2004 Water Use Efficiency Proposal Solicitation Package

Project Information Form

Applying for: ☒ Urban ☐ Agricultural

1. **(Section A)** Urban or Agricultural Water Use Efficiency Implementation Project
   - ☐ (a) implementation of Urban Best Management Practice, #___________________________
   - ☐ (b) implementation of Agricultural Efficient Water Management Practice, #_______________
   - ☐ (c) implementation of other projects to meet California Bay-Delta Program objectives, Targeted Benefit # or Quantifiable Objective #, if applicable _______________
   - ☐ **(d) Specify other: ____________________**

2. **(Section B)** Urban or Agricultural Research and Development; Feasibility Studies, Pilot, or Demonstration Projects; Training, Education or Public Information; Technical Assistance
   - ☒ (e) research and development, feasibility studies, pilot, or demonstration projects
   - ☒ (f) training, education or public information programs with statewide application
   - ☐ (g) technical assistance
   - ☐ **(h) other**

3. Principal applicant (Organization or affiliation): **Dept. Land, Air, and Water Resources, University of California Davis – UC Regents**

4. Project Title: Demonstration and Application of New Water Use Efficiency Tool for Reducing Urban Landscape Irrigation Water Use

5. Person authorized to sign and submit proposal and contract:

Name, title	**David Ricci** **Contracts and Grants Analyst**
Mailing address	**Office of the Vice Chancellor for Research, Sponsored Programs, 118 Everson Hall** **One Shields Avenue** **Davis, CA 95616**
Telephone	**(530) 752-9753**
Fax.	**(530) 754-9233**
E-mail	**fdricci@ucdavis.edu**

6. Contact person (if different):

	Name, title.	**Qingfu Xiao** **Research Water Scientist**
	Mailing address.	**Department of Land, Air, and Water Resources, UC Davis** **One Shields Ave.** **Davis, CA 95616**
	Telephone	**(530) 752-6804**
	Fax.	**(530) 752-6634**
	E-mail	**qxiao@ucdavis.edu**

7. Grant funds requested (dollar amount): **$915,026**
(from Table C-1, column VI)

8. Applicant funds pledged (dollar amount):

9.Total project costs (dollar amount): **$915,026**
(from Table C-1, column IV, row n)

10. Percent of State share requested (%) **100%**

(from Table C-1)

11. Percent of local share as match (%)

(from Table C-1)

12. Is your project locally cost effective?

Locally cost effective means that the benefits to an entity (in dollar terms) of implementing a program exceed the costs of that program within the boundaries of that entity.
(If yes, provide information that the project in addition to Bay-Delta benefit meets one of the following conditions: broad transferable benefits, overcome implementation barriers, or accelerate implementation.)

☐ (a) yes
☒ (b) no

11. Is your project required by regulation, law or contract?
If no, your project is eligible.
If yes, your project may be eligible only if there will be accelerated implementation to fulfill a future requirement and is not currently required.
Provide a description of the regulation, law or contract and an explanation of why the project is not currently required.

☐ (a) yes
☒ (b) no

12. Duration of project (month/year to month/year):	12/01/05 to 11/30/08
13. State Assembly District where the project is to be conducted:	5, 8, 39, 51, 70
14. State Senate District where the project is to be conducted:	5, 6, 20, 26, 35
15. Congressional district(s) where the project is to be conducted:	1, 5, 28, 33, 48
16. County where the project is to be conducted:	Yolo, Los Angeles, Orange, Sacramento
17. Location of project (longitude and latitude)	121.74 W, 38.55 N 117.80 W, 33.66 N 118.41 W, 34.11 N 118.33 W, 34.19 N 121.47 W, 38.13 N
18. How many service connections in your service area (urban)?	
19. How many acre-feet of water per year does your agency serve?	

20. Type of applicant (select one):

- ☐ **(a) City**
- ☐ **(b) County**
- ☐ **(c) City and County**
- ☐ **(d) Joint Powers Authority**
- ☐ **(e) Public Water District**
- ☐ **(f) Tribe**
- ☐ **(g) Non Profit Organization**
- ☒ **(h) University, College**
- ☐ **(i) State Agency**
- ☐ **(j) Federal Agency**
- ☐ **(k) Other**
  - ☐ **(i) Investor-Owned Utility**
  - ☐ **(ii) Incorporated Mutual Water Co.**
  - ☐ **(iii) Specify ___________________**

21. Is applicant a disadvantaged community? If ‘yes’ include annual median household income. (Provide supporting documentation.)

- ☐ **(a) yes, ________ median household income**
- ☒ **(b) no**

2004 Water Use Efficiency Proposal Solicitation Package
Signature Page

By signing below, the official declares the following:

The truthfulness of all representations in the proposal;

The individual signing the form has the legal authority to submit the proposal on behalf of the applicant;

There is no pending litigation that may impact the financial condition of the applicant or its ability to complete the proposed project;

The individual signing the form read and understood the conflict of interest and confidentiality section and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant;

The applicant will comply with all terms and conditions identified in this PSP if selected for funding; and

The applicant has legal authority to enter into a contract with the State.

____________________	____________________________	_________
Signature	Name and title	Date

Demonstration and Application of New Water Use Efficiency Tool for Reducing Urban Landscape Irrigation Water Use

Executive Summary

Fresh water is a precious natural resource that impacts the quality of life and sustainable economic development of urban ecosystems. In recent years, urban water use has increased dramatically in California due to the increasing pace of urbanization. Urban water use now accounts for more than 21% of the total fresh water use (http://www.landwateruse.water.ca.gov/). In California, approximately 73% of the water consumed by customers in single family residential communities is used outside the home primarily for landscape irrigation. Because future urban water use is projected to continue to increase dramatically, DWR and CALFED have adopted strategic goals and priorities aimed at achieving more efficient water use. The Water Use Efficiency Program will benefit local water users, districts, regions, and the State by reducing the mismatch between California water supplies and the current and projected beneficial uses that are dependent on them.

Urban landscape irrigation water use is driven by demand and consumption. Accurate information on the demand, in terms of landscape irrigation area and type of vegetation being irrigated is lacking. This information is critical to the development of realistic demand forecasts and conservation goals. Increasing the efficiency of landscape water use in residential parcels has the potential to significantly reduce consumption.

Pilot studies have mapped irrigated landscapes in San Diego (Allen Hope et al., 2003) and Santa Clara (CALFED project, http://www.water.ca.gov/) using remote sensing. However, these studies have not provided information on the type of vegetation that is being irrigated. Also, they relied on aerial photography-based mapping, which is labor intensive and less cost efficient than digital multispectral, high resolution imagery analyzed within a GIS platform.

Best management practices (BMPs) have been developed to conserve water outside the home and have been applied in California. For example, California Irrigation Management Information Services (CIMIS)-based irrigation forecasting is used statewide, and rainwater harvesting is used in Southern California ("Saving Drops, Filling Buckets", Los Angeles Times, October 30, 2003). However, these BMPs are primarily aimed at landscape professionals managing commercial properties and large turf areas. There are no science-based tools for non-professionals to design and manage the smaller landscapes where they live and play. Without such a tool, it is impossible for city dwellers to evaluate the economic, aesthetic, and environmental tradeoffs associated with water efficient landscapes. Also, there is little information about the aggregate effects of water-conservation practices at the parcel-scale on regional water demand, microclimate change, urban heat island effects, air quality, stormwater runoff, and other ecological and economic costs and benefits that would accrue from wider use.

Decision-support tools that will assist residents and water resource managers to increase urban landscape irrigation efficiency are urgently needed due to the limited water supplies and increasing water demand in California associated with rapid urbanization. The goals of this research and demonstration project are to: 1) develop a science-based urban landscape water use tool, applicable for both professional and non-professionals, 2) evaluate the effectiveness of this tool after providing training to professionals and non-professionals and demonstrate its use in typical urban gardens and parks, 3) develop an urban vegetation database, and 4) develop a

mapping method for characterizing the urban landscape and extending the results of the study to other regions of the state.

This research will be conducted in two urban watersheds and at four demonstration sites. The two watersheds are the Sun Valley Watershed in the San Fernando Valley, Los Angeles County metropolitan area, and the North Natomas Watershed in the Sacramento Valley, Sacramento County metropolitan area. The four demonstration gardens and park sites are: 1) The Urban Pesticide Mitigation and Education Center located at 7601 Irvine Blvd, Irvine, where the South Coast Research and Extension Center is located. This site is centrally located in urbanized Orange County and is presently under construction, to be completed summer 2005. Landscapes are being built to monitor water quality and pesticides, but the majority of the BMPs utilized will increase water efficiency in the landscape. BMPs that will be installed in this site include cisterns and rain barrels, California friendly plants, pervious driveways and pathways, and ET controllers for landscape irrigation. 2) The TREE demonstration house located at 1828 West 50th Street in the Crenshaw district of Los Angeles. 3) The Sustainable Garden of the Center for Urban Forest Research located at Department of Plant Science, University of California Davis. And 4) Redwood Park at 1001 Anderson Street in Davis. Demonstrations at these sites will maximize information on landscape irrigation water use efficient BMPs to professionals, the general public, and policymakers.

Statement of Work

Relevance and Importance

The abundance and quality of fresh water impacts the quality of life and sustainable economic development of urban ecosystems. Urban water use has increased dramatically in California due to the increasing pace of urbanization. It now accounts for more than 21% of the total fresh water use (http://www.landwateruse.water.ca.gov/). Urban water use continues to increase dramatically due to rapidly increasing pace of urbanization. Approximately 73% of the water consumed by single family residential areas is used outside the house, primarily for landscape irrigation. Maintaining vegetated urban landscapes is important because green vegetation not only provides aesthetic and recreational benefits, it also reduces air pollution and storm runoff, conserves energy, stores carbon, provides protection from ultraviolet radiation, creates habitat for wildlife, and moderates air temperatures (McPherson et al., 1999; Xiao and McPherson, 2002; McBride and Jacobs, 1986). Because future urban water use is projected to increase dramatically, the California Department of Water Resources (DWR) and CALFED have adopted strategic goals and priorities aimed at achieving more efficient water use. The Water Use Efficiency Program will benefit local water users, districts, regions, and the State by reducing the mismatch between Bay-Delta water supplies, and current and projected beneficial uses that are dependent on the Bay-Delta system.

Vegetation coverage is an indicator of sustainability of the city, though it comes at the cost of fresh water. In most California urban areas, landscape irrigation provides the principal water consumed by plants during their growing season. Our limited fresh water resource also supports agriculture, rangeland, and freshwater wetlands. The competition for water resources increases with the annual increase in urban populations in California. Currently, population of the Sate increase by 2% between 1998 and 2001 (http://www.landwateruse.water.ca.gov/). These competing demands intensify the challenge to our water resources managers. Urban water use is driven by demand and consumption. Managers lack accurate information on the demand, in terms of the total irrigated area and type of vegetation being irrigated. This information is critical in developing realistic demand forecasts and conservation goals. Increasing the landscape water use efficiency of residential parcels has potential to substantially reduce individual consumption and extend the amount of water available to the expanding population. Accurate measurement of the irrigated urban landscape, agriculture lands, and associated plant types will significantly improve demand forecasting and dry-year planning efforts of state and local water agencies. Pilot studies have mapped irrigated landscapes in San Diego County (Hope et al., 2003) and in urban watersheds (Xiao, 2003) in Los Angeles County and Santa Clara County (CALFED project, http://www.water.ca.gov/) using remote sensing. However, these studies did not contain information on the type of vegetation that is being irrigated. The IKONOS satellite has four visible and near-infrared bands. At 4.0m pixels, the imagery has limited spatial resolution for parcel scale vegetation mapping. Aerial photography can provide higher spatial resolution in three visible bands or as color-infrared bands. However over broad areas, it is not as cost effective to use over broad areas as digital multispectral, high spatial resolution imagery that can be used to develop GIS databases. The Quickbird satellite images are similar to IKONOS, but with greater spatial resolution (2.4m for the multispectral data and 0.61m for panchromatic data). This spatial resolution should sufficiently improve parcel scale mapping.

