking lot must comply with the ordinance when it is "expanded by an amount, in area or number of spaces, equal to or greater than fifty (50) percent within any continuous three-year period" http://www.qcode.us/codes/sacramento/view.php?topic=17-iii-17_68-17_68_040&frames=off (July 27, 2010).
[158] McPherson, "Sacramento's Parking Lot Shading Ordinance."

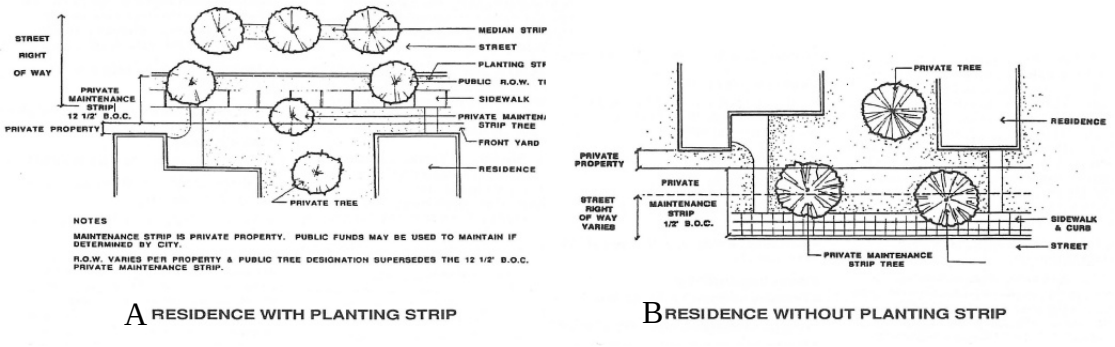

Figure 3.1 Sacramento residences with and without planting strips. *Source*: Wolfe Mason Associates, Sacramento Urban Forest Management Plan Draft 1992 (Sacramento: City of Sacramento Parks and Community Services, 1992), Figure J. Residential Public/Private Tree Jurisdiction.

3.3 Municipally-led mainstreaming of the ecological street tree, 1990-2000

Based on available data, the City did not produce any tree legislation between 1983 and 1990. In 1990, the City passed a moratorium ordinance which transferred responsibility for trees growing in the public easements of private front yards (or the maintenance easement strip) to adjacent property owners (Figure 3.1). At the time, these 57,500 trees accounted for approximately 38% of the city's public tree canopy cover. Management costs were the primary reason for the establishment of the moratorium.[159] The development of an effective and efficient urban forest management system was a catalyst for the 1992 City of Sacramento Draft Urban Forest Management Plan (UFMP) written by Wolfe Mason Associates which was adopted in 1994. Key management and operational issues identified by the plan are outlined by McPherson and Luttinger.[160] The first goal defined in the UFMP is most relevant to this study:

> *Establish a value for Sacramento's urban forest, one that defines its environmental, economic and aesthetic benefits. The Plan identifies an "ideal" model of canopy cover, composition, age and species diversity which maximizes this value. Value is measured by real estate investment, tax assessments, energy savings and tree replacement assessment.*[161]

Whereas the 1983 Parking Lot Shade Tree ordinance had addressed the environmental benefits associated with tree shade, it was limited to a particular subset of the urban forest –

[159] Wolfe Mason Associates, *Draft Sacramento Urban Forest Management Plan* (Sacramento: City of Sacramento Parks and Community Services, 1992); Larry Hicks, "Council Prunes Its Tree Maintenance Services," *Sacramento Bee* November 17, 1993, Metro Final, Metro: B1 (*NewsBank*, October 28, 2009); McPherson and Luttinger, "From Nature to Nurture"; SAC1, personal interview, October 15, 2009.
[160] Wolfe Mason Associates, *Draft Sacramento Urban Forest Management Plan* (Sacramento: City of Sacramento Parks and Community Services, 1992); Larry Hicks, "Council Prunes Its Tree Maintenance Services," *Sacramento Bee* November 17, 1993, Metro Final, Metro: B1 (*NewsBank*, October 28, 2009); McPherson and Luttinger, "From Nature to Nurture"; SAC1, personal interview, October 15, 2009.
[161] Wolfe Mason Associates, *Draft Sacramento Urban Forest Management Plan*, 4.

parking lot trees. The 1992 UFMP addressed a larger population of trees ("Sacramento's urban forest") which included the primary tree population of interest in this study: street trees. Although the responsibility for trees located in the public easements of private front yards (or maintenance easement strips) was transferred to residents in 1990, these trees are still used in accounting for public right of way shade benefits:

> *We look at it, at the Tree Foundation, a little differently too because what we're really concerned with the public tree is a tree that's going to shade the sidewalk or public space whether or not it's in your front yard or not. If you've got a street and a five foot sidewalk and then a tree, that's just as effective at shading the public space as a tree inside the planting strip.*[162]

In later chapters of the 1992 UFMP, its authors elaborated on the environmental benefits to be gained from Sacramento's urban forest. In the addition to benefits of trees excerpted below, the management plan offered six specific actions to establish and maintain short- and long-term canopy goals.

> *The City of Sacramento, which encompasses 96 square miles, has a significant urban forest canopy. The foliage covering the City acts as a shelter, an umbrella to screen sun and wind, while providing many environmental benefits. Benefits include shade, the reduction of ground surface temperatures, prevention of rainfall runoff and wind screening....A broad-reaching environmental benefit of trees is large scale carbon storage which can ease greenhouse gasses which contribute to global warming. Sacramento's forest of 150,000 trees currently stores 46,000 tons of carbon. Sacramento has a 28% residential tree canopy cover….By increasing this percentage to 50%, many environmental benefits can be maximized.…A 50% canopy cover should be considered Sacramento's long- term goal, while short-term goals for the City's neighborhoods must balance increasing the canopy coverage with planting and caring for existing trees.*[163]

Energy conservation and energy efficiency were recognized through the development of the 1983 Parking Lot Shade Tree Ordinance and the 1996 Sacramento Shade program (to be discussed in the section about Sacramento Tree Foundation), respectively. The1992 UFMP, according to available data, represented the first official acknowledgement of the role of public trees in carbon sequestration.[164]

In 1993, the County of Sacramento adopted its General Plan. Surprisingly, tree resources were not addressed in either the Open Space or Air Quality Elements but their environmental role was addressed in the Land Use and Conservation Elements.[165] In the Land Use Element,

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[162] SAC3, personal interview, October 16, 2009.
[163] Wolfe Mason Associates, *Draft Sacramento Urban Forest Management Plan*, 45.
[164] The urban forest was defined as: "Trees that make up the urban forest are found in front yards, parks, schools, cemeteries, city streets and medians, plazas, vacant lots, parking lots, in pockets of natural open spaces and along waterways" (Wolfe Mason Associates, *Draft Sacramento Urban Forest Management Plan*, 45). Note: it was only two years prior to the release and adoption of the plan that front yard trees were considered public-realm trees.
[165] In the Air Quality Element, environmental amelioration strategies were limited to auto-use reduction.

participation in SMUD's energy-saving tree planting program (and installation of "white surfaces") was recommended to reduce the county's urban heat island.[166] In the Conservation Element, a distinction was made between native and landmark trees and urban trees. The County's General Plan described the role of urban trees thus:

> *Trees in urban areas provide aesthetic and environmental benefits to residential and commercial areas. Trees enhance a community's livability by softening street noise, and enhancing pedestrian use. Trees also provide a cool green canopy of shade to reduce the heating effects of summer sun and consequently reduced energy consumption to cool buildings. The urban forest in Sacramento has provided distinct identities for local neighborhoods and has reduced summertime temperatures by minimizing reflective heat. As the county's urbanized area expands the need for trees and associated canopy cover will grow greater. Since an urban forest is not static, the planting and maintenance of trees will be required to encourage healthy growth and to protect the biologic well being of the urban forest. It is the intent of this section to form a framework which shall preserve and protect Sacramento County's tree resources and guide the County in formulating a comprehensive tree management and propagation program.*[167]

Regarding these trees, the plan proposed three specific objectives: achieve Tree City USA status by 1995, plant one million new trees by 2000, and manage urban trees to capture economic and environmental benefits. Tree City USA status was recommended in order to place "greater emphasis" on "integrat[ing] trees into the urban environment."[168] Urban heat island reduction and air quality improvement via the "filtering of particulate matter and absorption of certain gaseous pollutants" were listed as goals of the one million trees by 2000 campaign.[169] The plan specified policies that mandate tree planting on residential lots and on existing and new parking lots to meet canopy coverage associated with "the advantages trees offer."[170] The urban tree management objective recommended public education campaigns and cooperative tree planting with utilities to promote and support an urban forest that "maximize energy conservation and air quality benefits."[171]

Ecological characterization of the urban forest and street trees continued with the release of the (first) city- and county-wide State of the Urban Forest Report in 1996.[172] Although the report was attributed to the Sacramento Tree Foundation, the task force included the City and

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[166] Sacramento, County of Sacramento, Planning and Community Development, *County of Sacramento General Plan Land Use Element 1993* (Sacramento: County of Sacramento, 1993). http://www.msa2.saccounty.net/planning/Documents/General-Plan/LandUseElement-updated-General%20Plan.pdf (July 24, 2010).

[167] Sacramento, County of Sacramento, Planning and Community Development, *County of Sacramento General Plan Conservation Element 1993* (Sacramento: County of Sacramento, 1993), 84. http://www.msa2.saccounty.net/planning/Documents/General-Plan/conservationelement.pdf (July 24, 2010).

[168] Sacramento, *County of Sacramento General Plan Conservation Element 1993*, 89.

[169] Sacramento, *County of Sacramento General Plan Conservation Element 1993*, 90.

[170] Ibid.

[171] Sacramento, *County of Sacramento General Plan Conservation Element 1993*, 91.

[172] Sacramento, Urban Forest Task Force, *State of the Urban Forest Report 1996* (Sacramento: City of Sacramento, 1996).

County of Sacramento among other participants. The task force evaluated Sacramento's urban forest along three axes: the state of the resource across land uses, the benefits of the urban forest, and community investment in the urban forest (community defined broadly to include residents, government, plans and policies, and funding). Six benefits were identified, four of which are ecosystem services: air quality improvement, carbon sequestration, energy use avoidance, stormwater management, sustainable water use (selection of drought tolerant and water thrifty tree species), and human health improvement (human comfort, UV radiation exposure reduction, and psycho-social benefits). The discussion of each benefit was supported by city- and county-specific scientific evidence produced by the Sacramento Municipal Utility District, the California Air Resources Board, and the Center for Urban Forest Research. In addition, the scientific evidence presented was used to make a case for the greater efficacy of tree-based environmental improvement versus other, more traditional technologies. For example,

> *On average, daily uptake by Sacramento's urban forest amounted to 7.2 metric tons per day. As massive as this is, it represents mitigation for only 1% of the daily NO2 emissions, 2% of the daily particulate matter emissions, and 4% of the daily SO2 emissions in the County. While these contributions may seem minor, the reality is that the costs of pollution control by other technologies is [sic] so expensive, and thus the value of trees for air pollution control is similarly high.*[173]

The report could have mentioned that in addition to cost considerations, trees planted for air quality or any other environmental benefit provide associated or co-benefits.

[173] Sacramento, *State of the Urban Forest Report 1996*, 22.



Figure 3.2. Tree inventory of Central City, Sacramento. *Source:* Nathan Stephens, City of Sacramento Urban Forestry, Maps of City Tree inventory, Inventory taken by Davy Resource Group, Canton OH 12/2008 to 12/2009.

3.4 Municipally-led mainstreaming of the ecological street tree, 2000-2009

In 2003, a decade after the adoption of the 1992 UFMP, the Parks and Recreation Department commissioned a review and report of best management practices for the Urban Forest Services division to address operational issues.[174] The 2003 Sacramento Tree Services: Best Management Practices: Review and Report (BMP) offered 25 recommendations to improve urban forest operations and management in the city.[175] Like the 1992 UFMP, the 2003 BMP report identified several values and benefits of Sacramento's urban forest. Of the 17 benefits

[174] SAC1 follow-up, email communication, December 8, 2009.
[175] Robert L. Tate Associates, Inc., *Sacramento Tree Services: Best Management Practices: Review and Report* (Sacramento: Parks and Community Services, 2003).

listed, approximately one-half of them are ecosystem services. Although the BMP cited specific environmental benefits, it did not elaborate on these benefits as was done in the 1996 State of the Urban Forest Report. However, the BMP did stress the development of a canopy cover goal to guide the city's tree planting. BMP created several new positions in the Parks and Recreation Department – a manager, program analyst, and general supervisor – and eliminated the parks superintendent. This restructuring gave urban forestry "a seat at the budget table, and presumable a management level position to deal with policy issues [and] 5 years later we are finally starting on the policy issues."[176]

Following the BMP, the City, the Citizens Advisory for Parks and Recreation, and other community participants developed an implementation plan for the BMP (BMP-IP) and an Urban Forest Enhancement Program (UFEP) both of which were approved by City Council in 2005. The UFEP was composed of four objectives and ten phases including completing a city tree inventory and reforestation plans. As part of the BMP-IP, city staff is addressing the 25 BMP recommendations. One of the items, the City Tree Inventory (which affects the implementation of the Benchmarking System recommendation for, among other items, canopy cover), was completed in 2009 (Figure 3.2).[177] The UFEP was composed of four objectives and ten phases including completing a city tree inventory and reforestation plans. Of the four objectives, only two of the ten phases (English Elm Preservation) were funded by City Council, including reforestation, supplemented by a State grant, and an English Elm preservation project. The preservation project was overfunded with a $600,000 allocation as a result of fewer than expected tree removals; the balance from the original allocation was used to develop a work management program and a city tree inventory.[178] Between 2005 and 2009, Urban Forest Services, the division that "provides tree care for the City's public trees," focused on developing operational metrics and a cohesive organization.

> *I don't think we can make intelligent decisions about how to manage our urban forest without good metrics, without knowing what we had. And we did not know what we had. Not only did we not know what we have, we had no reliable metrics in terms of cost and benefit….*[179] *[The] Point here is not only did we not have good information about the forest, but we also did not have good budgeting practices and cost controls. Regardless of the UFMP approval 10 years prior, there was no "Plan" being implemented, nor was there any thought towards a proactive approach to budgeting as a component of that. It was impossible to identify how much was being spent on specific programs.*[180]

In the interim, the city adopted the Sustainability Master Plan in 2007 and the 2030 General Plan in 2009. Discussion of tree resources in the Sustainability Master Plan is limited to the Parks, Open Space and Habitat Conservation chapter. The Parks, Open Space and Habitat Conservation chapter (Chapter 7) includes specific environmental benefits ("improved air

[176] SAC1 follow-up, email communication, December 8, 2009.
[177] Ibid.
[178] SAC1, personal interview, October 15, 2009.
[179] Ibid.
[180] SAC1 follow-up, email communication, December 8, 2009.

quality by storing carbon dioxide") and specific targets ("work with community partners to achieve an urban tree canopy goal of 35% per the region's Greenprint Plan").

> *The urban forest is a key contributor to sustainability in a place named the City of Trees. Trees provide environmental and ecological benefits through improved air quality by storing carbon dioxide that would otherwise contribute to global warming, improving water quality by naturally filtering overland runoff, reducing flood risk through bank stabilization and increased water storage, and providing bird nesting habitat. The urban forest contributes economic benefits by increasing property values and lowering building energy use by providing incidental shade. Trees improve public health and well-being by reducing UV radiation exposure and converting CO2 to oxygen.*[181]

Urban trees are not discussed in the chapters on energy, climate, and air quality.[182] Instead of urban forestry strategies, vehicular-based technologies such as reductions in sulfur levels in fuels and reductions in idling through improved signal technology are recommended in the chapter on air quality, for example. The follow-up to the Sustainability Master Plan, the Sustainability Implementation Plan, was adopted in 2009. This plan called for the alignment of the Urban Forest Services Best Management Practices Implementation Plan with the Sacramento Tree Foundation's Greenprint Initiative (the latter will be discussed in a later section).

The 2007 Sustainability Master Plan and the 2030 General Plan were developed concurrently. The former is described as "a road map" for city departments, while the latter is not only a state requirement, it is the city's "policy guide for the future."[183] The environmental benefits of trees were included in two sections of the General Plan: the Land Use Element and the Environmental Resources Element. The urban forest is defined as an element of the city's "green infrastructure" in Land Use Goal 2.3.

> *A defining physical feature of Sacramento, provides visitors and residents with access to open space and recreation, and is designed for environmental sustainability.*[184]

Urban shade trees were one of several strategies mentioned in Land Use Goal 2.6 (The City Sustained and Renewed) to mitigate the city's urban heat island.

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[181] Sacramento, City of Sacramento, General Services, *Sustainability Master Plan, Creating a Sustainable City: A Master Plan to Move the City of Sacramento towards Sustainability 2007* (Sacramento: General Services, 2007), 15. http://www.cityofsacramento.org/generalservices/sustainability/documents/Sustainability-Master-Plan.pdf (July 24, 2010).

[182] In a 2004 study of community leaders' knowledge of the urban forest, McLean and Jensen observed that leaders with "a mature understanding of the urban forest cited specific environmental benefits" (596). Daniel D. McLean and Ryan R. Jensen, "Community Leaders and the Urban Forest: A Model of Knowledge and Understanding," *Society and Natural Resources* 17, no. 7 (2004): 589-598.

[183] Sacramento, *Sustainability Master Plan, Creating a Sustainable City*, 15.

[184] Sacramento, *Sacramento General Plan 2030*, II-18.

> *The City shall reduce the "heat island effect" by promoting and requiring, where appropriate, such features as reflective roofing, green roofs, light colored pavement, and urban shade trees and by reducing the unshaded extent of parking lots.*[185]

The heat island reduction effect of urban trees was recognized in the Environmental Resources Element. Also, urban trees were counted as a resource along with oak woodlands and "significant stands of oak trees." The Element does three things. One, it encourages the city to implement the Urban Forest Management Plan. Two, it reiterates the ability of urban trees to mitigate the urban heat island effect. And three, it lists air quality improvement as a function of urban trees.

> *Extensive tree canopies reduce the urban heat island effect and make streets and sidewalks more pleasant places to walk. Trees also absorb carbon dioxide and pollution and produce oxygen, which contributes to improved air quality and human health.*[186]

The 2030 General Plan has been used in claims about the management of the urban forest where the urban forest is defined as "street trees." The environmental benefits outlined in the above quote from the General Plan were included in an unsigned letter to the City of Sacramento from Central City urban forest advocates.[187] The letter used the city's own claims about the environmental functions of city trees to question the city's commitment to managing the Central City urban forest in ways commensurate with its stated goals.

3.5 Municipally-led mainstreaming of the ecological street tree, 1990 to 2000 and 2000 to 2009

Discussion about benefits such as the reduction of the urban heat island effect and the sequestration of carbon are evidence that street trees are being reframed as having ecological value. The emergence of the ecological street tree is evident in city documents published in the time period under study (1980 to 2008). This assertion is made more evident with a comparison of the city's 2030 General Plan to the plan's predecessor, the 1988 General Plan.

Not only were urban trees rarely mentioned in the 1988 General Plan, Policy 5 (Urban Conservation and Infill Areas) of the introduction to the 1988 Plan stated that

> *It is the policy of the City to promote infill development, rehabilitation, and reuse that contributes positively to the surrounding area and assists in meeting neighborhood and other City goals, including [trip reduction and air quality improvement] and [environmental improvement].*[188]

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[185] Sacramento, *Sacramento General Plan 2030*, II-22.
[186] Sacramento, *Sacramento General Plan 2030*, II-311.
[187] Urban Forest Position Letter (67223428) to the City of Sacramento http://sacmidtown.org/yahoo_site_admin/assets/docs/Urban_Forest_Position_Statement.67223428.pdf (October 29, 2009).
[188] Sacramento, *Sacramento General Plan* 2030, I-39.

Trees were mentioned in Goal 4 of Policy 5: "The City should promote infill development that meets the following neighborhood, housing, economic and project design objectives" which included the preservation of heritage trees.[189] Policy 10 (Open Space and Natural Resource Conservation) also in the introductory chapter, mentioned trees, but only those located in natural resource and "planned open space" areas.

> *The City will continue programs established by the Department of Parks and Community Services in maintaining parks, trees, and other landscaping. The City will conserve riparian forests and grassland vegetation.*[190]

Street trees were addressed in the Plan's Circulation Element, under Policy 3 (Goals, Policies, Actions for Pedestrianways). The policy did not articulate any ecological values of trees; it is urban design oriented in its language.

> *Encourage existing and new commercial and office establishments to develop and enhance pedestrian pathways using planting, trees and creating pedestrian crosswalks through parking areas or over major barriers such as freeways or canals.*[191]

Further evidence of the emergence of the ecological street tree between 1980 and 2008 is evident in the County of Sacramento Draft General Plan which is in the environmental review stage. The county's General Plan was last updated in 1993. One piece of evidence is the absence of canopy coverage goals in the 1993 Plan. The 1993 Plan did not address canopy coverage goals; instead, it focused on individual trees.[192] As previously mentioned, canopy coverage goals are typically developed to achieve improvements in environmental quality. In addition to canopy coverage, the updated version of the General Plan will articulate standards "that will help with air quality" including tree planting as part of new and redeveloped road segments.[193] As part of the revisions to the Air Quality Element, the County's Air Quality Program mitigation measures will be revised and new policies such as Cool Communities[194] and Transportation Management Funding will be incorporated into it. (The City of Sacramento began participating in Cool Communities in 1998.) When probed about the ranking of tree benefits in the County, one Sacramento interview participant responded that existing policies were not "designed around environmental benefits," and although the environmental benefits of trees "do not supersede aesthetics," these benefits are "not too far behind."[195]

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[189] Ibid.
[190] Sacramento, *Sacramento General Plan 2030*, I-43.
[191] Sacramento, *Sacramento General Plan 2030*, 5-35.
[192] SAC5, personal interview, November 2, 2009.
[193] Ibid.
[194] Cool Communities is sponsored by the Department of Energy and the Environmental Protection Agency and promotes the use of three urban heat island mitigation strategies: reflective roofing, light colored paving, and urban shade trees. http://www.coolcommunities.org/ (November 2, 2009).
[195] SAC5, personal interview, November 2, 2009.

3.6 Nonprofit-led mainstreaming of the ecological street tree

Like its city and county counterparts, the Sacramento Tree Foundation (STF) contributed to the emergence of the ecological street tree. During the time period under study (1980 to 2008), STF drafted policy documents and participated in activities that signaled the changing role of urban trees.[196]

Nonprofit policy and planning documents

In terms of planning documents, STF was the lead author of the 1996 State of the Urban Forest Report.[197] This policy document was followed in 2000 by the State of the Trees Report.[198] While the State of the Trees is shorter than the State of the Urban Forest (12 pages versus 44 pages), it reads like a template for the six-county-wide urban forestry Greenprint Initiative launched in 2005. The executive summary of the State of the Trees begins with an emotionally evocative description of the city's canopy:

> *Trees are Sacramento's crowning glory. Anyone who has strolled beneath the cooling, soothing canopy of towering elms and sycamores knows the city is graced by a special relationship with trees. In Sacramento, at the heart of California's great Central Valley, our tree-lined boulevards, parks and residential foliage evoke far more than an appreciation for natural beauty. They represent 150 years of commitment to trees based on a profound understanding of the economic, social and civic benefits that trees bequeath.*[199]

Note that the excerpt ends with recognition of the multiple values and benefits of trees for values "far more than an appreciation for natural beauty." (Aesthetic values have not disappeared with the rise of the ecological street, nor are these valuations mutually exclusive of each other. From the perspective of an STF staff person, the visual appeal of the trees distributed by the organization is a given, but in face-to-face interactions with residents, the organization highlights other benefits of trees.[200]) The more-than-beauty benefits are distinctly environmental:

> *Ironically, this under funding of tree care services comes at a time when mounting scientific evidence shows that planting thousands of new trees each year will effectively reduce the Sacramento region's energy needs, improve air quality, and bolster public health. In fact, our existing tree canopy returns over $50 million in environmental benefits annually. New studies show that planting three to five million additional trees will result in dramatic improvements in air quality – and help bring the Sacramento region into compliance with state and federal air quality standards.*[201]

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[196] Nikolic and Koontz, "Nonprofit Organizations in Environmental Management."
[197] Sacramento, Urban Forest Task Force, *State of the Urban Forest Report 1996*.
[198] Sacramento Tree Foundation, *State of the Trees Report 2000*.
[199] Sacramento Tree Foundation, *State of the Trees Report 2000*, 1.
[200] SAC4, personal interview, October 22, 2009.
[201] Sacramento Tree Foundation, *State of the Trees Report 2000*, 1.

Not only are the environmental benefits of trees reiterated in a section titled "Benefits Beyond Beauty," but the benefits listed are specified in terms of reductions in environmental harms:

> *In fact, the Sacramento region is uniquely positioned to capitalize on the benefits of trees. For example, scientists have shown that Sacramento's six million trees reduce atmospheric carbon dioxide levels by storing around 238,000 tons of carbon dioxide as woody and leafy biomass each year. Another 76,000 tons of carbon emissions are avoided annually due to energy savings from trees. Although Sacramento's trees release 9,400 tons of carbon dioxide annually as they die, that total is a mere 3 percent of the amount sequestered and avoided through reduced energy use. The result is a net removal of 334,400 tons of carbon dioxide annually by the urban forest, an amount valued at $3.3 million annually.*[202]

The State of the Trees concluded with two recommendations that further underscore the ecosystem function value of trees. From the first recommendation:

> *We know that Sacramento, because of its climate, reaps benefits from a healthy urban forest – particularly in improving air quality and saving energy – that far exceed the costs. Therefore, we will guide our community and neighborhood development to maximize those benefits and in so doing make the Sacramento region a model for the world for generations to come.*[203]

And from the second recommendation: "This plan should focus on the urban forest's role in improving air quality and reducing energy costs."[204]

The State of the Trees Report reads like a template to STF's Greenprint initiative for two reasons. One, it advocates a regional approach to urban forest management (the six-county Sacramento Area Council of Governments (SACOG) region versus Sacramento County). Two, it is a framework for managing the urban forest; STF cannot and will not plant five million new trees in the region on its own[205] nor is the initiative enforceable (participation is voluntary). The geographic reach of the initiative is the counties within the SACOG region: Sacramento, El Dorado, Yolo, Placer, Yuba, and Sutter Counties.[206] One of the populations of trees under consideration is public trees throughout the region.

> *City and county streets and parks are home to most of our public trees. These are often the signature trees of a community, because they are typically the largest and most frequently seen. Properly managed, they serve as models to showcase the best*

[202] Sacramento Tree Foundation, *State of the Trees Report 2000*, 5.
[203] Sacramento Tree Foundation, *State of the Trees Report 2000*, 10.
[204] Ibid.
[205] SAC1, personal interview, October 15, 2009; SAC2, personal interview, October 15, 2009; SAC3, personal interview, October 16, 2009.
[206] Only Sacramento, El Dorado, Yolo, and Placer Counties have signed the Greenprint Initiative. Twenty-two cities across the six counties have signed the Initiative. Greenprint Initiative website, http://greenprintonline.org/doc.aspx?10 (October 30, 2009).

tree selection, pruning, and care. The values of a community are displayed daily by the presence and quality of public trees, or by their absence.[207]

The Initiative was designed to encourage tree planting that "optimize[s] the benefits of trees throughout [the] region."[208] While the Initiative does not presuppose the benefits of interest for each jurisdiction, its language provides some clues. One of the steps in the second phase of the first element is an urban forest value assessment "using a program developed and endorsed by the U.S. Forest Service."[209] The assessment program could be one of two: the Urban Forest Effects Model (UFORE) or the Street Tree Resource Analysis Tool for Urban Forest Managers (STRATUM). UFORE was developed by the Northeastern Research Station in Syracuse, New York. The software provides estimates of urban forest ecosystem functions such as hourly pollution removal and "associated percent air quality improvement throughout a year," total carbon storage and sequestration, and avoided carbon emissions.[210] STRATUM was developed by the USDA Forest Service Pacific Southwest Research Station which houses the Center for Urban Forest Research (CUFR). The STRATUM software quantifies the monetary value associated with aesthetic (property value) and environmental (ecosystem functions) benefits of street trees.

Other clues are found in the second element of the Greenprint Initiative. Participating jurisdictions are asked to develop "shade cover objectives for various land uses" and to adopt "urban forest goals" in such plans as the General Plan, urban heat island mitigation policy, green infrastructure principles, smart growth and green planning policies.[211] Shade cover percentages are often correlated to ecosystem functions as opposed to increases in property values. According to American Forests, "tree cover is directly related to environmental quality. Maintaining a robust enough tree cover to function as green infrastructure reduces the need and expense of building infrastructure to manage air and water resources."[212]

Nonprofit projects and activities

The emergence of the ecological street tree can also be witnessed in activities and events sponsored by and in which the Sacramento Tree Foundation has participated. For example, the organization partnered with the Sacramento Municipal Utility District (SMUD) in 1990 to launch a shade tree program known as Sacramento Shade which was precipitated by the closure of SMUD's Rancho Seco Nuclear Power Plant. In 1989, by public referendum, the power plant was closed. The closure of the power plant represented a 50% loss in power generation capacity for the utility district.[213] In response, SMUD "had to look under every

[207] Greenprint Initiative website, http://greenprintonline.org/doc.aspx?107 (October 30, 2009); Privately held trees, which account for "80% of the region's urban forest," are also included in the Initiative.
[208] Greenprint Initiative website, http://greenprintonline.org/doc.aspx?105 (October 30, 2009).
[209] Greenprint Initiative website, http://greenprintonline.org/doc.aspx?107 (October 30, 2009).
[210] UFORE website, http://www.ufore.org/about/index.html (October 30, 2009).
[211] Greenprint Initiative website, http://greenprintonline.org/doc.aspx?108 (October 30, 2009).
[212] American Forests website, Greenprint Initiative, http://www.americanforests.org/resources/urbanforests/treedeficit.php (October 8, 2009).
[213] SAC2, personal interview, October 15, 2009.

rock" to make up for this significant loss in power generation.[214] One of the rocks under which SMUD looked was trees, or their ability to cool ambient temperatures. SMUD pledged to provide STF with 500,000 energy-saving trees over a 10-year period beginning in 1990.[215] (SMUD's 500,000 trees represented one-half of STF's Trees for Tomorrow planting goal. The Trees for Tomorrow campaign was launched in 1989.) Since 1990, Sacramento Shade trees have been planted on private property (though depending in lot size, some have been planted in the public easements of private front yards). Despite the private property orientation of the Sacramento Shade program, the realization of co-benefits such as the mitigation of the urban heat island effect, air pollution removal, development of community spirit, positive public relations, and more recently, carbon sequestration, prompted SMUD to develop a more public realm oriented tree program with STF.[216] Community Shade was launched in 1998 and provides trees for schools, parks, and streets.

The Sacramento Shade program is not only significant as a precursor to a more public tree planting program; it represents the first nonprofit-utility, energy-saving tree planting partnership in the country. By at least one account, it was the Sacramento Tree Foundation (STF) that approached the utility district.[217] STF has a reputation as an instigator. According to one source, prior to its collaboration with the utility district, STF's executive director successfully lobbied the U.S. Forest Service to locate a research station in Davis.[218] The establishment of a research station on the west coast, according to a Center for Urban Forest Research (CUFR) newsletter, was the brainchild of a retired researcher, Dr. Rowan Rowntree; STF's executive director and others supported the idea.[219]

[214] Ibid.
[215] As of October 15, 2009, 450,000 trees have been planted under the auspices of the Sacramento Shade program. The energy saving potential of the trees was based on strategic planting scenarios which were based on the cardinal location of tree, the distance of the tree from the house, and the mature size of the tree. These scenarios and rules were developed as part of the program's redesign in 1996. Between 1990 and 1996, SMUD provided loose guidelines and as a result the trees that were planted did not generate the expected energy savings (SAC 2 interview, personal interview, October 15, 2009).
[216] SAC2, personal interview, October 15, 2009.
[217] SAC2, personal interview, October 15, 2009. The participant's statement is supported by STF's "Celebrating 25 Years" publication. http://www.sactree.com/assets/files/STF_25YrHistoryFINAL.pdf (July 27, 2010).
[218] SAC3, personal interview, October 16, 2009.
[219] Center for Urban Forest Research, Pacific Southwest Research Station, USDA Forest Service, Urban Forest Research, Spring 2003, 4. http://www.fs.fed.us/psw/programs/cufr/products/newsletters/UF5.pdf (September 8, 2009).

