Socioeconomic and policy implications from long-term monitoring of Sacramento Shade trees

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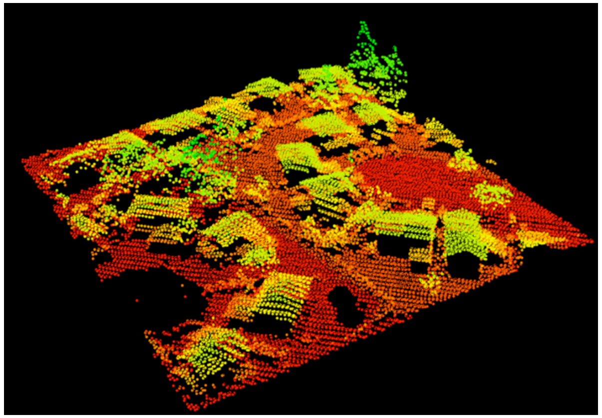
Previous research on urban form and residential energy consumption

Summer Cooling Electricity Use = f {

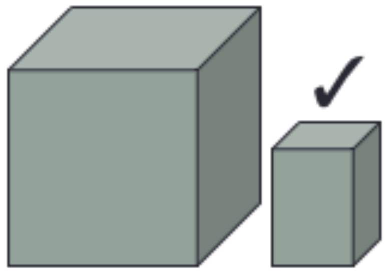
1. Occupant Behavior
2. Property Conditions
3. Demographic & SES
4. **Urban Form**

}

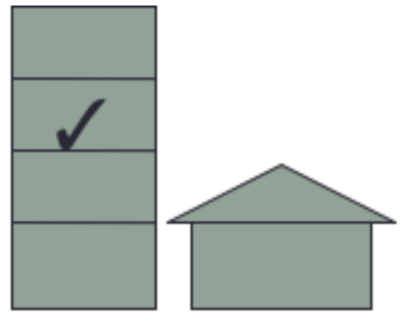


- Ko, Yekang (2013) Urban form and residential energy use: a review of design principles and research findings. *Journal of Planning Literature* 28(4):327-351.

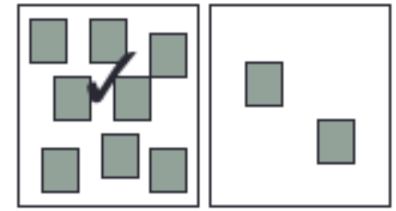
- Ko, Yekang. and John D. Radke (2014) The effect of urban forms on residential cooling energy use in Sacramento, California. *Environment and Planning B: Planning and Design* 41(4): 573 – 593.



Housing Size
Large vs. small



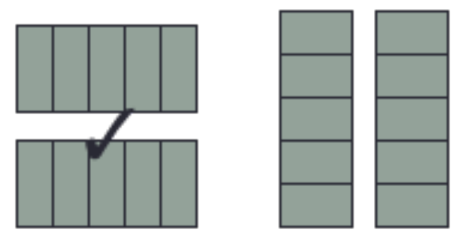
Housing types
Multifamily vs. Single family



Dwelling Unit Densities
High vs. Low

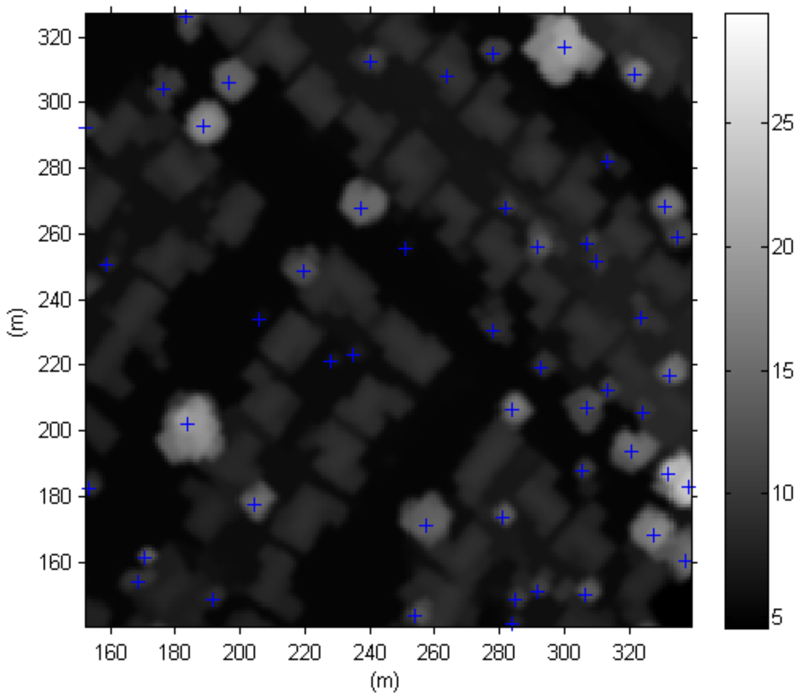
Vegetation Volume & Configuration
Large vs. Small
North, South, East & West