BMPs to conserve water outside the home have been developed and applied in California. For example, CIMIS based irrigation forecasting is used statewide, and rainwater harvesting is used in Southern California ("Saving Drops, Filling Buckets", Los Angeles Times, October 30, 2003). However, these BMPs are primarily aimed at landscape professionals managing commercial properties and large turf areas. A study of the effect of BMPs on hydrological processes at the residential scale found that combinations of BMPs could save annually landscape irrigation water use by 40-70% as compared with traditional irrigation practices (Xiao et al., 2004). There are few science-based tools for use by non-professionals for designing and managing smaller landscapes. Without such tools, the consideration by urban residents of the economic, aesthetic, and environmental tradeoffs associated with water-efficient landscapes is inhibited. Also, there is little information about the aggregate effects of water-conservation practices at the parcel-scale on regional water demand, microclimate change, urban heat island effects, air quality, storm water runoff, and other ecological and economic costs and benefits.

Most existing landscape water use efficiency tools are designed for professionals or require input data based on professional judgment. One exception is the most recent urban landscape irrigation and runoff tool, developed by the Center for Urban Forest Research (CUFR), USDA Forest Service, that is targeted to both professionals and non-professionals (www.ecosmart.gov). This web-based software is relatively easy to use and landscape irrigation water use is one components of that software. This program is favored because of the detail input required (e.g., parcel dimensions, land cover, soil, and climate). An enhancement for capturing the necessary resource and climate data from remote sensing data and GIS databases will limit user input to better serve both professional and non-professional users.

Decision-support tools that will assist residents and water resource managers to increase urban landscape irrigation efficiency are urgently needed due to limited water supplies and increasing demand in California. The goals of this research and demonstration project are to: 1) develop a science-based urban landscape water use tool for both professional and non-professionals, 2) Evaluate the effectiveness of this tool after providing training to professionals and non-professionals and demonstrating its use in gardens and parks, 3) develop an urban landscape vegetation growth and water use database, and 4) develop a mapping method for characterizing the urban landscape and extending the results of the study to other regions of the state.

This approach will demonstrate the new tool and BMPs at various sites in southern and northern California to maximize dissemination of the information on landscape irrigation water-use efficiency BMPs to professionals, the general public, and policymakers. This research will take place in two urban watersheds and four demonstration gardens and park sites (Figure 1). The two watersheds are the Sun Valley Watershed (Figure 2) in the San Fernando Valley, Los Angeles metropolitan area, and the North Natomas Watershed (Figure 3) in the Sacramento Valley, Sacramento County metropolitan area. The four demonstration gardens and park sites are: 1) the Urban Pesticide Mitigation and Education Center at the South Coast Research and Extension Center, located at 7601 Irvine Blvd, Irvine, Orange County; 2) the TREE demonstration house (Figure 4) located at 1828 West 50th Street in the Crenshaw district of Los Angeles; 3) the Sustainable Garden (Figure 5) of the Center for Urban Forest Research located at Department of Plant Science, University of California Davis, in Yolo County; and 4) Redwood Park (Figure 6) at 1001 Anderson Street in Davis, in Yolo County.

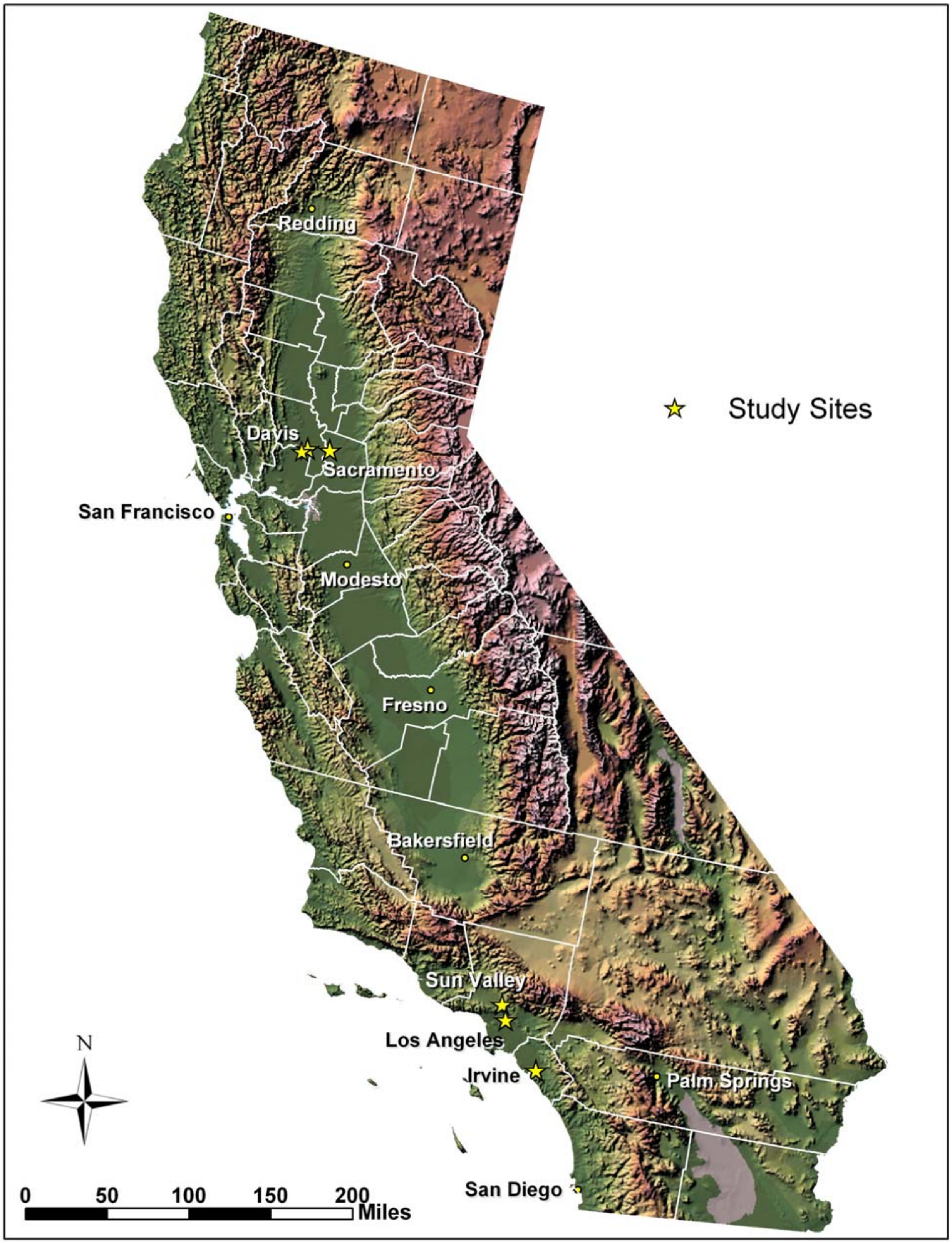

Figure 1. Study sites

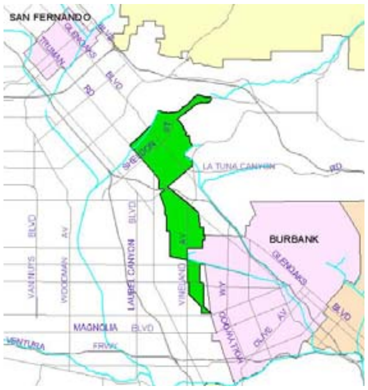

Figure 2. Sun Valley Watershed

Figure 4. TREES demonstration house

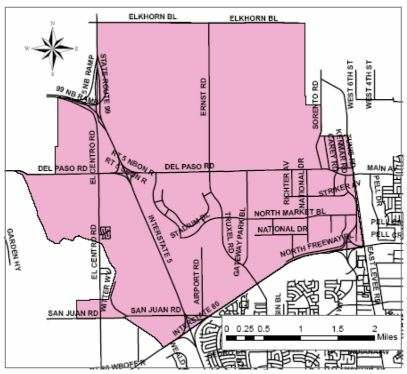

Figure 3. North Natomas Watershed

Figure 5. Sustainable Garden

Figure 6. Redwood Park

Technical/Scientific Merit, Feasibility

In this research and demonstration project, we will first develop a scientifically based New Water Use Efficiency Computer Tool for Reducing Urban Landscape Irrigation Water Use. This scientifically based tool will have a user-friendly web interface with limited user input requirements (e.g. user's address or parcel number). It will allow users to evaluate changes in landscape irrigation water use due to landscape retrofits, changing irrigation setups, and installing BMPs that are typically used in urban settings of California. The other parameters of the tool, such as soil type, climate, and existing land cover, will be pre-constructed. The output of the tool is both graphic and tabular data of estimated daily, monthly, and annual landscape irrigation water use. We will develop regional databases to support the application of this tool and the methodology to expand the application to the entire State. We will conduct a statewide education and outreach program to transfer the urban landscape water use efficiency tool from research into management practice through University of California Cooperative Extension programs, turf and urban planning conferences, demonstration sites, and urban forest managers. The detailed approaches to these objectives are described below.

1. Develop a new water use efficiency tool for reducing urban landscape irrigation water use

Existing landscape irrigation computer tools are designed for professionals and are used for relatively large areas or require detailed parameter inputs for small areas, such as home parcels. With data collected for more than three years and modeling hydrologic processes at the parcel scale, scientists at the University of California developed a physically-based numerical model that simulates the interactions of hydrological processes with different BMPs and landscape retrofits. That study was funded by the USDA Forest Service and the California Department of Forestry and Fire Protection. It was found that landscape irrigation water use can be significantly reduced by reducing the irrigation duration and scheduling irrigations at times during the day that are appropriate for the vegetation type and in association with other BMPs (Xiao et al., 2004). The parcels were separated into patches for scheduling separate irrigation cycles specific to the plant type (daily water demand), soil water storage and holding capacity, and soil moisture status. Substantial improvement in water usage was achieved in this model using three irrigation scheduling methods. The first method is based on existing irrigation controller settings. Only the irrigation frequency, start time, and duration were modified. The ET method, based on the ET controller technique used in Southern California, irrigated to replace moisture losses that were estimated by modeled evapotranspiration for each vegetation type. The third method applied water based on the direct measurements of the soil moisture and the calculated plant water demand.

1.1 Methodology

For this project, we will develop a New Water Use Efficiency Tool for Reducing Urban Landscape Irrigation Water Use based on our previous residential scale research. The Tool will utilize a user-friendly web interface and will require few user parameter inputs to characterize the parcel. The Tool will run at the parcel scale and, with outreach activities, will provide information to residents to reduce landscape irrigation water use. The Tool will calculate the amount of irrigation water to be applied for each specified vegetation patch of the parcel based on plant water demand, weather, soil type, soil moisture status, slope, and aspect of each irrigation unit. This model will demonstrate directly to the homeowner how their investments in irrigation systems, landscape retrofits, and BMP installations will be beneficial in reducing their water use.

In an urban setting, especially at the parcel level, the energy balance of the irrigated landscape is strongly affected by surrounding micro environments. For example, trees, buildings, and other tall man-made structures will change turf grass water demand compared to turf grass growing in an open space. The existing ET model-based irrigation scheduling may over-irrigate the landscape. Since the soil moisture controller method utilizes a direct measurement of soil moisture, the influence of the micro environment has little influence on the irrigation schedule compared to ET-based controlled irrigation. Using soil moisture controllers in irrigation management, landscape irrigation water waste will be further reduced. One existing problem associated with moisture controllers is that the lowest moisture level occurs in the afternoon when irrigation efficiency is low. This can be solved by delaying the irrigation start time. We will also include the most commonly used landscape irrigation BMPs in this tool, such as use of cisterns and rain barrels, California native plants and turf grass, mulch, and lawn water retention.