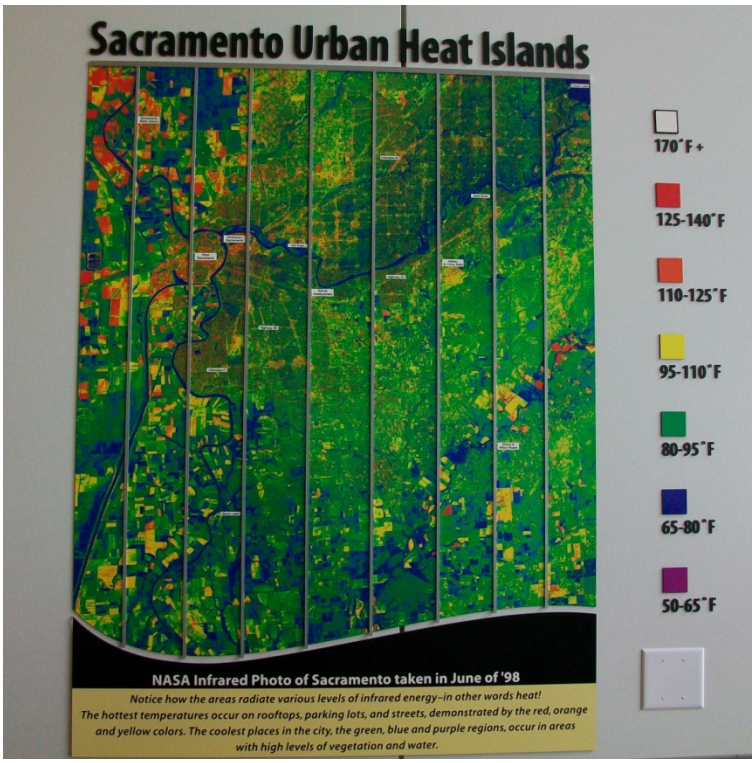

Figure 3.3 Sacramento's Urban Heat Island, 1998 NASA Flyover. *Source*: The author, 2009.

The Center for Urban Forest Research and STF engaged in projects that advanced the ecological street tree such as the Sacramento Urban Forest Ecosystem Study (1992 – 1998) which has generated 73 publications on the ecosystem benefits of the region's street trees and urban forest.[220] STF's application to the EPA-funded NASA Urban Heat Island Pilot Project was accepted in 1998 and followed by a flyover. There were several products from the flyover: a map of the city's urban heat island (Figure 3.3), an energy savings analysis, and an air quality analysis (the latter two were conducted by the Lawrence Livermore Berkeley Laboratory).[221] Of the results of the flyover, a NASA researcher remarked that "by choosing strategic areas in which to plant trees and by encouraging the use of light-colored, reflective building material, we think that the cities can be cooled."[222] The planting of shade trees was one of three heat island "reduction activities" demonstration projects undertaken by Sacramento as part of the Sacramento Cool Communities Program[223] and aligned with the

[220] Center for Urban Forest Research website, Programs and Projects, http://www.fs.fed.us/psw/programs/cufr/research/studies_detail.php?ProjID=8 (October 30, 2009). The 1992-1998 timeline and number of publications is based on information at the above website. According to STF's "Celebrating 25 Years" publication, the Sacramento Urban Forest Ecosystem Study was a three-year project that ended in 1996.
[221] EPA Urban Heat Island Pilot Project website, City Profile: Sacramento (Archived Page), http://www.epa.gov/hiri/pilot/archives/Sacramento.pdf (October 30, 2009).
[222] NASA press release, dated October 23, 1998, http://www.nasa.gov/home/hqnews/1998/98-195.txt (October 30, 2009).
[223] EPA Urban Heat Island Pilot Project website, http://www.epa.gov/hiri/pilot/archives/Sacramento.pdf.

EPA's goal to improve "air quality, specifically by reducing ozone" and "to cool the city and thereby reduce ozone pollution problems."[224]

Almost a decade after the NASA flyover, STF, CUFR, and the Sacramento Air Quality Management District began collaborating on the Sacramento Urban Forest for Clean Air Project.[225] Claims about the ability of the urban forest to effect changes in air quality were based on research evidence that showed that Sacramento region's existing six million trees remove "approximately 1,600 tons of air pollutants annually."[226] The project collaborators argued that additional trees would further improve air quality. The project sought to model an urban tree-based technology to ameliorate poor regional air quality (the Sacramento region is a "serious ozone non-attainment area" under EPA standards). Verification of the model's effectiveness would support the collaborators' claims about the role of "urban forest expansion" in reducing air pollution.[227] Furthermore, the technology's efficacy at improving air quality would make it a strong candidate for inclusion in California's State Implementation Plan or SIP.[228] If the air quality project was included in the SIP, funding would be allocated for Greenprint's tree planting element.[229]

In addition to large-scale policies and activities such as Greenprint and the Sacramento Urban Forest for Clean Air Project, STF has engaged in smaller-scale activities. An exemplar of this is the publication of its newsletter beginning approximately one year after the organization's founding in 1982. The newsletter was originally titled "Sacramento Trees" but the newsletter was renamed the "Urban Forest Monitor" in 2001. An accounting of the emergence of the ecological street tree based on an analysis of STF's newsletters follows.

Trends in the "Urban Forest Monitor" newsletter

Seventy-four issues of the Urban Forest Monitor were used in a regression to produce a trend line of the ecological street tree.[230] Based on newsletter content published from 1983 to 2008, the ecological characterization of street trees and urban forests has significantly increased (Figure 3.4).[231] The individual services that significantly increased during the

[224] NASA Science News, http://science.nasa.gov/newhome/headlines/essd20nov98_1.htm (October 30, 2009).
[225] Sacramento Urban Forest for Clean Air Project website, Project Profile http://www.fs.fed.us/psw/programs/cufr/products/cufr_668_SacAirQualityInit6-21-06.pdf (October 30, 2009); Charles L. Anderson, "Urban Forest for Clean Air Demonstration Project" presentation, April 24, 2007, http://www.epa.gov/hiri/resources/pdf/UrbanForestforCleanAirDemonstrationProject_SMAQMD.pdf (October 30, 2009).
[226] Sacramento Urban Forest for Clean Air Project website, Project Profile.
[227] Anderson, "Urban Forest for Clean Air Demonstration Project."
[228] Sacramento Urban Forest for Clean Air Project website, Project Profile. States are required to file SIPs in order to comply with clean air standards under the Clean Air Act; see also Trees for Cleaner Air, a U.S. Forest Service funded project focused on the inclusion of urban tree canopy cover into SIPs (http://www.treescleanair.org/) and CUFR's "Trees – The Air Pollution Solution" flier (http://www.fs.fed.us/psw/programs/cufr/products/cufr_658_Air%20Research%20Summary_3-06.pdf).
[229] Sacramento Urban Forest for Clean Air Project website, Project Profile.
[230] Refer to Table 2.2 for the specific issues included in the regression analysis.
[231] Refer to Chapter 2 for a discussion of analytic methods.

study period are air quality improvement, carbon sequestration, stormwater management, and wildlife habitat (Table 3.1).

Table 3.1 Sacramento: Individual Services that Significantly Increased between 1980 and 2008

Service	Significant rise in Sacramento
Air quality improvement	✔
Carbon sequestration	✔
Energy conservation and efficiency	✔ (weakest)
Stormwater management	✔
Wildlife habitat	✔

Source: Sacramento Tree Foundation newsletters (see Table 2.2).

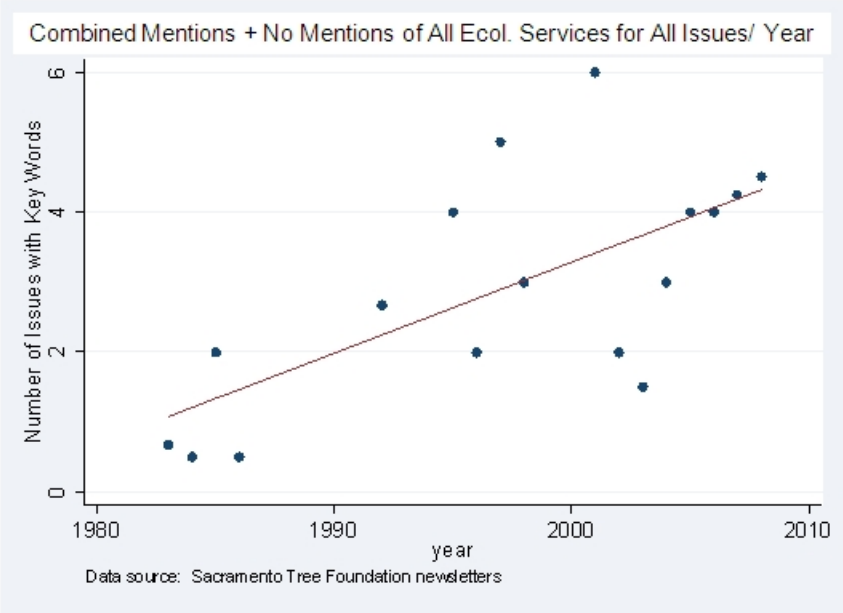

Figure 3.4 Trend in the overall ecological characterization of street in the "Urban Forest Monitor" newsletter. *Source:* Sacramento Tree Foundation's newsletters, 1983-2008 (see Table 2.2).

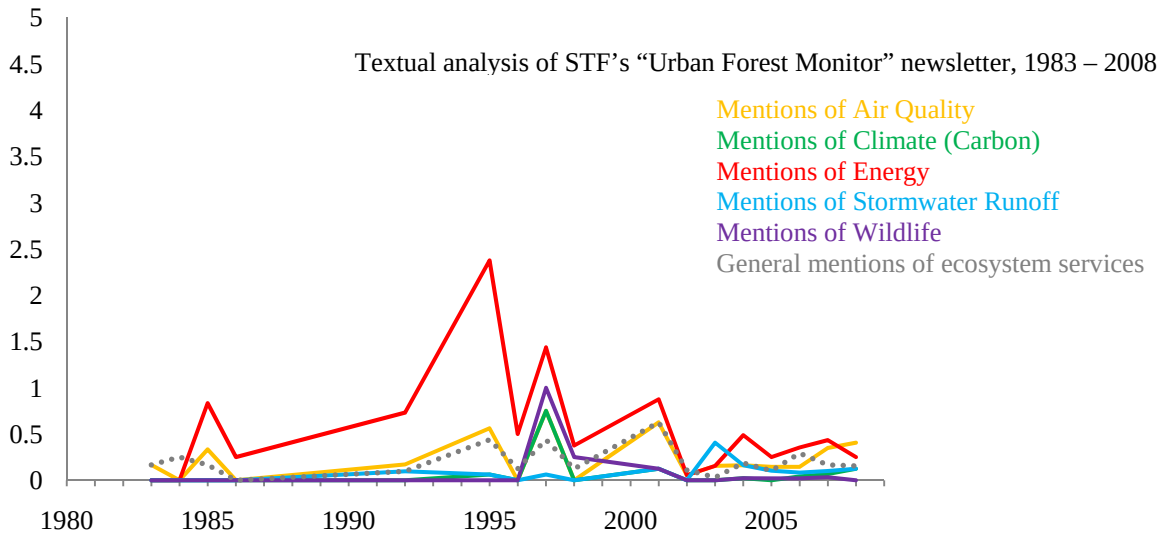

Figure 3.5 Number of mentions of each ecosystem service per issue weighted by the number of pages per issue (scaled to the mentions in the Canopy and Friends of the Urban Forest newsletters). *Source:* Sacramento Tree Foundation's newsletters, 1983-2008 (see Table 2.2).

A second analysis was conducted on the "Urban Forest Monitor" newsletter dataset. The analysis revealed spikes in the mentions of individual services which can be tied to program development and special issues (Figure 3.5). For example, the Sacramento Shade Program, a partnership between the Sacramento Tree Foundation (STF) and the Sacramento Municipal Utility District, was established in 1990 and redesigned in 1996. In 1993, 48,000 energy-saving shade trees were planted in 1993.[232] The spike in 1997 provides another example. In 1997, STF launched the Nature Program in partnership with the County of Sacramento.[233] Evidence for the presence of the ecological street tree in Sacramento was found in policies, activities, newsletters, and in interview transcripts with nonprofit staff. The latter is discussed in the following section.

Interviews with nonprofit staff

When asked to comment on the analyses conducted using STF's newsletters, participants agreed with the upward trend illustrated in Figure 3.4. Of the figure, one participant said,

[232] Sacramento Tree Foundation website, A Short History, http://www.sactree.com/doc.aspx?7 (October 26, 2009).
[233] The Nature acronym stands for Native Trees in Urban and Rural Environments. The county requires developers to fund a mitigation program when native trees are removed for development. STF uses this mitigation fund to plant native trees.

> *Yes, I would agree with that. Ten years ago, there was not much focus on environmental issues as we do know….*[234]

Another participant said,

> *It goes without saying, the issue of global warming. If you and I talked about this, let's say 5 years ago, 5 years earlier, we would spend most of the time debating if there is scientific evidence whether there is a global warming or not. Now we're past that point. No one is disputing anymore whether we have a global warming or not. The issue is how to mitigate global warming.* [235]

Based on interview evidence, early newsletter issues were not purposefully developed to communicate environmental benefits.[236] The rise and fall in the number of times tree-based ecosystem service benefits mentioned seem to be correlated to the launch and promotion of STF's programs. We expected the newsletter to be used to communicate the environmental benefits of trees, and one of the analyses (Figure 3.5) shows that this is the case. For example, there are rises and peaks associated with the original launch (1990) and redesign (1996) of the Sacramento Shade program as well as the launch of NATURE (Native Trees for Urban and Rural Environments) (1997) and Greenprint (2005). The printed newsletter is one of several modes of communication employed by the Sacramento Tree Foundation. Other modes of and venues for communication include events, tree plantings, committee meetings, policy documents, research collaborations, and e-newsletters.

There are several elements common to most of the issues: tree care tips, favorite tree column, stories about community involvement, donor recognition, and the executive director's message.

> *We do make sure that we have tree care information…We know certain things that people respond to well. I think the tree care is one. And people really like to see the community involvement stories. And then recognition of course….Director's letter which I think people really like as well.*[237]

Significant changes have been made to the newsletter. One, beginning with the launch of Greenprint in 2005, the tree care tips section was no longer a central feature of the newsletter.[238] Two, more recent issues feature a main article and related articles.[239] Sometimes the center spread or feature is about Greenprint, other times it is a special issue

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[234] SAC5, personal interview, November 2, 2009. Based on this participant's response to a later clarifying question related to the regression analysis, I realized this participant was using, as a frame of reference, "10 years" from an earlier question: "Now, think back 10 years, 5 years, what was the most pressing environmental issue?"

[235] SAC2, personal interview, October 15, 2009.

[236] SAC3, personal interview, October 16, 2009; SAC4, personal interview, October 22, 2009.

[237] SAC3, personal interview, October 16, 2009.

[238] SAC4, personal interview, October 22, 2009. The change in format is noticeable between the last issue of 2003 and the first issue of 2004.

[239] SAC4, personal interview, October 22, 2009; SAC3, personal interview, October 16, 2009. The change in format is noticeable between the last issue of 2003 and the first issue of 2004.

(the summer 2009 feature was titled "Conserving Water with Trees"). The theme of the feature, according to one participant, is developed in the following way:

> *It just kind of depends on what we've done, is newsworthy over the last quarter and then narrow it down to the most compelling stories*.[240]

Whereas earlier newsletters were not purposefully developed to communicate environmental benefits, per se, the content of recent newsletters was.[241] One participant described the changes to the newsletter, in particular the center spread feature and related articles, in terms of advocacy and funding:

> *Most of that is directed at officials because we need the money, we're a nonprofit. So the more that we can get information out there that this is what we are doing and this is why we need the money, not just because trees are pretty, that's why the changes, at least that I've seen, in the articles.*[242]

The roles of nonprofit and municipal actors in mainstreaming the ecological street trees in Sacramento have been identified and discussed. These institutions are not the only actors in reframing the role of street trees. The role of the Center for Urban Forest Research is addressed in the following section.

3.7 Knowledge production and dissemination: The Center for Urban Forest Research

The official story of the founding of the Center for Urban Forest Research (CUFR) is recounted in the March 2001 issue of the "Urban Forest Research" newsletter.

> *[The Center for Urban Forest Research was started in 1992 as the Western Center for Urban Forest Research and Education. The name change occurred in 2001.] The opening of the Center in April of 1993 was inspired by Dr. Rowan Rowntree, USDA Forest Service Research, retired, who had the vision of a research center in the west. It was his vision and the support of Ray Tretheway, Sacramento Tree Foundation; Dr. Jim Harding, UC Davis Department of Environmental Horticulture; Dr. Enoch Bell, USDA Forest Service, Pacific Southwest Research Station; and former Congressman Vic Fazio that made it all happen.*[243]

CUFR's mission is "to provide reliable scientific evidence" about the value of urban trees. More specifically, the Center

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[240] SAC3, personal interview, October 16, 2009.
[241] Efforts to contact the in-house newsletter manager were unsuccessful.
[242] SAC4, personal interview, October 22, 2009.
[243] Center for Urban Forest Research, Pacific Southwest Research Station, USDA Forest Service, Urban Forest Research, March 2001, 1, http://www.fs.fed.us/psw/programs/cufr/products/newsletters/UF1.pdf (November 5, 2009); Urban Forest Research, Spring 2003, 4, http://www.fs.fed.us/psw/programs/cufr/products/newsletters/UF5.pdf (November 5, 2009).

> *Conduct[s] research that describes the structure of urban forests and quantifies their benefits and costs. We hope that communities can use this information to improve the planting and care of their urban forests, and convince community leaders to support urban forest efforts with increased investments.*[244]

The biggest public for CUFR's research products is cities according to one participant, who then went on to describe the Center's research products as important strategies in funding allocations for urban forestry.

> *To argue for greater public funding for trees, helping them demonstrate in a different way from old fashioned 'Trees are beautiful and we need green cities and all of that.' For them to be able to go to their city councils or nonprofit boards and say 'Here is the dollar value for what these trees are doing for us. They deserve this much funding to increase our internal investment.'*[245]

The use of CUFR's research evidence in urban forest management and planning parallels evidence-based design in fields of landscape architecture and architecture. For example, both Clare Cooper Marcus and Robert Ulrich have written about the role of research in designing healthcare settings "as if people mattered." Marcus wrote,

> *Significant research in the 1980s and 1990s brought support to what one might intuitively believe to be so: that views to, or time in, nature have positive influences on health outcomes.*[246]

And Ulrich:

> *The key factor motivating awareness of facility design has been mounting scientific evidence that environmental characteristics influence patient health outcomes.*[247]

Further theoretical support for the role of scientific evidence in mainstreaming the ecological street tree comes from work conducted by Peluso on counter-mapping in Indonesian forests. Arguing for the significance of technology in legitimating land claims by local people, Peluso wrote that

> *Counter-mapping is a uniquely late-twentieth century phenomenon, made possible in part by both technological developments and the last decade's push toward participatory politics and management strategies. This paper presents two means by which local people are gaining access to the tools of the powerful – maps and mapping technologies developed by and for state international resource planners and*

[244] Center for Urban Forest Research, Urban Forest Research, March 2001, 1.
[245] SF6, personal interview, June 30, 2009.
[246] Clare Cooper Marcus, "Healing Gardens in Hospitals," *Interdisciplinary Design and Research e-Journal* 1, no.1 (2007): 1-27, http://www.idrp.wsu.edu/Vol_1/Cooper_Marcus.pdf (July 23, 2010).
[247] Roger S. Ulrich, "Evidence Based Environmental Design for Improving Medical Outcomes," http://www.swiz.nl/evidence_based_design_ulrich.pdf (July 24, 2010).

> *managers – and show how they are using them to legitimize their claims to land and resources.*[248]

Since its founding, the Center for Urban Forest Research (CUFR) has conducted research on urban forest systems throughout the Pacific-Southwest region. Of all the jurisdictions in the Pacific-Southwest region, CUFR has the oldest relationship with the Sacramento Tree Foundation (STF). First, STF's executive director played a role in the establishment of the Forest Service's research station in the region. Second, CUFR is located in Davis, California, a neighboring city to Sacramento and although Davis hosts an urban forest nonprofit, Tree Davis, STF is larger and more active, especially in the Sacramento region. Third, Sacramento's hot summers and related energy use represented "low hanging fruit" for CUFR both in terms of ease of access to information from the Sacramento Municipal Utility District (SMUD) and in terms of the "bigger mix [of benefits]" accrued from tree planting in Sacramento."[249] Tree planting for energy efficiency has several co-benefits such as air quality improvement, stormwater runoff management, and avoided greenhouse gas emissions.

One of the earliest collaborations between CUFR, STF, and SMUD was the redesign of the Sacramento Shade program, the energy efficiency tree planting collaborative of SMUD and STF. The program was launched in 1990 with loose guidelines for the planting radius around the house which resulted in few benefits to SMUD.[250] The District had an energy efficiency goal, not an urban forest program goal.[251] Small-stature trees planted on the south side of and/or far away from residential structures provided little direct shade so SMUD contracted with CUFR in 1995 to redesign the program.[252] CUFR was able to "model systematically the effect of shade trees on energy efficiency" using a random sample of 400 homes, 800 trees.[253] The redesign of Sacramento Shade coincided with state mandates on energy efficiency. California deregulated its electricity market and subsequently mandated that electricity providers spend a certain percentage of their gross revenue to fund "public goods" programs such as energy efficiency, low income household program, and research and development.

SMUD's collaboration with CUFR on the Sacramento Shade program lent credibility to the program.

> *The fact that I am working closely with them gives this program credibility, not only here in the company, locally, but also nation-wide. Like we posted tree benefit estimator, people asked where did you get those numbers and we tell them it came from the Center for Urban Forest Research and it's immediately treated differently.*[254]

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[248] Nancy Lee Peluso, "Whose Woods Are These? Counter-Mapping Forest Territories in Kalimantan, Indonesia," in *The Anthropology of Development and Globalization: From Classical Political Economy to Contemporary Neoliberalism*, ed. Marc Edelman and Angelique Haugerud, 273-281. Wiley-Blackwell, 2005, http://books.google.com (September 8, 2009).
[249] SF6, personal interview, June 30, 2009.
[250] SAC2, personal interview, October 15, 2009. Note the difference between strategic tree planting to achieve energy benefits) versus planting to fulfill a landscaping or community development mission.
[251] SAC2, personal interview, October 15, 2009.
[252] Ibid.
[253] Ibid.
[254] Ibid.

In addition to its energy efficiency research for SMUD, CUFR has evaluated other ecosystem functions of Sacramento's urban forest. The Center initiated the Sacramento Urban Forest Ecosystem Study in 1992 to evaluate "the benefits and costs associated with Sacramento's urban forest" and translate them into monetary values. [255] The study spanned the years 1992 to 1998 and led to 70 research publications.[256] Findings from the study have been cited by STF, for example, in its 1996 State of the Tree Report. One Sacramento-based participant described the relationship between STF and CUFR as follows:

> *CUFR is the scientific arm of urban forestry and they gather a lot of information ….Tree Foundation is a dispersal arm for that information, so we take that information and we will distill it into the components that we can feed then to the general public.*[257]

Another of CUFR's research collaborations is the Urban Forests for Clean Air Demonstration Project. CUFR, STF, and the Sacramento Air Quality Management District (SAQMD) have partnered to evaluate the role of additional urban tree cover to improve the region's air quality in order to achieve Environmental Protection Agency and California Air Resources Board standards. SAQMD covers the following jurisdictions within Sacramento County: Citrus Heights, Elk Grove, Folsom, Galt, Isleton, Rancho Cordova, City of Sacramento, and County of Sacramento. The mission of SAQMD is "to achieve clean air and protect public health and the environment" and its Clean Air Element is mandated by the California Clean Air Act (CCAA) of 1988 for nonattainment areas. [258] The Sacramento region is nonattainment for ozone and carbon monoxide. In 1991, SAQMD submitted an attainment plan for these pollutants as well as for PM 10 (particulate matter 10 microns in size or smaller).[259] Almost 20 years later, the region still has not met air quality standards.

> *We already have these trees in Sacramento County but we're still a nonattainment area. Let's plant more trees and see if we can't help lower or that threshold so we can achieve attainment.*[260]

The role of CUFR in the clean air demonstration project is to provide the scientific evidence that the addition of new trees to the region's urban forest is an effective air quality improvement tool. In a memo dated February 28, 2008 from the SAQMD Board of Directors to the SMAQMD air pollution control officer, the Urban Forests for Clean Air project was described as a non-traditional and "emerging" technology:

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[255] Center for Urban Forest Research website, Programs and Projects.
[256] Center for Urban Forest Research website, Programs and Projects.
[257] SAC3, personal interview, October 16, 2009. The "general public" is one of three groups to which information is disseminated. The Greenprint Initiative "recognizes three principal community groups: there is the business community, there is the elected officials, and then there is the general public" (SAC3, personal interview, October 16, 2009).
[258] Sacramento Metropolitan Air Quality Management District website, State Planning Requirements, http://www.airquality.org/stateplan/index.shtml (November 7, 2009).
[259] Ibid. The EPA designated Sacramento nonattainment for PM 2.5 in October 2009 (SMAQMD, AIRlines, 14, no. 3 (Fall 2009), http://www.airquality.org/communicationsoffice/2009/2009Fall.pdf (November 7, 2009).
[260] SAC3, personal interview, October 16, 2009.

> *The Urban Forest for Clean Air Demonstration Project is not a traditional emission control measure. The United States Environmental Protection Agency (USEPA) classified it as an emerging and voluntary measure. One of the requirements for emerging and voluntary measures is to quantify ozone benefits. Therefore, this modeling effort will satisfy EPA requirements to include the tree planting strategy in the State Implementation Plan for ozone.*[261]

A testament to the stature of CUFR's research legacy is that despite the emergent nature of the proposed ozone control measure, SAQMD has funded the demonstration project. Furthermore, there are only two "emerging and voluntary options" being pursued by the Air Quality District of which the urban forest expansion project is one. The following long excerpt from an ozone attainment planning report underscores the value of planting for ozone management:

> *It is imperative today that we look for new and innovative strategies to include in the SIP to offset the impacts of anthropogenic emissions. Emerging control measures are control strategies based on science and technology that are new, difficult to quantify, and do not possess the high level of certainty normally found in traditional control measures. Voluntary measures are strategies that will result in the reduction of a criteria pollutant or precursor that the State could claim as an emission reduction in a SIP for the purposes of demonstrating attainment of the National Ambient Air Quality Standard (NAAQS) or reasonable further progress (RFP), but that is not directly enforceable against a source. The Urban Forest and Spare The Air programs are the only two voluntary measures in this plan.*
>
> *Numerous scientific studies and research projects have documented the benefits of heat island strategies using urban forest expansion programs, and several states are exploring the benefits of adopting urban forest strategies into their SIPs. This emerging and voluntary control measure proposes one such strategy that is based on the selection of trees provided for the expansion of the urban forest to minimize biogenic volatile organic compound (BVOC) emissions.*
>
> *The Sacramento region has succeeded in creating a renowned urban forest. Our forest evolved over many years, with each generation of our community adding trees that met the needs of their day. In earlier years, urban trees were planted for comfort cooling and public health benefits. More recently, the Sacramento Municipal Utility District (SMUD) has invested millions of dollars in the strategic planting of an energy-saving urban forest. Today we have a pressing need to improve the purity of the region's air. While our urban trees make a major contribution to air quality, they were not planted with this in mind and so do not do as much as they could.*[262]

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[261] SMAQMD website, Urban Forest Board Letter and Resolution, http://www.airquality.org/bod/2008/FebUrbanForestBrdLtrandReso.pdf (November 7, 2009).

[262] Sacramento, Sacramento Metropolitan Air Quality Management District, *Sacramento Regional 8-Hour Ozone Attainment and Reasonable Further Progress Plan Draft Report September 10, 2008* (Sacramento: AQMD, 2008). http://www.airquality.org/notices/CAPUpdate/8hrAPandEIRWorkshopsSept2008DraftAPandRFP.pdf (November 7, 2009).

Not only does the ozone attainment plan suggest urban forestry as a "major contribution to air quality," the document also supports the underlying argument of this dissertation that street trees and urban forests are being planted to achieve ecological goals.

CUFR's production of scientific evidence for the role of urban trees in energy efficiency and air quality improvement is well established. However, it is not the only knowledge-producing institution in the region. The Sacramento Tree Foundation has relied on other experts for scientific evidence such as Thomas A. Cahill, Ph.D. with Breathe California. In particular, Dr. Cahill has evaluated the role of trees in removing very fine particulate matter (PM 2.5)[263] and the Sacramento Tree Foundation (STF) has been able to disseminate additional information about the role of trees in improving regional air quality.

> *Dr. Cahill has been working with Breathe California – I don't know if you are familiar with his particulate matter studies but when those studies came out we really started to use that information to inform people about particulate matter and how trees improve air quality. So it just depends on what information is coming out I suppose….*[264]

The ability of STF to legitimate their work and to generate funding is linked to their ability to illustrate the ecological role of trees vis-à-vis the availability of scientific evidence to that effect. James P. Evans has argued that "claims to ecological authority are proliferating under the science-driven rubric of sustainable development, and particularly the notion of evidence-based policy."[265] Although STF "has always been very aware of all the benefit streams of trees,"[266] intuition does not generate legitimacy or funding. The contemporary emphasis on evidence-based planning has elevated the role of scientific research in urban forestry planning and management. The particulars of planning for ecosystem services are discussed in the following section.

3.8 The Geography of Ecosystem Services

Sacramento's ecosystem services geography

A regression analysis of 44 issues of Sacramento Tree Foundation's newsletter revealed a positive and significant trend in the ecological characterization of the street tree (Figure 3.3). The individual services that contributed to this positive and significant trend were air quality improvement, carbon storage and sequestration, stormwater runoff management, and wildlife habitat (Table 3.1). Surprisingly, energy efficiency and conservation was not a contributing service. With descriptive overlap among codes for air quality improvement, carbon storage

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[263] Breathe California, *Removal Rates of Particulate Matter onto Vegetation as a Function of Particle Size: Final Report to Breathe California of Sacramento-Emigrant Trails' Health Effects Task Force (HETF) and Sacramento Metropolitan Air Quality Management District*, by Fujii, Erin, Jonathan Lawton, Thomas A. Cahill (principal investigator), David E. Barnes, Chui Hayes, and Nick Spada (Sacramento: Breathe California, 2001). http://www.sacbreathe.com (July 1, 2010).
[264] SAC3, personal interview, October 16, 2009.
[265] James P. Evans, "Wildlife Corridors: An Urban Political Ecology," *Local Environment* 12, no.2 (2007): 134.
[266] SAC3, personal interview, October 16, 2009.

and sequestration, and energy efficiency and conservation, it is probable that the latter was subsumed within the first two categories. Another surprise was the contribution of stormwater runoff management. While Sacramento does not get a lot of rainfall, when it does rain, runoff is warmed by surface materials and negatively impacts water quality. The contribution of the wildlife habitat value to the trend line is attributable to mentions of the Native Trees in the Urban and Rural Environment (NATURE) Program.

A review of municipally- and nonprofit-managed policies and activities as well as interviews with municipal and nonprofit staff revealed that energy efficiency and air quality improvement are the two most salient services in Sacramento. (Also, the contribution of trees to carbon storage sequestration is increasingly being recognized.[267] The relevance of carbon sequestration has increased with scientific corroboration and a rise in policy activities targeting this value.) Why are energy efficiency and air quality improvement the most salient services to Sacramento? Climate, topography, and urban form are contributing factors.

Climate

The extreme summer heat reflected in the common occurrence of 100°F days is a contributing factor to the salience of energy efficiency and conservation via urban forest strategies pursued by the City of Sacramento, the Sacramento Tree Foundation, and others. In response to a question about the most pressing environmental issues in Sacramento, one participant remarked that trees are "a no brainer" when it comes to addressing energy conservation.[268]

Topography

The other most pressing environmental issue in Sacramento is air quality. Five interviews were conducted in Sacramento; all five participants stated that air quality was the most pressing environmental issue. Of course, energy efficiency and air quality are linked; reductions in energy use avoid emissions at power plants which result in improved air quality Air quality has gotten worse in the county; Sacramento remains nonattainment for air quality standards set at the federal (Clean Air Act/ National Ambient Air Quality Standards), state (California Air Resources Board), and regional (Sacramento Metropolitan Air Quality Management District) levels. One participant tagged the source of the county's pollution as the San Francisco Bay Area.

> *The Bay Area doesn't have any problems because of ocean winds. The Bay Area pollution comes to Sacramento. The Foothills have the worst problems. Pollution is from the west and wind pushes the pollution into the Foothills.*[269]

[267] SAC2, personal interview, October 15, 2009; SAC3, personal interview, October 16, 2009.
[268] SAC1, personal interview, October 15, 2009.
[269] SAC2, personal interview, October 15, 2009.

Another participant described the pollution in the Foothills more severely – "the non-attainment in the foothill regions (Auburn, Grass Valley, Nevada City) is atrocious" – and noted that although the Bay Area is "a huge contributing factor" to the county's poor air quality, the region has its "own sources" as well.[270]

Urban form

In addition to the Foothills, other places in the County experience high levels of pollution such as neighborhoods adjacent to freeways (Figure 3.6). These neighborhoods have been identified as geographies where strategic tree planting would be beneficial.

