What Are Climate-Ready Trees?
Introducing the Climate-Ready Trees Study

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Cities in California are facing increasingly extreme climatic events.

- Urban trees are a **nature-based solution** to mitigating climate change and improving the livability in cities and towns.

- CA's urban tree canopy covers 15% of the urban areas (McPherson et al. 2017)

- CAL FIRE aims to significantly increase canopy %, targeting disadvantaged and low-canopy areas

But only **surviving** trees can yield the desired ecosystem services and social benefits over the long-term

How do we increase chance of survival and build in resilience to the urban forest overall?

What are climate-ready trees?

- Climate-ready tree species are those well-adapted to face both present and future climatic challenges such as heat, drought, extreme weather events, and pests and pathogens.

- Includes cultivars

Objective of the Climate-Ready Trees Study

Help **create a more resilient urban forest** by shifting the palate of tree species, to those that perform well when exposed to **climate stressors**
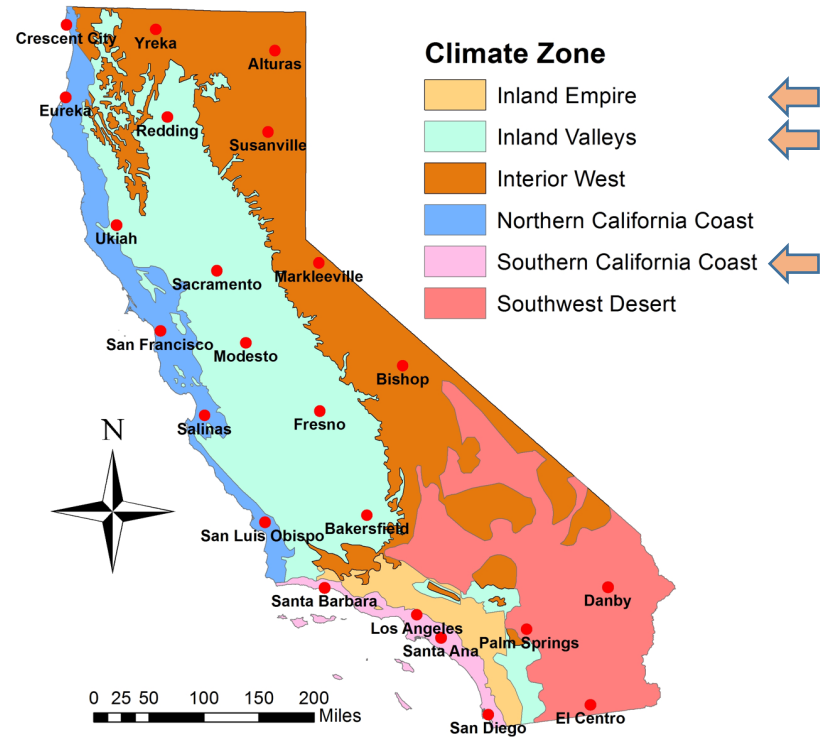