Vegetation Coverage
Large vs. Small



Street orientation
East-West vs North-South

Green space, trees and residential energy consumption



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Tree planting nationwide…

THE MILE HIGH MILLION
AN INITIATIVE OF GREENPRINT DENVER

million trees LA

milliontreesNYC
A PLANYC INITIATIVE WITH NYC PARKS AND NEW YORK RESTORATION PROJECT

SMUD®

SACRAMENTO TREE FOUNDATION

5 Million Trees for Our Future
Help us plant 5 million trees in the greater Sacramento region by 2025!

PLANT ONE MILLION

3 states. 13 counties. 1 tree at a time.

GeoJournal
DOI 10.1007/s10708-012-9446-x

Urban tree planting programs, function or fashion? Los Angeles and urban tree planting campaigns

Stephanie Pincetl · Thomas Gillespie · Diane E. Pataki · Sassan Saatchi · Jean-Daniel Saphores

NEXT CITY Inspiring Better Cities

A Million Trees? Only If We Can Keep Them Around

BY LEDA MARRITZ | APRIL 18, 2012

SCENARIO JOURNAL ISSUES BLOG PROJECTS SUBMISSIONS ABOUT

How Many Trees Are Enough? Tree Death And The Urban Canopy

by Lara A. Roman

Published in Scenario 04: Building the Urban Forest
Spring 2014

Sacramento Shade

5 Million Trees for Our Future

Help us plant 5 million trees in the greater Sacramento region by 2025!

- A partnership b/w the Sacramento Tree Foundation (STF) and Sacramento Municipal Utility Districts (SMUD) since 1990.
- Distributed 500,000 deciduous trees
- Residents are responsible for planting and maintenance of shade trees as advised by community foresters.

http://www.sactree.com/plant

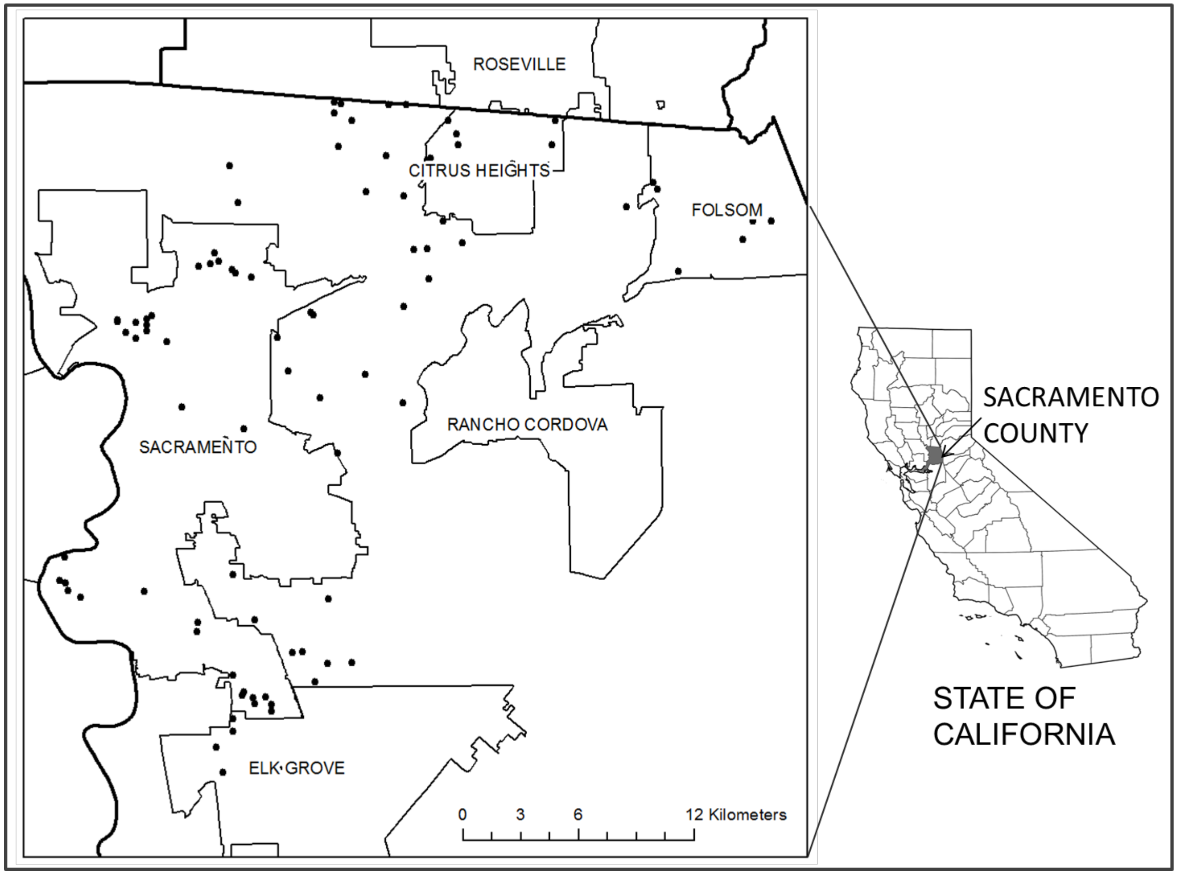
Long-term tree *survival* and *energy performance* of residential shade trees