> *Now the other thing, if the Air Quality District, they may, particularly if particulate matter makes it into the equation, they might fund us. Right now we don't have any funding to go out and plant trees along the sides of highways and the freeways. What a great thing to do to plant evergreens right up and down our freeways where there's space available to reduce particulate matter, reaching those neighborhoods. There [are] plenty of places everywhere but here in Sacramento where you have six lane freeways and little retaining walls and maybe there's 30 feet or so in a retaining wall and then there's homes right beyond that and certainly all that particulate matter that is being released in those freeway corridors and propagating on through the communities has a very negative health impact…diabetes, obesity, lung cancer, Alzheimer's, potential effects of just taking in this particulate matter, [sic] lower IQ.*[271]

[270] SAC1 follow-up, email communication, December 8, 2009.
[271] SAC3, personal interview, October 16, 2009.



Figure 3.6. Tree inventory of North Natomas, Sacramento. *Source:* Nathan Stephens, City of Sacramento Urban Forestry, Maps of City Tree inventory, Inventory taken by Davy Resource Group, Canton OH 12/2008 to 12/2009.

Other aspects of urban form are the predominance of car-oriented development and single-occupant vehicle use in the region. Both have contributed to poor air quality. North Natomas provides an example (see Figure 3.6). The community's Transportation Management Association has the following statement on its website:

> *The area is expected to generate 70,000 average daily trips within the next year, 165,000 trips over 5 years, and 700,000 trips at the build-out of the community. The overall goal is to reduce trips by 35 % and reduce air pollution emissions by 35 % at build-out.*[272]

[272] North Natomas Transportation Management Association website, http://www.neighborhoodlink.com/org/nntma/ (July 3, 2010).

Federal funding to the county is jeopardized unless the county meets air quality standards.[273] Methods of housing development have evolved and have contributed to the urban heat island effect. Although newly constructed homes are more energy efficient, new construction often results in fewer trees creating hotter neighborhoods.[274] Also, house size has increased while lot size has decreased, or at least houses are being built to the lot line, leaving less room to plant trees.[275] This situation stands in contrast to older neighborhoods within city limits such as those constructed between 1850 and 1890 with "separated sidewalks and stately [street] trees."[276] Beginning in the 1940s, front yard setbacks, especially in county subdivisions have declined. A 1940s neighborhood had front yard setbacks of 40 – 60 feet; a 1970s neighborhood had 30-foot setbacks; between 1990 – 2000, the average setback for a "production subdivision" was 20 feet; and today, the average setback is between "5 and 10 feet, 15 if you're lucky," which begs the question, asked by one participant, "where do you put a shade tree in 15 feet when you've got a sidewalk and an awning off the front of the house? We are not allocating space the way we used to."[277] The implication of these changes in the setback distance for realizing an ecological city is as a participant observed:

> *So, an interesting dichotomy between the "Blueprint" vision to reduce sprawl and increase density and the reality of what that looks like when it gets built. In a way, the Blueprint is a developer's dream of dramatically increasing the net saleable square footage by reduced lots and streets. When we talk about "mixed use" and high-density, are we going to be able to implement the ecological tree concept further? Not if there are no back or front yards…Street trees can't do it alone.*[278]

Another infrastructural element, planting strips, plays a role in the geography of ecosystem services in Sacramento, though this factor acts in concert with income. In general, if planting strips are present, people tend to plant trees. Also, the city plants and maintains trees in planting strips.[279] Neighborhoods with and without planting strips have high canopy cover. For example, Elmhurst has planting strips. It is known for its "old stately elms" which is "a characteristic of the neighborhood that unifies the neighborhood" but also provides other benefits such as "shaded sidewalks, heat island mitigation, reduced maintenance and increased longevity of infrastructure like asphalt."[280] The example of Elmhurst also illustrates the role of design intent. "Shade trees make sense in hot Sacramento climate," remarked one Sacramento participant, and historic neighborhoods were designed with trees to provide natural cooling.[281] The Fabulous ("Fab") 40s neighborhood does not have planting strips – trees are planted in generous, front yard setbacks – but has "great canopy" while the Oak Park, South Oak Park, Meadowview area (built in the 1940s and 1950s), also without planting strip, has low canopy cover. A Sacramento participant attributed this condition to income.

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[273] SAC5, personal interview, November 2, 2009.
[274] SAC2, personal interview, October 15, 2009.
[275] SAC2, personal interview, October 15, 2009; SAC1, personal interview, October 15, 2009; SAC3, personal interview, October 16, 2009.
[276] SAC1, personal interview, October 15, 2009.
[277] Ibid.
[278] SAC1 follow-up, email communication, December 8, 2009.
[279] SAC3, personal interview, October 16, 2009.
[280] SAC1, personal interview, October 15, 2009.
[281] SAC2, personal interview, October 15, 2009.

[In lower income communities, predominantly renters, households are] trying to put food on the table and all those other survivorship issues versus 'I'd like to go out and plant trees so I can walk my street.'[282]

Climate, topography, and urban form are contributing to the geography of ecosystem services in Sacramento. Local and regional institutions and funding mechanisms influence the strategies – policy setting and program development – used in Sacramento to capture ecosystem services. These factors are addressed in the next section.

Table 3.2 Selected Policies and Activities that Advanced the Ecological Street Tree in Sacramento

Name	Actors	Date	Goals
Parking Lot Shade Tree Ordinance	City of Sacramento, County of Sacramento	1983	Urban heat island mitigation; energy conservation
Sacramento Shade	Sacramento Tree Foundation (STF), Sacramento Municipal Utility District (SMUD)	1990	Energy efficiency
Sacramento Urban Ecosystem Study	Center for Urban Forest Research (CUFR)	1992	Air quality improvement; carbon sequestration; energy efficiency and conservation; stormwater management
State of the Urban Forest Report	Sacramento Urban Forest Task Force	1996	Air quality improvement; carbon sequestration; energy efficiency and conservation; stormwater management
NASA Urban Heat Island Pilot Project	STF	1998	Urban heat island mitigation; air quality improvement
State of the Trees Report	STF	2000	Air quality improvement; energy efficiency
Greenprint Initiative	STF and county jurisdictions	2005	Regional urban forest plan
Urban Forests for Clean Air Project	STF, CUFR, Sacramento Metropolitan Air Quality Management District (SMAQMD)	2006	Air quality improvement; carbon sequestration (emissions reduction)
Urban Forest Greenhouse Gas Reporting Protocol	*CUFR (approved by California Air Resources Board draft)*	*2009*	*Carbon sequestration (greenhouse gas emissions reduction; climate change mitigation)*

Strategies to capture tree-based ecosystem services in Sacramento

Policies and reports

One of the strategies for capturing tree-based services in Sacramento is the adoption of policies (Table 3.2). The City and County of Sacramento, and the Sacramento Tree

[282] SAC3, personal interview, October 16, 2009.

Foundation have developed or supported policies that have contributed to the mainstreaming the ecological street tree.

> *Current [county] policies are not designed around environmental benefits, but not too far behind.*[283]

Policies like the city's management plan[284] and heritage tree ordinance[285] as well as the county's protection ordinance for heritage and landmark trees and native oaks[286] and road standards and zoning regulations that require street trees and landscaped medians[287] do not directly mainstream the ecological street tree, per se. However, the preservation and management of trees is necessary to maintain an urban canopy from which ecosystem services can be derived. Both the city and county have adopted parking lot shade tree ordinances and as the name suggests, the ordinance mandates the shading of surface parking lots to reduce the urban heat island effect.[288]

Like the city and county, the Sacramento Tree Foundation (STF) has indirectly integrated the ecological value of street trees into policy. STF's Greenprint Initiative aims to standardize the "organizational structure that supports an urban forest"[289] among multiple jurisdictions within the six-county Sacramento region. The importance of the Greenprint initiative can be illustrated by a New York *Times* article about the confusion that results from town-level tree laws in a region composed of numerous towns. For example, in Westchester (NY), each of the more than 40 towns has its own tree ordinance.[290]

Street trees are directly framed in ecological terms in the joint city and county Stormwater Quality Design Manual (SQDM) and in the "state of" reports[291] authored by the Sacramento Tree Foundation. The latter pointed to the role of street trees in ameliorating poor environmental conditions in Sacramento. Air quality and energy use were specific areas of concern. While the stormwater runoff management benefits of trees were not emphasized in STF's 2000 "state of" report, these services were included in the Stormwater Quality Design Manual (SQDM). "Interceptor trees" are one of six runoff reduction measures included in the SQDM.[292]

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[283] SAC5, personal interview, November 2, 2009.
[284] Wolfe Mason Associates, *Draft Sacramento Urban Forest Management Plan 1992*.
[285] City of Sacramento's Heritage Tree Ordinance, City Code §12.64.
[286] County of Sacramento Tree Preservation and Protection Ordinance, County Code Title 19.
[287] SAC5, personal interview, November 2, 2009.
[288] City of Sacramento's Parking Lot Shade Tree Ordinance, City Code §17.64.030(H); County of Sacramento's Parking Lot Landscape and Shade Requirements, Zoning Code Chapter 30, Article 4
[289] SAC1, personal interview, October 15, 2009.
[290] Corey Kilgannon, "When Trees Fall Next Door, Neighbors Make the Noise," *New York Times*, November 29, 2009, Metropolitan, 1, 9.
[291] Sacramento Tree Foundation. *State of the Trees Report 2000*; Sacramento Urban Forest Task Force, *State of the Urban Forest Report 1996*.
[292] The six runoff reduction measures are porous pavement, disconnected pavement, alternative driveways, disconnected roof drains, interceptor trees, and green roof. Stormwater planter and vegetated swale are two of eight pollutant removal methods included in the SQDM. Trees are not mentioned in the description of the stormwater planter and tree planting within the flow line of vegetated swales is discouraged (trees should be planted outside the flow line). Sacramento, Sacramento Stormwater Quality Partnership, *Stormwater Quality*

> *Interceptor trees are those used in residential and commercial settings as part of the stormwater quality management plan to reduce runoff and pollution from the development project. Interceptor trees can be placed on residential lots, throughout landscape corridors, in commercial parking lots, and along street frontages. Trees installed in municipal right-of-ways may be protected through ordinances and can provide years of aesthetic benefit.*[293]

An explanation of how trees improve water quality was also provided in the SQDM. Also, the document cited Xiao's research; Xiao is affiliated with the Center for Urban Forest Research.

> *Interceptor trees are ideal for all projects, including those where space is limited, in which trees can be placed along street frontages and in common space. Urban areas with higher numbers of trees exhibit hydrology more similar to natural conditions compared to urban areas without a tree canopy. Trees intercept storm water and retain a significant volume of the captured water on their leaves and branches allowing for evaporation and providing runoff reduction benefits. For example, a large oak tree can intercept and retain more than 500 to 1,000 gallons of rainfall in a given year (Cappiella, 2004). While the most effective Interceptor Trees are large canopied evergreen trees, deciduous trees can also provide a benefit. For example, a leafless Bradford pear will retain more than one half the amount of precipitation intercepted by an evergreen cork oak (Xiao et al., 2000). The shade provided by trees keeps the ground under the trees cooler, thereby reducing the amount of heat gained in runoff that flows over the surface under the trees. This attenuation of heat in storm water helps control increases in stream temperatures. On slopes, tree roots hold soil in place and prevent erosion.*[294]

(Neither street trees specifically nor ecological values of trees generally are mentioned in the joint city and county Stormwater Quality Improvement Plan.[295] The primary focus of the plan is pollution prevention.)

Program development and activities

Another strategy to capture tree-based ecosystem services is program development (Table 3.2). Local institutions such as the Sacramento Municipal Utility District (SMUD) and the Sacramento Tree Foundation (STF) have developed programs to capture the ecological value of trees. In 1996, SMUD partnered with the Sacramento Tree Foundation to plant energy

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Design Manual May 21, 2007 (Sacramento: SSQP, 2007), http://www.sacramentostormwater.org/SSQP/documents/DesignManual/SWQ_DesignManual_May07_062107.pdf (June 7, 2010).

[293] Sacramento, *Stormwater Quality Design Manual*, INT-1.

[294] Sacramento, *Stormwater Quality Design Manual*, INT-2.

[295] Sacramento, Stormwater Quality Partnership, *Stormwater Quality Improvement Plan for the County of Sacramento and the Cities Of Sacramento, Citrus Heights, Elk Grove, Folsom, Galt, and Rancho Cordova November 2009* (Sacramento: SSQP, 2009), http://www.msa.saccounty.net/sactostormwater/documents.asp (June 7, 2010).

saving trees through the Sacramento Shade program. In 1998, SMUD partnered with STF on the Community Shade program. This program funds tree planting in public areas such as schools, parks, neighborhood streets, and business districts. Like Sacramento Shade, SMUD funds Community Shade to capture ecosystem services, in this case, the urban heat island mitigation benefit.

> *More and more emphasis placed on trees regardless [of] whether they are energy saving shade trees. Now we're just looking at trees that can give you the urban [heat island] mitigation benefit that could give you carbon benefit not necessarily energy capacity savings.*[296]

More recently, Sacramento Tree Foundation in partnership with the Center for Urban Forest Research (CUFR) and the Sacramento Metropolitan Air Quality Management District launched the Urban Forests for Clean Air Project to evaluate the effects of urban forest expansion on air quality. Other research activities include CUFR's Sacramento Urban Ecosystem Study and the NASA Urban Heat Island Pilot Project.

Funding streams

Attempts to capture tree-based ecosystem services in Sacramento are made possible by access to funding. One interview participant noted that

> *For every benefit of trees there is a potential funding source out there.*[297]

This is certainly the case for the various projects developed by the Sacramento Tree Foundation ranging from strategic tree planting to research projects. The energy saving benefit of trees was captured through the SMUD-STF Sacramento Shade program. The California Air Resources Board and the Sacramento Metropolitan Air Quality Management District (SMAQMD) are particularly concerned with air quality in the region. The Tree Foundation has partnered with SMAQMD on the Urban Forests for Clean Air Project. Traditionally, the Environmental Protection Agency has focused on pollution reduction at sources such as power plants, factories, and vehicles, but trees are now being considered as an air pollution reduction strategy. [298]

> *The Tree Foundation is engaged in a grant right now to quantify that and see how we can change the look and feel of the urban forest so that it reduces essentially right now volatile organic compounds, but we are working on incorporating things like particulate matter and…carbon as well.*[299]

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[296] SAC2, personal interview, October 15, 2009.
[297] SAC3, personal interview, October 16, 2009. Since trees also have social benefits, STF sought funding from community development agencies to develop it's at-risk youth program.
[298] Center for Urban Forest Research, "Trees and the Clean Air Act: Strategic Tree Planting in Sacramento" brochure, http://www.fs.fed.us/psw/programs/cufr (December 2, 2009).
[299] SAC3, personal interview, October 16, 2009.

The institutional partners of this project are hopeful that their air quality improvement through tree planting protocol can be included in the State Implementation Plan (SIP). Each nonattainment state required to develop a SIP under the Clean Air Act/ National Ambient Air Quality Standards.

The absence of funding also has bearing on capturing tree-based ecosystem services. For example, in 1992 with the adoption of the Urban Forest Management Plan, the city relinquished responsibility for trees in the maintenance strip zone of the sidewalk (Figure 3.1). Subsequent city plans have recommended that the city resume responsibility for trees in the maintenance strip, but the decision to plant and to maintain trees in this tree space remains with the adjacent property owner. Although these trees still provide environmental benefits they are no longer afforded the protection of the city which has implications for long-term environmental contributions of the urban canopy.

> *[It is] important to recognize that the suggestion to take back and reinitiate care for maintenance strip trees came from one or two individuals and not necessarily from all staff and without a lot of consideration as to what that meant to the budget and at the expense of care for other trees….Having said that, councilmember Ray Tretheway, who is the executive director of our local nonprofit, would very much like to see us take those trees back and care for those trees and as much as I would like to, I would love to be able to do that because in the end I think it would greatly benefit the city, I don't see that it's financially feasible.*[300]

Funding also plays a role at the county level; however, the story has an interesting twist. Because the county has consistently failed to meet federal air quality standards, federal money to fund the county's growth plans are being withheld.[301] Two concurrent strategies exist to deal with this issue. First, the update to the General Plan is based on housing, transportation, and conservation policies. It is predicted that these policies will "filter down into development standards" for infill, road standards (including tree planting), denser housing, and "pedestrian-friendly over car required" design and will "help with air quality."[302] Second, the Sacramento Metropolitan Air Quality Management District with its mission "to achieve clean air goals" is funding an urban forest project that could help the county meet federal air quality goals.

> *The Sacramento metropolitan area is among the ten most ozone-polluted areas in the country, exceeding the accepted levels as many as 40 days a year depending on weather conditions.*[303]

> *We already have these trees in Sacramento County but we're still a nonattainment area. Let's plant more trees and see if we can't help lower that threshold so we can achieve attainment….*[304]

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[300] SAC1, personal interview, October 15, 2009.
[301] SAC5, personal interview, November 2, 2009.
[302] Ibid.
[303] Center for Urban Forest Research, "Trees and the Clean Air Act."
[304] SAC3, personal interview, October 16, 2009.

3.9 Summary

Table 3.3 Support for Research Propositions in Sacramento

Proposition	Definition	Supported
1	The presence of an upwards trend in the ecological characterization of street trees	Yes
1a	The urban forest nonprofit played a significant role in advancing the ecological street tree	Yes
1a1	The nonprofit's newsletter is the primary mode of communicating the ecological benefits of street trees	While analysis of its newsletters revealed a rise in the ecological framing of street trees, the Sacramento Tree Foundation does not regard its newsletter as the primary method of communicating the ecosystem benefits of trees.
1b	The ecological street tree has been legitimated vis-à-vis the production of scientific research	Yes
2	Particular ecosystem services are salient in particular cities	Yes
2a	Different strategies are used by different actors to capture tree-based ecosystem services	Yes

Findings strongly support all the propositions in the case of Sacramento (Table 3.3). In Sacramento, the urban forest nonprofit and government have played roles in mainstreaming the ecological street tree, though the nonprofit, the Sacramento Tree Foundation, appears to be the dominant actor. The role of scientific evidence is also a driving factor in advancing the concept of the ecological street tree. The Center for Urban Forest Research is the primary provider of scientific evidence for the ecosystem functions of street trees and urban forests. Interview participants underscored the production of research data in supporting their efforts to mainstream the ecological street tree. Finally, findings points to a geography of ecosystem services in Sacramento. In a regression analysis of the Sacramento Tree Foundation's newsletters air quality, climate, hydrology, and wildlife habitat were the most frequently mentioned ecosystem services in Sacramento. In interviews with nonprofit and government staff, air quality followed energy efficiency were mentioned as the most important ecological values provided by street trees.

Chapter 4:: Palo Alto: A city named for a tree

> *A Tree is the symbol of Palo Alto. This is significant. Trees come to mind instantly whenever the city's name is heard. Even people not given to analyzing the source of their pleasures will say, "Palo Alto is a delightful place!" Unconsciously they are reacting to the harmonious environment which trees and space provide.*[305]

4.1 Overview

First, a history of street tree characterization based on city plans and interview transcripts is presented. For example, Section *1894-1993* describes the origins of tree planting in Palo Alto as well as the early focus on the aesthetic qualities of trees. Section *1993-2009* shows the gradual reframing of the role of the street tree in city planning documents. Second, a discussion of the role of Canopy is presented next, then that of the Center for Urban Forest Research. Third, this chapter ends with a description of the geography of ecosystem services in Palo Alto and conclusions based on an analysis of Palo Alto-based data sources.

4.2 Municipally-led planning of the ecological street tree, 1894-1993

In 1894 Palo Alto was incorporated and named for its landmark redwood tree, El Palo Alto, growing on the outskirts of what is now Stanford University.[306] Since its incorporation, reported the 1982 Palo Alto Street Tree Management Plan, street trees have been planted in the city. Sub-populations of Palo Alto's street tree population are specific to particular time periods identified in the 1982 Palo Alto Street Tree Management: (1) early plantings by residents, "mostly Stanford faculty from the east and the midwest [sic]" circa the founding of the city in 1894; (2) trees planted between 1920 and 1950; and (3) trees planted between 1950 and the publication of the plan in 1983.[307]

The first edition of *Trees of Palo Alto*, published jointly by the City of Palo Alto and Palo Alto Chamber of Commerce and Civic Association in 1959, listed the "practical" benefits of Palo Alto's trees:

> *While praising the beauty of trees, we often fail to see the practical virtues as well. Where Palo Alto's famous forest of trees exists, there is protection from prevailing northerly winds. Trees acts as noise buffers and give inter-property privacy. Trees*

[305] Palo Alto and Palo Alto Chamber of Commerce and Civic Association, *Trees of Palo Alto* (Palo Alto: City of Palo Alto and Palo Alto Chamber of Commerce and Civic Association, 1959).
[306] El Palo Alto now grows in .5-acre El Palo Alto Park at 117 Palo Alto Avenue, at the intersection of El Camino Real and Alma Street (City of Palo Alto website, El Palo Alto Park, http://cpau.com/depts/csd/news/details.asp?NewsID=107&TargetID=14, November 19, 2009).
[307] Palo Alto, Department of Public Works, Parks & Open Space Division, *The Palo Alto Street Tree Management Plan 1982* (Palo Alto: Public Works, 1982), 5-7. The plan was published in 1982 and approved by City Council on May 23, 1983.

filter dust, and make the air fresher because the leaves actually exhale moisture and oxygen. Welcome summer tunnels of shade soften the glare on pavings. Leaf green rests the eyes. Trees veil many a house or building from critical scrutiny—"the most therapeutic antidote to a city's appearance problems," as one architect has said.[308]



Figure 4.1. Tree-lined street, Palo Alto. *Source:* Canopy.org Flickr Set, http://farm3.static.flickr.com/2363/2074487628_952eebd829.jpg (July 3, 2010), used with permission.

In the 1976 edition of the book, the majority of the text was devoted to walking tours and a tree compendium. The book opened with a quote about the value of the Palo Alto's trees though the list of "practical virtues" is limited:

> *One's first impression of Palo Alto is of the size, variety, verdure of our trees, bestowing upon us their beauty of form and leaf and blossom, their varied fruit and protecting shade* (see Figure 4.1).[309]

Prior to the publication of the 1982 Street Tree Management Plan, few municipal policies dealt with street trees. With assistance from W.P.A. workers, the city completed a survey of its street trees in 1932. A Federal Housing Authority (FHA) ruling in 1946 mandated the planting of one tree per lot; this mandate "added approximately 2,000 trees per year to the

[308] Palo Alto and Palo Alto Chamber of Commerce and Civic Association, *Trees of Palo Alto*, unpaginated.
[309] Palo Alto, *Trees of Palo Alto* (Palo Alto: City of Palo Alto, 1976), 1.

City's streets as the southern area of Palo Alto was developed."[310] In 1950 the city created an approved species list. The 1973 General Plan did not mention street trees and ecosystem services such as air quality improvement, wildlife habitat, and water and soil conservation were linked to "large areas of non-urban development."[311] The Environmental Resources Element of the plan addressed the role of tree planting in ameliorating air quality, but there was no explicit mention of street trees. The tree planting mentioned could be referring to afforestation of "natural areas," for example.[312]



Figure 4.2 Palo Alto's Open Space Use: Urban Lands and Baylands. *Source:* City of Palo Alto, Comprehensive Plan, Open Space Element, 1972.

[310] Palo Alto, *The Palo Alto Street Tree Management Plan 1982*, 6.
[311] Palo Alto, Department of Planning and Community Environment, *Palo Alto General Plan 1973* (Palo Alto: Planning Department, 1973), 8.
[312] Palo Alto, *Palo Alto General Plan 1973*.

In the 1972 Open Space (OS) Element, "ecologically significant" areas were defined as "unusual, specific, resource-oriented open space areas such as wildlife sanctuaries, geysers, waterfalls, wetlands, and sand dunes," after HUD.[313] Two major thoroughfares or boulevards were designated as ecologically significant areas: the Bayshore Freeway and Oregon Avenue (Figure 4.2). In addition to major thoroughfares/boulevards, the OS Element contained a list of categories of open space such as the Baylands, Foothills, Stanford Lands; District Parks, Neighborhood Parks, Special Facilities, School District Sites, Other Public Uses, Institutions; Large Private Development Lands, Streams and Channels; University Ave Business District, California Ave Business District, Small Scale Private Lands; and Lawn Bowling Green. Each of these open spaces was categorized by scenic qualities and "degree of ecological fragility."[314] While parks were classified as having a minimal to moderate degree of ecological fragility and providing such ecological functions as erosion control, photosynthesis, wildlife habitat, and reoxygenation, road rights-of-way were classified as exhibiting low to severe ecological fragility and providing no ecological functions.[315]

The 1977-1990 Comprehensive Plan addressed the role of street trees in Palo Alto, from an urban design perspective. Policies 3 (Trafficways) and 4 of the Urban Design Element defined the role of street trees as promoting "visual continuity,"[316] making "El Camino a more attractive part of Palo Alto,"[317] and enhancing gateways.[318] The Environmental Resources Element of the Plan identified "planting and landscaping" as a noise pollution reduction strategy and Air Quality Policy 9 identified a role for trees and other vegetation in mitigating pollution from stationary and vehicular sources.

> *Landscaping, and plantings of trees, shrubs, and ground cover next to emission sources will mix, filter, and disperse pollutants, reducing subsequent human exposure.*[319]

Published in 1981, the 1980-1995 Comprehensive Plan reiterated the same role for trees as outlined in the 1977-1990 Plan.

The Palo Alto Tree Advisory Task Force was convened in 1981 to draft a street tree management plan to address three conditions related to structure (versus function) of Palo Alto's street tree canopy: (1) even-aged stands; (2) monocultures; and (3) species selection. Composed of residents "with expertise in landscape architecture, horticulture, and related subjects" and city maintenance staff,[320] the task force developed five goals to improve existing conditions. A tree canopy density of "continuous cover of tree foliage over a

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[313] Palo Alto, Department of Planning and Community Environment, *Palo Alto Comprehensive Plan, Open Space Element 1972* (Palo Alto: Planning Department, 1972), 6.
[314] Palo Alto, *Palo Alto Comprehensive Plan, Open Space Element 1972,* A1-A30.
[315] Ibid.
[316] Alto, Department of Planning and Community Environment, *Palo Alto Comprehensive Plan 1977-1990* (Palo Alto: Planning Department, 1976), 38, http://www.cityofpaloalto.org (November 9, 2009).
[317] Palo Alto, *Palo Alto Comprehensive Plan 1977-1990*, 40.
[318] Palo Alto, *Palo Alto Comprehensive Plan 1977-1990*, 41.
[319] Palo Alto, *Palo Alto Comprehensive Plan 1977-1990*, 51.
[320] Palo Alto, *The Palo Alto Street Tree Management Plan 1982*, 9.

minimum of 50% of an [sic] single, lineal block on both sides within the public right-of-way" (including private property trees that "extend into the public right-of-way").[321] The only indication that tree canopy was related to benefits (of any kind) was the following line: "for the general benefit it provides."[322] Solar access, species selection, replacement criteria, and public education and involvement were goals two through five, respectively. Plant physiology (tree characteristics and environmental tolerances) was the driving factor in developing the authorized list of species. Public meetings during the management planning process satisfied the public input goal. Public involvement could be satisfied by encouraging residents to plant and water young trees and to monitor certain species for insects and diseases.[323]

The Street Tree Management Plan was published in 1982 and approved by City Council in 1983. Although not mentioned throughout the plan, the benefits of street trees are outlined in the plan's Introduction. Trees provide "protection from climate," specifically shade from summer heat, barrier to wind, and diffusion and absorption of rain; "environmental" benefits such as oxygen provision, "humidifies our dry summer climate," trap dust and pollutants, provide wildlife habitat; and "fill our physical environment with life and beauty," and "reduce the stress of modern living."[324]

4.3 Municipally-led planning of the ecological street tree, 1993-2009

By 1993, the city had convened another tree task force "in response to citizen concern about Palo Alto's deteriorating urban forest."[325] The "rampant re-use of land" in the 1980s and 1990s was the perceived cause of the deterioration of the city's urban forest.[326] Residential redevelopment in Palo Alto involved the removal of everything on site (including mature trees and top soil) and the construction of large houses on 50-foot wide by 100-foot long lots. This approach severely limited growing space for trees.[327]

> *One of the things that was [sic] occurring in Palo Alto was that the residents began to see changes occurring that were that they didn't like. In one sense they saw an erosion of the character of the city whether it was old trees being taken out to facilitate larger homes going in. Whether it was tasteful or not was almost secondary to the fact that these large trees were being removed and they were asking questions like 'Maybe they didn't have to be removed' but the bottom line is there was a concern that the city urban forest was not being taken care of to the level that they wanted to see it taken care of.*[328]

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[321] Ibid.
[322] Ibid.
[323] Palo Alto, *The Palo Alto Street Tree Management Plan 1982*, 15.
[324] Palo Alto, *The Palo Alto Street Tree Management Plan 1982*, 3-4.
[325] Canopy website, History, http://www.canopy.org/history.html (November 9, 2009).
[326] PA3, personal interview, June 16, 2009.
[327] Ibid.
[328] Ibid.

At the end of a two-year study, the 1993 Tree Task Force made five recommendations. One recommendation was the placement of an arborist in the Planning Department to complement the Public Works arborist who dealt with publicly-owned trees.[329] The establishment of a Planning Arborist position was part of the larger recommendation to develop a Tree Preservation Ordinance.[330] Two of the recommendations dealt with a tree planting goal of 1,200 trees annually for 10 years and a 5-year tree trimming cycle. Two more recommendations dealt with the formation of an urban forest nonprofit. The nonprofit was "to maintain the increased number of trees and provide additional tree services" and to be partly funded by electricity revenues (the City of Palo Alto owns its own electricity utility).[331]

The 1997 Tree Preservation Ordinance (Chapter 8 of the Palo Alto Municipal Code) is defined as the "primary regulatory tool to provide for orderly protection of specified trees, to protect property values and to avoid significant negative impacts on adjacent properties"[332] and identified three classes of trees eligible for protection: (1) Protected Trees such as coast live and valley oaks with a minimum diameter of 11.5 inches, coast redwoods with a minimum diameter of 18 inches, and heritage trees or individual trees with "distinctive characteristics" located on private property; (2) Street Trees; and (3) Designated Trees or public or private trees associated with a development project designated for preservation by the City. Although the city's definition of the ordinance does not address the provision of ecosystem services, Section 8.10 provided specific reasons for preservation including ecological ones: (1) aesthetic and scenic beauty; (2) quality development; (3) environment of the city; (4) air pollution improvement; (5) reduce wind damage; (6) shade; (7) property values; (8) noise barrier; and (9) absorption of rainwater.[333]

One year after the passage of the Tree Preservation Ordinance, the city adopted its 1998 Comprehensive Plan. Of the seven elements in the plan, only the Natural Environment Element mentioned street trees or the urban forest and defined the urban forest in Goal N-3 (A Thriving "Urban Forest" that Provides Ecological, Economic, and Aesthetic Benefits for Palo Alto).

> *The "urban forest" is comprised of the street tree system, trees on parks and other public lands, and trees on private properties and in yards throughout the City. It functions as an extension of the woodland and grassland plant communities in the foothills and provides a "bridge" for wildlife between the foothills and the Bay. The urban forest is most established in the older parts of the City, where mature street trees provide a dense canopy. In addition to its biological benefits, the investment in Palo Alto's urban forest has provided a significant return by creating appealing streets and resulting higher property values.…The urban forest does not include trees*

[329] PA3, personal interview, June 16, 2009; City of Palo Alto website, About Palo Alto's Urban Forestry Program, http://www.cityofpaloalto.org (November 9, 2009).
[330] Palo Alto, Department of Planning and Community Environment, *Palo Alto Comprehensive Plan, Natural Environment Element 1998* (Palo Alto: Planning Department). http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=8176 (July 27, 2010).
[331] Ibid.
[332] City of Palo Alto website, Development and Trees, http://www.cityofpaloalto.org/environment/news/details.asp?NewsID=180&TargetID=64 (November 9, 2009).
[333] City of Palo Alto Municipal Code, http://www.amlegal.com/library/ca/paloalto.shtml (July 15, 2010).

> *contained in Palo Alto's open space lands (including Foothills Park and the Arastradero Preserve).*[334]

The plan did not detail the ecological services provided by street trees or strategies for capturing such services. The 50 percent canopy goal, first seen in the 1982 Street Tree Management Plan, is reiterated in the Comprehensive Plan but is not linked to ecosystem services. It is simply recommended as one of two strategic objectives to "protect, revitalize, and expand Palo Alto's urban forest" (Policy N-14).[335]

The late 1990s through the 2000s was a period of city policy-making targeting street trees. The Tree Technical Manual, a guide to Palo Alto's tree standards and specifications, was published in 2001. In the discussion of its purpose, the manual mentions the environmental services provided by trees though not in great detail (either in the Introduction or elsewhere in the manual).