We will demonstrate the use of this tool and the resulting water use reductions through conference presentations, public education, seminars, and field demonstrations at our education and demonstration sites (see Task 2).

Because the tool is a physically-based model, it will require detailed input parameters, such as type of soil and depth, plant water demand, and climate factors. For most property owners, the parameters required by the model would be outside their knowledge base. Thus, we will develop a serial database from existing data, such as remote sensing data, soil maps and databases, city building codes, tree growth data, plant water demand data, and climate network data. A tree growth and plant and grass water use database will include most plants and grasses in California (see Task 3). Detail of existing land cover, irrigated landscape, and plant types for each parcel will be mapped for the selected study areas, but the methodology developed in this study will be easy to extend to cover the entire State (See Task 4). Within the study areas, users can evaluate their landscape irrigation performance and how it can be improved by changing the management practice, retrofitting the landscape, and adding BMPs. For parcels that are outside the selected study areas or for a vacant lot, the user can design changes to their landscape by interactive tablet selections and graphic drawings.

The tool will be calibrated and validated with field data from our demonstration sites. The output of the tool will be both graphic and tabular data of estimated daily, monthly, annual landscape irrigation water use, and long term landscape irrigation water use predictions based on existing vegetation, vegetation changes (i.e., added, removed, or replaced), and landscape retrofits, and BMPs installed on the parcel.

1.2 Products

Deliverable items from our Task 1 will include a web based Tool for Reducing Urban Landscape Irrigation Water Use (including a user manual and "how to" information) and project report to DWR /CALFED. The tool will be made available at several popular landscape irrigation water use related web sites such as http://www.cimis.water.ca.gov/ (The California Irrigation Management Information System site), http://cufr.ucdavis.edu/, http://www.ecosmart.gov/ (Center for Urban Forest Research, USDA Forest Service), http://www.cstars.ucdavis.edu/, (Center for Spatial Technologies and Remote Sensing, Department of Land, Air, and Water Resources, UC Davis), local UCCE offices, and Master Gardener sites.

1.3 Work schedule and cost

Task	Start – End Dates	Cost
1. Model development	12/05 - 11/08	$161,523*
1.1 Structure design	12/05 - 3/06	
1.2 Algorithms and test	4/06 - 12/06	
1.3 Field monitoring system	3/06 - 11/08	
1.3.1 Design, installation, and test	3/06 - 10/06	
1.3.2 Field data collection	11/06 - 11/08	
1.4 Model calibration and validation	1/07 - 6/07	
1.5 Testing	1/07 - 9/08	
2. Web Interface	3/06 - 6/08	$73,800**
2.1 Markup	3/06 - 9/06	
2.2 Coding, testing, modifying	10/06 - 6/08	
3. Model application	12/05 - 9/08	$74,912***
3.1 Parameterization for each parcel	12/05 - 9/06	
3.2 Weather data system	10/06 - 12/07	
3.3 Touch screen system	10/06 - 12/07	
3.4 Test and application	1/07 - 9/08	

*: Salary: $128,567 Benefit: $21,856 Supply: $1,500 Travel: $9,600
The travel cost includes field monitoring systems installations, maintains, conferences, and meetings.
***: Salary: $60,000 Benefit: $13,200 Supply: $600 Travel: $0
***: Salary: $60,420 Benefit: $13,292 Supply: $600 Travel: $600

Note: Indirect cost by University of California Regents (25%) is not included.
The PI will contribute his time at no cost, approximately 10%, or $6,000 per year.
See Budget Justification for detail.

Dr. Qingfu Xiao, a water resources Research Scientist at the Department of Land, Air, and Water Resources, University of California Davis is in charge of this task. Two Assistant Specialists and a Computer Programmer will work with him, along with the entire project team, to conduct this research component. Dr. Xiao's research focuses on urban landscape irrigation, storm runoff reduction, rainfall interception, urban watershed protection and small scale hydrologic processes. He has been working on methods to reduce urban landscape irrigation water use since 2000. The project "Monitoring and modeling hydrological processes at residential scale" at Los Angeles significantly improved our understanding of the interaction of BMPs and urban hydrologic processes. His current research projects involve urban landscape irrigation.

2. Demonstrate and evaluate the effectiveness of the urban landscape irrigation efficiency tool and statewide landscape irrigation water use efficiency education and outreach

Demonstrate and evaluate the effectiveness of urban landscape irrigation efficientcy tool after providing training to professionals and non-professionals and demonstrating its use in gardens and park. As part of this task, we will conduct a Countywide landscape irrigation water use efficiency education and outreach program. Increasing public awareness on landscape irrigation water use efficiency, especially for home owners, will have significant benefits statewide in reducing urban landscape irrigation water use.

2.1 Method

A statewide outreach effort will be developed to enhance the public's awareness of the urban landscape irrigation water use issue utilizing workshops, demonstration sites, and web tools. University of California Cooperative Extension Specialists, Advisors, and the Director of Communications of the Center for Urban Forest Research, USDA Forest Service will conduct a series of seminars and workshops to provide training to an audience of UC Master Gardeners, public agencies, landscape professionals, and others who are interested in urban landscape irrigation water use efficiency. Information will be presented to both professional and non-professional operators on the implementation of both structural and non-structural BMPs that increase irrigation water use efficiency of urban landscapes. Two workshops will be held at UC Cooperative Extension, Irvine in Orange County and at UC Davis. Two entire urban watersheds and four demonstration sites will be used to demonstrate the application of the new tool. The residents of these two watersheds can use this tool with minimum input (e.g. street address). BMPs that are intgrated into the four selected sites will enable the public to see the effectiveness and benefits of these BMPs on reducing urban landscape irrigation water use.

The two watersheds are the Sun Valley Watershed in the San Fernando Valley of Los Angeles County, and the North Natomas Watershed in the Sacramento Valley of Sacramento County. Sun Valley is a district of the northeast San Fernando Valley. The watershed covers 2,800 acres (4.4 square miles) with 80,000 residents. Shallow soil and hard surfaces dominate the Sun Valley landscape. BMPs such as cisternsand underground water storage have been installed in this watershed. The North Natomas watershed covers 8,000 acres (12.65 square miles) and is a growth area of the City of Sacramento. It is projected that there will be 32,500 dwelling units with a population of 66,000 residents. A variety of residential uses are located within this area. The area is on the crest of a major growth periods about 1,500 homes per year have been built since 1999. A detailed database will be created for these two watersheds containing information of land cover, soil, and all vegetations (See Tasks 3 and 4). There are four demonstration gardens and park sites: 1) The Urban Pesticide Mitigation and Education Center located at 7601 Irvine Blvd, Irvine, where the South Coast Research and Extension Center is located. This site is centrally located in urbanized Orange County and is presently under construction, to be completed summer 2005. Three landscapes are being built to monitor water quality and especially pesticides in runoff, but the majority of the BMPs that will be installed will increase water efficiency in the landscape. The BMPs that will be installed in this site include cisterns and rain barrels, California friendly plants, pervious driveways and pathways, and ET- and soil moisture-based controllers for landscape irrigation. 2) The TREE demonstration house located at 1828 West 50th Street in the Crenshaw district of Los Angeles. The BMPs installed and used in this site includes a cistern, drywell, lawn retention basin, mulch, and driveway interceptor. This site has been use for public outreach about sustainable gardens for years by Tree People of Los Angeles. 3) The Sustainable Garden of the Center for Urban Forest Research, located at Department of Plant Science, University of California Davis, utilizes cisterns, rain barrels, low water consumption plants, and ground cover. 4) Redwood Park at 1001 Anderson Street in Davis. This 3.4 acre park is currently maintained by the City of Davis. In the summer, dry and wet spots are distributed over the park due to the poor irrigation system. We will use the tool as an example to help retrofit the park to improve the irrigation efficiency. Using these varied sites in both southern and northern California, we can maximize the dissemination of information on landscape irrigation water use efficient BMPs to professionals, the general public, policymakers.

Touch screen computer systems will be installed at sites 1 and 3 and the landscape irrigation system, soil moisture, and micro-climate at these two sites will be monitored through the duration of this project. Additional funding will be sought to extend the period of outreach and demonstrations at these two sites. Site 4, Redwood Park, is an older park. The irrigation efficiency is low due to mixing of many types of sprinklers that result in over-irrigation of the landscape. We will replace all of these 100 sprinklers and use a soil moisture-based controller to control irrigation. All irrigation events and water use will be tracked through the Rain Master irrigation monitoring system that is currently used by the City of Davis. Additional soil moisture and micro-climate data will be collected from this site during the time span of this project. These data along with the historical irrigation water use of this park and climate data from nearby CIMIS station will be statistically analyzed. The results will be presented in both graphic and table formats. The data collected from these three sites will also be used in Task 1 to calibrate and validate the new tool.

These are ideal sites for on-site education to demonstrate how to reduce landscape irrigation water use and show the effects on the landscape. The detailed tasks are:

2.1.1 Workshop

1) Develop a comprehensive database of contacts, including email addresses, using existing clientele lists from the UC Cooperative Extension and CUFR Forest Service.
2) Establish a schedule for two special workshops to demonstrate the new urban landscape irrigation water use tool. Establish a schedule for three workshops (one per fiscal year) to train UC Master Gardeners, professional landscapers, independent gardeners, interested citizens, and public agencies.
3) Prepare and distribute an announcement at least 30 days in advance of a scheduled workshop to the appropriate clientele.
4) Prepare an agenda providing details on speakers and the subjects to be presented during the workshop, such as improving irrigation efficiency utilizing new technology and irrigation efficiency monitoring.
5) Develop handouts to provide to the attendees focusing on methods and materials required to implement the BMP discussed and shown at the workshop.
6) Request input from attendees via email on their level of BMP adoption following a workshop and suggestions for future workshops.

2.1.2 Demonstration sites

1) On-site education and demonstration: Demonstrate the effectiveness of BMPs to reduce landscape irrigation water use to our clientele on the scheduled workshops.
2) Compile a four page booklet for each site and make it available on each demonstration site and in web sites. The booklet will describe the site, the BMPs installed on the site, the effectiveness of each BMP.
3) Biweekly maintainance information including turf mowing during the growing season, tree and shrub pruning, and measurement device check. Plant growth will also be monitored in each site.

As a part of the outreach effort, we will produce technology transfer products starting from the beginning of this project. A quarterly newsletter about the status of the project will be delivered to our clientele via email and web posting. Three one page fliers will be created to distribute the information at various professional conference and public events. Four page research summaries will be produced each year describing the results of reducing urban landscape irrigation water use, the irrigation effciency tool and BMPs that can be used to reduce urban landscape irrigation water use, and the final results of this project.

2.2 Deliverable products

Clientele database, schedule of workshops, announcements, agendas, handout materials, attendance lists, results of input obtained from attendees, booklets, newsletters, and research summaries. Most of these products will be available on web sites http://www.cimis.water.ca.gov/, http://cufr.ucdavis.edu/, http://www.ecosmart.gov/ http://www.cstars.ucdavis.edu/, local UCCE offices, and Master Gardener sites.

2.3 Time table and cost for tasks listed above

Task	Start – End Dates	Cost
1. Workshop	1/06-11/08	$63,450*
a. Contacts database develop	1/06-11/08	
b. Workshop schedule	1/06-6/06	
c. Scheduled workshop: announcement prepare and distribute	1/06-6/08	
d. Prepare workshop agenda	1/06-9/08	
e. Handouts develop	1/06-9/08	
f. Request input from attendees	10/06-10/08	
2. Demonstration sites	1/06-11/08	$109,430**
a. Onsite education and demonstration	1/06-11/08	
b. Four pages booklet for each site	1/06-10/08	
c. Sites maintain	1/06-11/08	
*: Salary: $35,000 Benefit: $14,700 Supply: $3,000 Travel: $4,800 **: Salary: $62,500 Benefit: $13,750 Supply: $33,180 Travel: $0 Note: 25% UC Regents indirect cost is not included. See Budget Justification for detail.		