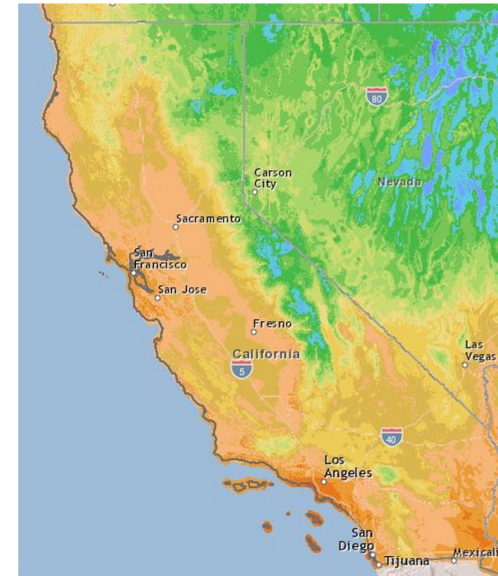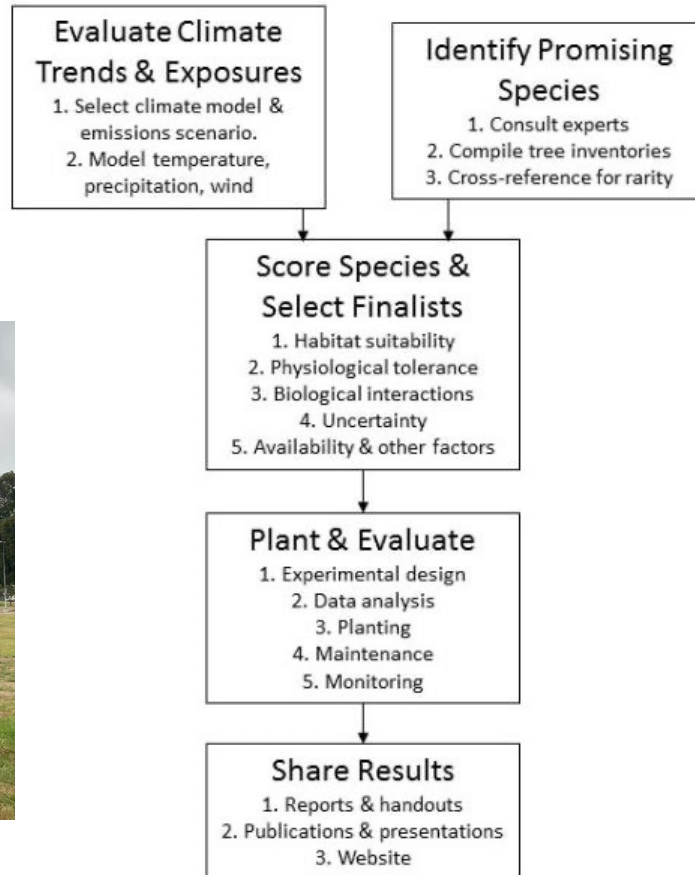http://www.ecosacramento.net/2016/01/changes-to-sacramento-city-tree-ordinance/

Approach

For promising tree species

- Evaluate survival & growth
- 3 climate zones in CA
- 20-year evaluation period

Five-step process

Evaluate Climate Trends & Exposures
1. Select climate model & emissions scenario.
2. Model temperature, precipitation, wind

Identify Promising Species
1. Consult experts
2. Compile tree inventories
3. Cross-reference for rarity

Score Species & Select Finalists
1. Habitat suitability
2. Physiological tolerance
3. Biological interactions
4. Uncertainty
5. Availability & other factors

Plant & Evaluate
1. Experimental design
2. Data analysis
3. Planting
4. Maintenance
5. Monitoring

Share Results
1. Reports & handouts
2. Publications & presentations
3. Website
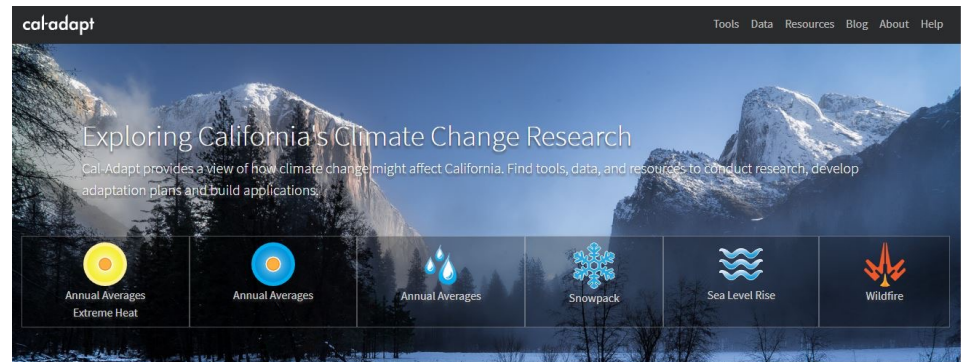

McPherson, E.G., A.M. Berry, and N.S. van Doorn. 2018. Performance testing to identify climate-ready trees. Urban Forestry & Urban Greening 29: 28-39.
doi:10.1016/j.ufug.2017.09.003

Step 1: Evaluate Climate Trends and Exposures

CalAdapt Climate Model, Next 75 Years

Temperature: In each climate zone, model projects **~5°F increase** in avg. min temps & **~6-9°F increase** in avg. max temps