> *The City of Palo Alto is endowed with a large population of trees, including magnificent individual trees, groupings of trees, native oaks, redwoods and heritage trees which give the City a unique visual character. Trees are a source of shade, air conditioning and other environmental benefits, and yield both a high quality of life and economic benefits to the community, including enhanced property values.*[336]

While the city released its first Sustainability Policy in 2001, the document does not specifically mention street trees or the urban forest. However, its elaboration in the 2009 Sustainability Background Report, drafted as part of the 2020 Comprehensive Plan Amendment, offered two local, tree-based strategies that are helping Palo Alto achieve environmental sustainability. The first, at the municipal level, is the Tree Preservation Ordinance. Although the ordinance was designed "to protect specified tree species and property values, as well as to prevent significant adverse impacts to adjacent properties," at its heart, it does prohibit removal of certain classes of trees such as street trees.[337] The second strategy listed is Canopy's work; the organization's advocacy "for the health of the urban forest" and its related programs were offered as nonprofit contribution to sustainability.[338]

A significant push for sustainability occurred in 2005 with then Mayor Kleinberg's signing of the 2005 U.S. Conference of Mayors Climate Protection Agreement. The agreement is a commitment by participating mayors to address climate change locally and to advocate for climate protection legislation at state and federal levels.[339] The following year, in 2006, Mayor Kleinberg established a Green Ribbon Task Force "to recommend tangible steps and

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[334] Palo Alto, *Palo Alto Comprehensive Plan, Natural Environment Element 1998*, N-9 – N-10.
[335] Palo Alto, *Palo Alto Comprehensive Plan, Natural Environment Element 1998*, N-10.
[336] Palo Alto, Department of Planning and Community Environment, *Palo Alto Tree Technical Manual 2001* (Palo Alto: Planning Department, 2001), xi.
[337] Design, Community & Environment, *Palo Alto Sustainability Background Report July 21, 2009* (Berkeley, CA: DC&E, 2009), 22, http://www.paloaltocompplan2020.org/files/file/Documents/_SustBkgrdRpt.pdf (November 9, 2009). Protected trees can be removed if "certain criteria are met."
[338] Design, Community & Environment, *Palo Alto Sustainability Background Report July 21, 2009*, 29.
[339] U.S. Conference of Mayors Climate Protection Agreement, http://www.usmayors.org/climateprotection/agreement.htm (June 8, 2010).

local actions by all stakeholder groups, including the city, to reduce global warming and encourage sustainable practices."[340] Also in 2006, Mayor Kleinberg delivered her State of the City Address which called for the identification of best management practices for climate protection. (On September 27, 2006, California passed AB32, the California Global Warming Solutions Act.) In 2007, the City Council identified its four top priorities as Prevention and Preparedness, Library Plan/Public Safety Building, Global Climate Protection, and Sustainable Budget.[341] In 2008, the Council's top four priorities were Library/Public Safety Building, Environmental Protection, Civic Engagement, and Economic Health.[342] In 2009, the Council identified three top priorities: Economic Health of the City, Civic Engagement for the Common Good, and Environmental Protection.[343]

The Palo Alto City Council began using the SEE-IT program in 2009 to track the completion of actions related to its top priorities.[344] Nine strategies were defined to meet the Environmental Protection priority: Climate Protection, Energy, Zero Waste, Green Building, Land Use, Parks & Open Space, Transportation, Water Conservation and Quality, and Green Purchasing. A Healthy Urban Forest is one of four actions selected to achieve Climate Protection. Unlike other actions, A Healthy Urban Forest does not have a scorecard or benchmarks. This action would be a logical strategy to meet other goals such as energy conservation and water conservation and quality. However, the urban forest is not identified as an action for these environmental protection strategies. Actions to achieve energy conservation are technology driven such as photovoltaic and related technologies and purchasing renewable energy.[345] Stormwater runoff reduction was identified as an action to achieve water conservation and quality but the urban forest was not listed as a runoff reduction measure (permeable pavement, rain barrels, cisterns, and green roofs were recommended).[346] Despite the lack of a scorecard or benchmark for the urban forest in the SEE-IT program or an elaboration of benefits in the Comprehensive Plan, inclusion of the urban forest in these policy documents and initiatives is significant. As one participant noted:

> *It's a really big successful tact [sic] you might say to be able to cite the Comprehensive Plan, City Council, and the city manager. Puts things in perspective where it needs perspective because often part of our big battlegrounds people can see the urban forest as this esoteric, pretty, touchy-feely green thing out there. 'It's nice but it's not essential. It's not part of the infrastructure.' And we're changing that paradigm. We're reframing it saying, 'No, trees are part of the infrastructure because the services they provide are hard-core monetary benefits.' So that I think in urban*

[340] City of Palo Alto, State of the City Address, Mayor Judy Kleinberg, March 27, 2006, http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=3577 (November 10, 2009).
[341] City of Palo Alto website, City Council's Top Priorities, http://www.cityofpaloalto.org/knowzone/news/details.asp?NewsID=625&TargetID=58 (November 10, 2009).
[342] City of Palo Alto website, City Council's Top Priorities.
[343] Ibid.
[344] City of Palo Alto website, SEE-IT, http://www.cityofpaloalto.org/depts/cou/see_it.asp (November 10, 2009).
[345] City of Palo Alto website, SEE-IT. The City of Palo Alto Utilities operates its own utilities http://www.cityofpaloalto.org/depts/utl/default.asp (July 27, 2010).
[346] City of Palo Alto website, SEE-IT.

forestry nationwide that's a new paradigm that is starting to take foot…that is a very popular newer strategy and it's really working too.[347]

4.4 Nonprofit-led mainstreaming of the ecological street tree

Nonprofit projects and activities

The concept of the urban forest as part of the city's infrastructure is recognized by Palo Alto's urban forest nonprofit, Canopy.

We forget this huge utility of the city and we need to bring it to the forefront.[348]

Canopy is developing an advocacy campaign to this end. From the organization's 2008 Annual Report:

Street tree plantings were once thought of as "beautification projects." But with 80% of our country's population living in urban settings like the Bay Area, we now plant for another reason—trees are as vital to a city's infrastructure as water, roads, and electricity.[349]

To protect this green infrastructure, Canopy has spoken against the use of recycled water in irrigating the city's trees as part of the City of Palo Alto Recycled Water Project.[350] (California's Recycled Water Policy requires municipalities to use recycled water in lieu of potable for landscape irrigation purposes.[351]) Canopy and others have argued that the chemical composition of recycled water, specifically its salt content, will damage the city's urban forest. In its advocacy with the city, Canopy frames the urban forest as a utility.

It's a utility so this is one thing we talk about more now. Not just the beauty and the value of the asset in itself but also the value of the ecosystem services that are brought to our community year after year after year.[352]

This framing of the urban forest was included in the organization's comment on the City of Palo Alto Recycled Water Project Initial Study Mitigated Negative Declaration.

Once an assessment of the value of these trees and the annual value of their benefits is made then the City will be in a better position to make a decision on whether the

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[347] PA3, personal interview, June 16, 2009.
[348] PA1, personal interview, June 16, 2009.
[349] Canopy, *Annual Report November 2008* (Palo Alto: Canopy, 2008), 2, http://www.canopy.org/Canopy_Report_2008.pdf (November 9, 2009).
[350] City of Palo Alto Recycled Water Project, http://www.cityofpaloalto.org (November 10, 2009)
[351] California. Environmental Protection Agency, State Water Resources Control Board. *Recycled Water Policy*. Sacramento: SWRCB, 2009. http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf (July 15, 2010).
[352] PA1, personal interview, June 16, 2009.

community is willing to take the risk of losing part of this asset and yearly payback it provides.[353]



Figure 4.3. East Palo Alto Tree Initiative. *Source:* Canopy.org Flickr Set, http://farm4.static.flickr.com/3180/3024925351_2cfc64dbb6.jpg (July 3, 2010), used with permission.

Canopy has been involved in other programs and activities that mainstreamed the ecological street tree. With funding from California ReLeaf and the California Department of Forestry and Fire Protection, Canopy co-developed the East Palo Alto Tree Initiative (EPA-TI) in 2006 to plant 1,000 trees along East and West Bayshore, the roads that run parallel to the 1010 Freeway (Figure 4.3).[354] The rationale for the EPA-TI was "not only are trees beautiful, they fight global warming and create a cleaner and more livable environment."[355] More specific reasons were offered such as carbon sequestration, air pollution removal, energy savings, stormwater management, and community building. The role of these trees in air quality

[353] RMC Water and Environment, City of Palo Alto Recycled Water Project Response to Comments, dated May 2009, http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=15979 (November 10, 2009).
[354] California ReLeaf, *Annual Report 2006* (Sacramento: California ReLeaf, 2006). http://www.californiareleaf.org/documents/2006AnnualReport.pdf (November 12, 2009); Canopy website, East Palo Alto Tree Initiative, http://www.canopy.org/pages/programs/tree-planting/east-palo-alto-tree-initiative.php (November 10, 2009).
[355] Canopy website, East Palo Alto Tree Initiative.

improvement was reiterated in an interview with the organization, albeit with a public health/ environmental justice bent:

> *I think something that gets kind of overlooked here because we're not on the Top 10 cities for bad air quality is that we do have big air quality issues here too in the Bay Area. We don't have the best air quality. The City of East Palo Alto, for example, has the highest rate for the hospitalization of asthma in the entire Bay Area. It's a way for us to say, you know, we've planted 1,000 trees along the 101 sound wall. The 101 borders this entire city and people are suffering from asthma over there due to the pollution.*[356]

The kick-off of the EPA-TI was attended by Nobel Laureate and founder of the Green Belt Movement, Wangari Maathai.[357] At the event, Maathai underscored the climate protection service provided by the urban forest when she challenged attendees to plant ten trees to offset their individual carbon footprint.[358]

Nonprofit policy and planning documents

Canopy has been involved in two planning efforts. Recognizing "the need for years to update that 82 plan" and a desire on the City Manager's part for a plan to "oversee all the tree management strategies in the city,"[359] a taskforce, with direction from the City Council, was convened to draft an update of the 1982 Street Tree Management Plan and create an Urban Forest Master Plan.[360] (Canopy offered to lead the drafting of the Urban Forest Master Plan but the City decided to take the lead.[361]) Two California Department of Forestry and Fire Protection grants were sought to update the management plan and to conduct a street tree inventory. The city's grant applications were selected for funding but were postponed due to state-level budget cuts in 2008-2009.[362] (Funding was released to Palo Alto in 2010.[363])

The proposed update to the management plan was adopted by City Council on Earth Day 2006; it was one of several environmental recommendations recommended to the Council.[364] The mission of the management plan working group was to "manage the City's urban forest to maximize sustainable outcomes for the community," but other than a reference to the

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[356] PA2, personal interview, June 16, 2009.
[357] The Green Belt Movement website, http://greenbeltmovement.org (November 10, 2009).
[358] Canopy, Canopy (Fall 2006).
[359] PA3, personal interview, June 16, 2009.
[360] City of Palo Alto website, Letter from City Manager to the City Council, "Adoption of Two Resolutions Supporting the City's Application for Funding from the Urban Forestry Grant Program Entitled "An Urban Forest For Every City," as provided through Propositions 40 And 84, For (1) An Urban Forestry Management Plan Grant And (2) An Urban Forestry Inventory Grant," dated March 10, 2008, http://www.cityofpaloalto.org (November 10, 2009); PA1 interview follow-up, email communication, July 9, 2010.
[361] PA1, personal interview, June 16, 2009; PA1 interview follow-up, email communication, July 9, 2010.
[362] Ibid.
[363] Canopy, TreE-NEWS (March 31, 2010).
[364] City of Palo Alto website, Letter from City Manager to the City Council, "Progress Report on Urban Forest Master Plan Development," dated January 22, 2007, http://www.cityofpaloalto.org (November 12, 2009).

update's consistency with the Comprehensive Plan's Goal N-3 (A Thriving "Urban Forest" that provides Ecological, Economic, and Aesthetic Benefits for Palo Alto), there is no discussion about the ecosystem functions of street trees.[365] The discussion was technical, oriented towards the "nuts and bolts" of an urban forestry program: community education, species selection, GIS-based integrated tree inventory, and a resource website.[366]

Canopy and the City have been more successful developing a recommended/approved species list.[367] The primary selection criteria for species are water needs and "tolerance" of reclaimed water irrigation. The updated recommended species list will be used as a water conservation policy tool. The water issue was framed this way:

> *I think that in today's environment, you know all the different environmental issues that are coming up with today's…political front, I don't think it's political, I think it's a real thought. Hetch Hetchy. Our population's getting bigger and if we didn't have global warming, we obviously [would] have another… tax on the water we have here in California. So to think about having a drought tolerant landscape is a very wise move. So yeah, we do have an eye on trying to identify as many drought tolerant species as we can and to recommend [them]…and to integrate those into our landscape….*[368]

In terms of in-house publications, there are several venues through which Canopy mainstreamed the ecological street tree. One is its funders appeal (Figure 4.4). The 2008 appeal was offered as an example of the organization's highlighting of the environmental benefits of the urban forest, though this approach was resisted by some board members.[369] The effort was perceived as risky and unproven. In several "call-outs" in its 2008 Annual Report, Canopy provided numeric values of the environmental benefits of the city's urban forest:

> *Palo Alto's urban forest neutralizes the CO_2 emissions of about 2,000 cars a year.*[370]
>
> *Palo Alto street and park trees can intercept 135 million gallons of rainwater. Less runoff reduces flooding, decreases water pollution going into the Bay and prevents further damage to the banks of the San Francisquito Creek.*[371]
>
> *Palo Alto's lush canopy ensures that summer temperatures are at least 6 to 8 degrees lower than in comparable neighborhoods without trees.*[372]

These values are estimates rather than Palo Alto-specific scientific data. A study of the functions of Palo Alto's urban forest has not been conducted.

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[365] Letter from City Manager to the City Council, "Progress Report on Urban Forest Master Plan Development."
[366] Ibid.
[367] PA1, personal interview, June 16, 2009; PA4 interview, June 16, 2009.
[368] PA4 interview, June 16, 2009.
[369] PA1, personal interview, June 16, 2009.
[370] Canopy, *Annual Report November 2008* (Palo Alto: Canopy, 2008), 4, http://www.canopy.org/Canopy_Report_2008.pdf (November 9, 2009).
[371] Canopy, *Annual Report November* 2008, 6.
[372] Canopy, *Annual Report November* 2008, 7.



Figure 4.4 Canopy 2008 Funders Appeal. *Source:* Canopy.

The Center for Urban Forest Research (CUFR) completed a regional-level analysis of the urban forest – San Francisco Bay Area State of the Urban Forest Final Report – in 2007.[373] The study relied on canopy cover taken from satellite imagery, not on tree inventories. Canopy would like a Street Tree Resource Analysis Tool for Urban Forest Managers (STRATUM) analysis of Palo Alto which requires a street tree inventory (recall that funding for an inventory was only made available in 2010). A Canopy participant recalled the first time she learned about STRATUM and CUFR's planned Bay Area analysis:

> *I thought, 'Oh my gosh, we had better latch on those guys. This is what this organization Canopy should do.' I had already noticed that Canopy's work was not based on a lot of scientific data or hard fact…. [I was] attuned to STRATUM at the very beginning.*[374]

In addition to the funders appeal, Canopy uses an electronic newsletter service to email its Canopy TreE-NEWS. The e-newsletter is used to recruit volunteers; to share stories about the environment, the urban forest, or tree care tips; and to calendar upcoming events.[375] Recently, the organization used the e-newsletter to communicate with subscribers about the premature and wholesale removal of 63 holly oaks that lined California Avenue.

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[373] James R. Simpson and E. Gregory McPherson, *San Francisco Bay Area State of the Urban Forest Final Report December 2007* (Center for Urban Forest Research, U.S.D.A. Forest Service, Pacific Southwest Research Station, 2007), http://www.fs.fed.us/psw/programs/cufr/products/2/psw_cufr719_SFBay.pdf (November 10, 2009).

[374] PA1, personal interview, June 16, 2009.
[375] PA2, personal interview, June 16, 2009.

Trends in the "Canopy" newsletter

Canopy also publishes a print newsletter – "Canopy" – which is available online. The organization is required to produce three issues annually in its contract with the City of Palo Alto. Canopy acknowledged that the newsletter is expensive to produce and is seeking an amendment to its contract with city that would allow it to produce a minimum of two issues per year.[376] When asked about the role of the newsletter in providing information about the ecosystem functions of street trees, organizational representatives revealed that Canopy has not "been particularly deliberate about the decision process."[377] Sharing stories about its programs is ranked higher than sharing the research of the Center for Urban Forest Research.[378] Canopy "doesn't know if the Center for Urban Forest Research's research in newsletters is what's needed" for the nonprofit.[379] Despite these revelations, the regression performed on the organization's newsletters show that the ecological characterization of street trees has increased and that this increase is significant (Figure 4.5) and participants corroborated this evolution in the framing of street trees.

Table 4.1
Palo Alto: Individual Services that Significantly Increased between 1980 and 2008

Service	Significant rise in Palo Alto
Air quality improvement	✔
Carbon storage and sequestration	
Energy conservation and efficiency	
Stormwater runoff management	✔ (weaker)
Wildlife habitat	

Source: Canopy newsletters (see Table 2.2).

[376] PA1, personal interview, June 16, 2009.
[377] Ibid.
[378] PA2, personal interview, June 16, 2009.
[379] PA1, personal interview, June 16, 2009.

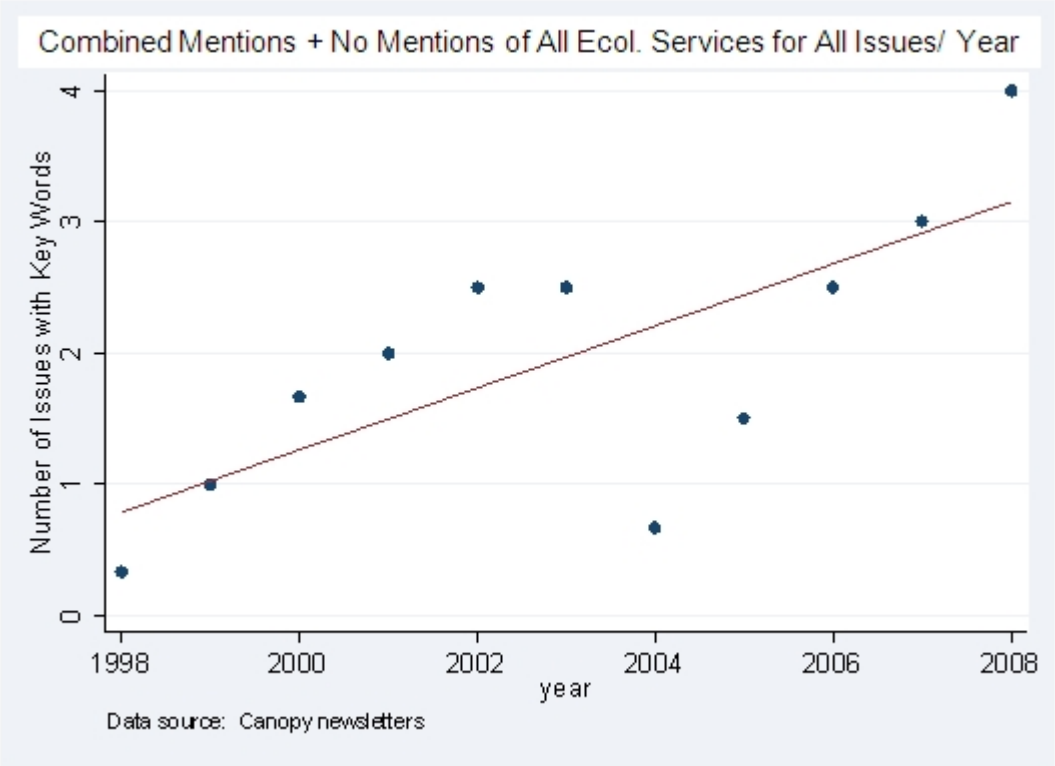

Figure 4.5 Trend in the overall ecological characterization of street trees in the "Canopy" newsletter.

The individual service that significantly increased during the study period is air quality improvement (Table 4.1). In a discussion about the regression analysis of individual services (Figure 4.5), a participant responded,

> *I would never have thought that in the beginning they would have talked about energy the most….It seems totally contrary to what I thought, at least in the newsletter. The newsletter is not the only way we communicate. Certainly, I thought we were doing a much better job here than here* [referring to spikes in the 1990s versus those in the 2000s].[380]

[380] PA1, personal interview, June 16, 2009. Figure 4.4 was not shown during the interview; it would have better represented the spikes in the mentions of individual services. Instead, the scaled graph was shown; this graph dampens the effect of the spikes.

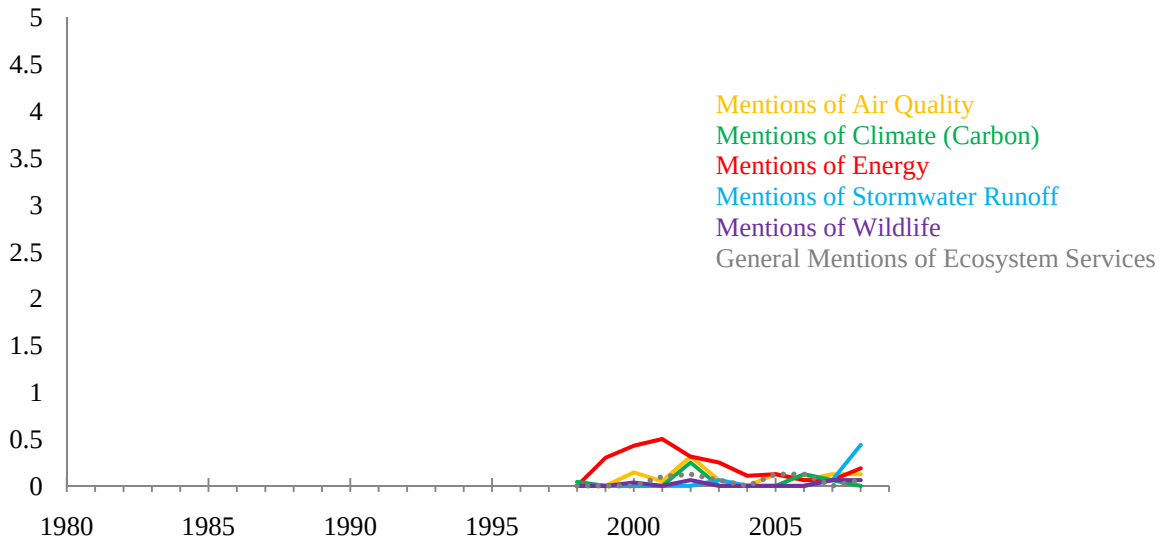

Figure 4.6 Number of mentions of each ecosystem service per issue weighted by the number of pages per issue (scaled to the mentions in the Sacramento Tree Foundation and Friends of the Urban Forest newsletters). *Source:* Canopy's newsletters, 1998-2008 (see Table 2.2).

Canopy's newsletter is not the organization's only mode of communication.

> *I think we are at a time when we are thinking, we are going to start thinking more about the newsletter and the role it plays in the landscape of the other communications that we have.*[381]

The organization communicates the environmental functions of the urban forest, for example, through its school programs (and through its advocacy with the city). However, it "looks like we don't talk that much about it in the newsletter" at least based on the finding that only one ecosystem service – air quality – contributed to the positive and significant trend seen in Figure 4.5.[382]

[381] PA1, personal interview, June 16, 2009.
[382] Ibid.

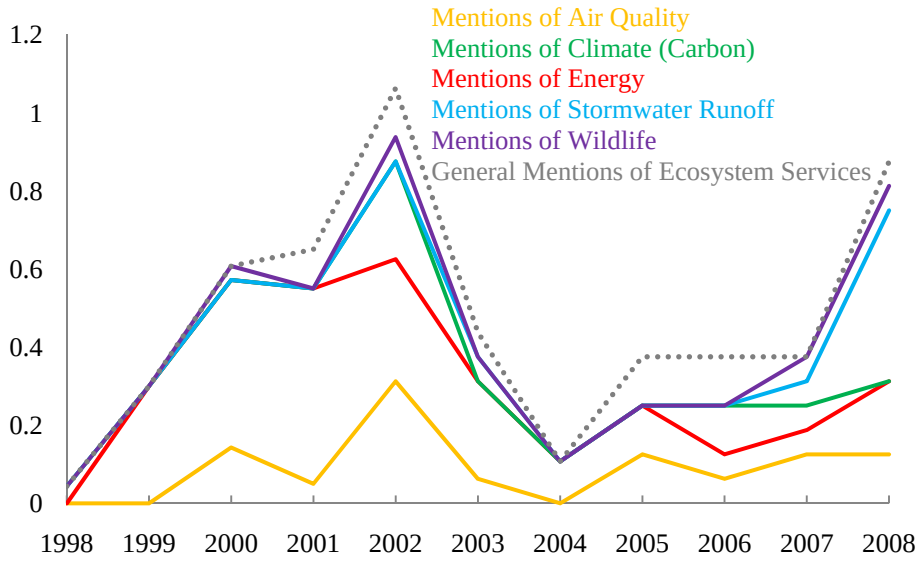

Figure 4.7 Number of mentions of each ecosystem service per issue weighted by the number of pages per issue (not scaled to findings from other cities). *Source:* Canopy's newsletters, 1998-2008 (see Table 2.2).

Figure 4.7 was not shown during the interview; instead, the scaled graph (Figure 4.6) was shown. Figure 4.4 dampens the effect of the spikes while Figure 4.5 more clearly illustrates the spikes in the mentions of individual services and shows two distinct periods of mentions separated by the year 2004. These periods can be defined by staff changes at Canopy. During the period 1998 to 2000, the program director contributed "much more technical articles about tree care [and] tree species"[383] but attention was also paid to issues of climate change,[384] energy efficiency,[385] habitat,[386] and urban heat islands.[387] Canopy had a different program director between 2000 and 2002 and a new executive director took leadership of the organization in the fall of 2004. These staff changes could explain the rise in mentions of ecosystem services before and after 2004. In addition to staff changes, special articles contributed to large spikes in mentions of services. The large spike in 2002 was a result of the article, "Trees Fight Crime and Do Other Wonderful Things," in which the multiple benefits of Palo Alto's urban forest were outlined.[388] Similarly, in 2008, a special article about watersheds outlined the hydrological and other benefits of the city's urban forest.[389]

4.5 Knowledge production and dissemination: The Center for Urban Forest Research

Environmental benefits of trees were detailed in the spring 2002 issue (as well as in the winter 2008 issue) of "Canopy." For example, "An acre of trees absorbs as much carbon dioxide as

[383] Ibid.
[384] For example, in Canopy, Canopy (Autumn 1998).
[385] For example, in Canopy, Canopy (Winter 1999-2000).
[386] For example, in Canopy, Canopy (Autumn 2000).
[387] For example, in Canopy, Canopy (Winter 2000-2001).
[388] Canopy, Canopy (Spring 2002).
[389] Canopy, Canopy (Winter 2008).

a car produces in 26,000 miles" or "a single tree can produce the cooling effect of 10 room-size air conditioners operating 20 hours a day," but these data are not specific to trees in Palo Alto. The Center for Urban Forest Research (CUFR) has not conducted an ecosystem structure and function analyses of Palo Alto as it has of Sacramento. The most specific information about the ecosystem functions of Palo Alto's urban forest is available at the county level (Santa Clara) and was published in CUFR's 2007 San Francisco Bay Area State of the Urban Forest Final Report.[390]

Both the City of Palo Alto and Canopy would like an ecosystem analysis of Palo Alto's urban forest conducted.[391] Both institutions spoke of the significance of the scientific research produced by the Center and others in advancing urban forestry. An interview participant remarked,

> *When Canopy was founded, and until I joined the organization, what Canopy was talking about was how beautiful the trees were and how special Palo Alto was for having all these trees and that was basically it. There was very little…the benefits of trees – environmental, economic, psychological benefits of trees – but it was not really embraced and it was not something that people would talk about very much. Mostly 'look how beautiful' and 'we can't live without them' and things like this. And I think several things have happened. One of those things is that the research in urban forestry has started really putting numbers on those benefits and have [sic] allowed us to communicate those more, better.*[392]

Another participant commented on the role of CUFR:

> *The legwork that they [CUFR] have done to actually quantify to an economic basis is absolutely critical to all of this so we can actually boil it all down and say 'Trees give back two bucks for every one buck spent. After all of everybody's salaries are paid for, all of this $2M budget is done, trees give back twice'…twice the benefit. And that can only be verified by virtue of the urban forest research station. What they have done is absolutely probably the biggest paradigm shift, the biggest shift, leapfrog in urban forestry….I consider the biggest advance in urban forestry in a hundred years is because of UFORE [Urban Forest Effects Model] because they've been able to quantify what we've all known and felt in our gut for years and years the benefits of these trees. But now the stormwater management aspects, flooding, all of the benefits, long-term benefits can be quantified. It's absolutely huge.*[393]

The Center for Urban Forest Research is not the only resource for those making claims about the ecological legitimacy of street trees. Canopy celebrated Arbor Day 2004 by co-sponsoring with the City a presentation by Kathleen L. Wolf, Ph.D., research director of Human Dimensions of Urban Forestry and Urban Greening at the University of

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[390] Simpson and McPherson, *San Francisco Bay Area State of the Urban Forest Final Report, December 2007*.
[391] STRATUM or Street Tree Resource Analysis Tool for Urban Forest Managers was developed by CUFR; UFORE or Urban Forest Effects Model was developed by the Northern Research Station in Syracuse, New York.
[392] PA1, personal interview, June 16, 2009.
[393] PA3, personal interview, June 16, 2009.

Washington.[394] The talk, titled "Does Money Really Grow on Trees?: Economics of Urban Forest Benefits," provided several case studies of the monetary costs and benefits of city tree canopy. The benefits most pertinent to Palo Alto are discussed in the next section.

4.6 Palo Alto's ecosystem services geography

The regression analysis of 25 issues of Canopy's newsletter revealed a positive and significant trend in the ecological characterization of the street tree (Figure 4.5) and pointed to air quality improvement as the strongest contributing factor to this trend (Table 4.1). A review of policies and activities and interview transcripts supports this trend. Other services were highlighted as important in municipal documents and in interviews. The city has highlighted the contribution of a "healthy urban forest" to its climate protection goals vis-à-vis emissions reduction.[395] The stormwater management value of trees was also identified as a salient benefit by both city and nonprofit staff.[396] Why are these ecological values salient in Palo Alto? Air quality improvement is linked to the overlap between local geography, urban form, and driving patterns while stormwater management is linked to the presence of urbanized creeks.

Local geography, urban form, and driving patterns

Palo Alto is located in the San Francisco Bay Area which is out of compliance with national ambient air quality standards. Between 2003 and 2005, Palo Alto did not meet "state level standards for ozone and particulate matter of 10 microns or less in diameter (PM10)."[397] The same topographic features that have contributed to East Palo Alto's childhood asthma hospitalization rate that is "2.5 times higher than the [San Mateo] county average" are common to Palo Alto.[398]

> *…a low-lying area where the topography concentrates air pollutants that migrate from the East and North Bay regions, and where homes are in close proximity to Hwy.*

[394] Canopy, Canopy (Winter 2004). Wolf's presentation can be accessed at http://www.naturewithin.info/Talks/PaloAlto.pdf). The presentation was funded by California ReLeaf's 2004 Capacity-Building Grant Program and the California Department of Forestry and Fire Protection.
[395] City of Palo Alto website, SEE-IT; Palo Alto. Department of Planning and Community Environment. *Palo Alto Climate Protection Plan 2007*. Palo Alto: Planning Department, 2007, http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=9986 (December 8, 2009).
[396] PA1, personal interview, June 16, 2009; PA2, personal interview, June 16, 2009.
[397] Palo Alto, Palo Alto Public Safety Building Project Blue Ribbon Task Force, "Public Safety Building Project, Draft Environmental Impact Report, Section 5, Air Quality," in *Palo Alto Public Safety Building Project, Draft Environmental Impact Report July 11, 2007* (Palo Alto: City of Palo Alto, 2007), http://gatekeeper.city.palo-alto.ca.us/civica/filebank/blobdload.asp?BlobID=9760 (December 10, 2009).
[398] Sue Dremann, "Santa Clara County Gets an 'F' for Air Quality: American Lung Association Evaluation Pegs County in Top 25 for Dirtiest, *Palo Alto Online*, Wednesday, April 30, 2008, http://www.paloaltoonline.com/news/show_story.php?id=7898 (December 10, 2009).