Drs. Loren Oki (Department of Plant Science, UC Davis) and Darren L. Haver (University of California Cooperative Extension, Orange County) will lead this task working along with Jim Geiger (CUFR, USDA Forest Service), Roy Jones (City of Davis), and Andy Lipkis (TreePeople, Los Angeles). Dr. Loren Oki, is a CE Specialist with expertise in management of irrigation in landscapes and nurseries. Dr. Darren L. Haver is a Watershed Management Advisor. They have successfully provided various training of the UC Master Gardeners and other professionals in landscape and nursery water use. Jim Geiger, Director of Communications, administers CUFR's outreach, education, training, and public relations. Roy Jones, Parks Supervisor, is in charge of all parks irrigation and maintainers of the City of Davis.

Andy Lipkis, President of TreePeople of Los Angeles, has conducted various water saving projects in Los Angeles area using both construction and education.

3. Develop statewide urban landscape vegetation growth and water use database

Scientists at the U.S. Forest Service, Center for Urban Forest Research (CUFR) have developed growth equations for 120 tree species, approximately twenty dominant species in each of six climate zones (Figure 7). To develop these relationships, 30 to 70 randomly selected trees of each species were selected to survey in each reference city. Tree measurements included DBH, tree crown and bole height, crown diameter in two directions, tree condition and location, and crown pruning level. Tree age was determined by street and park tree managers, interviews with residents, and historical planting records. Linear regression was used to fit predictive models—DBH as a function of age—for each of the sampled species. Predictions of crown projection area (CPA), leaf surface area (LSA), tree height, and other metrics were modeled as a function of DBH using best-fit models (Peper et al 2001). These biometric data have been used with numerical models to quantify annual tree benefits in dollar terms for energy conservation, stormwater runoff reduction, air quality improvement, carbon dioxide sequestration, and property value increase at the level of individual trees and urban forests (McPherson et al. 1999, 2000, 2001). They also have been used to model tree planting and care costs such as irrigation, pruning, removal, waste wood recycling, storm clean-up, sidewalk repair, pest/disease control, and administration.

To estimate the water requirements of landscape plantings formulas are applied that include a crop coefficient or species factor (Ks). This term ranges from 0 to 1 and reflects irrigation demands of established plants in good condition. The Water Use Classification of Landscape Species (WUCOLS) project assigned species factors to over 1,100 landscape plants for each of six geographical regions (Costello and Jones 1992).

This proposed study will build upon previous work to develop a database that contains landscape plant growth and water use information for inclusion in the urban landscape irrigation water use efficiency tool. These data will make it possible to “grow” the landscape and estimate future irrigation water requirements.

3.1 Methodology

This study will develop a relational database in Microsoft Access that includes information required to “grow” landscape plants and estimate current and future irrigation demand. The database will contain the following fields of information critical to this objective:

- Scientific Name
- Common Name
- Climate Zone (zones where each plant species grows)
- Species factor (ks for each species by climate zone)
- Crown projection area (CPA) by age by climate zone
- Crown projection area (CPA) by DBH by climate zone

The project will consist of the following tasks.

1. Design the database structure
2. Compile the WUCOLs landscape plant data and enter it into the database
3. Compile CUFR tree growth data (CPA) and enter it into the database.

4. Develop CPA growth curves for remaining shrubs, vines, and groundcovers using existing references and enter these into the database.
5. Test the database for quality control and usability.
6. Revise, document, and deliver the database for integration into the urban landscape irrigation water use efficient tool.
7. Assist in testing and application.

3.2 Products

Results will be presented in a report, as well as on a CD for use by the development team. Our Communications Director will work with the urban landscape irrigation water use project partners to develop a 4-page research summary and Powerpoint presentation for posting on our web-site. The research summary will be e-mailed to over 3,000 persons via our list serve with TreeLink.

3.3 Research timetable and cost

Task	Start – End Dates	Cost
1. Initial Scoping and Database Design	1/06-3/06	$62,600*
2. Compile and Enter WUCOLs Data	3/06-5/06	
3. Compile and Enter CUFR Data	6/06-7/06	
4. Develop CPA Growth Curves for Other Plants	3/06-9/06	
5. Quality Control/Usability Testing	10/06-12/06	
6. Deliver Revised Database and Documentation	1/07-3/07	$33,650**
7. Assist in Testing/Application	4/07 – 6/08	$21,150***

*: Salary and benefit: $60,500 Supply: $500 Travel: $1,600
**: Salary and benefit: $32,750 Supply: $500 Travel: $400
**: Salary and benefit: $20,250 Supply: $500 Travel: $400

Note: 1). The Forest Service PI will contribute their time at no cost, approximately 10% each, or $25,000 per year.
2). 19.2% Forest Service indirect overhead cost and an additional $6,250 (25% of $25,000) UC Regent indirect overhead cost are not included.
See Budget Justification for detail.

Drs E. Gregory McPherson and Jim Simpson of the Center for Urban Forest Research USDA Forest Service, Pacific Southwest Research Station will lead this task. Dr. McPherson conducts research that measures and models the benefits and costs of urban forests. Dr. Simpson focuses on the effects of urban trees on the environment. Their research group has been studying urban forest structure, growth, and water use since 1993.

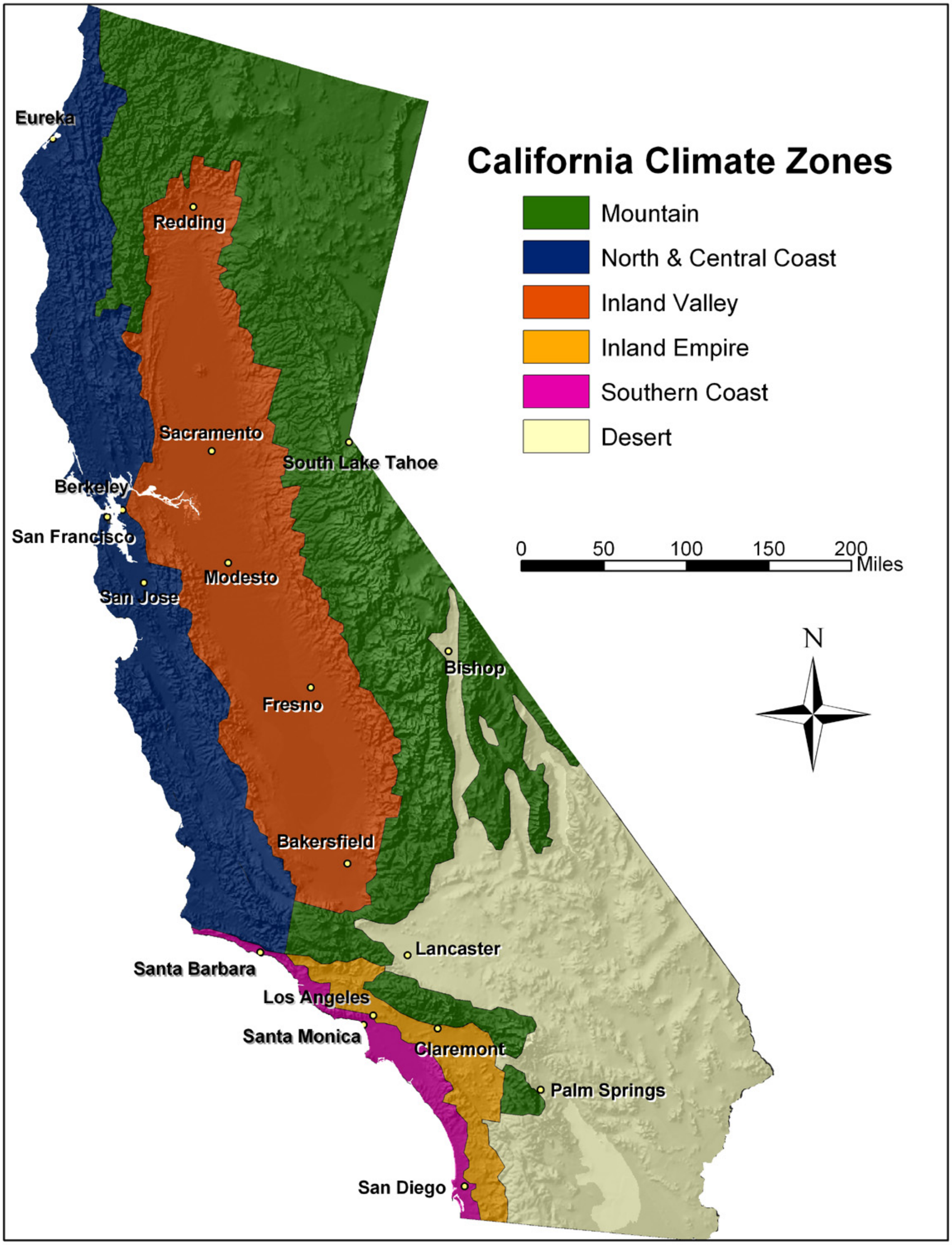

Figure 7. Climate zone of California

4. Urban landscape and vegetation characterization

Accurate measurement of the irrigated urban landscape, agricultural lands, and associated landscape will significantly improve the forecasting for water demand and dry-year planning efforts of state and local water agencies. Quickbird satellite images are similar to IKONOS in spectral resolution but with greater spatial resolution (2.4m for the multispectral data and 0.61m for panchromatic data). This enhanced resolution should improve parcel scale mapping. The goal of this study is to use Quickbird images to map and quantify the distributions of urban land cover, irrigated landscape, and type of irrigated vegetation. The study areas for this project are the Sun Valley Watershed in the San Fernando Valley of Los Angeles County and the North Natomas Watershed in the Sacramento Valley of Sacramento County. These two urban watersheds are uniquely suited to study water demand in California. The 2,800 acres (4.4 square miles) Sun Valley Watershed has shallow coarse sandy and sandy loam soils. The land in this watershed is well developed, dominated by industrial (53%) and residential (35%) uses. The North Natomas Watershed (8,000 acre, 12.65 square miles) has clay soil and is on the crest of a major growth period with a variety of residential uses. Both watersheds have landscape vegetation of different types and degrees of maturity. They are representative of many urban landscapes in the State of California.

4.1 Method

Landscapes will first be classified by land cover type (e.g., tree, shrub, grass, other ground cover, and non-vegetation) using multiple techniques to analyze Quickbird images. Supervised and unsupervised classifications will be employed to analyze the multispectral data. The Normalized Vegetation Index (NDVI), Water Index, and Soil Index will be calculated and the resulting mages will be further classified based upon the threshold values of these indexes. Linear spectral mixture analysis (SMA) will be performed with the multispectral Quickbird data to derive vegetation, soil, and shade fractions. Further image classifications will be performed to map irrigated and non-irrigated vegetation. Multiple masks will be generated for mapping these vegetation properties (Xiao et al., 2004). Quickbird images acquired in both middle summer and later winter will be used in this analysis, which will improve separation of deciduous and evergreen trees. A method having relatively high mapping accuracy combined with low processing costs will be selected so that it will be easy to apply these methods to other areas.

Validation of the mapping results will be performed using a combination of ground sampling and analysis of the QuickBird satellite high resolution data with 2004 color orthophotographs at 2-foot resolution DOQQs (Digital Orthorectified Quarter Quadrangles).

The project will consist of the following tasks.

1) Quickbird image (Multispectral and DOQQs) acquisition
2) Image pre-processing (atmospheric correction using ACORN if needed). Techniques used are supervised and unsupervised multiband classifications, vegetation indexes, and spectral mixture analysis.
3) Develop mapping methodology for urban land cover, vegetation type, and irrigated landscape.
4) Land cover mapping
5) Vegetation type mapping
6) Irrigated landscape mapping
7) Validation and quality control and usability check.

