Climate ready urban trees for Central Valley cities

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Abstract

Urban forests provide many societal and ecological services to cities and their inhabitants. Many species of trees are under stress due to anthropogenic and natural climate changes. Projected climatic shifts will change temperature, precipitation, and the incidences of pest and disease outbreaks. The tolerance of urban trees to these stressors varies considerably among species and the perpetuation of urban forests depends on tree species resilience to climate induced stress within particular climate zones. The purpose of this study is to provide new information on what tree species to plant in which climate zones, by field-testing the most promising cultivars. Trees will be selected for testing based on evaluation of climate induced risk factors that impact their vulnerability or resilience, specifically for urban areas in the Central Valley. Risk factors used in the analysis are (1) habitat specificity: sunlight exposure, soil texture and pH, soil moisture (2) physiology: drought tolerance, salt tolerance, wind tolerance (3) biological interactions: invasiveness, major or minor pests and diseases, emerging pests and diseases. Long-term field testing (20 years) at University of California Experiment Station field plots and in nearby parks will allow for direct comparisons of growth and longevity under a range of site conditions. Results will help urban foresters, landscape architects and planners select trees for planting that can improve the stability and long term success of future urban forests.

Parkinsonia x **'Desert Museum'**
Desert Museum Palo Verde

Justification

Urban forests provide many economical, environmental, psychological, and cultural benefits. The socio-ecological benefits of urban forests include: increased tree canopy and carbon storage, reduced heat island and energy use, improved air quality and human health, and water quality protection (Alberti & Marzluff 2004, McPherson et al. 2005).

There is an increased probability of extreme weather events that could increase the number of tree failures.

Climate change poses many challenges to horticulture in the Central Valley of California. An already water-limited region is expected to get hotter and drier. The region will face increased heat and severe droughts that will impact our current urban forests and how we manage and grow future trees (Ketterings et al. 2001). In addition, urban trees will face other climate induced stressors. There is an increased probability of extreme weather events that could increase the number of tree failures. Warmer temperatures may increase pest development and pressure, while heat-induced drought may reduce tree vigor and increase susceptibility to pests and diseases (Tubby & Webber 2010). Restricted and limited water will lead to tradeoffs between conserving water and meeting the demands of an increasing population (Niinemets & Penuelas 2008). Tree species with high water needs will be vulnerable in the changing conditions and the use of saline reclaimed water will adversely impact the health of sensitive trees.

The goal of this study is to evaluate the growth and survival of climate-ready trees in the Central Valley. By identifying trees that perform best under stressors associated with climate change, we can help shift the palette of trees commonly planted to species that will provide the most environmental, social, and economic value in the future.

Previous work

The investigators are well-suited to the challenges inherent to this line of inquiry. They conducted a 14-year evaluation of drought tolerant species that were obtained from a nursery in the arid southwest and planted in central California. The study assessed the survival, growth, and water tolerance of seven different species with six individuals of each species planted in a variety of site conditions in Modesto, Sacramento and Davis (McPherson and Albers, 2014).

They collected current street tree inventories for eight Inland Valley cities (Clovis, Oakley, Roseville, Stockton, Tulare, West Sacramento, Sacramento, Brentwood) and identified the dominant species and their relative vulnerability in terms of pests and other risk factors (McPherson & Kotow 2013). Also identified were species that were not abundant but their large stature indicated that some individuals have proven to be well-adapted.

Their experience with long-term tree evaluation studies will benefit this project. They participated in the National Elm Trial, conducted in 18 locations across the U.S. to determine the growth and horticultural performance of commercially available Dutch Elm Disease resistant cultivars in various climate regimes (McPherson et al. 2009, 2014). Dr. Berry, along with Dr. Larry Costello, initiated and developed the California Tree Failure Report Program database, a long-term data collection project (Costello & Berry 1991) that has now become an International Tree Failure database (**http://www.fs.fed.us/foresthealth/technology/pdfs/FS_natfd.pdf**).

Objectives

1. Conduct a long-term study that compares the longevity, health and growth of tree species that show promise for resilience to future climate change in Central Valley cities.
2. Establish and monitor a planting of ornamental trees that have been selected as possible future urban trees for the Central Valley based on a risk-factor selection tool. Height, trunk diameter, crown diameter and other traits will be measured. Pest or health problems and pruning requirements will be noted.
3. Assemble and analyze the data for annual reports, publications, and outreach to urban forest managers, landscape architects and others.