> *101. And University Avenue is a main artery for traffic commuting across the Dumbarton Bridge.*[399]

Sources of air pollution include wood burning stoves and vehicle emissions. Vehicle emissions have been linked to car-oriented development and single occupant vehicle use.[400] At the county-level, between 2004 and 2006, "Santa Clara County ranked 19 out of the 25 of counties most polluted by short-term particle pollution" with the primary contributors identified as "vehicles and trucks, generated locally and also by drift from other regions."[401] The 1972 Open Space Element designated the Bayshore Freeway an ecologically significant area; in 2009, the ecological significance of one of the region's major freeways (also known as Highway 101) is debatable.[402] The other ecologically significant boulevard designated in the 1972 Open Space Element, Oregon Avenue, is a major thoroughfare in the city.

The link between climate change and other environmental factors has been made in Palo Alto. Mayor Judy Kleinberg was mayor of Palo Alto at the time of the 2005 U.S. Conference of Mayors. Mayor Kleinberg signed the Climate Protection Agreement which specified a role for urban forestry in addressing climate change.

> *Strive to meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns.*[403]

Mayor Kleinberg's involvement with the U.S. Conference of Mayors eventually led to the formation of the Green Ribbon Task Force on Climate Protection in 2006. The task force made climate protection recommendations at the end of 2006 one of which was to "use trees to save energy"[404] or as it was elaborated in the 2007 Climate Protection Plan to "employ urban forest opportunities to reduce energy use and increase carbon sequestration."[405] Of trees, the plan itself noted that

> *Palo Alto has CO2 "sinks," as well, such as City-owned trees, which can absorb CO2. Given the framework of this Plan, these sinks are not included. The City is working actively to manage its forest resources in open spaces and is currently working on a revised Urban Forestry Master Plan. Staff recommends that future reports and updates include the impact of municipal and community actions to increase biotic sinks and sequestration impacts and coordinate the Climate Protection Plan actions with those of the Urban Forestry Master Plan.*

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[399] Dremann, "Santa Clara County Gets an 'F' for Air Quality."
[400] Palo Alto, "Public Safety Building Project, Draft Environmental Impact Report, Section 5, Air Quality."
[401] Dremann, "Santa Clara County Gets an 'F' for Air Quality."
[402] Palo Alto, Department of Planning and Community Environment, *Palo Alto Comprehensive Plan, Open Space Element 1972* (Palo Alto: Planning Department, 1972).
[403] U.S. Conference of Mayors Climate Protection Agreement.
[404] Palo Alto, Mayor's Green Ribbon Task Force on Climate Protection., *Report of Mayor's Green Ribbon Task Force on Climate Protection December 18, 2006* (Palo Alto: Green Ribbon Task Force on Climate Protection, 2006), 8, http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=7478 (July 28, 2010).
[405] Palo Alto, Department of Planning and Community Environment, *Palo Alto Climate Protection Plan 2007* (Palo Alto: Planning Department, 2007), 31, http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=9986 (December 8, 2009).

Urbanized creeks

On the stormwater front, there are several creeks in Palo Alto—San Francisquito, Matadero, Adobe, Barron, Permanente, and Stevens Creek—and "flooding has been a significant issue" in the city[406] despite the fact that 40.5 percent of Palo Alto's land area is Parks/Preserves/Open Space.[407] The San Francisquito Watershed Council has identified four factors that threaten the health of the watershed: loss of riparian vegetation, channel modifications, declining flows, and stormwater runoff. Polluted runoff, and erosion and flooding due to the greater volume and rate of runoff are issues the watershed council is seeking to redress.[408]

On the other side of the coin is water conservation and while not an ecosystem service per se, it does impact trees. Water conservation has not been highlighted by Canopy because of fear that residents will stop watering trees but Palo Alto residents consume a lot of water.

> *We are one of the communities on the flat land that uses the most water per capita. And we have environmentalists on the city council, etc., so we know that this is an issue.*[409]

Strategies to capture tree-based ecosystem services in Palo Alto

Program development and activities

The strategies employed by actors in Palo Alto range from policy to demonstration projects. The most significant activity undertaken in Palo Alto to demonstrate the ecological value of street trees is the East Palo Alto Tree Initiative (EPA-TI). Another activity is the launch of a street tree inventory in June 2010.[410] A current tree inventory is a significant step towards completing an ecosystem analysis. The latter has not been conducted in Palo Alto. As a result, the "flood avoidance" value of street trees is unknown. A participant anticipates an ecosystem analysis in order to "have more numbers to support a feeling in the gut."[411]

Policies and reports

Street trees were not identified as a strategy to address water conservation and quality, one of nine strategies identified by City Council to achieve environmental protection.[412] A mayor appointed Blue Ribbon Committee recommended reducing stormwater runoff versus

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[406] PA3, personal interview, June 16, 2009.
[407] Palo Alto, Department of Planning and Community Environment, *Palo Alto Comprehensive Plan Land Use & Design Element July 17, 2007* (Palo Alto: Planning Department, 2007), http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=8170 (December 11, 2009).
[408] San Francisquito Watershed Council website, Urban Runoff Reduction, http://www.sanfrancisquito.org/runoff/index.htm (December 10, 2009).
[409] PA1, personal interview, June 16, 2009.
[410] Canopy, TreE-News (June 10, 2010).
[411] Canopy, TreE-News (June 10, 2010).

increasing storm drain capacity.[413] The resulting 2005 Storm Drain Ballot Measure provided funding for "innovative projects" including a stormwater rebate program.[414] The program, implemented in 2008-09, is not tree-oriented; rain barrels, cisterns, permeable pavement, and green roofs are eligible for the rebate.[415] The San Francisquito Watershed Council also promotes permeable surfaces (driveways, patios, walkways, etc.) and rain gardens, barrels, and disconnected downspouts.[416] None of these measures are tree-oriented. In interviews, Canopy and city staff mentioned the role of the urban forest in managing stormwater; however, this ecological value of trees has not been explicitly included in city policies.

> *I know that if we did not have the urban forest we have now the flooding would have been so much more worse [sic]. That's a hard one to sell, to convey to public works water management folks, storm drain management. To tell them, 'If we didn't have all of these street trees, our storm drains would have been peaked out a day earlier.' Right now they do a good job of holding back the flood event by I think it's the key 11 minutes.…It's not that they soak up, they stall the flood effect by a key 11 minutes. And if you can do that that allows downstream stuff in the storm drain to exit out just in time so that it doesn't flood the manhole covers. It is absolutely a key dynamic that you can stall things by just a few minutes. Key. Then you've won it all. We have so much canopy cover here, just that component alone it's worth all of the expenditure we give it every year, frankly. That is probably the most valuable.*[417]

Street trees and the urban forest have been identified as significant strategies in environmental protection. The city's recommended species list was described by municipal and nonprofit participants as an essential element to the water conservation issue.

> *Our population's getting bigger and if we didn't have global warming we [sic] obviously have another more [sic] tax on the water we have here in California. So to think about having a drought tolerant landscape is a very wise move. So yeah, we do have an eye on trying to identify as many drought tolerant species as we can and to recommend…and to integrate those into our landscape.*[418]

The city's Climate Protection Plan underscored the importance of the urban forest in emissions reduction. Another municipal policy initiative is proposed update to the 1983 Street Tree Management Plan. In FY07-08, the city of Palo Alto received an Urban Forestry

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[412] Palo Alto, SEE-IT.
[413] City of Palo Alto Stormwater Rebate Program, Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) C.3 Workshop, June 17, 2009, http://www.scvurppp-w2k.com (December 10, 2009).
[414] Palo Alto, SCVURPPP C.3 Workshop.
[415] Palo Alto, Department of Public Works, *City of Palo Alto Urban Runoff Program Annual Report 2008-2009* (Palo Alto: Public Works, 2009), http://www.cityofpaloalto.org/civica/filebank/Blobdload.asp?BlobID=8509 (December 10, 2009).
[416] San Francisquito Watershed Council website, Urban Runoff Reduction Materials and Techniques, http://www.sanfrancisquito.org/runoff/techniques/index.htm (December 11, 2009).
[417] PA3, personal interview, June 16, 2009.
[418] PA4, personal interview, June 16, 2009.

Management Plan Grant from the California Department of Forestry and Fire Protection (Cal Fire).[419] In its application, the city described the plan as

> *A road map for the effective and efficient management of the urban forest. The development of the comprehensive urban forest master plan is the key mechanism for achieving the objectives set forth for Palo Alto's urban forest. It will guide staff and the community in a way that ensures the continued health and success of the Urban Forest.*[420]

4.7 Summary

Table 4.2 Support for Research Propositions in Palo Alto

Proposition	Definition	Supported
1	The presence of an upwards trend in the ecological characterization of street trees	Yes
1a	The urban forest nonprofit played a significant role in advancing the ecological street tree	Both nonprofit and municipality played a role, neither stronger than the other.
1a1	The nonprofit's newsletter is the primary mode of communicating the ecological benefits of street trees	While analysis of its newsletters revealed a rise in the ecological framing of street trees, Canopy does not regard its newsletter as the primary method of communicating the ecosystem benefits of trees.
1b	The ecological street tree has been legitimated vis-à-vis the production of scientific research	Yes
2	Particular ecosystem services are salient in particular cities	Yes
2a	Different strategies are used by different actors to capture tree-based ecosystem services	Yes

Both municipal and nonprofit actors in Palo Alto have contributed to the emergence of the ecological street tree, but neither appears to have played a stronger role (Table 4.2). The role of scientific evidence is also a driving factor in advancing the concept of the ecological street tree. The Center for Urban Forest Research is the primary provider of scientific evidence for the ecosystem functions of street trees and urban forests. Interview participants underscored the production of research data in supporting their efforts to mainstream the ecological street trees. Finally, findings point to a geography of ecosystem services in Palo Alto; in a regression analysis of Canopy's newsletters, air quality was the most frequently mentioned ecosystem. The importance of this service was corroborated in interviews with both city and nonprofit staff. Other salient services emerged through interviews such as climate protection and stormwater runoff management.

[419] California Department of Forestry and Fire Protection (Cal Fire) –funded urban forestry projects were placed on hold due to a statewide budget crisis.
[420] California Department of Forestry and Fire Protection Northern California Projects 06-08, emailed to author, October 6, 2009.

Chapter 5:: San Francisco: "Paris of the West" without the "Champs-Elysees"

> *Unlike cities in other parts of the United States, the vegetation native to San Francisco consisted of primarily low-growing shrubs and ground covers. The ambitious goal of establishing an urban forest from scratch was set forth by the Board of Supervisors in the 1870s….Interestingly, the "Paris of the West" gave little thought to re-creating the Champs-Elysees or other Parisian boulevards with their famous, arching trees.*[421]

5.1 Overview

This chapter proceeds as follows. A history of street tree characterization based on city plans and interview transcripts is presented first. Section *1870-1955* and Section *1955-1991* tell the story of early tree planting and the development of the municipal tree division, respectively. Section *1991-2003* and Section *2003-2009* describe the process of framing the street tree in ecological terms. A discussion of the role of the Friends of the Urban Forest is presented next, then that of the Center for Urban Forest Research, and finally a description of San Francisco's geography of ecosystem services. This chapter concludes with a summary of the emergence of the ecological street tree in San Francisco.

5.2 Municipally-led planning of the ecological street tree, 1870-1955

During a 1959 visit to San Francisco, Soviet premier Nikita Khrushchev reportedly admired the city's beauty but bemoaned its lack of street trees.[422] The city's pre-incorporation landscape was not a heavily forested one (Figure 5.1).

> *Thousands upon thousands of trees comprise San Francisco's urban forest. It is important to note that few of these trees are naturally occurring. Much of San Francisco's urban forest has its origins in planting efforts from the period 1825 to 1925.*[423]

[421] San Francisco, Tree Advisory Board (TAB), *San Francisco: The State of the Urban Forest 1992* (San Francisco: City of San Francisco, 1992), 1.
[422] Michael J. Sullivan, *The Trees of San Francisco* (Petaluma, CA: Pomegranate Communications, 2004); Patricia Yollin, "Group Brings City under the Canopy," *San Francisco Chronicle*, November 19, 2006, http://articles.sfgate.com/2006-11-19/bay-area/17322020_1_urban-forest-tree-plantings (July 28, 2010).
[423] San Francisco, Department of the Environment (DoE), Urban Forestry Council, *Urban Forest Plan, City and County of San Francisco April 2006* (San Francisco: SFEnvironment, 2006), 1.



Figure 5.1 Presidio of San Francisco, 1887. This photograph was taken facing west and shows the Presidio Boulevard approach to the Post. The trees, planted in 1882 when Major General Irwin McDowell was Commander of the Western Department, today cover the hillsides. (This text was written on the back of the photograph.) *Source:* San Francisco Public Library, Presidio of San Francisco, Cal. 1887. [graphic], 1947 Mar. 12. http://sflib1.sfpl.org:82/record=b1015295~S0, November 19, 2009.

The city's historic landscape has been described as follows:

> *In 1769, when the first Spanish soldiers and missionaries set foot on the peninsula that later became San Francisco, the native vegetation consisted primarily of low-growing shrubs, grasses, and ground covers that were perfectly adapted to the area's predominantly sandy soils, maritime climate, and strong coastal winds. Oaks and willows were among the native tree species, but the few native stands of coast live oak and California buckeye were cut down for firewood and nearly wiped out when the population exploded after the Gold Rush years.*[424]

The tree planting campaign initiated in the 1870s was limited to open space areas and parks such as Mount Sutro Open Space Reserve, the Presidio, and Golden Gate Park.[425] By 1892,

[424] San Francisco Environment website, History of San Francisco's Urban Forest, http://www.sfenvironment.org/our_programs/interests.html?ssi=4&ti=8&ii=65 (November 19, 2009).
[425] Ibid.

approximately 350,000 trees were planted in the Presidio,[426] and prior to 1955, street tree planting was limited in extent and was accomplished via annual Board of Supervisors appropriations for "street beautification."[427] For example, a 1947 San Francisco Chronicle article reported on a $25,000 appropriation for planting 1137 trees on selected streets including both sides of Nineteenth Avenue between Lincoln Way and Sloat Boulevard and both sides of Guerrero Street between Market and Army Streets. In 1955, the Board of Supervisors by ordinance established a dedicated Tree Planting Division in the Department of Public Works (DPW).[428]

Prior to 1955, two documents called for street tree planting in San Francisco. One was Burnham's 1905 Report on a Plan for San Francisco and the other was Glenn Hall's 1945 Outline of a Street Tree Program for San Francisco. In the former, Burnham wrote about San Francisco's reluctance to plant street trees because of climatic considerations, specifically the loss of sunlight. In favor of trees, he argued that trees would ameliorate windy (and dusty) conditions making sidewalks warmer. He recommended "trees of smaller growth" and also emphasized "the beauty imparted to streets by tree planting."[429] Glenn Hall, a City Planning Commission staff person, submitted his plan for a street tree program for San Francisco as a private citizen. The first section of the document underscored what Nikita Khrushchev would say of the city in 1959:

> *Many people, on their first visit to San Francisco, are depressed by the almost barren and treeless appearance of the streets in closely-built residential sections. It seems paradoxical in a city which prides itself on its civic center, art museums and parks.*[430]

Hall went on to provide three reasons why the city lacked a street tree canopy: (1) residents placed "a very high value on sunshine" because of the city's cool, foggy, and rainy climate and trees would block access to sunshine; (2) districts had limited setbacks and sidewalks had little room for planting strips; and (3) municipal or other "unified effort of street beautification" was absent.[431] From there, Hall went on note, more strongly than Burnham did, that the primary benefit of street tree planting was beautification:

> *It is evident then that the chief value of street planting in San Francisco is for its ornamental effect.*[432]

Also like Burnham and even Olmsted before him, Hall distinguished between the landscapes of Eastern cities and San Francisco. He wrote that Eastern cities require large trees at

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[426] San Francisco, DoE, *Urban Forest Plan 2006*.
[427] Streets Selected for Tree Planting," *San Francisco Chronicle*, December 19, 1947, 19, Access World News.
[428] San Francisco, DoE, *Urban Forest Plan 2006*; San Francisco, TAB, *The State of the Urban Forest 1992*.
[429] Daniel Hudson Burnham, Edward Herbert Bennett, and Edward F. O'Day, *Report on a Plan for San Francisco* (San Francisco: Sunset Press, 1905), 108, http://books.google.com (November 19, 2009).
[430] Glenn Hall, "Outline of a Street Tree Program for San Francisco, March 1945," (San Francisco: Tree Committee, San Francisco Planning and Housing Association, 1945), 1, San Francisco Public Library Archives, SF History Stacks, 715.2 H142o.
[431] Hall, "Outline of a Street Tree Program for San Francisco March 1945," 1.
[432] Ibid.

maturity because of climatic conditions such as hot summers whereas San Francisco was cool in summer and did not require species such as oaks, elms, and maples:

> *As a general rule only smaller types of trees or larger types which can be easily kept small by pruning are suitable for the average street in San Francisco.*[433]

Hall did recommend several tree planting and maintenance systems for San Francisco. The city's current tree planting system most resembles Hall's second option, the semi-ideal program, where tree planting and maintenance responsibilities are split between the city and adjacent property owners.

Glenn Hall was not the only citizen vocal about establishing a street tree planting program in San Francisco. A 1955 campaign – "You Can Help Make San Francisco's Streets Beautiful" – sponsored by the Citizens Council for San Francisco Street Planting encouraged San Franciscans to support the Street-Planting Plan then under consideration by the Board of Supervisors. After the passage of the Street-Planting Plan ordinance and the establishment of a municipal tree division, San Franciscans continued to mount street tree planting campaigns. In 1955, San Francisco Beautiful, a Chamber of Commerce affiliate, published the "Plant Trees and make the streets of San Francisco Beautiful" brochure. The document emphasized making San Francisco "more beautiful" via tree planting, specifically in response to tourists' complaints about the city's lack of trees. Also, there were references to urban renewal and the role trees played in mitigating the "shabby" appearance of neighborhoods. Although the brochure did list the ability of trees to filter and purify the air, this function was framed as a way to "make the city a more pleasant place to live."

5.3 Municipally-led planning of the ecological street tree, 1955-1991

In this era, civic and municipal actors were engaged in tree planting advocacy. In 1968, the Jos. Schiltz Brewing Company sponsored a tree planting campaign and a contest titled "Support Plant Parenthood" asked entrants to write a slogan about "Beautifying San Francisco through landscaping our city streets." The Trees for the City brochure won the won the Jos. Schlitz Achievement Award in 1968. The brochure stated that "San Francisco is everyone's favorite city" but unfortunately, lacks trees. However, this situation could be improved "by the simple process of planting sidewalk trees" which "aside from their aesthetic value…help combat smog, upgrade community values, [and] enhance an attractive building and flatter an ordinary one." The emphasis is clearly on the scenic values of street trees. The reference to smog is real; post-war, dump fires, backyard burning, industrial and auto emissions contributed to smog in the Bay Area.[434]

In 1972 and 1974 respectively, the Department of Public Works and the Department of City Planning to Assist Neighborhood Projects published "Tree Make Good Neighbors: A Guide

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[433] Hall, "Outline of a Street Tree Program for San Francisco March 1945," 1-2.
[434] Bay Area Air Quality Management District website, History of Air District, http://www.baaqmd.gov/Divisions/Communications-and-Outreach/News-Media-and-Features/History-of-Air-District-2005.aspx (July 28, 2010).

for District Associations and Householders" and "Tree Planting in Neighborhoods." The former recommended tree planting for the following reasons: (1) to "soften the harsh lines of our streets and buildings"; (2) to "make for a more livable environment"; (3) to "improve one's property without increasing the taxes"; (4) to "produce oxygen, thereby diluting the polluted air"; (5) to "temper winds and the cold drafts"; and (6) to "lift the spirits of man."[435] Visual benefits led the "Tree Planting in Neighborhoods" publication; decorative and ornamental trees were highlighted as "particularly important" because of "density of development and lack of building setbacks and side yards."[436] Benefits that "make the city a more [sic] healthy place in which to live" were also discussed. Trees "filter dirt from the atmosphere", "replenish oxygen in the air we breathe", "muffle street noise", and "serve as wind breaks."[437]

For approximately 23 years, the city maintained a robust street tree planting division but in 1978, as a result of Proposition 13-induced budget cuts, the Department of Public Works "essentially halted" the municipal tree planting program.[438] Several years later, in 1981, the Friends of the Urban Forest (FUF) formed to assume street tree planting duties. Until the Department of Public Works resumed tree planting in 1992, street trees were planted by FUF and by the Redevelopment Agency.[439] While FUF and the Redevelopment Agency were planting street trees, the city continued to set policy. In 1986, a new urban forestry ordinance established criteria for significant and landmark trees and penalties for violations. The San Francisco *Chronicle* reported that the penalty was increased from "from $100 to $500 for an infraction and up to $1000 for a misdemeanor."[440] The article also noted that FUF was involved in "revamping" the city's ordinance. (In 2005, the San Francisco Urban Forest Council supported revision of the ordinance; the resolution made note of characteristics of landmark trees such as historic, cultural, and visual importance and environmental benefits. [441] The latter was not expanded upon.) The 1986 ordinance established a volunteer, 15-member Tree Advisory Board (TAB).[442]

5.4 Municipally-led planning of the ecological street tree, 1991-2003

In cooperation with the Department of Public Works (DPW), TAB conducted the city's first street tree survey in 1991. The survey counted 62,738 street trees which meant a loss of "estimated 40-50,000 street trees" between 1975 and 1990.[443] With the designation of

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[435] San Francisco, Department of Public Works, "Tree Make Good Neighbors: A Guide for District Associations and Householders" (San Francisco: DPW, 1972).
[436] San Francisco, Department of City Planning to Assist Neighborhood Projects, "Tree Planting in Neighborhoods" (San Francisco: Planning, 1974).
[437] Ibid.
[438] San Francisco, TAB, *The State of the Urban Forest 1992*.
[439] San Francisco, TAB, *The State of the Urban Forest 1992*; SF4, personal interview, June 10, 2009.
[440] "S.F. Law Increases the Penalties for Damaging Trees," *San Francisco Chronicle*, August 7, 1986, 2, Access World News (November 19, 2009).
[441] San Francisco Urban Forestry Council, "Resolution No. 002-05-UFC," dated July 22, 2005, http://www.sfenvironment.org/downloads/library/forestryordrevisions072205.pdf (November 19, 2009).
[442] "S.F. Law Increases the Penalties for Damaging Trees."
[443] 1992 The State of the Urban Forest.

Transportation Bond (Gas Tax) funds for tree planting and maintenance, DPW resumed tree planting in 1992.[444] (In 2008, in additional to General Funds, permits, and citations, DPW's Bureau of Urban Forestry activities were funded by Sales Tax/ Proposition K (planting and maintenance) and by Gas Tax (maintenance).[445] In 2009, Bureau of Urban Forestry was only funded by Sales Tax/ Proposition K (planting and maintenance).[446] The Gas Tax will be renewed in 2010.[447])

In addition to leading the city's first street tree survey, TAB provided street tree policy recommendations in the 1992 The State of the Urban Forest report. As its name implies, TAB was an advisory body to the Department of Public Works and not a rule-making body. The board provided the following recommendations in its 1992 report: consolidate street tree management and planning functions, require quarterly meetings between urban forestry and open space planning agencies, explore options to reduce urban forestry costs and increase revenues, develop a public education program including a focus on tree maintenance by private property owners, and enforce the 1986 Urban Forestry Ordinance and related street tree laws.[448] More importantly, the 1992 TAB report reframed the role of San Francisco's street trees even as it acknowledged the long-held value of beautification:

> *Trees are also a telling indicator of a city's self image: all the great, thriving cities of the world from Paris to Shanghai are renowned for beautiful, tree-lined boulevards. Today, our growing awareness of the environment has radically changed the view of city trees as mere aesthetic props to beautify our neighborhoods. The urban forest is not a collection of individual trees; rather it is a vital connected system of vegetation, soil, and wildlife in our city….Street trees and parks provide wind barriers, reduce noise and air pollution, provide homes for birds and wildlife, and create attractive screening and visual highlights that please residents and tourist alike. They also dramatically reduce storm-water runoff which otherwise flows over concrete and asphalt with no interruption.*[449]

Even as the State of the Urban Forest report provided an ecosystem-oriented view of the city's street trees, this perception was not fully incorporated into the city's 1996 General Plan. Street trees were mentioned in three elements of the 1996 General Plan: Air Quality, Recreation and Open Space Element (ROSE), and Urban Design. (The 2009 Draft ROSE addressed the urban forest under Objective 4 (Improve Access and Connectivity to Open Space), Policy 3.6 (Maintain, restore, and expand the urban forest.)[450])

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[444] San Francisco, TAB, *The State of the Urban Forest 1992*; SF4, personal interview, June 10, 2009.
[445] San Francisco, Department of the Environment, Urban Forestry Council, *Annual Report September 2008* (San Francisco: SFEnvironment, 2008).
[446] San Francisco, Department of the Environment, Urban Forestry Council, *Annual Report September 2009* (San Francisco: SFEnvironment, 2009), http://www.sfenvironment.org/downloads/library/sfe_urban_forest_annual_report_2009.pdf (July 20, 2010).
[447] SF4, personal interview, June 10, 2009.
[448] San Francisco, TAB, *The State of the Urban Forest 1992*.
[449] Ibid.
[450] "Trees and understory plantings in city parks, public open spaces, city streets and private property collectively form the urban forest. This urban forest contributes substantially to our quality of life and to the ecological

In the 1996 Air Quality Element, tree planting was touted as a strategy to create walkable streets which would lead to reductions in vehicle use. Mentions of trees and air quality goals were limited to the planting of species with low volatile organic compound emissions.[451] Within ROSE, only Policy 2.9 (Maintain and expand the urban forest) dealt directly with street trees. The benefits of the urban forest listed were quality of life, sense of nature, provide shade (shade for human comfort or for energy efficiency and conservation was not specified), and moderate microclimate (again, no specifics were provided). Street trees were included for their contribution to "the streetscape environment and can be used to visually screen unattractive and incompatible land uses."[452] The role of street trees outlined in the Urban Design Element Policy 1.10 seems highly influenced by Kevin Lynch's *The Image of the City*.

> *One type of feature that can be readily adjusted to the street system is landscaping. Accordingly, a plan should be put into effect for street landscaping that indicates the relative importance of streets by the degree of formality of tree planting and the species and size of the trees. In addition to differences in traffic-carrying functions, the plan recognizes the width and visual importance of certain streets, the special nature of various activity areas, and the need for screening or buffering of residential uses along streets carrying heavy traffic. Special consideration is also required for major intersections, and for important views that should not be blocked by landscaping.*[453]

One of the San Francisco participants was asked to provide examples of legislation, situations, or projects that led the individual to state that the aesthetic values of trees remain very important in San Francisco even as the ecological benefits of trees are being touted. The participant responded:

> *My statement is primarily based on our adopted City Policies as stated in the General Plan. These policies have been approved by the Planning Commission, the Board of Supervisors and signed by the Mayor in various Ordinances.*[454]

A year after the adoption of the 1996 General Plan, the Sustainability Plan for San Francisco was adopted. The 1997 Sustainability Plan was drafted by Sustainable City, a group of 350 San Franciscans including "community activists and people representing many city

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functioning of our city. Trees and landscaping soften the urban environment, provide habitat, and mitigate stormwater runoff" (San Francisco, Planning Department, *Draft Recreation and Open Space An Element of the General Plan of the City and County of San Francisco May 2009* (San Francisco: Planning, 2009), http://openspace.sfplanning.org/docs/Recreation_and_Open_Space_Element.pdf (July 24, 2010)).

[451] San Francisco, Planning Department, *San Francisco General Plan, Air Quality Element 1996* (San Francisco: Planning, 1996), http://www.sf-planning.org/ftp/General_Plan/I10_Air_Quality.htm (July 16, 2010); San Francisco meets air quality standards set by the BAAQMD, but it contributes to poor air quality in the nine-county region.

[452] San Francisco, Planning Department, *San Francisco General Plan, Recreation, Open Space, and Environment 1996* (San Francisco: Planning, 1996), http://www.sf-planning.org/ftp/General_Plan/I3_Rec_and_Open_Space.htm (July 16, 2010).

[453] San Francisco, Planning Department, *San Francisco General Plan, Urban Design Element 1996* (San Francisco: Planning, 1996), http://www.sf-planning.org/ftp/General_Plan/I5_Urban_Design.htm (July 16, 2010).

[454] SF3 follow-up, email communication, September 29, 2009.

government agencies, over 100 businesses, and academia."[455] The group was convened in 1993 as the Commission on San Francisco's Environment by the Board of Supervisors. The Plan was modeled after the Agenda 21 Implementation Plan and plans developed by Sustainable Seattle. (The Department of the Environment, established in the winter of 1996-1997, was charged with implementing the 1997 Sustainability Plan.[456]) Trees were not mentioned in issue chapters on which trees have direct bearing such as air quality; biodiversity; energy, climate change, and ozone depletion; and water and wastewater. Street trees were included in the Parks, Open Spaces and Streetscapes chapter of the 1997 Sustainability Plan.

> *Parks, squares, street trees, and other greenery and open space in San Francisco are vital assets of a healthy and livable city. The ecological benefits of these resources are substantial: landscape improves air quality and lowers dust levels, provides vital habitat and corridors for birds and wildlife, reduces water runoff and erosion, and allows groundwater recharge. Trees and other plants absorb carbon dioxide and thus lower the city's contribution to global warming, an important capacity since the phenomenon of global warming has recently passed from theory to confirmed reality.*[457]

The Parks, Open Spaces and Streetscapes chapter also mentioned the economic development role of street trees via associated increases in property values. The discussion of the ecological benefits of trees preceded the Center for Urban Forest Research's (CUFR) structural and functional analysis of San Francisco's street trees using the then new Street Tree Resource Analysis Tool for Urban Forest Managers (STRATUM) software.[458] The analysis was conducted in 2002 and the report was published in 2003.[459] The benefits listed in the 1997 Sustainability Plan can be described as specific rather than general, but CUFR's findings provided ecological data specific to San Francisco. For example, the Sustainability Plan stated that "landscape…reduces water runoff" compared to the STRATUM report that stated

> *Annual interception of rainfall by San Francisco's urban forest for the urbanized area was only about 2% due to the winter rainfall pattern and predominance of non-evergreen species. However, average interception on land with tree canopy cover ranged from 6-13% (150 gal per tree on average), close to values reported for rural forests.*[460]

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[455] Sustainable City website, http://www.sustainable-city.org (November 23, 2009).
[456] Sustainable City website.
[457] Sustainable City, *Sustainability Plan for San Francisco, Parks, Open Spaces and Streetscapes, 1997*, http://www.sustainable-city.org/Plan/Intro/intro.htm (November 23, 2009).
[458] Center for Urban Forest Research, "US Forest Service Measures Benefits San Francisco's Street Trees" press release, dated November 25, 2002 (Davis, CA: USDA Forest Service, PSW Research Station, 2002), http://www.fs.fed.us/psw/programs/cufr/products/cufr_175.pdf (November 23, 2009).
[459] Scott E. Maco, E. Gregory McPherson, James R. Simpson, Paula J. Peper, and Qingfu Xiao, *City of San Francisco, California: Street Tree Analysis* (Davis, CA: Center for Urban Forest Research, USDA Forest Service, PSW Research Station, 2003), http://www.sfenvironment.org/downloads/library/visstreettreeanalysisforsf.pdf (November 23, 2009).
[460] Maco et al., *City of San Francisco, California: Street Tree Analysis*, 28.

The Tree Advisory Board (TAB) evolved into the Urban Forest Council in 2002. The Council was established in San Francisco's Environment Code Chapter 12. Like TAB, the Council's role is advisory. A list of its responsibilities include action verbs such as advise, review and make recommendations, establish criteria and adopt guidelines, encourage, facilitate, notify and involve, provide a regular forum, assist with, serve as a clearinghouse, and prepare plans and reports.

5.5 Municipally-led planning of the ecological street tree, 2003-2009

In a 2003 resolution, the Urban Forestry Council recommended that the Planning Commission elevate the visibility and importance of street trees in the General Plan."[461] The resolution defined right-of-way trees as "a vital infrastructure element" that, in addition to socio-economic benefits, provide the following benefits:

> *Trees in the public right-of-way reduce levels of atmospheric carbon that lead to climate change; and…Trees in the public right-of-way improve air quality, and public health by absorbing gaseous pollutants, intercepting dust, ash, and smoke, and releasing oxygen through photosynthesis; and…Trees in the public right-of-way reduce storm water runoff through the interception and storage of rainfall on leaf and branch surfaces, thereby reducing runoff volumes, delaying the onset of peak flows, limiting the need to expand storm drainage systems; and reducing soil erosion…* (emphasis in the original).[462]

The resolution was signed on November 14, 2003. 2003 was a big year for advancing the ecological benefits of street trees. In addition to the publication of CUFR's STRATUM analysis and the Council's Resolution about integrating street trees into the General Plan, then mayoral candidate, Gavin Newsom, released a policy brief titled "A Green and Clean San Francisco."[463] The first action item was to "grow our urban canopy by placing a priority on tree planting and care**."**[464] Candidate Newsome listed the multiple benefits of the urban canopy including its ecosystem functions.