8) Revise, document, and deliver the database for integration into the urban landscape irrigation water use efficiency tool.

4.2 Products

Results will be presented in a report, as well as on a CD for use by the development team. A report with detailed urban land cove mapping methodology will be delivered. The results will be presented at CALFED and other professional conferences and meetings.

4.3 Research timetable and cost

Task	Start – End Dates	Cost
Data acquisition	1/06-1/07	$88,653*
Image pre-processing	2/06-2/07	
Develop mapping methodology	1/06-12/06	
Land cover mapping	3/07-12/07	
Vegetation type mapping	3/07-12/07	
Irrigated landscape mapping	3/07-12/07	
Validation, quality control, usability check	3/07-6/08	
Document and data deliver	8/06-10/08	
*: Salary: $61,250 benefit: $13,475 Supply: $9,278 Travel: $4,200 Note: 25% of UC Regents indirect cost is not included. See Budget Justification for detail.		

Dr. Susan L. Ustin is in charge of this task. Dr. Ustin is an Environmental and Resource Sciences Professor (Center for Spatial Technologies and Remote Sensing (CSTARS) Department of Land, Air, and Water Resources, UC Davis) whose research focuses on remote sensing of environmental properties and landscape analysis utilizing optical, radiation interactions in plant canopies, and application to hydrological and ecological problems.

Monitoring and Assessment

The tool developed in this project will be available in both digital and print format. A CD ROM and hard copy will be delivered to DWR and CALFED. The tool will be available at the CUFR web site at: http://www.ecosmart.gov/. The report, research summary, and other outreach material will available at the website at: http://cufr.ucdavis.edu/. Other popular landscape-irrigation sites will link to this site and use these materials. For example:

- California Irrigation Management Information System
- Center for Spatial Technologies and Remote Sensing
- Department of Land, Air, and Water Resources, UC Davis
- UCCE offices
- California Master Gardener sites.

The project monitoring plan will coordinate all partners associated with this project. The plan will include project work schedules, project progress, meetings, quarterly project reports to DWR, and products delivered.

All raw data collected from both demonstration sites and other public or private agencies on paper will be photocopied and store in the filing cabinet in Department LAWR, UC Davis. All raw data will be entered into Excel spreadsheets or Word documents and stored in the server maintained by the Department LAWR. Raw data collected via datalogger will be downloaded onto our office computer in the Department of LAWR. A backup copy (CD ROM) of all data in the department server is stored at a private location as well. Data will be also backed up weekly. All data will be available for sharing via internet or CD.

All demonstration sites will be checked weekly during the summer and biweekly during other seasons.

We will keep a log of users for the landscape irrigation water use tool, number of visitors to each demonstration site, number of people attending our workshops, and quantity of outreach material given to individuals at public events such as Earth Day, UCD Picnic Day, etc. We will also record the number of presentations that we make at different professional conferences and meetings.

We will calculate the reduction of landscape irrigation water use by accessing historical irrigation water use data at our demonstration site in Redwood Park, Davis, CA. We believe that it is vital to integrate urban landscape irrigation water use into a user-friendly web tool. By doing so, and then using on-site demonstrations to show the effectiveness of BMPs, we can highlight how critical improved landscape irrigation water use is to our overall water efficiency goal. This will maximize our capacity to deliver science and technology to the public.

Qualifications of the Applicants and Cooperators

We have assembled a team of investigators with both broad technical expertise in urban landscape irrigation and a strong commitment to public service and outreach. All of our study and demonstration sites are well-equipped with resources for our project. Investigators are: Drs. Qingfu Xiao and Susan L. Ustin, Department of Land, Air, and Water Resource, University of California Davis; Drs. E. Greg McPherson and Jim Simpson, and Jim Geiger, Center for Urban Forest Research, USDA Forest Service; Dr. Darren L. Haver, University of California Cooperative Extension; Dr. Lorence Oki, Department of Plant Sciences, UC Davis; Roy Jones, City of Davis; and Andy Lipkis, TreePeople, Los Angeles. Resumes are attached at the end of this proposal.

Dr. Xiao, a water resources Research Scientist at the Department of Land, Air, and Water Resources, University of California Davis, is leading Task 1, new tool development. Two Assistant Specialists and a Computer Programmer are working with him, along with the entire project team. Dr. Xiao's research focuses on urban landscape irrigation, storm runoff reduction, rainfall interception, urban watershed protection and small scale hydrologic processes. He has been working on reducing urban landscape irrigation water use since 2000. A project in Los Angeles, CA, "Monitoring and modeling hydrological processes at residential scale," has significantly improved our understanding of the interaction of BMPs and urban hydrologic processes. His current research projects, "Development of a Green Infrastructure Technology that Links Trees and Engineered Soils to Eliminate Runoff from Pavement," and "Stormwater BMPs for Green Streets," are studying urban landscape irrigation water use and storm runoff problems. Dr. Xiao has extensive research experience, dating back to 1992, in developing and applying physical-based hydrologic models (Xiao et al., 1996; Ustin et al., 1996; Xiao et al., 1998; Xiao et al., 2000). He was one of the development partners of the Ecosmart Design Software, and has been working with this entire project team for many years.

Drs. Lorence Oki (Department of Plant Sciences, UC Davis) and Darren L. Haver (University of California Cooperative Extension) will lead Task 2 working along with Jim Geiger (CUFR, USDA Forest Service), Roy Jones (City of Davis), and Andy Lipkis (TreePeople, Los Angeles). Dr. Loren Oki is a CE Specialist with expertise in management of irrigation in landscapes and nurseries, and Dr. Darren L. Haver is a Watershed Management Associate Advisor. They have successfully provided various training of the UC Master Gardeners and other professionals in landscapes and nurseries water use. Jim Geiger, Director of Communications, administers CUFR's outreach, education, training, and public relations. Roy Jones, Parks Supervisor, is in charge of all park irrigation and maintenance for the City of Davis. Andy Lipkis, President of TreePeople of Los Angeles, has conducted various water saving projects in the Los Angeles area that demonstrated state-of-the-art concepts as well as equip residents to apply the concepts at home.

Dr. Oki will be in charge of the workshops that will be held in Northern California and Dr. Haver will conduct workshops in Southern California. Jim Geiger will produce newsletters, research summaries, and other outreach materials including press releases. Roy Jones will oversee research and demonstration work at the Redwood Park site, while Andy Lipkis will continue to conduct outreach and education on the demonstration house in Los Angeles. Dr. Haver will be in charge of the demonstration site at Irvine. Jim Geiger, Dr. Oki, and Dr. Xiao will upgrade the sustainable garden site at UC Davis.

Drs E. Gregory McPherson and Jim Simpson of the Center for Urban Forest Research USDA Forest Service, Pacific Southwest Research Station will lead Task 3. Dr. McPherson conducts research that measures and models the benefits and costs of urban forests. Dr. Simpson focuses on the effects of urban trees on the environment. Their research group has been studying urban forest structure, growth, and water use since 1993 in the western United States. They will supervise, provide guidance, and work with their research team on this task. Chad Delany, GIS Technician of CUFR will coordinate with GIS Technicians at CSTARS for GIS data collection, processing, and applications.

Dr. Susan L. Ustin will be in charge of Task 4. Dr. Ustin is an Environmental and Resource Sciences Professor (Center for Spatial Technologies and Remote Sensing (CSTARS) Department of Land, Air, and Water Resources, UC Davis) whose research focuses on remote sensing of environmental properties and landscape analysis utilizing optical, radiation interactions in plant canopies, and application to hydrological and ecological problems. Quinn Hart, a Computer Programmer at CSRATS and a Technical Researcher at California Environmental Resources Evaluation System (CERES) will provide and work on database connection, communication, data storage among different data collection systems. Dr. Ustin will supervise, provide guidance, and work with Assistant Specialist at CSTARS for all activities involved in this project.

We will have a project manager (Hollis Manaker, Faculty Support Assistant at the Department of Land, Air, and Water Resources, UC Davis) manage the entire project. She will provide communication between DWR /CALFED and the research team, and will work with other public and private agencies on problems related to this project. She will work with all PIs to make sure that all reports are delivered to DWR /CALFED on time.

Outreach, Community Involvement, and Acceptance

Objectives of this project are to develop and deliver science and new technology to public and private landscape irrigation management agencies and to individual home owners. The wide-spread use of computers and web access that is available to most people offers new opportunities for technology transfer to bring research directly from the laboratory to the end user. Our new landscape irrigation water use web tool will do this. It will provide property owners, landscape designers, and landscape irrigation managers with a way to interactively see if their plan or installation will actually result in a water savings. Since the tool allows users to change irrigation rates resulting from the use of different BMPs, they will easily be able to examine the effect of a landscape retrofit on overall water use. For example, by replacing an existing tree with a California native tree that consumes less water, the user will be able to quickly see a reduction in irrigation water use and possibly be encouraged to plant the California native. In another example, a user would be able to test different soil moisture regimes to determine the best irrigation schedule for their property. This application, which is based on soil moisture and plant demand, will not only improve landscape irrigation management knowledge, but will also reduce landscape irrigation water use through proper scheduling.

The demonstration sites and urban landscape irrigation water use reduction (BMPs) will provide on-site demonstration and education to our customers. The newsletters, research summaries, and other outreach materials will be delivered to users electronically through our website and various email lists. Hard copies of material will be produced for distribution at various outreach events including conference, workshops, etc. CD copies will be made at our cost for these users they don’t have internet access upon their request.

Innovation

The new landscape irrigation water use tool proposed in this project will be a web based tool. It is a first-ever parcel scale tool for this kind of application. It will show how landscape irrigation water use can be reduced for any small parcel. Unlike traditional irrigation management tools used by professionals, this tool is designed for everyone, and it can be used for existing landscape irrigation management. The tool will also be helpful during landscape retrofits by providing designers the ability operate at the single plant level. The interactive graphics and tabular outputs provide visual information for users to see how landscape water use will change while selecting different irrigation practices, plant material, and various irrigation systems. The on-site demonstration of BMPs to reduce landscape irrigation water use will provide another outreach and education platform for this tool. The combination of the web tool and onsite demonstration is unique. We believe it will dramatically improve the ability of users to design and implement more water-efficient landscapes and thus reduce overall water use.

Cost and Benefits

Applicant: **Qingfu Xiao, E. Greg McPherson, Susan L. Ustin, Lorence Oki, Drren L. Haver, Roy Jones, and Andy Lipkis**

Project: **Demonstration and Application of New Water Use Efficiency Tool for Reducing Urban Landscape Irrigation Water Use**

Table: Project Costs (Budget) in Dollars

	Category **(I)**	**Project Costs** **$** **(II)**	**Contingency % (ex. 5 or 10)** **(III)**	**Project Cost + Contingency** **$** **(IV)**	**Applicant Share** **$** **(V)**	**State Share Grant** **$** **(VI)**
	Administration[1]					
	Salaries, wages	$521,237	$0	$521,237	$0	$521,237
	Fringe benefits	$81,524	$0	$81,524	$0	$81,524
	Supplies	$50,108	$0	$50,108	$0	$50,108
	Equipment	$0	$0	$0	$0	$0
	Consulting services	$0	$0	$0	$0	$0
	Travel	$21,600	$0	$21,600	$0	$21,600
	Other	$51,000	$0	$51,000	$0	$51,000
(a)	Total Administration Costs	$725,468		$725,468	$0	$725,468
(b)	Planning/Design/Engineering	$500	$0	$500	$0	$500
(c)	Equipment Purchases/Rentals/Rebates /Vouchers	$0	$0	$0	$0	$0
(d)	Materials/Installation /Implementation	$0	$0	$0	$0	$0
(e)	Implementation Verification	$0	$0	$0	$0	$0
(f)	Project Legal/License Fees	$200	$0	$200	$0	$200
(g)	Structures	$0	$0	$0	$0	$0
(h)	Land Purchase/Easement	$0	$0	$0	$0	$0
(i)	Environmental Compliance/Mitigation /Enhancement	$0	$0	$0	$0	$0
(j)	Construction	$0	$0	$0	$0	$0
(k)	Other (Specify)	$182,558	$0	$182,558	$0	$182,558
(l)	Monitoring and Assessment	$0	$0	$0	$0	$0
(m)	Report Preparation	$6,300	$0	$6,300	$0	$6,300
(n)	**TOTAL**	$915,026		$915,026	$0	$915,026
(o)	Cost Share -Percentage				0	100

Budget Justification

Total Project Costs: $915,026

1) Salaries, wages: $521,237

For salaried employees, the following figures reflect the total compensation for each year, whether the individual works part- or full-time. For employees paid hourly, the compensation rate is given per hour.