Precipitation: increased variability, **more precipitation** during each storm event, **stronger winds** but also **mega-droughts**

cal-adapt pcm1

http://cal-adapt.org/tools/

Step 2: Identify Promising Species

- Consult experts & UF managers
- Compile tree inventories
- Cross-reference for rarity
- Included native and non-native

Step 3: Score Species

Tree Vulnerability Matrix

Habitat	Physiology	Biological Interactions
Soil Moisture	Drought Tolerance	Invasiveness
Soil Texture and pH	Wind Tolerance	Current Pest and Disease Threats
Sunlight Exposure	Salt Tolerance	Emerging Pest and Disease Threats
	Cold Hardiness	

System for Assessing Vulnerability of Species (Bagne et al. 2011) and Pest Vulnerability Matrix (Laćan & McBride 2008)

Added Considerations Important for Urban Systems

- Low biogenic emissions
- Low root damage potential
- High longevity and high biomass for its stature class

- Strong branch attachment
- High salinity tolerance (recycled irrigation water)

http://www.pasadenanow.com/main/councilmembers-want-city-responsibility-for-sidewalk-upkeep/#.WYlXhlTyu00

http://invasivore.org/2014/04/species-profile-bradford-or-callery-pear/

Native tree species were welcomed but not exclusively considered

1. Focus is on urban areas:
   - CA's urban areas have relatively few tree species native within a given city's boundary.
   - Most cities have < 4 native species that aren't already used

2. Focus on increasing diversity and canopy:
   - Increasing diversity has been shown to promote resiliency

3. Climate change stressors
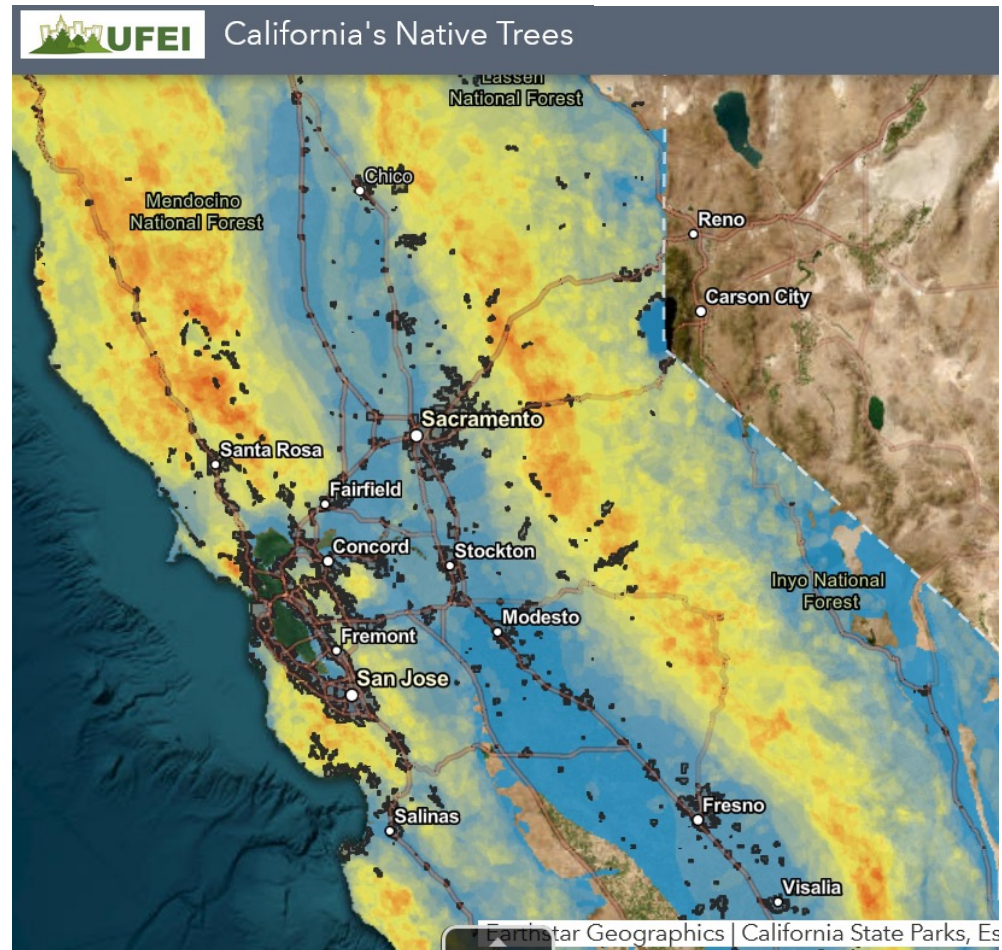
Pawlak et la. 2023. California's native trees and their use in the urban forest. Urban Forestry & Urban Greening, 89, p.128125.