> *Street and park trees provide tremendous benefits to cities. Trees are the lungs of the city that capture air pollution, reduce carbon dioxide, and produce oxygen. Trees capture stormwater runoff polluted with lead, mercury, oil and grease, keeping it out of the Bay. They provide shelter for birds and other wildlife. They provide privacy,*

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[461] San Francisco Urban Forestry Council, "Resolution No. 001-03-UFC, UFC Street Tree Policies," dated November 14, 2003, 3, http://www.sfenvironment.org/downloads/library/streetstreetpolicies111403.pdf (November 23, 2009).
[462] Urban Forestry Council , "Resolution No. 001-03-UFC," 1-2.
[463] Gavin Newsom, "A Green and Clean San Francisco Policy Brief," http://www.ci.sf.ca.us/site/uploadedfiles/mayor/policy/NEWSOM_clean_green.pdf (last accessed November 23, 2009). This website no longer exists. Attempts to find the original document were unsuccessful. See Allen Grossman, "Newsom's missing trees
Spinning out the Urban Forest," San Francisco Bay Guardian, April 23, 2008, http://www.sfbg.com/2008/04/23/newsoms-missing-trees (July 28, 2010) for reference to this document.
[464] Ibid.

> *help to reduce noise and glare, and increase property values. The sight, sound, smell, and touch of plants can help reduce the stress of urban life. And research has shown that crime is reduced in neighborhoods with extensive street tree plantings and well-landscaped parks. When they are chosen wisely and consistently, trees can also provide identity to a street, giving people another kind of mental map for navigating the city.*[465]

Candidate Newsom, running as a "green mayor,"[466] set a goal of planting new trees in 30 blocks annually for a total of 200 blocks over his first term.[467] To bolster his position in the policy brief, the candidate cited his role in the establishment of a tree advisory board (TAB now the Urban Forest Council); San Francisco's historic undervaluation of street trees ("San Francisco lags behind other communities in providing a vital, vibrant and ecologically sustainable urban canopy"[468]); the subsequent disadvantage the city has compared to other "world-class" cities; and the success of streetscape efforts in other U.S. cities such as Chicago. In his first term as mayor, Newsom launched the Trees for Tomorrow campaign with a goal of planting 5,000 trees per year by all departments. (A criticism of the program is that the city's canopy has not been expanded at a rate of 5,000 new trees per year because some of the new trees replaced dying or dead trees).[469] The San Francisco *Chronicle* reported that 26,408 trees have been planted through the initiative.[470]

In 2004, the mayor announced the first phase of his "Clean and Green" Streets Initiative. The initiative was the implementation plan for goals outlined in the Policy Brief. Several streets were identified for tree planting – Van Ness Avenue between Grove and Lombard Streets and the medians of Geary and Lombard Streets and Junipero Serra Boulevard. The press release announcing the initiative described the program as "part of the Mayor's commitment to make San Francisco one of the cleanest and greenest cities in the country."[471] Interestingly, the use of the term "greenest" does not imply "ecological" but well vegetated. The design goal for the initiative was described as providing "a fresh, unified appearance with new plantings and replace the disconnected designs now found in different blocks."[472] (The mayor released his Climate Action Plan approximately a month before announcing the "Clean and Green" initiative. The San Francisco plan did not list the urban forest as a climate strategy. Reductions in transportation, energy, and solid waste were linked to "alternative fuel and

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[465] Newsom, "A Green and Clean San Francisco Policy Brief," 2.
[466] SF3, personal interview, June 10, 2009.
[467] Newsom, "A Green and Clean San Francisco Policy Brief."
[468] Newsom, "A Green and Clean San Francisco Policy Brief," 2.
[469] SF5, personal interview, June 18, 2009.
[470] Phillip Matier and Andrew Ross, "S.F. Meets Goal of Trees, but Workers Get Ax" *San Francisco Chronicle*, November 16, 2009, http://articles.sfgate.com/2009-11-16/bay-area/17180119_1_new-trees-chauncey-bailey-budget-cuts (July 28, 2010).
[471] San Francisco, Mayor's Office, "Mayor Newsom Unveils Major "Clean and Green" Streets Initiative" press release, not dated, http://www.sfgov.org/site/mayor_page.asp?id=27965 (last accessed November 24, 2009). This website no longer exists. Attempts to find the original document were unsuccessful.
[472] Ibid.

hybrid transportation fleets, transit improvements, increased transit ridership, investing in alternative energies, recycling and conservation."[473])

In addition to the mayor's tree initiative, the Urban Forest Council released its Street Tree Action Plan (the street tree component of the 2006 Urban Forest Plan). The 2004 Street Tree Action Plan recommended four action steps to maintain and to expand San Francisco's street tree canopy: develop guidelines for tree care activities such as pruning, planting, and removals; provide education for residents and city staff on appropriate tree care; plant 5,000 trees annually (reflecting the mayor's Trees for Tomorrow campaign goal); and establish a maintenance cycle of three years (down from the existing seven year cycle). The rationale for the actions was "to beautify its neighborhoods and improve the environmental quality of communities with more and healthier street trees." The plan summarily referenced the 2003 STRATUM report:

> *Early findings have shown that San Francisco's roughly 99,000 street trees provide about $ 7.5 million dollars in environmental and economic benefits each year including reduced storm water runoff and improved air quality….*[474]

The plan also referenced benefits not captured by STRATUM such as "reduced crime, and a heightened sense of community pride."[475]

The years 2005 and 2006 were also busy ones in terms of greening policy with implications for the ecological argument for street trees. The mayor signed the United Nations Urban Environmental Accords; the 2006 Urban Forest Plan described the mayor's participation as significant for San Francisco's urban forest.

> *Mayor Gavin Newsom signed the United Nations Urban Environmental Accords with an Urban Nature section that includes specific actions for urban forestry. Action 11 of the Urban Environmental Accords calls for measuring canopy cover, increasing canopy cover, and maintaining at least 50% of available street tree sites. Actions 10 and 12 are related to the community and wildlife benefits of urban forests.*[476]

The plan also mentioned the mayor's launch of the Livable Cities Initiative (LCI) which included a role for street trees. LCI "supports streetscapes that integrate street trees and landscaping… to improve the livability of the city while reducing environmental impacts and infrastructure costs."[477] The mayor announced the second phase of the "Clean and Green" Street Initiative in 2005. The Better Streets Program (BSP) was touted as a multi-pronged initiative that would "better balance all the functions of a street, make our streets a truly

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[473] San Francisco, Department of the Environment, "Mayor Newsom Unveils "Climate Action Plan" to Cut Local Emissions, Combat Global Warming" press release, dated September 27, 2004, http://www.sfenvironment.org/our_sfenvironment/press_releases.html?topic=details&ni=144 (July 28, 2010).
[474] San Francisco, Department of the Environment, Urban Forestry Council, *San Francisco Street Tree Action Plan 2004* (San Francisco: SFEnvironment, 2004), 1, http://www.sfenvironment.org/downloads/library/streettreeactionplan.pdf (November 24, 2009).
[475] San Francisco, *San Francisco Street Tree Action Plan 2004*, 1.
[476] San Francisco, DoE, *Urban Forest Plan 2006*, 1.
[477] Livable City website, Complete Streets, http://www.livablecity.org/campaigns/completestreets.html (November 24, 2009).

public realm and put people and the environment first."[478] The description of BSP's four initiatives did not explicitly mention street trees and their ecosystem values. In fact, in his October 2005 State of the City address, the mayor stated that the Livable Cities Initiative allocation of $11 million dollars would "transform major thoroughfares like Van Ness and 19th Avenues into lushly planted thoroughfares" and the Better Streets Program would include "comprehensive standards for landscaping and street design."[479] However, subsequent development of the Better Streets Plan fleshed out the ecological street tree.

The Urban Forest Council considered the Sidewalk Landscaping Permit in 2005 and in 2006 issued a resolution supporting the permit. The permit allows residents to remove sidewalk panels to create or expand tree planting basins. The permit was developed with cooperation from organizations like the Department of Public Works and Plant*SF.[480] The Council supported the permit because of its potential to manage stormwater runoff and air quality, to provide wildlife habitat, to encourage community participation, to improve the health and function of the urban forest vis-à-vis greater growing space, and to encourage walking vis-à-vis "the presence of beautiful public space."[481]

Also in 2006, the Council released the Urban Forest Plan. The 25-page, 2006 Urban Forest Plan was drafted by the Urban Forest Council and the Department of the Environment. Its authors offered the plan as a "standard reference document" fulfilling the Council's mandate to create a management plan.[482] The road map is based on five goals and nine specific actions. The goals overlap those outlined in the 2004 Street Tree Action Plan and the 1992 The State of the Urban Forest (written by the Tree Advisory Board). The authors relied on other policy precedents such as the 2001 State of the Urban Forest and the 1997 Sustainability Plan for the City of San Francisco, in particular, the Parks, Open Spaces and Streetscapes chapter.[483] The nine specific actions were listed in order of priority: developing best practices for tree selection, purchase, installation, and maintenance; protecting trees during development; establishing a "no net loss" goal and a reforestation program for the city's aging stands; allocating and securing funds for planting and maintenance; establishing canopy goals (increase cover to 15%); revising the list of recommended trees; engaging "elected and community leaders" on equitable canopy cover; and assisting county and city agencies to develop planting and maintenance programs.[484]

The plan included several statements that are salient to this dissertation. Two are provided here. One, a distinction was made between "most San Franciscans" and the city's "resource managers" in terms of conceptualizing the role of the street tree:

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[478] San Francisco, Mayor's Office, "Newsom Unveils Phase II of the Clean and Green Initiative: Better Streets Program" press release, dated August 11, 2005, http://www.plantsf.org/Greening_PressRelease.pdf (November 24, 2009).
[479] San Francisco, Mayor's Office, "Second Annual State of the City, October 26, 2005," http://www.sfgov.org/site/uploadedfiles/mayor/SoCFinal.pdf (July 28, 2010). This link is broken.
[480] SF4, personal interview, June 10, 2009.
[481] San Francisco Urban Forestry Council , "Resolution 004-06-UFC," dated March 24, 2006, http://www.sfenvironment.org/downloads/library/alklandscapingpermit032406.pdf (July 28, 2010).
[482] San Francisco, DoE, *Urban Forest Plan 2006*, 2-3.
[483] I was unable to locate a copy of the *State of the Urban Forest 2001* report.
[484] San Francisco, DoE, *Urban Forest Plan 2006*.

> *Most San Franciscans readily acknowledge that the urban forest makes the City a nicer place to live. They appreciate the beauty of parks, gardens and the trees along city streets. However, the management of the urban forest presents many challenges that may not be apparent to the average person.*
>
> *Many resource managers in San Francisco have lacked specific knowledge as to the number and location of trees under their care. The Department of Public Works (DPW) is the exception, having a decade-long work history. Even with such information, DPW has lacked a quantitative understanding of the functional roles that street trees play in the community until recently. Through collaboration with the United States Department of Agriculture (USDA) Forest Service, San Francisco now has a better understanding of its street tree and total tree population. As a result, there is quantitative information on tree population, age distribution, tree species, tree condition and associated benefits on canopy cover, environmental benefits and costs.*[485]

Another statement emphasized the unique role of the street or public right-of-way tree in ameliorating urban environmental ills.

> *The urban street tree, more than any other element in the city landscape, can most effectively mediate due to its proximity, the environmental impacts of vehicular exhaust, noise, urban runoff and pollution.*[486]

The Urban Forest Council, in 2007, passed a resolution to incorporate the 2006 Urban Forest Plan into the General Plan. This is reminiscent of the Council's 2003 resolution – Resolution No. 001-03-UFC – which recommended that "the Planning Commission elevate the visibility and importance of street trees in the General Plan."[487] The 2006 Urban Forest Plan was not incorporated into the General Plan. It was decided that the 2008 Urban Forest Plan would be incorporated into the Better Streets Plan. The Planning Department hired a consultant (EDAW) to manage the urban forest master plan process but the effort was postponed due to state budget cuts.[488]

The urban forest management plan process was postponed, but the Better Streets Plan (BSP) is under development. However, it falls outside the timeframe of this dissertation. Briefly, the Urban Forest Council's 2009 Annual Report described BSP as follows:

> *This plan recognizes the importance of including natural elements into the built environment for aesthetic, economic, and safety reasons. As such, the plan recommends many uses for right-of-way tree planting and landscaping.*[489]

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[485] San Francisco, DoE, *Urban Forest Plan 2006*, 8.
[486] San Francisco, DoE, *Urban Forest Plan 2006*, 11.
[487] San Francisco Urban Forestry Council, "Resolution No. 001-03-UFC."
[488] EDAW was being paid through a California Forest and Fire Protection grant. I contacted the San Francisco Urban Forest Plan project manager at EDAW and was told that the plan was postponed before any formal drafts were completed. (Email communication, September 30, 2009).
[489] San Francisco, DoE, *Annual Report September 2009*, 24.

Although BSP is primarily a street design framework, it does address the urban forest. The urban forest is defined as a streetscape element composed of trees, understory plantings, and aboveground plantings. Although trees are defined as "the most important organizing element," their stated role seems limited to "enhanc[ing] streetscape character…and property values in residential neighborhoods and commercial areas."[490] Understory landscaping, not street trees, is invested with "habitat and ecological value."[491] One of the plan revisions suggested during the June 2008 public review period called for the elimination of the "discussion of selecting tree species based on food value for wildlife."[492] Despite these issues, the Better Streets Plan and conversations about the content of the revised Urban Forest Plan reveal a trend towards characterizing San Francisco's street trees in ecological terms.

> *… if you look at the Urban Design Element, for example, or the General Plan which is policy that is relatively old, there is very little mentioning of ecological function. It's purely based, it's a design discussion. And experiential in terms of 'it's nice for a pedestrian to walk on the street with trees.' If you look at more recent policy developments like the Better Streets Plan, what the Urban Forest Master Plan was doing, and specifically at some large scale capital projects there is much more discussion on the scientific and the eco-functioning of trees.*[493]

5.6 Nonprofit-led planning of the ecological street tree

Nonprofit planning and policy documents

The Friends of the Urban Forest (FUF), San Francisco's primary urban forest nonprofit, entered the urban forestry arena in 1981. In 1978, responding to budget constraints, the city halted its municipal tree planting program.[494] FUF formed in direct response to this gap in municipal service provision.[495] Prior to its formal organization in 1981, FUF produced a document titled "Tree Kit." A "how-to" guide to planting a tree in San Francisco, from applying for a permit, to selecting the planting site and the tree species, to planting and caring for the tree, it was funded by Pacific Lumber Company, Foremost-McKesson Foundation, and Bank of America and presented to the City in 1980. The guide also included a micro-climate map of the city and a list of recommended trees. Dianne Feinstein wrote a foreword for the "Tree Kit" emphasizing the contribution of trees to "the living vitality that is San

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[490] San Francisco. Planning Department. *Draft Better Street Plan: Policies and Guidelines for the Pedestrian Realm, July 2009* (*Streetscape Elements*), (San Francisco: Planning, 2009), 176, http://www.sf-planning.org/ftp/BetterStreets/proposals.htm#Final_Draft (July 17, 2010).

[491] San Francisco, Planning, *Draft Better Street Plan*, 170.

[492] San Francisco, Planning Department, *Plan Revisions to the Better Streets Plan Draft for Public Review, October 14, 2009* (San Francisco: Planning, 2009), 7, http://www.sf-planning.org/ftp/BetterStreets/docs/BSP_Plan_Revisions_Summary_Memo_Final_10.14.09.pdf (July 17, 2010).

[493] SF2, personal interview, June 10, 2009.

[494] There is a discrepancy about the year the city program was cancelled. In the San Francisco, *State of the Urban Forest 1992*, the date is given as 1978, while 1981 is listed in Sullivan, T*rees of San Francisco* and in Gregory Dicum, "If We're so Green, Why is San Francisco's Treescape so Lame?," *San Francisco Chronicle*, June 14, 2006, http://articles.sfgate.com/2006-06-14/home-and-garden/17297231_1_urban-forestry-council-planting-trees (July 28, 2010).

[495] Sullivan, *Trees of San Francisco*.

Francisco."[496] A U.C. Berkeley research associate, Elizabeth McClintock, also contributed to the foreword. McClintock noted that the city's indigenous landscape was "hilly grassland and coastal sand dunes," and not forest. However, with urbanization, "street trees became of paramount importance," though she did not expand on this statement.[497] Presumably the third portion of the foreword was written by FUF. Its contribution listed the reasons that San Franciscans plant trees:

> *Residents of our city plant trees for many reasons; for neighborhood beautification, as sound barriers, as living air filters, and as assets to property values.*[498]

Later in the document, a broader range of benefits were listed. Of the 10 benefits listed, five could be described as ecosystem services. [499]

- *Trees represent nature and contact with natural resources for many city dwellers.*
- *Trees increase neighborhood pride by involving people in improving and caring for their surroundings.*
- *Trees help draw customers to business areas.*
- *Trees screen harsh development and give a community visual character and unity.*
- *Trees block winds, settling dust, creating comfortable outdoor spaces, and reducing heat loss from buildings.*
- *Trees soften noise by breaking up sound waves with leaves and branches.*
- *Trees release oxygen and absorb carbon dioxide, freshening city air.*
- *Trees cool air by giving shade and releasing moisture.*
- *Trees hold soil with their roots and break the fall of raindrops with their leaves.*
- *Trees provide wildlife habitat for birds and mammals.*

Planting trees for the purpose of blocking wind, "freshening city air" (smog), and reducing noise were important benefits between the 1950s and the 1980s. In addition to their inclusion in the 1980 "Tree Kit," these benefits of trees were also mentioned in the flyer "Street Tree Planting in San Francisco" by the San Francisco Chamber of Commerce Publicity Department; in two brochures – "Plant Trees and make the streets of San Francisco Beautiful" by San Francisco Beautiful and "Trees for the City" by Trees for the City; and in two guides – "Trees Make Good Neighbors" by the Department of Public Works and "Tree Planting in Neighborhoods" by the Department of City Planning to Assist Neighborhood Projects.[500]

In 1983, FUF's Tree Kit Committee published a follow-up to the 1981 "Tree Kit" titled "Trees for San Francisco: Street-Tree Planting and Care." The purpose of the book did not make any reference to ecosystem services; instead, the purpose identified beauty, neighborhood unity, and socializing as the role of trees.

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[496] Friends of the Urban Forest, *Tree Kit* (San Francisco: FUF, 1980).
[497] FUF, *Tree Kit.*
[498] Ibid.
[499] FUF, *Tree Kit*, 5.
[500] None of the brochures included the date of publication.

> *Trees help make a city even more beautiful and alive, and the process of planting trees together unifies neighborhoods, getting people acquainted and working for a common purpose. Friends of the Urban Forest wants to help you green your street and make San Francisco into a glorious urban forest for the enjoyment of all.*[501]

Note the use of the term "green your street." It would appear, based on the stated purpose, that "green" is in reference to the act of adding vegetation (trees) to the street. In the 1980s, the term "green" as in urban greening usually referred to adding vegetation to the landscape. Its meaning began to change in the 1990s and became increasingly associated with sustainability and ecological function. In any case, the ecological value of street trees was included in "Trees for San Francisco: Street-Tree Planting and Care," though some of the benefits were framed in terms of human comfort, similar to the terminology in the 1981 Tree Kit.

> *Trees create comfortable outdoor spaces. They release oxygen and absorb carbon dioxide, contributing fresher air. They block winds, settle dust and smog particles, cast shade, release moisture, and reduce reflected heat from buildings and pavement. They hold soil in place with their roots, preventing erosion; soften the fall of raindrops with their leaves; slow runoff with their roots; and provide temporary shelter from a winter's downpour.*[502]

Excluding FUF's newsletters, the next formal document that referenced the ecological street tree was the 2009 Neighborhood Organizer's Manual. As the name suggests, the manual was written to assist residents who "wish to help strengthen community" through tree planting.[503] The manual was 12 pages long and the majority of its content was oriented towards profiling one's community, developing an outreach calendar, preparing oneself, building one's outreach team, conducting outreach, and scheduling and managing planting days. On the second to last page of the manual, eight benefits of trees were listed, of which three were ecosystem benefits – air quality improvement, global warming reduction, and runoff reduction.

> *According to the U.S. Forest Service research, through photosynthesis the average tree in a residential neighborhood will annually clean about 330 pounds of carbon dioxide from the air as well as provide enough oxygen for a family of four. Trees trap and hold particulate matter, reducing exposure to toxins which cause asthma and cancer.*
>
> *Trees reduce the emission of carbon dioxide (by decreasing energy needs) and then absorbing the carbon dioxide released from our cars, homes, and power plants. Too much carbon dioxide in our atmosphere is the primary cause of global warming.*

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[501] Friends of the Urban Forest, *Trees for San Francisco: Street-Tree Planting and Care* (San Francisco: FUF, 1983), 1.
[502] FUF, *Trees for San Francisco*, 3.
[503] Friends of the Urban Forest, *Neighborhood Organizer's Manual* (San Francisco: FUF, 2007), 1, http://www.fuf.net/treePlanting/resources/Organizer_Manual09.pdf (December 16, 2009).

> *Trees reduce flooding by helping to reduce runoff. A typical community forest of 10,000 trees will retain approximately 10 million gallons of rainwater per year (U.S. Forest Service Research). San Francisco's ailing sewer system profits from large trees soaking up and cleaning rainwater.*[504]

The manual was published in 2007, the same year in which the Forest Service's Northern Research Station released its urban forest effects and values assessment of San Francisco's urban forest.[505] Unlike the 2003 STRATUM report, the 2007 UFORE report considered the entire urban forest, not just street trees. Like the 2003 report, the 2007 report analyzed the ecosystem functions of trees and assigned monetary values to those functions. The 2007 report was released in February and it is unclear when in that year the FUF manual was released; the manual does not include San Francisco-specific ecological valuations of trees. However, the language used in the "Neighborhood Organizer's Manual" is more "mature"[506] than the previous descriptions of the ecological value of street trees found in FUF documents such as the "Tree Kit" and the "Trees for San Francisco: Street-Tree Planting and Care."

The most recent annual report did not reference the ecological value of street trees.[507] The report summarized accomplishments in tree planting and tree care and provided audited financials as of December 31, 2008. Friends of the Urban Forest also produces an email newsletter and calendar. Topics covered by the e-newsletter include ways to support the organization, tree care tips, information about special tree tours and neighborhood plantings, and volunteer profiles. The content is relatively similar to that of the print newsletter but the format and frequency of distribution are different.

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[504] FUF, *Neighborhood Organizer's Manual*, 11.

[505] David J. Nowak, Robert E. Hoehn III, Daniel E. Crane, Jack C. Stevens, and Jeffrey T. Walton, *Assessing Urban Forest Effects and Values, San Francisco's Urban Forest, Resource Bulletin NRS-8* (Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station, 2007), http://www.sfenvironment.org/downloads/library/sfuforefinal.pdf (July 23, 2010).

[506] McLean and Jensen, "Community Leaders and the Urban Forest."

[507] Friends of the Urban Forest, *Annual Report 2008* (San Francisco: FUF, 2008), http://www.fuf.net/about/pdf/AnnualReport2008.pdf (November 25, 2009). A search of the organization's office for annual reports from prior years was unsuccessful.

Trends in the "Treescapes" newsletter

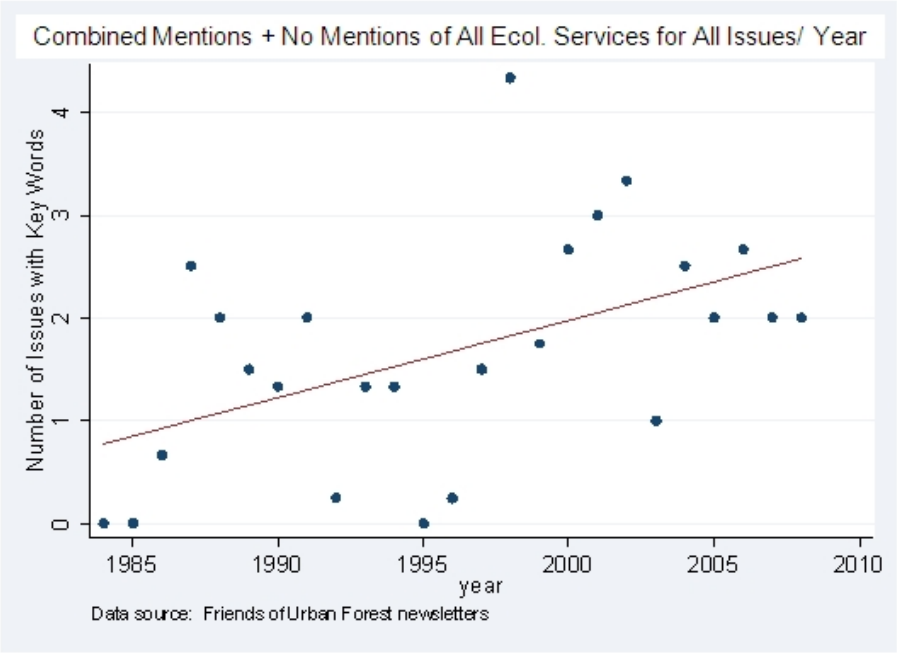

Figure 5.2 Trend in the overall ecological characterization of street trees in the "Treescapes" newsletter, 1984-2008.

The ecological value of street trees is mentioned in FUF's print newsletter. A regression of 74 of the organization's newsletters published between 1984 and 2008 revealed a positive and significant trend in the ecological characterization of street trees (Figure 5.2). The individual services that significantly increased during the study period are air quality improvement, carbon sequestration, and stormwater management (Table 5.1).

Table 5.1 San Francisco: Individual Services that Significantly Increased between 1980 and 2008

Service	Significant
Air quality improvement	✔
Carbon sequestration and storage	✔
Energy conservation and efficiency	
Stormwater runoff management	✔
Wildlife habitat	

Source: Friends of the Urban Forest newsletters (see Table 2.2).

Interview participants in San Francisco agreed with the overall trend illustrated in Figure 5.1. One participant remarked that the trend line showed a "nexus between green structure and ecological functioning," but suggested that aesthetics are still important.[508] Another

[508] SF3, personal interview, June 10, 2009.

participant suggested the need to "count aesthetics" but noted a greater "science based awareness" which would account for the upward trend in the ecological characterization of street trees.[509] Commenting on the contribution of air quality improvement, one participant said,

> *I think because the focus is on street trees that makes perfect sense. If this were for example, San Francisco Parks Trust or Friends of Rec [sic] and Park, you might see a focus on wildlife and/or maybe climate. We are trying to make the case that these trees should be planted near streets so the ecological services that might deal with pollution, cars, that sort of thing would be stronger.*[510]

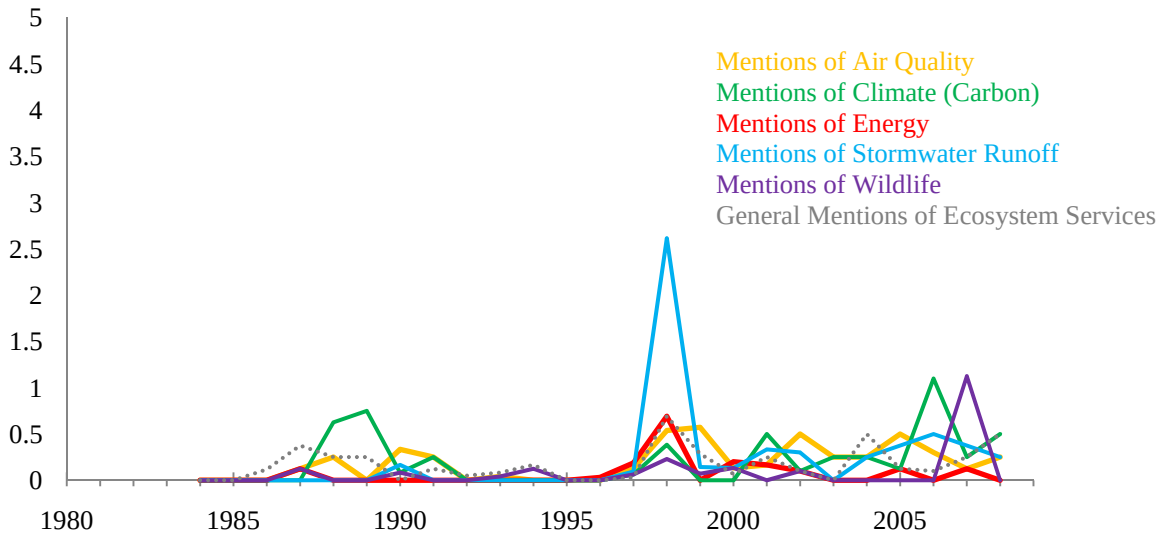

Figure 5.3 Number of mentions of each ecosystem service per issue weighted by the number of pages per issue (scaled to Sacramento Tree Foundation and Canopy newsletters). *Source:* Friends of the Urban Forest's newsletters, 1984-2008.

[509] SF2, personal interview, June 10, 2009.
[510] SF4, personal interview, June 10, 2009.

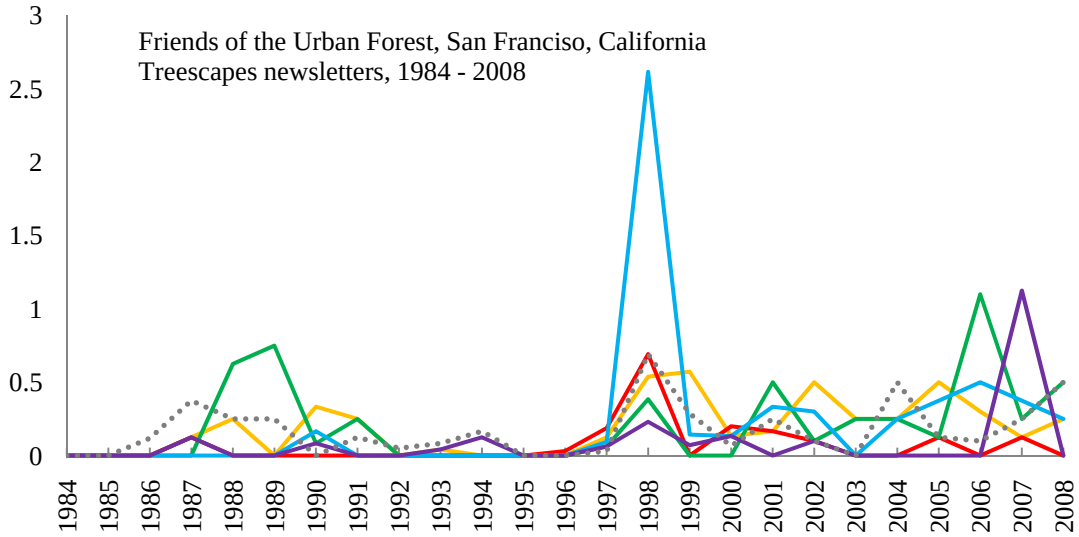

Figure 5.4 Number of mentions of each ecosystem service per issue weighted by the number of pages per issue (not scaled). *Source:* Friends of the Urban Forest's newsletters, 1984-2008.