- The duties of each of the following employees are described in the "Qualification of the Applicants and Cooperators" Section. The following are total hours for the three years. We used 1,920 hours for 100 percent time.
- Salary and hourly compensation. Estimated rate of compensation proposed for each individual. For salaried employees, the following figures reflect the total compensation for each year, whether the individual works part- or full-time. For employees paid hourly, the compensation rate is given per hour.

Task	Employees	Hours in three years	Salary ($)
1	Research Scientist	3,712	66,500
1	Assistant Specialist	2,805	41,350
1	Computer Programmer	1,920	60,000
2	Research Scientist	634	53,000
2	Assistant specialist	813	41,350
2	Research Scientist	580	41,350
2	Assistant specialist	1,161	41,350
2	Outreach Coordinator	533	45,000
2	Outreach Coordinator	436	55,000
3	Research Associate	1,850	40.65 per hour
3	Research Assistant	600	28.46 per hour
4	Assistant Specialist	2,612	41,350
4	Computer Programmer	160	60,000

2) Fringe benefits: $81,523

The overall benefit rate for each category of employee in the project is: 17% for Research Scientist; 22% for Assistant Specialist, Computer Programmer, and Outreach Coordinator; 23% for both Research Assistant and Research Associate.

3) Supplies: $50,108

Task 1: $300 per year for computer supplies; $400 per year for weather station instrument calibration and data communication; $400 for hourly historical weather data from National Climatic Data Center of the four demonstration sites. And $200 for copying and other office supplies (pen, notes book etc.).

Task 2: Supplies for two touch screen computer systems ($3,000 each) that will be installed at Irvine and UCD demonstration sites. Spring header replacement at Los Angeles site for

$100, UCD site for $100 and at the Redwood Park site for $5601 (100 headers at $56.01 each; installation cost included). Three solar panels will be installed at Irvine, UC Davis, and the Redwood park site ($400 each) to supply power to data collection system (data logger, flow meter, soil moisture sensor etc.). Irrigation controller system cost for Irvine, Los Angeles, UCD, and Redwood park sites are $300, $50, $300, and $500, respectively. 12, 10, and 25 soil moisture blocks will be installed in Irvine, UCD, and Redwood park site at $75 each to conduct the soil moisture controlled irrigation study (task 1 and 2). TDRs will be installed at all sites (except Los Angeles site) (three TDR sites, $300 each). Pressure transducer will be installed at Irvine and UCD site at $500 each. All other measurements will provided by UC and CUFR at no cost during the three years. $3,900 is estimated for handout materials for workshops (500 copies at $6 each), research summaries (3 issues, 100 copies per issue at $2 each), and $300 for computer supplies. The annual cost for site maintainance for three years (mow grass, tree pruning, and clean trash etc.) is $2,280 for Irvine site, $4,104 for Los Angeles site, $2,280 for UC site and $2,240 for Redwood park site.
Task 3: $500 per year for computer and field work supplies.
Task 4: $4,620 for Quickbird remote sensing data (two seasons) purchased from DigitalGlobal at $18 per square kilometer. $4,608 for purchase of DOQQ data from DigitalGlobal at $576 per DOQQ; and $500 for computer supplies.

4) Equipment: $0

   There is no budget for equipment.

5) Consulting services: $0

   There is no budget for consulting services.

6) Travel: $21,600

   The estimated travel costs are for all non-local travel.

   Task 1: During year one, two people, one round trip, $400 per person, to Irvine for field measuring, soil sample collecting, and meeting with partners at Irvine and Los Angeles. Three people, one round trip, $400 per person to Irvine for installing measurement system at the demonstration site. One person, one round trip, $400 to Irvine and Los Angeles demonstration sites for presentation at workshop (task 2). $800 for project manager to meet all partners and oversee the work at all demonstration sites (task 2).

   During year 2, two people, two round trips, $400 per person to Irvine demonstration site to install, test, and maintain the touch screen system at the demonstration site. One person, two round trips, $400 per person to Irvine and Los Angeles for outreach workshops and demonstration presentations. One person, two round trips to attend and present our research progress and findings at urban landscape irrigation water use conferences. Two round trips to southern California at $400 per trip for the project manager to attend outreach events (task 2).

   During year 3, two people, one round trip, $400 per person to Irvine demonstration site to check and maintain the measurement and demonstration computer system at the demonstration site. One person, one round trip, $400 to Irvine and Los Angeles for outreach workshops and demonstration presentations. One person, three round trips to attend and present our research progress and findings at urban landscape irrigation water use conferences. One round trip to southern California at $400 for the project manager to attend outreach events. $400 travel during preparation of final products and report.

Task 2: Four round trips among Irvine, Los Angeles, Sacramento, and Davis for outreach events, workshops, and conference presentations. $400 each.

Task 3: Two round trips to Los Angeles, two people each, $400 /person for field data collection in the first year. One round trip ($400 /person) to Southern California for field data collection in the second year. And one trip ($200) for urban landscape irrigation water use conference and public events and one trip ($200) for public outreach presentation.

Task 4: One trip, four people to Sun Valley, Los Angeles to collect spectral data ($2,200). One trip, two people to Sun Valley, Los Angeles for field validation result (land cover mapping) ($800). One trip for irrigated landscape and vegetation type mapping accuracy check and one trip for conference presentation in San Francisco or Los Angeles area.

7) Other: $51,000

This includes $14,700 for workshops in Southern California (Irvine) and Northern California and $36,300 for project manager's time (Salary $29,754 and benefit (22%) $6,546). The project manger will work 422, 384, and 461 hours for year 1 (22%), year 2 (20%), and year 3 (24%). The salary rate used here is Associate Specialist at $45,048 per year. We estimate 50 attendees per workshop. The itemized list for the ten workshops (five at UC Davis and five at Irvine) is:

Item	At UC Davis	At Irvine	Total
Room Rental	2,500	2,500	5,000
Food	2,000	2,400	4,400
Computer lab	800	800	1,600
Transportation	1,500	1,500	3,000
Misc.	200	200	400
Total	7,000	7,400	14,400

The room rental fee is based on $250 per day for each of the five (two days) workshops. Food includes breakfast, lunch and a beverage (e.g., coffee, tea, and water). It is estimated $8 per person at UC Davis and $9.6 at Irvine. Computer lab includes all charges for computers setup and printing. Transportation is for parking fee at $6 per car. The Misc. includes any other cost for these workshops.

(b) Planning/Design/Engineering : $500

This cost is for preparation of the material to apply for Redwood Park field work permits at City of Davis. It includes detailed drawings of the field monitoring system and for changes that will be made to the irrigation system at the park (task 2).

(c) Equipment Purchases/Rentals/Rebates /Vouchers: $0

There is no budget for this category.

(d) Materials/Installation /Implementation: $0

There is no budget for this category.

(e) Implementation Verification: $0

There is no budget for this category.

(f) Project Legal/License Fees: $200

This cost is for the permit from City of Davis (task 2).

(g) Structures: $0

There is no budget for this category.

(h) Land Purchase/Easement: $0

There is no budget for this category.

(i) Environmental Compliance/Mitigation /Enhancement: $0

There is no budget for this category.

(j) Construction: $0

There is no budget for this category.

(k) Other (Specify): $182,558

Indirect costs. UC Regents charge 25% of the project cost for all tasks conducted by UC employees (task 1, 2, and 4). 19.2% indirect cost is charged by USDA Forest Service for the task conducted by CUFR (task 3). An additional 25% (the first $25,000) is charged by UC Regent for the task 3.

(l) Monitoring and Assessment: $0

There is no budget for this category.

(m) Report Preparation: $6,300

This cost is based on $3,000 for editing the final report and all of our outreach materials (75 hours at $40 per hour). $300 for layout and $3,000 for printing the final report (200 copies at $15 per copy).

Literature Cited

Costello, L.R.; Jones, K.S. 1992. WUCOLS Project. Water Conservation Office, California Department of Water Resources: Sacramneto, CA.

Hope, A., L. Coulter, D. Stow, D. Service, T. Schutte, S. Redlin, S. Peterson, M. Lowenfish, J. Kaiser and A. Walters. Irrigated Vegetation Assessment in Urban Environments: A project of the NASA Affiliated Research Center at SDSU, AgriCast Incorporated Partnership, May, 2001.

Mcbride, J. R., and Jacobs, D. F., 1986, Presettlement forest structure as a factor in urban forest development. Urban Ecology, 9, 245–266.

McPherson, E.G., Simpson, J.R., Peper, P.J. and Xiao, Q.F. (1999) Benefit-cost analysis of Modesto's municipal urban forest. Journal of Arboriculture, 25, 235–248.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Scott, K.; Xiao, Q. 2000. Tree Guidelines for Coastal Southern California Communities. Local Government Commission: Sacramento, CA. 97 pp.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q. 1999. Tree Guidelines for San Joaquin Valley Communities. Local Government Commission: Sacramento, CA. 63 pp.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q. Pittenger, D.R.; Hodel, D.R. 2001. Tree Guidelines for Inland Empire Communities. Local Government Commission: Sacramento, CA. 116 pp.

Peper, P.J.; McPherson, E.G. 2003. Evaluation of four methods for estimating leaf area of isolated trees. Urban Forestry and Urban Greening 2:19-30.

Peper, P.J.; McPherson, E.G.; Mori, S. 2001. Predictive equations for dimensions and leaf area of Coastal Southern California municipal trees. J. Arboric 27(4): 169-180.

Xiao, Q.F., E.G. McPherson, and S.L. Ustin. 2004. Using AVIRIS Data and Multiple-Masking techniques to Map Urban Forest Tree Species. International Journal of Remote Sensing, 25:5637–5654.

Xiao, Qingfu and E. Gregory McPherson, 2002. Rainfall interception by Santa Monica's municipal urban forest, Urban Ecosystems, 6: 291–302.

Xiao, Qingfu, Using IKONOS Data and Moving Mask Technique to Characterization Urban Land Cover, 30th International Symposium on Remote Sensing of Environment (ISRSE) Honolulu, Hawaii, November 10-14, 2003.

Xiao, Q. F; E.G. McPherson, S.L. Ustin, and M.E. Grismer. 2000. A new approach to modeling tree rainfall interception, Journal of Geophysical Research Atmospheres, 105(D23):29173-29188.

Xiao, Q.F., E.G. McPherson, J.R. Simpson and S.L. Ustin. 1998. Rainfall interception by Sacramento's urban forest. Journal of Arboriculture 24(4): 235-244.

Xiao, Q.F., S.L. Ustin and W.W. Wallender. 1996. A spatial and continuous surface-subsurface hydrologic model. Journal of Geophysical Research-Atmospheres 101D: 29,565-29,584.

Ustin, S.L., W.W. Wallender, L. Costick, R. Lobato, S.N. Martens, J. Pinzon and Q.F. Xiao. 1996. Modeling terrestrial and aquatic ecosystem responses to Hydrologic Regime in a California watershed. Sierra Nevada Ecosystem Project, Final Report, Volume III. Pg.275-291, 22 figures.