Methods

To compare potentially resilient urban tree species we will have two types of plots: mixed plots at city parks and a complete random block plot at the Experiment Station at UC Davis. In total we will evaluate 12 tree species, with 12 individuals of each species, for a total of 144 trees.

At the UC Davis field plot we will plant and measure 48 trees, with 4 replicates of the 12 study species. Trees will be planted in 4 rows with 12 trees in each row. Trees will be planted in a complete randomized block design, since variations in soils or other site conditions are minimal. Each tree will be planted on 25 ft. by 25 ft. centers, for a total land area of 100 ft. by 300 ft. All trees will be subjected to the same irrigation and maintenance regimes. Once established, irrigation and maintenance will be minimal. We will assist with planting and we will prune young trees annually as needed for structure and form.

In 4 Sacramento city parks we will plant 96 trees, with 8 replicates of the 12 study species. Two replicates of each study species will be planted in mixed plots in each of the 4 parks (24 trees per park). Planting in four parks will allow us to observe performance under a variety of different growing conditions. Volunteers trained and coordinated by the Sacramento Tree Foundation will plant trees in three parks, while the other park will be planted by City of Sacramento Departments of Parks and Public Works staff.

Chilopsis linearis 'Bubba'
Desert Willow

List of Tree Cultivars to Test in the Central Valley

Scientific Name	Common Name
Acacia aneura	Mulga
Acacia stenophylla	Shoestring acacia
Celtis reticulata	Netleaf Hackberry
Chilopsis linearis 'Bubba'	Desert Willow
Dalbergia sissoo	Rosewood
Ebenopsis ebano (Pithecellobium flexicaule)	Texas Ebony
Eucalyptus papuana	Ghost gum
Maclura pomifera 'White Shield'	White Shield Osage Orange
Parkinsonia x 'Desert Museum'	Desert Museum Palo Verde
Prosopis glandulosa x Maverick	Thornless Honey Mesquite
Quercus canbyi	Canby's Oak
Ulmus propinqua	Emerald Sunshine Elm

We will monitor the trees annually for the first ten years because mortality is most likely during this establishment period. Thereafter, trees will be measured biannually. Tree measurements include diameter at breast height (dbh) (to nearest 0.1 cm by tape), tree height (to nearest 0.1 m by range pole), and crown diameter in two directions (to nearest 0.1 m by tape). Observations of the presence of pests and diseases and pruning requirements will be made. Pruning requirement ratings are based on growth rate and structural characteristics. Structural characteristics include central leader development when appropriate (i.e., some natural forms may be preferable if architecture appears strong), branch competition or codominant stems, branch size relative to the trunk, and branch attachment characteristics. Cultivars viewed as needing a considerable amount of pruning to develop strong structure are assigned a high score (5), while those needing less pruning are given a lower score (1). All evaluations are conducted without prior knowledge of cultivar identification (blind ratings).

Outreach

The results of this research will be useful to urban tree researchers, arborists, urban foresters, NGOs, landscape architects, and all others growing, planting, and maintaining urban trees. To disseminate the results we will publish biannual reports and give presentations at conferences held by the Western Chapter International Society of Arboriculture, American Society of Landscape Architects, UC Ornamental Horticulture Extension Coordinating Conference (OHECC) and others. UC Cooperative Extension Environmental Horticulture Advisors will participate in the research analysis and will lead local outreach efforts.

Timetable

This project is a twenty-year study to compare the performance of 12 tree species with tolerance to climate change impacts. The study trees will be planted during the first winter and spring, 2015. In the future, the scope of the project will be extended to other California climates including the Inland Empire and Coastal Southern California, with test plantings at UC Riverside and the South Coast Research & Extension Center.

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Partners

Britton Fund, Western Chapter, International Society of Arboriculture

City Plants and the Los Angeles Center for Natural Resources Sustainability

UC Davis Department of Plant Science

USDA Forest Service, Pacific Southwest Research Station

Climate Ready Trees for Central Valley Communities

The goal of this study is to evaluate the survival and growth of seldom used but promising trees in the Central Valley. We can create more resilient urban forests by shifting the palette of trees planted to those proven to perform best when exposed to climate stressors such as heat, drought, high winds, pests, disease and soil salinity.

1. Mulga (*Acacia aneura*) ➔

Mulga is native to arid Western Australia and tolerates hot and dry conditions. It can grow in sandy, loam, or clay soil types. This versatile and hardy tree produces ascending thornless branches and grows 15 to 20 feet in height. The evergreen foliage is gray-green and the tree has yellow flowers in the spring. Maintain leader to avoid suckering.