A second analysis of the newsletter dataset revealed spikes and troughs in the annual mentions of individual services. Regarding this analysis, one participant observed that not only is there "more chatter in recent years and more discussion in recent years," but "it's kind of flat before then."[511] Another participant felt the graphs in Figures 5.3 and 5.4 confirmed "the observation that I have heard from others [that] there has been an increased emphasis on the role of trees beyond a purely aesthetic one."[512] Regarding the spikes in the climate category in the 2000s, one participant stated,

> *I think that climate would be something that is spiking now and probably continue to spike as general awareness about global climate is increased. And that is something that we probably talk about more than I don't know how often BUF talked about it before I started there but certainly I will use that as an example to people trying to talk about the general benefits of trees but I think the societal understanding and grasping and acceptance of global climate change as a real happening helps make the case for providing for trees, preserving trees and that sort of thing. It wouldn't surprise me to see that additionally. And I think in San Francisco, I wouldn't be surprised to see another hydrology spike because there's a lot of sewer upgrading happening right now….*[513]

Another participant mentioned stormwater but was surprised that this service was "not mentioned more later [in the 2000s] because I think it is becoming a bigger issue to people."[514] It is important to note that the information presented in Figures 5.2, 5.3, and 5.4 were limited to information published in Friends of the Urban Forest's newsletters. Also, participants were shown the graph scaled to other nonprofits' newsletters and weighted by the

[511] SF3, personal interview, June 10, 2009.
[512] SF2, personal interview, June 10, 2009.
[513] SF4, personal interview, June 10, 2009.
[514] SF1, personal interview, June 9, 2009.

number of pages per newsletter (Figure 5.3) and not the graph with weighted but un-scaled data (Figure 5.4). Dramatic spikes (ex: stormwater runoff in 1998) skew the reading of the graph. For the most part, services are consistently mentioned in the 2000s. Regarding these points, a participant said,

> *I am not surprised to see a general – seems to be a general diversification – a lot of things are coming up more frequently here [participant pointed to spikes in the 2000s]….People are becoming more aware of environmental issues and more concerned about them and more concerned about how trees can relate to those issues they are concerned about because they have far reaching benefits on so many fronts.*[515]

In response to the spikes of the 2000s (see Figure 5.3), another participant remarked,

> *I think that's cool that it's increasing. I know that we've gotten an increasing amount of data from USDA and from our own surveys and we're all trying to quantify value of trees, so many in the last few years. There's some data that we're putting out [reflected in the spikes in the 2000s] from others that have data too.*[516]

This participant also pointed to the low numbers shown in the y-axis of the graph in Figure 5.3; the data comprising this graph was weighted and scaled, so its effect appears less dramatic than the weighted data which was not presented to participants (see Figure 5.4). It was noted that FUF's newsletter is "not necessarily the way to have outreach."[517] FUF conducts advocacy "with supervisors in the political realm."[518] Not only is the newsletter perceived by the organization as a public relations tool and a way to document its activities and events, it is also seen as a loss of "lots of opportunity for education."[519] Furthermore, the print newsletter is not widely read; this is based on the number of solicitation envelopes returned from each issue.[520] Beginning in 2008, the newsletter was published in-house. Previously the organization contracted with a writer who developed the lead story though the newsletters' content during this period was described as "completely our baby" (staff would "plug in local, on-the-ground issues" to complement the lead story).[521]

In addition to its publications and advocacy with district supervisors, Friends of the Urban Forest (FUF) has been involved in other planning efforts: the recommended street tree list and the San Francisco Urban Forest Mapping System (launched as the Urban Forest Map in 2010).[522] The mapping project, a partnership between FUF, the City, and the California Department of Forestry and Fire Protection, was developed "to create an open-source urban forest management application, to improve interagency communication, to streamline manual workflows, to increase public access to urban forest information, to develop an accurate

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[515] Ibid.
[516] SF5, personal interview, June 18, 2009.
[517] Ibid.
[518] Ibid.
[519] Ibid.
[520] Ibid.
[521] Ibid.
[522] Urban Forest Map website, http://www.urbanforestmap.org (June 12, 2010).

cost/benefit analysis for San Francisco's urban forest, and to encourage public participation and volunteerism."[523] Only one of these goals has direct bearing on mainstreaming the ecological street tree: to develop an accurate cost/benefit analysis for San Francisco's urban forest. On this goal, a project participant outlined the benefits of the city's street trees.

> *It is no secret that trees deliver substantial economic, environmental, and aesthetic benefits. And, their role is even more important in the hustle and bustle of San Francisco. Trees absorb rain, reducing runoff and lessening the burden on the sewer and storm water systems. Trees reduce wind and provide shade that lowers the energy costs of nearby buildings. Green landscapes reduce carbon dioxide and absorb air pollutants, improving the city's air quality. Attractive, green landscapes and tree-lined boulevards attract more tourist dollars and improve property values. Not to mention, they provide an excellent habitat for birds and other wildlife. And, recent studies have linked trees and green landscapes to reduced crime, stronger inner city communities, and a greater sense of optimism among citizens.*[524]

Nonprofit projects and activities

FUF is also engaged in on-the-ground activities that mainstream the ecological street tree. The best example of this is the organization's Basin Expansion Program which relies on the 2007 Permeable Sidewalk Landscaping Permit. The permit allows residents to create sidewalk gardens by removing sections of city sidewalk.[525] The first phase of the program was launched in 2008; it targeted existing tree basins, expanding growing space to improve the health of existing trees. More recently, the program has been used to create new tree basins. FUF's shared grant application with the San Francisco Planning Department to the Environmental Protection Agency was recently awarded (to the Planning Department). FUF will apply these funds "to remove additional sidewalk concrete to create 'rain gardens' & plant trees to capture and delay storm water in the Cesar Chavez watershed."[526] The Cesar Chavez Street Design project is being developed by the Planning Department and has been described as "never done in San Francisco" and "sets an important precedent."[527] The project's hydrological goal was zero contribution to the city's combined sewer system.[528] In response to a question about the ways in which people talk about street trees now as compared to five or ten years ago, one participant responded:

> *The whole notion of the interplay of urban forestry and LID and stormwater and things like that is definitely something that people see, something that is more*

[523] SF Tree Map website, http://www.sftreemap.org (November 27, 2009).
[524] Autodesk Geospatial Solutions MapGuide Open Source, Customer Success Story, "Friends of the Urban Forest & San Francisco Department of Public Works, Bureau of Urban Forestry," http://images.autodesk.com/adsk/files/sf_urban_forest_map_project_story.pdf (November 27, 2009).
[525] Friends of the Urban Forest website, Sidewalk Greening, http://www.fuf.net/otherProjects/sidewalkgreening.html (November 27, 2009).
[526] Friends of the Urban Forest, FUF e-News (November 23, 2009).
[527] SF2, personal interview, June 10, 2009.
[528] Ibid.

> *understood. And the relationship between hydrological benefit and street trees, I think definitely something is that is much more on the forefront of what we do.*[529]

The permit that enables Friends of the Urban Forest to implement its Basin Expansion Program includes language about the ecological value of permeable landscapes ("permeable landscaping has numerous environmental benefits including storm-water management, air filtration and wildlife habitat"). This statement is based on research findings though none are specifically referenced in the body of the resolution.[530] In the Pacific and Southwest regions, much of the urban forestry research is conducted by the Center for Urban Forest Research in Davis, California.

5.7 Knowledge production and dissemination: The Center for Urban Forest Research

One proposition of this dissertation is that the ecological street tree has been made possible through knowledge production and sharing of scientific evidence from research stations such as the Center for Urban Forest Research (CUFR). In general, participants in San Francisco agreed with this statement. When probed about the trend illustrated in Figure 5.3, one participant said that research has contributed to the ecological characterization of street trees. Furthermore, it is not that the ecological value of street trees is suddenly more important to and in cities; instead, access to research findings has been a limiting factor.

> *It takes time for stuff from the academic world to permeate into the policy world.*[531]

Evidence of this evolution in thinking about the role of street trees can be found in municipal planning documents over time.

> *If you look at…policy that is relatively old, there is very little mentioning of ecological function. It's purely based, it's a design discussion.…If you look at more recent policy developments…and specifically at some large scale capital projects, there is much more discussion on the scientific and the eco-functioning of trees.*[532]

Though the city through the Bureau of Urban Forestry (BUF) has informal ties to CUFR, it has relied on the center's research. For example, CUFR and BUF "are sort of exploring, and this is very preliminary, being one of the pilot sites for a carbon offset program."[533] The California Climate Action Registry's Board of Directors approved CUFR's Urban Forest

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[529] Ibid.
[530] San Francisco Urban Forestry Council, Resolution No. 004-05-UFC, "Recommending Support for Community-Based Permeable Landscaping Projects," dated September 9, 2005, http://www.sfenvironment.org/downloads/library/permeablelandscaping090905.pdf (July 17, 2010); San Francisco Board of Supervisors, Resolution No. 775-05, "Commending Plant*SF, Sidewalk Pocket Park Gardens, and Other Community-Based Permeable Landscaping and Open-Space Garden Projects," dated October 27, 2005, http://www.sfbos.org/ftp/uploadedfiles/bdsupvrs/resolutions05/r0775-05.pdf (July 17, 2010).
[531] SF2, personal interview, June 10, 2009.
[532] Ibid.
[533] SF4, personal interview, June 10, 2009.

Project Protocol on August 12, 2009.[534] The premise of the protocol is that urban trees can reduce greenhouse gas emissions in three ways: sequestering carbon, avoiding emissions production at the power plant vis-à-vis shading and cooling buildings, and producing less polluting fuels (wood can be used as a bio-fuel and for thermal heating and cooling).[535] Cities and other institutions can use the protocol to report not only levels of emissions, but levels of emissions reduction vis-à-vis urban forestry strategies.[536] (The City of San Francisco's Climate Action Plan was adopted in 2004 and is centered on local emissions-reducing actions in the sectors of transportation, energy efficiency, renewable energy, and solid waste management.[537] Urban forestry strategies for emissions reduction are not included in the city's climate plan.)

Two of the Forest Service's research stations completed assessments of San Francisco's street trees and urban forest. The Center for Urban Forest Research published its STRATUM analysis of the city's street trees in 2003[538] and the Northern Research Station in Syracuse released its UFORE analysis of the city's total tree population in 2007.[539] The 2003 report found that the property value benefit had the highest monetary value (approximately $6.9M or $70.12/tree) of all the benefits provided by the city's street trees and trees in general. The benefit that generated the second largest monetary value was stormwater management ($466,544 or $4.73/tree) followed by energy ($85,742 or $0.87/tree), air quality ($42,718 or $0.43/tree), and carbon ($37,097 or $0.38/tree). The 2007 UFORE assessment of the city's entire urban forest concluded that the then 669,000 trees removed 260 tons of pollution annually (at $1.3 million/year), stored 196,000 tons of carbon (at $3.6 million/year), and sequestered 5, 200 tons of carbon (at $95,000/year).

Although the monetary value of the property benefit outweighs ecosystem benefits, at least one person interviewed felt that "the data out now" about ecosystem services "are taking us away from the aesthetic," yet this participant has used findings about the ecosystem benefits of street trees to persuade residents to choose larger stature, less showy tree species.

> *How long is that little tree going to live? It's only 20 years. Is it worth it? Don't you want a 50, 100, 80 year-old tree instead of that cherry tree that only lives 20 years? Sharing with people the ecosystem services whether its length of time the tree lives, leaf area index.*[540]

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[534] The approved version of the Urban Forest Project Protocol is available at http://www.fs.fed.us/psw/programs/cufr.

[535] Center for Urban Forest Research website, Urban Forests and Climate Change: Greenhouse Gas Reporting Protocols, http://www.fs.fed.us/psw/programs/cufr/protocols.shtml (November 27, 2009).

[536] CUFR website, Urban Forests and Climate Change.

[537] San Francisco, Department of the Environment and the Public Utilities Commission, *Climate Action Plan for San Francisco September 2004* (San Francisco: SFEnvironment, PUC, 2004), http://www.sfenvironment.org/downloads/library/climateactionplan.pdf (November 27, 2009).

[538] Maco et al., *City of San Francisco, California*.

[539] Nowak et al., *Assessing Urban Forest Effects and Values, San Francisco's Urban Forest*.

[540] SF5, personal interview, June 18, 2009. Leaf area index or the ratio of a tree's leaf cover to the ground space in which the tree grows directly influences its contributions to services such as particulate matter filtration and stormwater interception whereas leaf area index is not correlated to property values.

Also, the afore-referenced participant discounted the real estate value of San Francisco's trees because it overshadows the other benefits of street trees such as stormwater management, but also health and air quality values such as reductions in asthma hospitalization rates. This sentiment was echoed by two other participants who questioned the over-reliance on monetary valuation (in reference to the 2007 UFORE report) which tends to obfuscate other benefits like experience and habitat which cannot (as yet) be measured monetarily.[541] Despite these critiques, there is general agreement about the potential net benefits of quantifying environmental services of street trees. Support can be illustrated with two comments and a story. First, the following comment was made by a participant:

> *To put a number and a dollar value on the benefits that trees are providing does not in any way it seems to me detract from any of those other benefits. To say that a tree lowers your energy bill is not to say that your child cannot play in it. Mostly I think its benefit is to speak a different language. So when we talk about these numbers we're aiming for a target audience whose job it is for instance to manage the taxpayers money…We have an obligation to explain to them in their language what we would like them to do with it. So I think to say that we don't want to speak that language is a little bit like going to a foreign country and demanding that everyone speak English.*[542]

Second, another participant, talking about changes in the way people talk about street trees, underscored the role of research:

> *I think ten years ago it's different. Aesthetics were the, 'get a tree and make your neighborhood look beautiful or its blooming or something that intrigues the property owner that way. So I think the discussion has moved more towards the benefits, the environmental benefits, so it has changed. Five years ago, I think it was there, too. It was there. I just see this really in the last ten years a progression towards that [environmental benefits] than property value. Everyone has always known the property value thing but it [environmental benefits] hasn't been fully documented until recently.*[543]

Third, as of November 27, 2009, CUFR's website has posted a story about the 1991 proposed budget cuts to the City of Modesto's tree planting program and the role that a scientific assessment of tree values played in saving the program. Modesto's story was chronicled in CUFR's Spring 2003 newsletter. Though not about San Francisco, Modesto's situation is still illustrative of the role that scientific evidence plays in funding (and policy) decisions.

> *While all agreed that the city trees provided beauty and other benefits, quantifiable values were more elusive. So, Peter Cowles, Operations and Maintenance Director for the city, decided to consult with Dr. Greg McPherson, Director of the Center for Urban Forest Research. Because the city maintained excellent records of its street trees, beyond a simple inventory, the job of extracting data from their records was greatly simplified….This detailed account of management activities allowed our*

[541] SF2, personal interview, June 10, 2009; SF3, personal interview, June 10, 2009.
[542] SF6, personal interview, June 30, 2009.
[543] SF5, personal interview, June 18, 2009.

Center to construct a more thorough report of the value of the Modesto urban forest, than if we only had a simple inventory to work with. After considerable crunching of data, we produced a report that showed the benefits obtained from Modesto's public trees exceeded management costs by nearly a factor of 2. In other words, while the city spent $2.6 million per year on their urban forestry program, the total annual benefits to the community were $4.8 million. This translated into a net annual benefit back to the city of $2.2 million – a value the city manager couldn't ignore. Peter Cowles used the findings to convince the city manager and other city policy makers to retain full funding for the tree program while funding for most other programs was cut. The budget crisis for the tree program was over. He also set out on a campaign to increase public awareness about the benefits of street and park trees.[544]

A 1999 study of Modesto's municipal urban forest, i.e. street and park trees concluded that the city's investment in its urban forest "is providing tangible air quality, flood control, energy conservation, and CO2 reduction benefits."[545]

5.8 San Francisco's ecosystem services geography

Air quality improvement, carbon sequestration and storage, and stormwater runoff management are the most tangible benefits of street trees in San Francisco. Mentions of these services in 74 issues of the Friends of the Urban Forest's newsletter yielded a positive and significant trend in the ecological characterization of the street tree (Figure 5.2). Additional support for these three services was found in both municipal and nonprofit documents and interviews with staff from both sectors. The factors that led these three services to be salient to San Francisco include climate and infrastructure.

Stormwater runoff management

Managing stormwater runoff was the service consistently identified by most participants as the number one contribution of San Francisco's street trees. Also, it was the benefit that generated the second largest monetary value ($466,544 or $4.73/tree) in the 2003 Forest Service ecosystem assessment. The problem of stormwater runoff management in San Francisco is directly related to local climate (winter rainfall) and infrastructure (combined sewer system). Annual average precipitation is 22.1 inches with approximately 80 percent of this rainfall occurring between November and March.[546] It only takes a "0.1 year rain event" to cause a combined sewer discharge (CSD). This rain event is described as "a small event

[544] Center for Urban Forest Research, Urban Forest Research, Spring 2003, http://www.fs.fed.us/psw/programs/cufr/products/newsletters/UF5.pdf (November 27, 2009).
[545] E. Gregory McPherson, James R. Simpson, Paula J. Peper, and Qingfu Xiao, "Benefits-Cost Analysis of Modesto's Municipal Urban Forest," *Journal of Arboriculture* 25, no. 5 (1999): 246, http://www.treelink.org/joa/1999/sep/02mcpherson.pdf (July 24, 2010).
[546] City-data.com website, San Francisco: Geography and Climate, http://www.city-data.com/city/San-Francisco-California.html (July 28, 2010).

[and] anything that holds back that small event and either infiltrates it or holds it back permanently will reduce CSDs."[547]

In addition to infrastructural factors, biophysical and cultural conditions influence the geography of services in San Francisco. Despite the lack of tree canopy cover, San Francisco's western, coastal neighborhoods have sandy, highly permeable soils so has limited contributions to combined sewer overflows.[548] Low tree canopy cover has been attributed to climatic (windy, salt spray, foggy) and attitudinal factors. One attitude about tree planting is tied to the fact that high canopy cover is not historic to San Francisco.[549] Another participant framed this attitude thus:

> *Unlike people from the East Coast for example where I think most people who grew up on the East Coast grew up around trees because there is so much tree canopy all over the East Coast, there is a general acceptance that trees are part of life and raking leaves happens every fall and it's just what people do. So I think people who grew up in areas where there were not naturally a lot of trees found like the western part of San Francisco perceive trees differently and many times perceive them as leaf litter is in fact litter…more of an otherness to the trees and a resistance to them….*[550]

Interestingly, the central neighborhoods of the city – Bernal, Castro, Hayes, and Twin Peaks – have "good canopy cover" and this level of cover is possibly associated with an Eastern-bias for street trees.

> *I think in part income, knowledge, education, expectation of trees, street trees. Are they from the East Coast? Where are they from? I don't know.*[551]

Although these neighborhoods have the highest canopy cover, city staff has identified this area as an important area in which to make improvements because in terms of the city's watershed, these neighborhoods are the downstream source of runoff.[552] (There is planting space in backyards but the neighborhoods have narrow sidewalks.[553])

Another limiting attitude that affects tree canopy cover in the Sunset is culturally-based.

> *Cultural in the sense that a lot of Chinese Americans who practice feng shui have concerns about specific tree location. Don't want to generalize too much…something that has come up when we've tried to plant trees in certain areas in the Sunset where it's predominantly Chinese and Chinese American people have those concerns…sometimes it's concerns about specific types of trees…we want to be*

[547] SF7 interview follow-up, email communication, October 5, 2009.
[548] SF2, personal interview, June 10, 2009.
[549] SF1, personal interview, June 9, 2009.
[550] SF4, personal interview, June 10, 2009.
[551] SF5, personal interview, June 18, 2009.
[552] SF2, personal interview, June 10, 2009.
[553] SF2, personal interview, June 10, 2009; SF5, personal interview, June 18, 2009.

cultural sensitive but we also want to try to encourage people to appreciate the benefits of these trees.[554]

Air quality improvement

Climate, infrastructure, and cultural factors have contributed to poor air quality in San Francisco. The region is a nonattainment area under national ambient air quality standards. Ozone via vehicle emissions is the primary contributor to poor air quality in the summer while particulate matter via wood burning for heat is the main contributor to air pollution in the winter. Also, high levels of particulate matter have been identified in neighborhoods such as Bayview-Hunters Point, Potrero Hill, and Visitacion Valley, neighborhoods adversely affected by the location of power–generating infrastructure within their boundaries.[555] Finally, the air quality improvement value of trees was identified in ecosystem assessments conducted by the Forest Service research stations in 2003 and in 2007. The air quality benefit was ranked fourth in terms of dollar value in 2003 ($42,718 per year or $0.43 per street tree) and it was ranked second in terms of dollar value in 2007 (the entire urban forest removed 260 tons of pollution annually at $1.3 million per year).[556]

The Bayview-Hunters Point neighborhood also has low tree cover. It is also one of the city's neighborhoods that suffers from poor air quality. Several interview participants noted that not only is there high spatial potential for planting trees, but plantings "are environmentally needed because of air quality."[557] However, re-development history and economics are limiting factors. One participant, when asked about low street tree cover in the neighborhood, responded that "perhaps tree planting is not a high priority when trying to meet basic needs."[558] Although it is one of the neighborhoods with high levels of homeownership, it is one of the lowest income neighborhoods and many households are on fixed incomes.[559] Tree maintenance is expensive; on average, a property owner spends $700 every three years to maintain a street tree.[560] In terms of the other limiting factor, redevelopment history, one participant spoke from experience with neighborhood residents on the tree planting issue.

There is also history I don't know a lot about so I'm hesitant to raise it but it has come up….Tree planting might be an effort to gentrify an area….I was trying to argue that

[554] SF4, personal interview, June 10, 2009.
[555] Greenaction website, PG&E Hunters Point Factsheet, http://www.greenaction.org/hunterspoint/factsheet.shtml (December 9, 2009); San Francisco, Department of the Environment, Resolution No. 003-05-COE, "Resolution Duke Energy Settlement," dated March 22, 2005, http://www.sfenvironment.org/downloads/library/nergysettlementmarch222005.pdf (December 9, 2009); San Francisco, Department of the Environment, Resolution No. 001-05-COE, "Resolution Duke Energy Settlement," dated February 24, 2005, http://www.sfenvironment.org/downloads/library/gysettlementfebruary242005.pdf (December 9, 2009).
[556] Nowak et al., *Assessing Urban Forest Effects and Values, San Francisco's Urban Forest*; Maco et al., *City of San Francisco, California*.
[557] SF5, personal interview, June 18, 2009.
[558] SF1, personal interview, June 9, 2009.
[559] SF1, personal interview, June 9, 2009; SF5, personal interview, June 18, 2009.
[560] SF4, personal interview, June 10, 2009.

'this isn't gentrification. You guys should be demanding trees as environmental justice. You shouldn't be living in a place where there are fewer trees and be threatened by the planting of trees….'[561]

Carbon sequestration and storage

The contribution of trees to carbon sequestration was not identified in the city's Climate Protection Plan but the Forest Service ecosystem assessments assigned the following monetary values: $37,097 or $0.38 per street tree in 2003 and the entire urban forest sequestered 5, 200 tons of carbon at $95,000 annually in 2007.[562] Using 2002 remotely sensed data, the Center for Urban Forest Research calculated that San Francisco's total tree cover provided $66,000 in CO2 benefits in 2007.[563]

Strategies to capture tree-based ecosystem services in San Francisco

Numerous strategies to capture tree-based ecosystem services have been employed by various actors in San Francisco. Among them are policies and reports, funding opportunities, and project development.

Policies and reports

The ecosystem assessments conducted by the Center for Urban Forest Research and the Forest Service Northern Research Station are one way in which San Francisco has attempted to capture the environmental benefits of its tree cover. Other policy and documentary strategies are the 1992 State of the Urban Forest (1992), the Street Tree Action Plan (2004), the Urban Forest Plan (2006), and annual reports written by the Urban Forest Council. One policy measure that has not been discussed in any detail is pruning standards. The trees proposed for the Cesar Chavez Street Design project will be maintained by Public Works Bureau of Urban Forestry. Recall that San Francisco has a hybrid urban forest management system with approximately two-thirds of the city's street trees planted and maintained by adjacent property owners and the remaining one-third are planted and maintained by the Bureau of Urban Forestry. Based on existing practices, it is likely that the Cesar Chavez trees will be pruned to arboricultural standards. Pruning practices on neighborhood streets are highly variable. In some instances, street trees are pruned, sometimes improperly, to create or to maintain views.[564] This practice has implications for stormwater management in that a tree's leaf area index is implicated in the amount of rainfall it can intercept. Therefore, trees with lower leaf area indices provide smaller contributions to stormwater management. The issue of the

[561] Ibid.
[562] Nowak et al., *Assessing Urban Forest Effects and Values, San Francisco's Urban Forest*; Maco et al., *City of San Francisco, California.*
[563] Simpson et al., *San Francisco Bay Area State of the Urban Forest Final Report, December 2007.*
[564] SF5, personal interview, June 18, 2009; SF6, personal interview, June 30, 2009.

enforcement of acceptable pruning practices of neighborhood trees was to be addressed in the Urban Forest Plan but this master planning process has been placed on hold for budgetary reasons.

Program development and activities

Turning now to project development, strategic tree planting for air quality represents an effective approach to capturing ecosystem services. Approximately five percent or $250,000 of the $207.5 million Duke Energy Settlement was designated for tree planting and maintenance of new trees in the Bayview-Hunters Point, Potrero Hill, and Visitacion Valley neighborhoods.[565] (The 2004 lawsuit brought against Duke Energy alleged price spikes and electricity shortages caused by "unlawful conduct" on the part of the energy company.[566]) Although the funding for tree planting came from the Duke Energy Settlement, the energy providers located in the afore-mentioned neighborhoods are Pacific Gas & Electric Hunters Point Power Plant (closed in 2006) and Mirant's Potrero Power Plant.[567] As mentioned previously, the neighborhoods selected were "affected by electric power generation," i.e. these neighborhoods experienced poor air quality defined by high levels of particulate matter.[568] The tree planting project was managed by the San Francisco Bureau of Urban Forestry and the Department of the Environment. 240 trees were slated to be planted in Bayview-Hunters Point and 528 additional trees in Bayview-Hunters Point and the other two neighborhoods.[569] Friends of the Urban Forest is also a planting partner. The Friends received funding which allows them to plant trees in the three affected neighborhoods at a reduced fee of $65.[570] Beginning around the establishment of the city's tree planting program in 1955, the role of trees in ameliorating poor air quality (then primarily referred to as smog) was promoted in tree planting materials published by the city and various beautification committees.

One service that was not captured in either the Forest Service ecosystem assessments or the regression analysis of Friends of the Urban Forest's (FUF) newsletters is wildlife habitat. One participant attributed the absence of the service in the analysis of the FUF's newsletters to the fact that FUF is focused on street trees while an analysis of San Francisco Parks Trust or Friends of Recreation and Park might have yielded a different result.[571] Another participant argued for the habitat role of additional trees in San Francisco.

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[565] San Francisco, Public Utilities Commission and Department of the Environment, "Duke Energy Settlement: Solar Systems in Southeast San Francisco, March 10, 2005 (Draft)," http://www.docstoc.com/docs/3837374/Duke-Energy-Settlement (December 9, 2009); San Francisco, Resolution No. 003-05-COE.
[566] San Francisco, PUC, "Duke Energy Settlement."
[567] Greenaction website, PG&E Hunters Point Factsheet.
[568] San Francisco, PUC, Resolution No. 003-05-COE; San Francisco, PUC, Resolution No. 001-05-COE.
[569] San Francisco, PUC, Resolution No. 001-05-COE.
[570] FUF website, Tree Planting in Bayview & Vis Valley, http://www.fuf.net/treePlanting/bayviewVisValley.html (December 9, 2009).
[571] SF4, personal interview, June 10, 2009.

> *If I was going to argue for more trees to be planted in San Francisco, it would be from a habitat connection from the city out to the countryside perspective.*[572]

The role of streetscape vegetation in providing wildlife habitat is increasingly being recognized by both FUF and newer organizations like Mission Greenbelt. The mission of Mission Greenbelt is to install gardens that support bees, birds, and butterflies in sidewalk and rooftop spaces.[573] Mission Greenbelt's sidewalk gardens in existing and new tree basins are permitted by the city's 2007 Sidewalk Landscaping Permit.[574]

The Sidewalk Landscaping Permit is also used by Friends of the Urban Forest and a new organization, Plant*SF, to manage stormwater runoff in the sidewalk (Figure 5.5). Both organizations expand or create new tree basins to reduce runoff to the city's combined sewer-stormwater system. These efforts increase vegetation which "will likely reduce the total peak flows of runoff at the beginning of a storm"[575] while a planter system such as Portland's SW 12th Avenue Green Street Project (Figure 5.6) which was designed to capture and manage in-situ stormwater, would "permanently remove the volume of water contributing to a CSO."[576]

[572] SF6, personal interview, June 10, 2009.
[573] Mission Greenbelt Project website, http://www.art-eco.org/mgp/missiongreenbelt.html (December 9, 2009). I participated in the installation of the Sangati Center Garden for the Birds in January 2009.
[574] San Francisco, Department of Public Works, Bureau of Urban Forestry, Sidewalk Landscaping Permit, http://www.sfdpw.org/ftp/uploadedfiles/sfdpw/buf/Sidewalk%20Landscaping%20Permit%20Application%20%28PDF%29.pdf (July 17, 2010).
[575] SF7 interview follow-up, email communication, October 18, 2009.
[576] SF7 interview follow-up, email communication, October 18, 2009. A case study of the SW 12th Avenue Green Street Project is available at the City of Portland , Bureau of Environmental Services website http://www.portlandonline.com/bes (July 17, 2010).



Figure 5.5 a: Friends of the Urban Forest (FUF) basin expansion, Valley Street, Noe Valley neighborhood, San Francisco; b: FUF tree tag. *Source:* the author, 2009.



Figure 5.6 a: SW 12th Avenue Green Street, Portland State University campus, Portland, Oregon; b: Green Street stormwater planter detail. *Source:* the author, 2007.

The San Francisco Public Utilities Commission (SFPUC) in partnership with the Public Works Bureau of Urban Forestry (BUF) would be the municipal agency to administer "green street" type projects, however, a cost-benefit analysis of this type of stormwater management system has not been conducted. Even with positive findings from a cost-benefit analysis, this

type of system would require "a lot political buy in about the concepts."[577] (The PUC would be the greater financial partner; it is an enterprise agency in contrast to Public Works which competes with other departments for General Fund allocations.[578]) Additional constraints include maintenance and plant vigor. SFPUC reported that trees planted in flow-through planters require more intensive maintenance, and often show limited growth and vigor, thus containers should not be used for street tree plantings except in limited situations with underground constraints and where sidewalk widths are sufficient to accommodate large containers.[579]

SFPUC and the Department of Public Works have partnered on two stormwater management demonstration projects but neither involved street trees, though trees were planted as part of the swale project. The swale system is located at the Lake Merced Sunset Circle Parking Lot and the green roof is located at the Summit Pump Station.[580] SFPUC advocates for low impact design approaches and on its website showcases Portland's "bioretention in tree planting strips."[581] However, street tree planting is limited to one best management practice (bioretention planter with curb cuts) in the draft Stormwater Management Guidelines.

Funding streams

Emergent funding streams for street trees tend to be based on the ecosystem functions trees provide. One participant, commenting about the audience for street tree research findings and its relationship to funding, said that research scientific evidence is a

> *tool to argue for greater public funding…for trees…helping [cities] demonstrate in a different way from old fashioned 'trees are beautiful and we need green cities and all of that,' for them to be able to go to their city councils and nonprofit boards and say 'here is the dollar value for what these trees are doing for us. They deserve this much funding to increase our internal investment'….*[582]

In the form of two ecosystem assessments of its street trees and urban forest, San Francisco has evidence that its tree population could provide significant returns to the costs of expanding and maintaining its tree cover. However, funding opportunities or lack thereof have affected the ability of the city to implement its tree cover expansion plans, significantly, the urban forest management plan which has been placed on hold for lack of funding.

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[577] SF7 interview follow-up, email communication, October 18, 2009.
[578] SF1, personal interview, June 9, 2009; SF4, personal interview, June 10, 2009; SF7, personal interview, July 24, 2010.
[579] San Francisco, Public Utilities Commission, *Stormwater Design Guidelines November 2009*, https://infrastructure.sfwater.org/fds/fds.aspx?lib=SFPUC&doc=468841&ver=1&data=180503785 (SFPUC-#468841v1.PDF) (December 9, 2009).
[580] San Francisco Public Utilities Commission website, Demonstration Projects, http://sfwater.org/mto_main.cfm/MC_ID/14/MSC_ID/361/MTO_ID/563 (December 9, 2009).
[581] San Francisco Public Utilities Commission website, Low Impact Design, http://sfwater.org/mto_main.cfm/MC_ID/14/MSC_ID/361/MTO_ID/541 (December 9, 2009).
[582] SF6, personal interview, June 30, 2009.

5.9 Summary

Table 5.2 Support for Research Propositions in San Francisco

Proposition	Definition	Supported
1	The presence of an upwards trend in the ecological characterization of street trees	Yes
1a	The urban forest nonprofit played a significant role in advancing the ecological street tree	The nonprofit had a weak role in advancing the ecological street tree
1a1	The nonprofit's newsletter is the primary mode of communicating the ecological benefits of street trees	While analysis of its newsletters revealed a rise in the ecological framing of street trees, Friends of the Urban Forest does not regard its newsletter as the primary method of communicating the ecosystem benefits of trees.
1b	The ecological street tree has been legitimated vis-à-vis the production of scientific research	Yes
2	Particular ecosystem services are salient in particular cities	Yes
2a	Different strategies are used by different actors to capture tree-based ecosystem services	Yes

Both municipal and nonprofit actors in San Francisco have contributed to the emergence of the ecological street tree, but the urban forest nonprofit appears to have a weaker role (Table 5.2). The nonprofit appears to have a weaker role because of its social forestry orientation to be discussed in Chapter 6 (Conclusions). The role of scientific evidence is also a driving factor in advancing the concept of the ecological street tree. Interview participants underscored the production of research data in supporting their efforts to mainstream the ecological street trees. Finally, preliminary findings point to a geography of ecosystem services in San Francisco. In a regression analysis of the Friends of the Urban Forest's newsletters, stormwater management, air quality, and climate were mentioned most frequently and the significance of managing stormwater runoff was corroborated in interviews with nonprofit and city staff.