Step 3: Select Finalists

Australia	
Acacia aneura	Mulga
Acacia stenophylla	Shoestring acacia
Corymbia aparrerinja	Ghost gum

Ghost gum

Southwest US (e.g., CA, AZ)	
Chilopsis linearis	Desert willow
Hesperocyparis forbesii	Tecate cypress
Mariosousa willardiana	Palo blanco
Parkinsonia x 'Desert Museum'	Desert Museum palo verde
Prosopis glandulosa x 'Maverick'	Thornless honey mesquite
Prunus ilicifolia subsp. lyonii	Catalina cherry
Quercus fusiformis	Escarpment live oak
Quercus tomentella	Island oak

Thornless honey mesquite

Palo verde "Desert Museum"

Step 3: Select Finalists

‘Emerald Sunshine’ elm

Dutch elm disease & elm leaf beetle resistance

Oklahoma-Texas-Western US	
Celtis reticulata	Netleaf hackberry
Ebenopsis ebano	Texas ebony
Maclura pomifera 'White Shield'	White Shield osage orange
Quercus canbyi	Canby's oak

Canby's oak

Asia	
Dalbergia sissoo	Rosewood
Pistacia 'Red Push'	Red Push pistache
Ulmus propinqua	Emerald sunshine elm
South America	
Cedrela fissilis	Brazilian cedarwood

Step 4: Plant & Evaluate

Experimental Design

In Each Climate Zone:

4 Park Sites
- 2 reps per species
- 96 trees total

1 Reference Site
- 4 reps per species
- 48 trees total

Plant and Maintain

Many different contributors (one of the keys to success)

- City agencies
- Non-profits
- Volunteers
- Univ. staff

Monitoring

Every year for first 5 years, then every 2 years

- Survival; growth
- Tree structure, pest, disease, etc.
- Stem water potential (limited surveys)

Step 5: Share Results

Prelim results – Inland Valleys climate zone

Inland Valley Survival (2015-2023)	Park (%)	Ref. Site (%)	Total (%)
Acacia aneura	25	100	50
Acacia stenophylla	100	100	100
Chilopsis linearis 'Bubba'	50	100	67
Corymbia aparrerinja	25	50	33
Celtis reticulata	75	100	83
Dalbergia sissoo	50	100	67
Ebenopsis ebano	38	100	58
Maclura pomifera 'White Shield'	55	100	67
Parkinsonia x 'Desert Museum'	50	25	42
Prosopis glandulosa x Maverick	88	100	92
Quercus canbyi	100	100	100
Ulmus propinqua	63	75	67
Total	60	88	69

Acacia stenophylla

Inland Valleys Reference Site

Inland Valleys Park Site

Acacia stenophylla

Quercus canbyi

Inland Valleys Reference Site

Inland Valleys Park Site

Prosopis glandulosa x Maverick

Inland Valleys Reference Site

Inland Valleys Park Site

Chilopsis linearis 'Bubba'

Inland Valleys Reference Site

Inland Valleys Park Site

Maclura pomifera 'White Shield'

Inland Valleys Reference Site

Inland Valleys Park Site

Dalbergia sissoo

Inland Valleys Reference Site

Inland Valleys Park Site

Parkinsonia x 'Desert Museum'