2. Shoestring Acacia (*Acacia stenophylla*) ➔

This evergreen thornless acacia from Australia grows rapidly into an arresting specimen. The canopy is open with weeping, linear leaves. Shoestring acacia reaches a height of 20 to 30 feet. Fragrant and showy yellow flowers grow in clusters from fall to spring. The tree is drought tolerant and prefers welldrained soil. It may require staking and can sprout from roots.

3. Netleaf Hackberry (*Celtis reticulata*) ➔

The Netleaf Hackberry is native to riparian areas in the Southwest. A deciduous tree, it reaches heights of 25 to 35 feet with a spreading or weeping canopy. The ovate leaves are medium green and turn yellow in the fall. The flowers mature into red drupes that attract birds. The Netleaf Hackberry is drought tolerant and able to thrive in a variety of soil types.

4. Desert Willow (*Chilopsis linearis* 'Bubba') ➔

The Desert Willow is a small flowering desert tree native to California and the Southwest. The cultivar Bubba can reach 25 to 30 feet with a spread of 20 to 25 feet. It has profuse, long-lasting blooms. The showy flowers are pink and white. Leaves are linear blue green and turn golden in the fall. The Desert Willow is very drought and heat tolerant.

5. Rosewood (*Dalbergia sissoo*) ➔

The Rosewood is native to Northern India and its evergreen foliage can be damaged by frost. The tree recovers quickly in the spring. It reaches a height of 30 to 50 feet with a 40 foot canopy spread. Rosewood tolerates periods of drought and can grow in sandy, clay, and loam soil types. Its roots host nitrogen-fixing bacteria. The flowers are inconspicuous.

6. Texas Ebony (*Ebenopsis ebano*) ➔

The Texas Ebony is native to Texas and Northern Mexico, where it is evergreen. It tolerates modest frost but goes deciduous. The tree can reach a height of 30 feet, but is slow growing. Once established, it is very drought tolerant. It has a distinctive branching pattern, thorns, and fragrant yellow flowers that mature into large woody pods.

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7. Ghost Gum (*Eucalyptus papuana*) ←

The Ghost Gum is native to Australia and is a smaller eucalyptus, reaching 60 feet. Some strains have a weeping habit. The trunk is smooth and snow white. It has gray green evergreen leaves that are tinged purple by frost. White flowers bloom in the summer. It tolerates drought but can be used in well-irrigated landscapes. The goal of this study is to evaluate the survival and growth of seldom used but promising trees in the Central Valley. We can create more resilient urban forests by shifting the palate of trees planted to those proven to perform best when exposed to climate stressors such as heat, drought, high winds, pests, disease and soil salinity.

8. White Shield Osage Orange (*Maclura pomifera* 'White Shield') →

Osage orange is native to the western Great Plains and Texas. It grows quickly to a height of 35 feet with equal spread. The deciduous foliage is dark green turning yellow in fall. The White Shield cultivar is thornless and fruitless.

9. Desert Museum Palo Verde (*Parkinsonia* x 'Desert Museum') ←

The Desert Museum is a Palo Verde hybrid that exhibit qualities of the Blue, Foothills, and Mexican Palo Verde. It has a strong upright branching structure and grows rapidly to 25 feet. This hybrid is thornless and the yellow flowers in spring are outstanding. It produces some fruit pod litter.

10. Thornless Honey Mesquite (*Prosopis glandulosa* x Maverick) ←

The Honey Mesquite is native to the southwestern United States. Maverick is an upright-growing, thornless cultivar of the Honey Mesquite. It can quickly reach a height of 30 feet with equal spread. The tree is drought tolerant and adaptable to a range of soil types. Some fruit and foliage litter.

11. Canby's Oak (*Quercus canbyi*) ←

The Canby oak is native to northern Mexico and Texas. It grows rapidly with an upright habit to reach 30 to 50 feet. The thick leathery leaves are semi-evergreen and resemble red oak. Acorns are small and narrow. It is heat tolerant.

12. Emerald Sunshine Elm (*Ulmus propinqua*) →

The Emerald Sunshine Elm is a deciduous tree that reaches 35 feet in height with a 25 foot spread. It has a vase shaped growth habit. The foliage is deep green turning yellow in fall. Emerald Sunshine is insect resistant and tolerant of hot and windy conditions.