Chapter 6:: Conclusions

6.1 Overview

This dissertation concludes with a cross-case analysis and discussion of research findings followed by directions for future research. In this study, several propositions about the ecological characterization of street trees during the period 1980 to 2008 were made and examined in a multiple-case study of the northern California cities of Sacramento, Palo Alto, and San Francisco (Table 6.1). A literature review was presented in Chapter 1 followed by a description of methods in Chapter 2. Findings from the case studies were presented in Chapter 3 (Sacramento), Chapter 4 (Palo Alto), and Chapter 5 (San Francisco).

Table 6.1 Propositions and Research Questions

Proposition	Research Question
There has been an upwards trend in the ecological characterization of street trees (the ecological street tree) (1).	Has there been a rise in the ecological characterization of the street tree?
The urban forest nonprofit has played a role in advancing the ecological street tree (1a).	What is the role of the urban forest nonprofit?
The nonprofit's newsletter is the primary mode of communicating the ecological benefits of street trees (1a1).	Has the concept of the ecological street tree been mainstreamed through the nonprofit's newsletter?
The ecological street tree has been made possible through the sharing of research findings (1b).	How is the production of research evidence implicated in mainstreaming the ecological street tree?
A geography of ecosystem services exists, i.e. particular services are salient to particular cities (2).	If different services are salient to different cities, what factors account for this difference?
Different strategies are used by different actors to capture tree-based ecosystem services (2a).	What strategies are used by different actors, in different cities to capture tree-based ecosystem services?

The results from the quantitative analysis of nonprofits' newsletters as well as analysis of interview transcripts, newspaper archives, and nonprofit and municipal planning and policy documents support most of the propositions for each city (Table 6.2).

Table 6.2 Support for Research Propositions in Sacramento, Palo Alto, and San Francisco

Proposition	Supported		
	Sacramento	Palo Alto	San Francisco
1	Yes	Yes	Yes
1a	Yes	Both nonprofit and municipality played a role, neither stronger than the other.	The nonprofit had a weaker role in advancing the ecological street tree.
1a1	While an upwards trend in the ecological framing of the street tree was observed in its newsletter, Sacramento Tree Foundation does not regard its newsletter as the primary mode of sharing the eco-benefits of trees.	While an upwards trend in the ecological framing of the street tree was observed in its newsletter, Canopy does not regard its newsletter as the primary mode of sharing the eco-benefits of trees.	While an upwards trend in the ecological framing of the street tree was observed in its newsletter, Friends of the Urban Forest does not regard its newsletter as the primary mode of sharing the eco-benefits of trees.
1b	Yes	Yes	Yes
2	Yes	Yes	Yes
2a	Yes	Yes	Yes

6.2 Cross-case analysis and discussion

In this section, results of individual case analysis are compared and discussed under six themes: emergence of the ecological street tree, network of actors, communicating the ecological value of street trees, legitimating effect of urban forestry research, strategies used to capture tree-based ecosystem services, and the geography of ecosystem services.

Emergence of the ecological street tree

Generally, the ecological street tree is present in Sacramento, Palo Alto, and San Francisco. Specifically, the presence of the ecological street tree occurred earliest and strongest in Sacramento, followed by Palo Alto and San Francisco in order of decreasing intensity. Several factors account for the situation: (1) legacy of municipal tree planting, (2) proximity to the Center for Urban Forest Research, and (3) individual actors.

Sacramento has a legacy of municipal tree planting to deal with environmental issues beginning with the incorporation of the city in 1850.[583] The planting initiatives were, at the time, coached as public health measures, such as attenuating summer heat and drying out stagnant water.[584] This legacy continues through the period under study as the region deals with energy and air quality issues. In contemporary times, the city's planting legacy is exemplified by policies and activities like the 1990 Sacramento Shade program (energy-saving trees), 1992 Sacramento Urban Ecosystem Study, 1996 State of the Urban Forest Report, 1998 NASA Urban Heat Island Pilot Project, 2000 State of the Trees Report, and the 2006 Urban Forests for Clean Air Project (see Table 3.2).

[583] McPherson and Luttinger, "From Nature to Nurture."
[584] McPherson and Luttinger, "From Nature to Nurture"; STF, *State of the Trees Report 2000*.

This legacy does not exist in San Francisco or in Palo Alto. In both cities, tree planting – both municipal and civic – has been driven primarily by beautification impulses. Based on available evidence, it was not until 2009 with the release of the Palo Alto City Council Priorities that street trees and the urban forest were linked to ecological goals. Environmental Protection is one of three priorities and "a healthy urban forest" is one of four actions selected to achieve Climate Protection.[585] In San Francisco, municipal tree planting started about 100 years later than in Sacramento and Palo Alto. The campaign to establish municipal tree planting in 1955 was focused primarily on the aesthetic value of trees with a secondary discussion of the link between street trees and smog. One of the first acknowledgments of the ecological value of street trees – there is a "growing awareness of the environment [that] radically changed the view of city trees as mere aesthetic props to beautify our neighborhoods" – was made in the 1992 State of the Urban Forest report.[586] More recent recognition of the ecological street tree includes the Planning Department's Better Streets Plan and the Friends of the Urban Forest's Basin Expansion Program.

Proximity to the Center for Urban Forest Research (CUFR) has played a role in the emergence of the ecological street tree. On the one hand, CUFR's research products provided the necessary scientific evidence (which will be discussed in a later section) and on the other hand, CUFR's proximity to Sacramento made that city a natural laboratory. (Also, as acknowledged by one participant, Sacramento's hot summers and high energy use provided "low hanging fruit" for the researchers at CUFR.[587]) San Francisco and Palo Alto are less proximate to the center and of these two cities, only San Francisco has had an ecosystem assessment of its street trees and urban forest completed.

Finally, particular individuals have contributed to the mainstreaming of the ecological street tree. Sacramento Tree Foundation's executive director has been influential; Ray Tretheway was involved in bringing CUFR to Davis, California. The focus on the environmental protection value of Palo Alto's street trees can be attributed, in part, to city manager James Keene. Keene met the Palo Alto council's criteria including "an individual who was passionate about environmental and climate protection and technology."[588] Interview participants in San Francisco highlighted the value of the mayor's stance on greening in providing "leverage" to them in their activities such as "emphasizing the primacy of street trees over these other needs of the street."[589] Talk about the "natural benefits of trees" has been on the rise, especially at city-sponsored forums. Some of these discussions "spilled over into Supervisor Newsom's mayoral campaign"[590] and the mayor has been touted for his follow through on campaign pledges.

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[585] City of Palo Alto website, City Council's Top Priorities.
[586] San Francisco, TAB, *The State of the Urban Forest 1992*. (not paginated).
[587] SF6, personal interview, June 30, 2009.
[588] Mary Duan, "James Keene, Former City Manager in Berkeley and Tucson, Takes Post in Palo Alto," *Silicon Valley / San Jose Business Journal*, September 26, 2008, http://sanjose.bizjournals.com/sanjose/stories/2008/09/29/focus2.html (December 18, 2009).
[589] SF2, personal interview, June 10, 2009.
[590] SF3, personal interview, June 10, 2009.

Network of actors

Recent academic literature has expanded the set of roles environmental nonprofits play in urban areas. Pincetl argued that

> *The role of the nonprofit sector as an active and effective actor in local urban regimes ought to be considered as it can play an important part in determining land-use allocations; it is an important player in the new urban politics and the emerging structures of governance… Although there remains a great deal of empirical research to be done to fully trace the rise of power of environmental nonprofits in the local politics of land-use allocation generally, and in Los Angeles specifically, sufficient evidence exists to point to the emergence of environmental nonprofits as important players in the governance of the Los Angeles metropolitan area and to believe that Los Angeles is not an isolated case*.[591]

Despite these predictions, this study found that policymaking and governance roles are not necessarily predominant functions of every urban forest nonprofit, though "nonprofit involvement in promoting urban environmental quality"[592] is occurring. The urban forest nonprofits studied for this dissertation assume a variety of roles and they are one of several actors in a network which includes municipal and other governmental agencies (Table 6.3).[593] The role of the federal government is most evident in funding of urban forest initiatives. For example, the Center for Urban Forest Service is a research arm of the USDA Forest Service. NASA funded Sacramento Tree Foundation's urban heat island project through its Urban Heat Island Pilot Project. The other role the federal government has played is that of legislator, beginning with Lyndon Johnson's urban beautification program via the 1965 Housing Act,[594] the 1962 President's Outdoor Recreation Resources Review Commission which first designated "urban forestry" as an autonomous division with the Forest Service,[595] and followed by the Cooperative Forestry Assistance Act of 1978 and the establishment of the National Urban and Community Forestry Advisory Committee through the 1990 Farm Bill.[596] The Cooperative Forestry Assistance Act of 1978 mentioned the role of the urban forest in carbon sequestration, energy conservation, and urban heat island mitigation.[597] Regional forms of government are also actors in the ecological street tree network. As an example of this is the Sacramento Municipal Air Quality Management District-funded urban forest expansion for air quality project.

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[591] Pincetl, "Nonprofits and Park Provision in Los Angeles," 981.
[592] Pincetl, "Nonprofits and Park Provision in Los Angeles," 982.
[593] Peter Evans, "Looking for Agents of Urban Livability in a Globalized Political Economy," in *Livable Cities? Urban Struggles for Livelihood and Sustainability*, ed. Peter Evans (Berkeley: University of California Press, 2002). This network concept was also developed in personal communication with Randolph Hester, Robert Ogilvie, and Ananya Roy.
[594] Lisa Selin Davis, "Urban Legend," Wildflower Magazine, Spring 2005, http://www.wildflower.org/pastissues/?id=26 (July 17, 2010).
[595] Alice Ewen Walker, "Why is Urban and Community Forestry Not Getting More Public Support?," Woodnotes 5, no. 4 (2003), http://www.treelink.org/woodnotes/vol5/no4/article1.html (December 17, 2009).
[596] Walker, "Why is Urban and Community Forestry Not Getting More Public Support?"; Treelink website, NUCFAC, Cooperative Forestry Assistance Act, Section 9, http://www.treelink.org/nucfac/nfcfaa.htm, (December 17, 2009).
[597] Treelink, Cooperative Forestry Assistance Act, Section 9.

Table 6.3 Nonprofit Roles

Nonprofit Role		Nonprofit	
	Sacramento Tree Foundation	Canopy	Friends of the Urban Forest
Liaison between residents and government process			Administers planting permits via informal with BUF
Replace or supplement municipal program	plants trees (does not replace municipal program)	Through an MoU with the city plants trees (does not replace municipal program)	plants trees through MoU; acted as a replacement to municipal efforts when it was founded and now acts as a supplement to municipal efforts (City plants trees only on certain streets)
Educator (provide information and promote stewardship)	educator (part of its mission)	through an MoU with the city	via an MoU
Policy maker	involved in urban forestry planning (ex: Greenprint Initiative)	involved in urban forestry policy making (ex: Palo Alto Approved Tree List) but has not led/ initiated a major piece of UF policy but was involved in the early phases of the update to the 1983 Street Tree Management Plan	FUF has not led/ initiated any major UF policy but has been involved in the development of UF policies such as the Street Tree Recommendations List, the 2008 Urban Forest Plan (now on hold), and the Better Streets Plan

In Sacramento, both government and nonprofit actors have strong roles, but based on policies and activities, the nonprofit has played a consistently greater role in mainstreaming the ecological street tree. The situation is similar in Palo Alto but different in San Francisco. In the former, both types of actors were involved in mainstreaming but the nonprofit has a slightly longer history of doing this. By contrast, in San Francisco, government actors have been more active in mainstreaming the ecological street tree, though newer non-governmental organizations are focusing attention on the ecological amenity of sidewalk landscaping. Of the three nonprofits in this study, FUF remains a classic social forestry nonprofit. Defined by Grove et al., social forestry is forestry that "work[s] with people in a community to develop tree-based systems that meet their needs and interests."[598] This type of forestry is common in developing countries; in the U.S., tree-based systems don't typically provide firewood or fodder but often provide a medium for socializing while improving the local environment which is the case for Friends of the Urban Forest.

[598] Morgan Grove, Kerry E. Vachta, and William R. Burch, Jr., "The Urban Resources Initiative: Community Benefits from Forestry," in *Proceedings of the Urban Forestry, Ethnic Minorities and the Environment Sessions. North American Symposium on Society and Resource Management, May 17-22, 1992: Urban and High Recreation Settings,* eds. Paul H. Gobster and Jim F. Dwyer, Jr. (St. Paul, Minnesota: USDA Forest Service, NC Forest Experiment Station, 1992), 24.

> *We are seeing neighborhood groups come together still. So the stuff we started in the 80s is still happening in 2009. So I guess that's pretty invaluable when it comes to a crisis on your block, people losing their jobs, out of work, hanging out more, watering their trees, maybe sharing community, block parties happen. There is a lot of stuff that can happen in a city that's pretty dense, when there are trees. So I am still, it's kind of a 60s thing, but it still happens, and we see it.*[599]

The urban forest nonprofit is not always the lead actor in mainstreaming the ecological street tree and the municipal actor does not always devolve responsibility for planning for ecosystem services to the nonprofit sector. The implication here is that municipal and nonprofit actors can and do play complementary roles. Many interview participants noted the strengths of each type of actor in urban forest management.

Communicating the ecological value of street trees

Based on Louise Fortmann's work on discursive strategies, specifically that "if the story tellers are strategically placed, their stories will diffuse into a wider societal discourse which will strengthen their hand in waging their struggle,"[600] this study proposed a strong role for the nonprofit newsletter. The role of nonprofit newsletters in communicating the ecological value of street trees was examined in this study. While the ecological characterization of street trees in the newsletters of the three nonprofits studied was found to be positive and significant, none of the three nonprofits were systematic in their portrayal of the ecological street tree in their newsletter. All three nonprofits do not perceive their newsletter, at least prior to 2008, as being their central communication tool about trees. At the scale of the city, the nonprofit newsletter is only one mode of communication. An analysis of Canopy's newsletters revealed air quality as a significant service but a review of other documents and interviews conducted with nonprofit and municipal staff revealed that climate protection and hydrological benefits (both runoff reduction and avoided water use) were important services of trees. Of note here, too, is the overlap and linkages between ecosystem services; air quality and climate protection are connected by greenhouse gas emissions.

Discursive strategies vis-à-vis the newsletter remain important, however. Nonprofits have made changes to their newsletters and in all cases, the inclusion of the ecosystem services provided by street trees in city-produced planning documents has given ecological legitimacy to the street tree, as corroborated in interviews and in cross-references among documents.

Legitimating effect of urban forestry research

The ability of the city and the nonprofit to legitimate the ecological value of street trees is based on scientific evidence. In the context of this dissertation, the role of the Center Urban Forest Research (CUFR) was examined. CUFR's research was found to play a substantial

[599] SF5, personal interview, June 18, 2009.
[600] Fortmann, "Talking Claims."

role in mainstreaming the ecological street tree. The importance of the Center's research products were cited by both municipal and nonprofit participants.

The implication here is that the science of tree-based ecosystem services is critical to contemporary environmental and urban forest planning. Writing about the emergence of evidence-based policy in the 1990s, Evans observed that "claims to ecological authority are proliferating under the science-driven rubric of sustainable development, and particularly the notion of evidence-based policy."[601] Specifically about street trees and urban forests, McLean and Jensen argued that the "urban forest [is] being increasingly recognized as a viable policy vehicle for…mitigating some of the environmental impacts of urbanization."[602] Meindl et al. on environmental claims-making noted that

> *In the realm of public science, scientific claims are often appropriated and used by corporations, mass media, governments, and other special interested to augment their own representations of the environment.*[603]

Thus, urban forest research products enable cities and nonprofits to represent street trees as well as cities as ecological objects and spaces. Also of importance is the role of other knowledge producers such as Breathe California whose report on the removal of particulate matter by evergreen trees was cited as important by a Sacramento participant.[604]

Geography of ecosystem services

The previous discussion illustrated that there is not a generic approach to mainstreaming the ecological street tree. Neither is each city identical in terms of the services that are most salient to it (Table 6.4). Different ecosystem services are salient in different cities and contributing factors include geography, climate, urban form, infrastructure, and culture. Sacramento has consistently focused on energy efficiency and conservation and air quality improvement while the discourse in San Francisco is around the hydrological management functions of trees. Sacramento's hot summers results in high energy use. Emissions from energy production contribute to poor air quality as does fall wood burning and transportation emissions.[605] The latter is exacerbated by the region's sprawling form. San Francisco experiences concentrated rainfall in the winter months. This factor, in concert with a combined sewer system that handles the city's waste- and storm-water, causes frequent overflows. Cultural contributions to the geography of services are particularly active in San Francisco where the Department of Public Works assumes responsibility for trees on approximately one-third of the city's streets. This leaves trees on the remaining two-thirds of

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[601] Evans, "Wildlife Corridors,"134.
[602] McLean and Jensen, "Community Leaders and the Urban Forest," 589.
[603] Christopher F. Meindl, Derek H. Alderman, Peter Waylen , "On the Importance of Environmental Claims-Making: The Role of James O. Wright in Promoting the Drainage of Florida's Everglades in the Early Twentieth Century," *Annals of the Association of American Geographers*, 92, no.4 (2002), 685.
[604] SAC3, personal interview, October 16, 2009; Breathe California, *Removal Rates of Particulate Matter onto Vegetation as a Function of Particle Size*.
[605] SMAQMD, *Report to the Community 2009*.

the city's streets under the care of the adjacent homeowner. Street trees are pruned to preserve views, sometimes aggressively. Ecosystem service provision is correlated with leaf area index so a tree is less able to provide services with a reduction in its leaf area. The Center for Urban Forest Research has found for Western cities, on average, that "mature large trees deliver an annual net benefit two to six times greater than mature small trees."[606] Another cultural effect on the geography of services derives from household economics. Homeowners on fixed incomes might decline tree planting to eliminate costly tree maintenance such as sidewalk repair and tree pruning.[607]

Climate and watershed protection have been identified as services of interest in Palo Alto. Several creeks flow through the city and the creeks last flooded in 1998. In the winter for 2007-2008, backed-up storm drains led to "localized street flooding" reported the Palo Alto Online News.[608] Not only do emissions from transportation (commuting to/from Palo Alto and non-commute travel) and energy use (electricity and natural gas) account for 59% of Palo Alto's total emissions, but also, "per capita Palo Alto emissions…are estimated at 14 metric tons, or 26% above the statewide average."[609] Urban forestry for climate protection has been formalized in the city's Climate Protection Plan and in the City Council's 2009 Priorities; however, tree planting for watershed protection has not.

As previously mentioned, heavy rains in the winter of 2007-2008 led to localized flooding in Palo Alto. This event points to the geography of services at the neighborhood scale. Although the run-off reduction potential of trees has not been included in city policy, a municipal participant underscored the role of trees in ameliorating flooding in creek side neighborhoods.

> *I know that if we did not have the urban forest we have now the flooding would have been so much more worse [sic]. That's a hard one to sell, to convey to public works water management folks, storm drain management. To tell them, 'If we didn't have all of these street trees, our storm drains would have been peaked out a day earlier.' Right now they do a good job of holding back the flood event by I think it's the key 11 minutes.…It's not that they soak up, they stall the flood effect by a key 11 minutes.*[610]

When asked about the localized ecological value of street trees in Palo A lot, one participant answered in the negative: "No. I think that the city is not that big."[611] Probing revealed two exceptions: trees for shade and cooling in South Palo Alto, a neighborhood of fewer and younger trees (and tree planting for commercial benefits on the California Avenue corridor).[612] Interestingly, when strategic planting has been employed at the neighborhood level, it was done so in another town. Canopy planted 1000 trees along the Highway 101

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[606] Center for Urban Forest Research, Urban Forest Research (Fall 2003).
[607] SF4, personal interview, June 10, 2009.
[608] "Streets Flood, but Creeks Don't: As Second of Three Weekend Storms Tapers Off, Residents Breathe Sigh of Relief," *Palo Alto Online* UPDATE, January 4, 2008, http://www.paloaltoonline.com/news/show_story.php?id=6756 (June 29, 2010).
[609] Palo Alto, *Palo Alto Climate Protection Plan 2007*, 13.
[610] PA3, personal interview, June 16, 2009.
[611] PA1, personal interview, June 16, 2009.
[612] Ibid.

sound walls in East Palo Alto. One possible explanation for this situation is the fact that Palo Alto is "a heavily treed city,"[613] a legacy of large trees from the first phases of tree planting after incorporation. This distinguishes the city from Sacramento and San Francisco. Recall, that while the older areas of the City of Sacramento have heavy canopy cover, newer areas of the city and the county have lower canopy cover. San Francisco's lower canopy cover can be attributed to the fact that its historical landscape cover was not forest land and to the fact that municipal street tree planting was not established until 1955.

Low tree canopy cover in San Francisco's western, coastal neighborhoods with sandy, highly permeable soils have limited the contributions of these neighborhoods to combined sewer overflows.[614] The Bayview-Hunters Point neighborhood also has low tree cover but the presence of power plants has led to poor air quality. Several interview participants noted that not only is there high spatial potential for planting trees, but plantings "are environmentally needed because of air quality."[615] On the other hand, central neighborhoods such as Bernal, Castro, Hayes, and Twin Peaks have "good canopy cover" but city staff has identified these neighborhoods as important in making improvements to the city's watershed. These neighborhoods are the downstream source of runoff.[616]

In Sacramento, poor air quality is common in the foothills neighborhoods where polluted air "backs up"[617] and in neighborhoods located along highway corridors. Current construction methods have been implicated in changes in energy use in that the site development process eliminates existing shade trees resulting in warmer neighborhoods.[618] In response to stunted tree growth, in 2003, the Sacramento Municipal Utility District exclusively markets its energy-saving shade tree program to new construction areas.[619] Another infrastructural element, planting strips, plays a role in the geography of ecosystem services in Sacramento. "Shade trees make sense in hot Sacramento climate," remarked one Sacramento participant, and historic neighborhoods were designed with trees to provide natural cooling.[620]

Palo Alto has developed a city-wide Climate Protection Plan but has experienced localized flooding most recently in 2008. CUFR's State of the Bay Report (2007) found that San Francisco's total tree cover not only provided $4,444,000 in hydrological (stormwater runoff) benefits, but also $165,000 in air quality benefits. Recall localized air pollution in neighborhoods with a history of power plant operations. The existence of these co-occurrences implies the need for a layered approach to capturing ecosystem services, combining citywide goals and neighborhood plans.

[613] PA4, personal interview, June 16, 2009.
[614] SF2, personal interview, June 10, 2009.
[615] SF5, personal interview, June 18, 2009.
[616] SF2, personal interview, June 10, 2009.
[617] SAC1, personal interview, October 15, 2009.
[618] SAC3, personal interview, October 16, 2009.
[619] SAC2, personal interview, October 15, 2009.
[620] Ibid.

Strategies to capture tree-based ecosystem services

The strategies employed by nonprofit and municipal actors in Sacramento, Palo Alto, and San Francisco fall into three categories: (1) policies and reports, (2) programs and activities, and (3) external funding streams. All three types of strategies were used in each city; however, particular strategies were relied on more heavily in particular cities and by certain actors.

Nonprofits tend to rely more heavily on external funding streams than do municipal agencies. This is especially the case in Sacramento. The Sacramento Tree Foundation (STF) has identified "all the benefit streams of trees"[621] and aggressively pursues relevant funding sources. Although Friends of the Urban Forest and Canopy have received external funding, STF is attractive to funders because of the scale of its work (region vs. city) and the uniqueness of its programs (first nonprofit-utility partnership). (Cities also pursue external funding but many state-funded proposals have been placed on hold (San Francisco's urban forest management plan) or were delayed (Palo Alto's street tree inventory and management plan) due to state's recent fiscal crisis.)

The Sacramento case has also initiated more programs and activities than the other cases. Many of these initiatives can be attributed to the nonprofit Sacramento Tree Foundation (STF). Between 1983 and 2006, STF was involved in three major programs: Sacramento Shade, the NASA Urban Heat Island Pilot Project, the Greenprint Initiative, and the Urban Forests for Clean Air Project (see Table 3.3). In San Francisco and Palo Alto, strategic tree planting occurred later. In Palo Alto, the nonprofit Canopy is leading strategic tree planting (for example, with the East Palo Alto Tree Initiative) while in San Francisco, both the nonprofit and municipal agencies are active. For example, there is Friends of the Urban Forest's Basin Expansion Program for runoff reduction and the Cesar Chavez Street Design project spearheaded by the Planning Department with a hydrological goal of zero contribution to the city's combined sewer system.[622]

Finally, policies and reports have been used in all three cases. Policies and reports not only communicate the ecosystem benefits provided by trees but also serve as part of each city's "inherited institutional landscape"[623] on which future claims about the ecological street tree can be based. For example, the 2006 Urban Forest Plan by the San Francisco Urban Forestry Council and the Department of the Environment (San Francisco Environment) referenced several precursors – the 1992 and 2001 State of the Urban Forest, the 1997 Sustainability Plan for the City of San Francisco – arguing that the 2006 plan "is a result of long history of concern for the City's urban forest."[624] Sacramento also has a set of policies and reports including the 1983 Parking Lot Shade Tree Ordinance, the 1996 State of the Urban Forest Report, the 2000 State of the Trees Report, and the launch of the Greenprint Initiative in 2005.

[621] SAC3, personal interview, October 15, 2009.
[622] SF2, personal interview, June 10, 2009.
[623] Brenner and Theodore, "Cities and the Geographies of 'Actually Existing Neoliberalism.'"
[624] San Francisco, DoE, *Urban Forest Plan 2006*, 2.

Table 6.4 All Cities: Individual Services that Increased Significantly between 1980 and 2008

	Sacramento	Palo Alto	San Francisco
Air quality improvement	✔	✔	✔
Carbon storage and sequestration	✔		✔
Energy efficiency and conservation	✔ (weakest)		
Stormwater runoff management	✔	✔ (weaker)	✔
Wildlife habitat	✔		

Source: Newsletters published by Sacramento Tree Foundation, Canopy, and Friends of the Urban Forest (see Table 2.2).

The dissertation examined the framing of the role of street trees between 1980 and 2008 in Northern California and found that (1) both nonprofit and municipal actors have characterized the street tree in ecological terms, (2) scientific evidence was used to support claims about the ecological value of street trees, (3) different ecosystem services were salient to different cities, and (4) different strategies were used to capture the ecosystem benefits provided by street trees.

6.3 Future research directions

This study could be extended to other U.S. and international cities. The presence and development of the ecological street tree could be examined in cities in the Northeast Corridor of the U.S. such as Boston, New Haven, New York, Pittsburgh, Baltimore, and Washington, D.C. The cities of the Northeast Corridor are particularly attractive because several of the cities in cooperation with nonprofits have announced major tree planting initiatives and goals in the last decade.

New York City's MillionTreesNYC, one of the 127 PlaNYC initiatives, has a planting goal of one million trees or a 20% increase in the city's tree canopy by 2030 to assist in the reduction of the city's carbon emissions, among other goals (MillionTreesNYC website). The primary municipal partner is the Parks Department and the nonprofit partner is the New York Restoration Project, though the city hosts older urban forest nonprofits such as Trees New York founded in 1976. Furthermore, a study of New York would enable a comparison of the role of the Center for Urban Forest Research (CUFR) in different regions of the U.S. CUFR's impact is not limited to the Pacific-Southwest region. CUFR's street tree analysis software (STRATUM) has been used by cities outside the region, for example, New York City used STRATUM to calculate the environmental benefits of the city's street trees as part of the PlaNYC development process.[625] Also, strategic tree planting for air quality improvement and runoff reduction in San Francisco's Bayview-Hunters Point and Cesar Chavez,

[625] New York City, Department of Parks and Recreation, *Calculating Tree Benefits for New York City: Tree Count Report 2005* (New York City: Parks, 2005), http://www.nycgovparks.org/sub_your_park/trees_greenstreets/images/treecount_report.pdf (December 27, 2009).

respectively can be compared to the Bronx's Morrisania. The neighborhood has been selected for the installation of 72 "stormwater tree pits."[626] Tree planting to improve air quality was recommended in the New York City Parks and Recreation Department's "Greening Morrisania: A Community Forestry Management Plan." The plan's authors noted that the neighborhood's "residents [not only] suffer from among the highest asthma rates in the country [but] air pollution is a significant concern, especially as a result of the community's close proximity to many heavily traveled roadways…."[627] The neighborhood is one of five neighborhoods targeted by the Trees for Public Health program which seeks to "to increase tree canopy cover in neighborhoods with fewer than average trees and higher than average public health burdens."[628]

New England cities have also announced urban tree cover goals. The City of Boston announced a canopy coverage goal of 35% by 2030; the Growing Boston Greener initiative will add 100,000 new trees to the city's tree canopy.[629] The primary municipal actor is the Boston Parks Department. Growing Boston Greener is the urban forest nonprofit partner, itself composed of members of the Boston Urban Forest Coalition. The City of New Haven's Mayor announced a 10,000 trees planting goal (2,000 trees annually for five years) in October 2009 (MacMillan 2009).

Cities further south in the Northeast Corridor have also announced tree planting initiatives. In Pittsburgh, a state agency, the Pennsylvania Department of Conservation and Natural Resources, has announced a regional tree planting initiative of 20,000 new trees by 2012, known as TreeVitalize.[630] The City of Pittsburgh is a partner as is the recently formed (in 2006) urban forest nonprofit, Friends of the Pittsburgh Urban Forest. The Friends received grant funding to conduct a STRATUM (Street Tree Resource Analysis Tool for Urban Forest Managers) analysis of the city's street trees in 2008 (Friends of the Pittsburgh Urban Forest website). Tree planting as a climate change strategy is included in the 2008 Pittsburgh Climate Action Plan (Pittsburgh Climate Action Plan). A larger goal was set in Washington D.C.; the district's urban forest nonprofit, Casey Trees, has set an urban tree cover goal of 40% or 216,300 over the next 25 years.[631]

This research protocol could be extended to international cities. For example, n July 2009, the UK's secretary of environment and climate, Ed Miliband, announced a 34% reduction in carbon emissions by 2020.[632] At the city level, London mayor Boris Johnson released

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[626] Urban Ecology Collaborative, Stormwater management with trees conference call/presentation led by Laura Wooley, email communication, June 9, 2010.
New York City, Department of Parks and Recreation, *Greening Morrisania: A Community Forestry Management Plan, June 2006* (New York City: Parks, 2006), 1, http://www.nycgovparks.org/sub_your_park/trees_greenstreets/morrisania_forest_plan/Morrisania_Plan.pdf (December 27, 2009).
[628] New York City, *Greening Morrisania*, 3.
[629] Growing Boston Greener website.
[630] City of Pittsburgh, Mayor's Office, "Mayor to Kick Off Treevitalize 'Root for Trees' Event" press release, dated May 4, 2010, http://www.city.pittsburgh.pa.us/mayor/html/city_press_releases.html (July 17, 2010).
[631] Casey Trees website, Urban Tree Canopy Goal, http://www.caseytrees.org/geographic/key-findings-data-resources/urban-tree-canopy-goals/index.php (July 17, 2010).
[632] "London to Plant 2M Trees by 2025, Says Mayor's Office," *Guardian News* (UK), July 30, 2009,

"Leading to a greener London," a CO2 and energy reduction plan which listed tree cover expansion as one of the emissions and energy reduction tools. The specific goal, a 5% tree cover increase or 2 million additional trees by 2025, was based on studies that showed that "increasing tree cover by 10 per cent can reduce the surface temperature of a city by between three and four degrees centigrade."[633]

These examples illustrate that both municipal agencies and nonprofit organizations are involved in initiating large-scale tree planting and the association between the production of ecosystem services and street trees has been made in some cities. A formal analysis of each city would examine these propositions as well as what role scientific evidence plays and which ecosystem services are prioritized in each city. Extending the study will make several contributions to the literature: (1) examine a specific and increasingly popular city greening strategy – tree planting initiatives as environmental management strategies; (2) compare several metropolitan regions within the U.S. and abroad; and (3) address the role of place/ local geography in tree planting programs.

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http://www.guardian.co.uk/environment/2009/jul/30/boris-johnson-london-trees (July 17, 2010); ASLA The Dirt blog, "London Will Plant Two Million Trees by 2025," http://dirt.asla.org/2009/08/04/london%E2%80%99s-new-plan-to-plant-two-million-trees-by-2025/ (July 17, 2010).

[633] Greater London Authority, *Leading to a Greener London: An Environment Programme for the Capital, July 2009* (London: GLA, 2009), 17, http://legacy.london.gov.uk/mayor/publications/2009/docs/leading-greener-london-300709.pdf (July 17, 2010); ASLA The Dirt Blog, "London Will Plant Two Million Trees by 2025."

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