Resumes of the PIs

Dr. Darren L. Haver
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EDUCATION

1993-1998	Ph.D. in Botany & Plant Sciences, University of California, Riverside.
1988-1993	B.S. in Ornamental Horticulture, California State Polytechnic University, Pomona.

WORK EXPERIENCE

2003-present	Associate Advisor I Watershed Management Orange County (80%) and San Diego County (20%)
2001-2003	Water Quality Program Representative III John Kabashima, University of California Cooperative Extension – Orange Projects related to sediment, nutrient, pathogen, and toxics.
1999-2001	Postgraduate Researcher Dr. Laosheng Wu and John Kabashima, University of California, Riverside. Agricultural Nutrient Monitoring Program Coordinator – Newport Bay and San Diego Creek Watershed.
1999-2000	Lecturer Orange Coast Community College, Costa Mesa, CA Introduction to Botany & Weed Identification and Weed Control
1998-1999	Postgraduate Researcher Dr. Jodie Holt (50%), University of California, Riverside. Phenology and degree-day modeling of common weed species. Dr. Carol Lovatt (10%), University of California, Riverside. Quantification of plant hormones utilizing radioimmunoassay.
1993-1998	Research and Teaching Assistant Dr. Ursula Schuch (50%), University of California, Riverside.
1991-1993	Field Technician John Kabashima, Farm Advisor Various field trails relating to herbicides, pesticides, and plant growth regulators.

PUBLICATIONS

Peer-reviewed

French, C., L. Wu, T. Meixner, D. L. Haver, J. N. Kabashima and W. A. Jury. 2005 Modeling Nitrogen Transport in the Newport Bay/San Diego Creek Watershed. Agricultural Water Management, *In review*.

J. Gan,* S.J. Lee, W.P. Liu, D.L. Haver, and J.N. Kabashima. 2005. Distribution and persistence of pyrethroids in runoff sediments. Journal of Environmental Quality, *In press.*

Haver, D.L. 2004. Farm Water Quality Plan Fact Sheet 3.9: Sediment management goals and recommended practices for nursery and floriculture. University of California Agriculture and Natural Resources, Publication 8124.

Kabashima, J. N., S. J. Lee, D. L. Haver, K. S. Goh, L. S. Wu and J. Gan. 2004. Pesticide Runoff and Mitigation at a Commercial Nursery Site. *In: Pesticide Decontamination and Detoxification*, ACS Symposium Series 863, Editors J. Gan, Peter Zhu, Steven Aust, and Ann T. Lemley. American Chemical Society.

Haver, D.L. 2004. Mitigation efforts to protect natural environments in highly urbanized watersheds. *In: Picogram and Abstracts, 227th ACS National Meeting*, March 28-April 1, 2004, Anaheim, CA.

Haver, D. L., U. K. Schuch and C. J. Lovatt. 2002. Exposure of Petunia Seedlings to Ethylene Decreased Apical Dominance by Reducing the Ratio of Auxin to Cytokinin. Journal of Plant Growth Regulation. 21(4): 459-468.

Haver, D. L. and U. K. Schuch. 2001. Influence of root restriction and ethylene exposure on apical dominance of petunia (*Petunia X hybrida* Hort. Vilm-Andr.). Plant Growth Regulation 35: 187-196.

Haver, D. L. and U. K. Schuch. 1996. Production and postproduction performance of two new guinea impatiens cultivars grown with controlled-release fertilizer and no leaching. J. Amer. Soc. Hort. Sci. 121: 820-825.

Non-Peer Review/Newsletters/Trade

Haver, D.L. and J.N. Kabashima. 2004. Minimize pesticide runoff. GMPro-Greenhouse Management and Production, pp.44-49.

Haver, D.L. 2003. Improving Water Quality with Buffers. Winter Issue of the California Ornamental Research Federation Newsletter.

Kabashima, J. N., D.L. Haver, and K. Goh. 2002. Mitigation of Bifenthrin in Nursery Runoff. Abstracts of Papers American Chemical Society, 224th Annual Meeting of the American Chemical Society, Boston, MA.

GRANTS

Funding Source	Year	Amount	Other PIs and Cooperators
Prop. 13 – Mitigation of Nutrients in Urban Runoff	2004	$54,500	County of Orange, Cal. State. Fullerton
PRISM – Prop. 13 Mitigation of Pesticides in Urban Runoff	2004	$1,000,000	South Coast Resource Conservation & Dev. Area, Drs. Wu, Gan, Rust, and Greenberg at UCR, Drs. McPherson and Oki at UCD, and John Kabashima and Dr. Cheryl Wilen with UCCE.
Prop. 13 Develop GIS Web-based Tool	2004	$311,000	South Coast Resource Conservation & Dev. Area
USDA – EQIP	2001-2002	$28,500	South Coast Resource Conservation & Dev. Area
SWRCB/EPA 319h	2000-2003	$349,750	Dr. Laosheng Wu and John Kabashima
USDA – EQIP	2000-2001	$28,953	South Coast Resource Conservation & Dev. Area
CDFA-FREP	1999-2002	$125,000	Dr. Laosheng Wu and John Kabashima

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EDUCATION

1984-1987	Ph.D. (Forestry) Dissertation: Effects of Vegetation on Building Energy Performance Advisor: Dr. Lee Herrington	College of Environmental Science and Forestry SUNY-Syracuse
1977-1981	Master of Landscape Architecture	Utah State University
1976-1977	A.A.S. (Landscape & Nursery Management)	Michigan State University
1971-1975	Bachelor of General Studies	University of Michigan

PUBLICATIONS

Maco, S.E.; McPherson, E.G. 2003. **A practical approach to assessing structure, function, and value of street tree populations in small communities**. Journal of Arboriculture 29: 84-97.

McPherson, E.G. 2003. **A benefit-cost analysis of ten tree species in Modesto, California, U.S.A.** Journal of Arboriculture 29: 1-8.

McPherson, E.G. 2003. **Urban forestry: The final frontier?** Journal of Forestry 101: 20-25.

Randrup, T.B.; McPherson, E.G.; Costello, L.R. 2003. **Tree roots and infrastructure damage.** Urban ecosystems 5: 1067-1076.

McPherson, E.G.; Simpson, J.R. 2002. **A comparison of municipal forest benefits and costs in Modesto and Santa Monica, California, U.S.A**. Urban Forestry and Urban Greening 1: 61-74.

McPherson, E.G.; Simpson, J.R. 2003. **Potential energy savings in buildings by an urban tree planting programme in California**. Urban Forestry and Urban Greening 2: 73-86.

Peper, P.J.; McPherson, E.G. 2003. **Evaluation of four methods for estimating leaf area of isolated trees**. Urban Forestry and Urban Greening 2: 19-29.

Maco, S.E.; McPherson, E.G. 2002. **Assessing canopy cover over streets and sidewalks in street tree populations**. Journal of Arboriculture 28(6): 270-276.

McPherson, E.G. 2001. **Sacramento's parking lot shading ordinance: environmental and economic costs of compliance.** Landscape and Urban Planning 57: 105-123.

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University of California Cooperative Extension

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EDUCATION

Ph.D., Ecology, University of California, Davis, March 2002. Dissertation: Effects of Substrate Salinity On Rose Stem Elongation. Advisor: Dr. Heiner Lieth

RESEARCH EXPERIENCE

Assistant Specialist, UC Davis, October 1, 2002 - present.'Evaluation of the Water Usage of California Native Plants with the Potential as Landscape Ornamentals (Slosson). Development of a self-contained closed irrigation system for nursery production (California Association of Nurseries and Garden Centers). Evaluating BMP effectiveness to reduce volumes and improve quality of runoff from urban environments (CA State Water Resources Control Board)

Postdoctoral Research, UC Davis, March 2002 - September 2002. Characterizing seasonal variations in patterns of stem elongation of *Rosa hybrida* Kardinal= for the development of crop growth models. Modeling of the effects of salinity on rose stem elongation. Advisor: Dr. Heiner Lieth.

Doctoral Research, UC Davis, July 1994 - September 2001. Modification of an irrigation system based on soil moisture tension for the production of rose cut flowers. Continuous measurement of substrate moisture electrical conductivity. Characterization of stem elongation patterns. Effects of salinity on stem elongation rates. Advisor: Dr. Heiner Lieth

TEACHING EXPERIENCE

Instructor. Introduction to Greenhouse Management. UC Davis Extension. October 28-29, 2002. June 29, 30, July 1, 2001.

Instructor. ENH198 Directed Group Study, Evaluation of flowering Annuals. Spring 2003

Instructor. LDA190 ProSeminar on Landscape Management, Fall 2003.

Instructor. Introduction to Plant Propagation. UC Davis Extension. June 25, 26, 2002.

Lecturer. Analysis of Horticultural Problems, ENH129/229, UCD. Spring 2002.

PUBLICATIONS

Oki, L.R., and J.H. Lieth. 2004. Effect of changes in substrate salinity on the elongation of *Rosa hybrida* L. 'Kardinal" stems. Sci Hort. 101: 103-119.

Oki, L.R., J.H. Lieth, and S. Tjosvold. 2001. Irrigation of *Rosa hybrida* L. >Kardinal= based on soil moisture tension increases productivity and flower quality. in: Proc. Int. Sym. Rose Research and Cultivation. ISHS. N. Zieslin and Agbari, H., eds. Acta Hort. 547: 213-219.

Eymar, E., **L.R. Oki**, and J.H. Lieth. 2001. Continuous measurements of electrical conductivity in growing media using a modified suction probe: Initial calibration and potential usefulness. Plant Soil.230 (1): 67-75.

Eymar, E., J.H. Lieth, and **L.R. Oki**. 1999. Continuous measurement of substrate electrical conductivity in container grown plants. in: Proc. Int. Sym. Models-Plant Growth/Control Shoot-Root Environments in Greenhouses. ISHS. Bar-Yosef, B. and I. Seginer, eds. Acta Hort. 507: 69-75.

Oki, L.R., J.H. Lieth, and S. Tjosvold. 1995. Reduction of run-off in greenhouse cut flower crops through automated irrigation based on soil moisture tension. 1994 Project report to the California Cut Flower Commission.

BIOGRAPHICAL DATA

James R. Simpson
Forest Meteorologist
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Education

1983	Ph.D., Forest Meteorology, College of Forest Resources, University of Washington.
1968	B.S. (cum laude), Physics, Pacific Lutheran University.

Employment

1992-present	Forest Meteorologist, USDA Forest Service, Western Center for Urban Forest Research, c/o Department of Environmental Horticulture, University of California, Davis, California
1985-1992	Assistant Professor, Department of Soil and Water Science, University of Arizona, Tucson, Arizona
1979-1985	Post-Doctoral Research Associate, Research Scientist, and Scientific Programmer, College of Forest Resources, University of Washington, Seattle, Washington
1974-1979	Graduate Research Associate, College of Forest Resources University of Washington, Seattle, Washington
1969-1973	Lieutenant, United States Navy, Naval Nuclear Propulsion Program
1969	Electrical engineer, The Boeing Company, Seattle, Washington

Memberships:

American Geophysical Union
American Meteorological Society
Xi Sigma Pi

Major Fields of Interest:

My major field of interest is environmental physics, which combines aspects of physical and biological sciences to understand organismal/environmental interactions at the soil-atmosphere interface. Current emphasis is on interactions of buildings with urban vegetation and soil in terms of water use, energy conservation and climatic effects, and water use of isolated plants or groups of plants.

Selected Publications:

Simpson, J. R. and E. G. McPherson. 1996. Potential of tree shade for reducing residential energy use in California. *J. Arboriculture* 22:10-18.