Inland Valleys Reference Site   Inland Valleys Park Site

- branch splitting
- blow over

Corymbia aparrerinja

Inland Valleys Reference Site

Inland Valleys Park Site

The need for tree maintenance

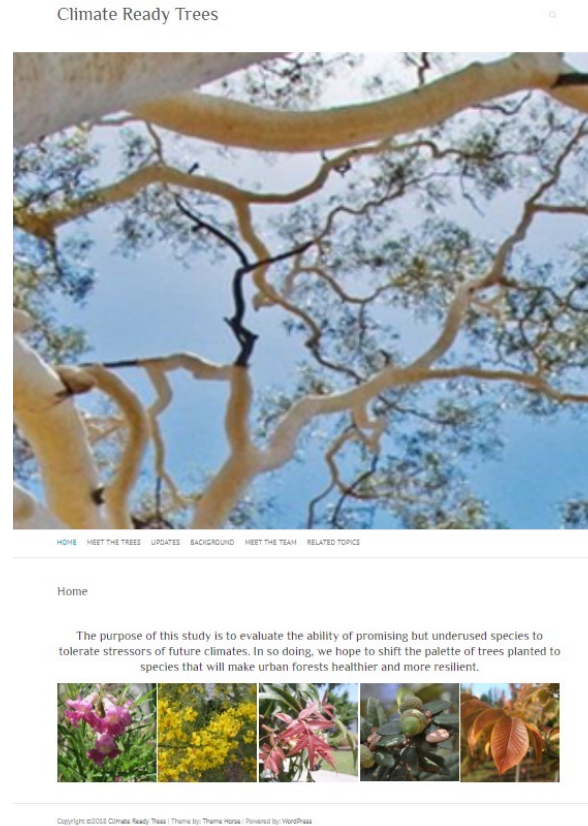**Unpruned** netleaf hackberry in NorCal park site, year 8 after planting

Pruned up netleaf hackberry in NorCal park site, year 8 after planting

Step 5: Share Results

- Reports & Handouts
- Website
- Publications & Presentations
- Media requests
- Consultations

http://climatereadytrees.ucdavis.edu/

Thanks to:

Tree Planting and Maintenance
- *Sacramento Tree Foundation, Los Angeles Beautification Team & the many volunteers*
- *City of Sacramento; LA Dept. of Rec and Parks*
- *UC Riverside Citrus Research Center; South Coast Research and Extension Center; UC Davis*

Trees graciously donated by:
- *Mountain States Wholesale Nursery*

Funding

- *The Britton Fund*
- *LA Center for Urban Natural Resources Sustainability*
- *ISA Western Chapter*
- *US Forest Service, Pacific Southwest Research Station*

Thank you

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Diversity & stocking in CA urban forests

- nearly one-half of all individuals belong to the top 5 genera of oak, cherry, juniper, cypress and pine.

- ~ 236.1 million vacant sites

(McPherson et al. 2017)

CALIFORNIA
Abundance
Quercus (22.0%)
Prunus (6.6%)
Juniperus (5.5%)
Cupressus (4.2%)
Pinus (3.5%)

Selected Finalists

Species	Common Name	Inland Valley (12)	Southern CA Coast (12)	Inland Empire (12)
Acacia aneura	Mulga	+	+	+
Acacia stenophylla	Shoestring acacia	+		
Cedrela fissilis	Brazilian cedarwood		+	
Celtis reticulata	Netleaf Hackberry	+	+	+
Chilopsis linearis 'Bubba'	Desert Willow	+		+
Corymbia papuana	Ghost Gum	+	+	+
Dalbergia sissoo	Rosewood	+	+	+
Ebenopsis ebano	Texas Ebony	+		
Hesperocyparis forbesii	Tecate cypress		+	+
Maclura pomifera 'White Shield'	White Shield Osage Orange	+		
Mariosousa willardiana	Palo Blanco		+	+
Parkinsonia x Desert Museum	Desert Museum Palo Verde	+		+
Pistacia 'Red Push'	Red Push Pistache		+	+
Propospis glandulosa Maverick	Maverick mesquite	+	+	+
Prunus ilicifolia subsp. lyonii	Catalina Cherry		+	
Quercus canbyi	Canby's oak	+		
Quercus fusiformis	Escarpment Live Oak		+	+
Quercus tomentella	Island Oak		+	+
Ulmus propinqua	Emerald Sunshine Elm	+		

Lessons learned

- Importance of the reference site
  (or unexpected issues in park sites)

Park site (now tiny home village)

Reference site

Lessons learned

- Value of park site for demonstration

Family enjoying shade from a 'Red push' pistache, 7 years after planting