Simpson, J. R. and E. G. McPherson. 1997. The effects of roof albedo modification on residential cooling loads of scale model residences in Tucson, Arizona. *Energy and Buildings* 25:127-137.
Simpson, J. R. and E. G. McPherson. 1998. Simulation of tree shade impacts on residential energy use for space conditioning in Sacramento. *Atmospheric Environment: Urban Atmospheres*, 32:69-74.
McPherson, E. G., K. I. Scott and J. R. Simpson. 1998. Estimating cost effectiveness of residential yard trees for improving air quality in Sacramento, California, using existing models. *Atmospheric Environment: Urban Atmospheres*, 32:75-84.
Simpson, J. R. 1998. Urban forest impacts on regional cooling and heating energy use: Sacramento County case study. *J. Arboriculture* 24:201-214.
Scott, K. I., E. G. McPherson and J. R. Simpson. 1998. Air pollutant uptake by Sacramento's urban forest. *J. Arboriculture* 24:224-234.
Xiao, Q., E. G. McPherson, J. R. Simpson and S. L. Ustin. 1998. Rainfall interception by Sacramento's urban forest. *J. Arboriculture* 24:235-244.
Simpson, J. and E. G. McPherson. 1999. Guidelines for evaluating atmospheric carbon dioxide reductions by urban forestry programs. In: Kinsman, J., C. Mathai, M. Baer, E. Holt, and M. Trexler, eds. Global Climate Change: Science, Policy, and Mitigation/Adaptation Strategies. Sewickley, PA, Air and Waste Management Association. pp. 789-790.
Scott, K. I., J. R. Simpson, and E. G. McPherson. 1999. Effects of tree cover on parking lot microclimate and vehicle emissions. *J. Arboriculture*. 25:129-141.
McPherson, E. G. and J. R. Simpson. 1999. Guidelines for Calculating Carbon Dioxide Reductions Through Urban Forestry Programs. General Technical Report PSW-GTR-171, USDA Forest Service, Pacific Southwest Research Station, January 19, 1999.
McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q. 1999. Benefit-cost analysis of Modesto's municipal urban forest. Journal of Arboriculture 25(5): 235-248.
Xiao, Q.; McPherson, E.G.; Ustin, S.L.; Grismer, M.E.; Simpson, J.R. 2000. Winter rainfall interception by two mature open grown trees in Davis, CA. *Hydrological Processes*.14:763-784.
McPherson, E. G., J. R. Simpson and K. I. Scott. 2001. Actualizing microclimate and air quality benefits with parking lot tree shade ordinances. *Wetter und Leben*, 4(98): 353-369.
Simpson, J. R. In Press. Improved Estimates of Tree Shade Effects on Residential Energy Use. 2002. *Energy and Buildings* 34(10):173-1082.

CURRICULUM VITAE
Susan L. Ustin

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Education

University of California, Davis, Ph.D. Botany, 1983; California State University, Hayward, M.A. Biology, 1978; California State University, Hayward, B.S. Biology, 1974

PROFESSIONAL EXPERIENCE

1995-2001 Associate Director, DOE's Western Regional Center for Global Environmental Change (WESTGEC), University of California, Davis, CA 95616
1995-present, Director, U. C. Davis Space Grant Program
1999-present Professor of Environmental and Resource Science, Dept. of Land, Air, and Water Resources, University of California, Davis, CA 95616
1996-1999 Associate Professor of Resource Science, Dept. of L.A.W.R., U.C., Davis, CA 95616
1991-1996 Assistant Professor of Resource Science, Dept. of L.A.W.R., U.C., Davis, CA 95616
1990-1991 Assistant Research Resource Scientist, Dept. of L.A.W.R., U.C., Davis, CA 95616
1990-1992 Research Associate with NASA Ames Research Center, Moffett Field, CA 94035

HONORS

1992 - IEEE Geoscience and Remote Sensing Society Transactions Prize Paper Award.
2002 – Elected Fellow, The Remote Sensing and Photogrammetry Society
2004 – Outstanding Service, American Society of Photogrammetry and Remote Sensing
2004 – Elected Senior Member, Institute of Electrical and Electronic Engineers
2004 – SERDP Conservation Project of the Year

Panels and Professional Committees

NASA MODIS Science Team Member, 2004-present.
NPOESS Science Advisory Board, Northrop-Grumman, 2002-present.
U.C. Davis Representative to the University Corporation for Atmospheric Research, 1993-present
Resource21 Science Advisory Board for Landsat LDCM Mission, 2000-2002.
Advisory Board Member, Environmental (Remote Sensing) Baselining Initiative, Chevron, Corp. 1999-2002.
Executive Committee, U.C. California Space Institute 1993-2002
Member, National Research Council, Committee on Earth Studies, Space Studies Board, Commission on Physical Sciences, Mathematics and Applications. 1999. Review of NASA's Post-2002 Plan.
Executive Committee Member and Vice Chair, for the UC Digital Media Innovation Program (DiMI), 1998-2002
UC Davis Advisor for the NASA Ames Associates Internship Program, 1997-2000
Member, National Research Council, Committee on Earth Studies, Space Studies Board, Commission on Physical Sciences, Mathematics and Applications. 1997-2000. Review of the NPOESS Program.
Member, National Research Council, Ecosystems Panel, Board of Agriculture, Commission on Geosciences, Environment and Resources and the Commission on Life Sciences. 1997-1999. Review of the Ecosystems program in the U.S. Global Change Research Program.

Member, National Research Council, Board of Agriculture. 1995-1997. Assessing Crop Yield: Site-specific farming, information systems, and research opportunities.

Science Team Member, Sierra Nevada Ecosystem Study (U.S. Congress Report), 1993-1996.

Science Team Member, NASA Earth Observing System (EOS), Interdisciplinary Science Team, Atmosphere-Biosphere Interactions, 1990-present

Chair, Graduate Ecosystem and Landscape Ecology Program in the Ecology Graduate Group, 1991-1997

Publications: 115 reviewed articles; >100 non-reviewed articles; >100 abstracts

114. Li, L. and S. L. Ustin, 2004. Application of AVIRIS data in detection of oil-induced vegetation stress at Jornada, New Mexico, Remote Sensing of Environment (accepted).

112. Rosso, P.H., Pushnik, J.C., Lay, M. and Ustin, S.L. 2004. Reflectance Properties and Physiological Responses of *Salicornia virginica* to Heavy Metal and Petroleum Contamination. Journal of Environmental Pollution (accepted).

108. Li, L., S.L. Ustin and M. Lay 2004. Mapping Coastal Salt Marsh Species with Multiple Endmember Spectral Mixture Analysis (MESMA) of Hyperspectral AVIRIS Imagery. Submitted to IEEE Geoscience and Remote Sensing (invited, accepted).

106. Xiao, Q-F., E.G. McPherson, and S.L. Ustin. 2004. Using AVIRIS Data and Multiple-Masking techniques to Map Urban Forest Tree Species. International Journal of Remote Sensing (in press).

103. Ustin, S.L., D.A. Roberts, J.A. Gamon, and G.P. Asner, 2004. Using Imaging Spectroscopy to Study Ecosystem Processes and Properties. Bioscience 54: 523-534.

102. Riano, D., E. Chuvieco, S. Condes, J. Gonzalez-Matesanz, and S.L. Ustin. 2004. Generation of crown bulk density for *Pinus sylvestris* L. from LIDAR. Remote Sensing of Environment. 92 (3): 345-352.

100. Whiting, M.L., L. Li, and S.L. Ustin, 2004. Predicting water content using Gaussian model of soil spectra. Remote Sensing of Environment 89: 535-552.

99. Wilson, M.D., S.L. Ustin, and D.M. Rock. 2004. Comparison of support vector machine classification to partial least squares dimension reduction with logistic discrimination of hyperspectral data. Transactions on GeoScience and Remote Sensing 42 (5): 1088-1095.

93. Roberts, D.A., S.L. Ustin, S. Ogunjemiyo, J. Greenberg, S.Z. Dobrowski, J. Chen, and T.M. Hinckley. 2004. Spectral and structural measures of northwest forest vegetation at leaf to landscape scale. Ecosystems 7(5): 545-562.

90. Underwood, E. and S.L. Ustin. 2003. Mapping non-native species using hyperspectral imagery. 2003. Remote Sensing of Environment 86(2): 150-161.

89. Ustin, S.L. (volume editor) 2004. Manual of Remote Sensing Vol. 4. Remote Sensing for Natural Resource Management and Environmental Monitoring.ASPRS. John Wiley and Sons, New York. 768p. +cd.

88. Kasischke, E.S., S. Goetz, M. Hansen, M. Ozdogan, J. Rogan, S.L. Ustin and C.E. Woodcock, Temperate and boreal forests. 2004. In Manual of Remote Sensing Vol. 4. Remote Sensing of Natural Resource Management and Environmental Monitoring (S.L. Ustin, vol. ed.). ASPRS. John Wiley and Sons, New York pages 147-238.

87. Ustin, S.L., S. Jacquemoud, P. Zarco-Tejada, and G. Asner. 2004. Remote Sensing of Environmental Processes: State of the Science and New Directions. In: Manual of Remote Sensing Vol. 4. Remote Sensing of Natural Resource Management and Environmental Monitoring (S.L. Ustin, vol. ed.). ASPRS. John Wiley and Sons, New York pages 679-730.

86. Zarco-Tejada, P.J., Rueda, C.A., and Ustin, S.L. 2003. Water content estimation in vegetation with MODIS reflectance data and model inversion methods. Remote Sensing of Environment 85: 109-124.

85. Riano, D., E. Meier, B. Allgöwer, E. Chuvieco, S.L. Ustin. 2003. Modeling airborne laser scanning data for the spatial generation of critical forest parameters in fire behavior modeling. Remote Sensing of Environment 86: 177-186.

82. Zarco-Tejada, P.J., Pushnik, J.C., Dobrowski, S., and Ustin, S.L. 2003. Steady-state Chlorophyll Fluorescence detection from Canopy Derivative reflectance and *Double-Peak* effects**.** Remote Sensing of Environment 84(2): 283-294.

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EDUCATION

University of California, Davis, Ph.D. Hydrology, 1998.
University of California, Davis, M.S. Hydrology, 1994.
Huazhong University of Science and Technology, P.R.C., B.S. Computer, 1983.

PROFESSIONAL EXPERIENCE

2002-present Research Water Scientist, Department of Land, Air, and Water Resources, University of California, Davis, CA 95616;
1998-2002 Postdoctoral Researcher, Dept. of Land, Air, and Water Resources, University of California,; Center for Urban Forest Research, USDA Forest, Davis, CA 95616
1996-1998 Research Associate, Western Center for Urban Forest Research, USDA Forest Service, Davis, CA 95616.
1996-1996 Postgraduate Researcher, Division of Environmental Study, University of California, Davis, CA 95616.
1992-1995 Researcher Assistant /Postgraduate Researcher, Dept. of Land, Air, and Water Resources, University of California, Davis, CA 95616

RECENT PUBLICATIONS

Xiao, Q.F., E.G. McPherson, J.R. Simpson, S.L. Ustin. 2004. Hydrologic processes at the urban residential scale. Submitted to Water Resources Research.
Xiao, Q.F., E.G. McPherson, and S.L. Ustin. 2004. Using AVIRIS Data and Multiple-Masking techniques to Map Urban Forest Tree Species. International Journal of Remote Sensing, 25:5637–5654.
Xiao Q.F., and E.G. McPherson. 2003. Rainfall interception by Santa Monica's municipal urban forest. Urban Ecosystems, 6: 291-302.
McPherson, E.G., J.R. Simpson, P.J. Peper, Q.F. Xiao, S.E. Maco and P.J. Hoefer. 2003. Northern Mountain and Prairie Community Tree Guide. Center for Urban Forest Research, Pacific Southwest Research Station, USDA Forest Service, Davis, CA.
McPherson, E.G., S.E. Maco, J.R. Simpson, P.J. Peper, Q.F. Xiao, A.M. VanDerZanden and N. Bell, 2002. Western Washington and Oregon Community Tree Guide: Benefits, Costs, and Strategic Planting. Silverton, OR: International Society of Arboriculture, Pacific Northwest: Chapter 76. . 84.
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