(1) How many of the shade trees planted between 1991 and 1993 were alive in 2013?

(2) How did tree survivorship affect their energy saving performance?

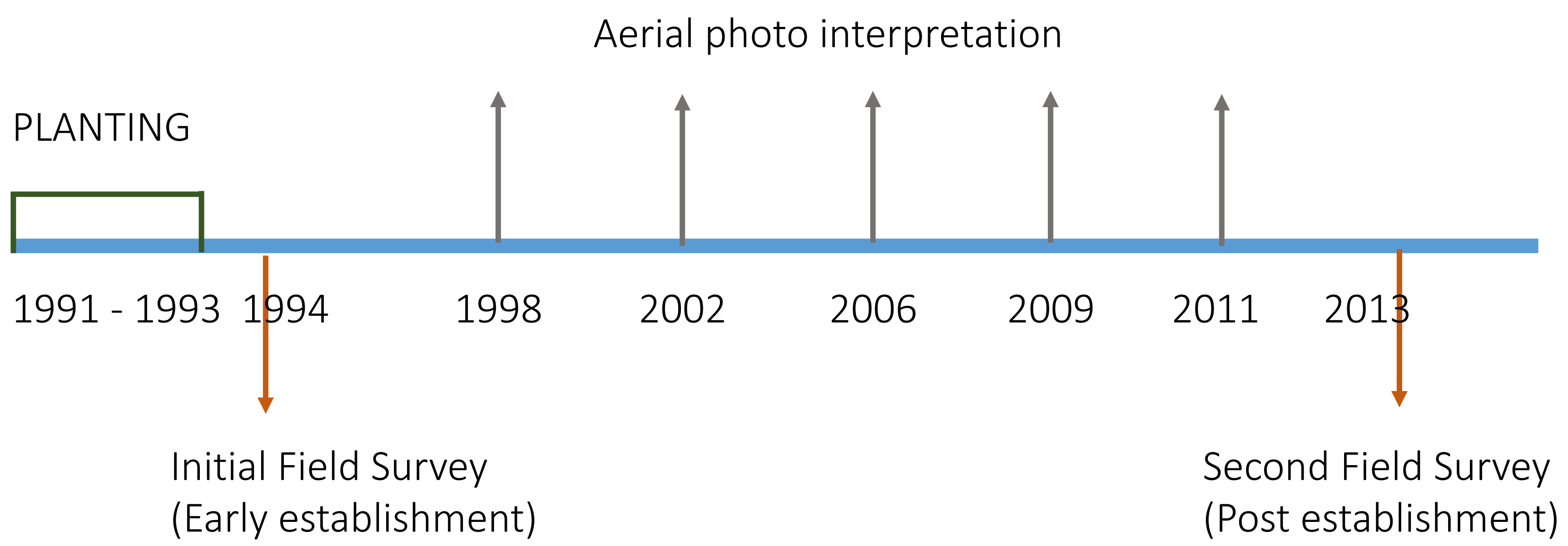
(3) What were the factors affecting tree survival?

Methodology: Data collection



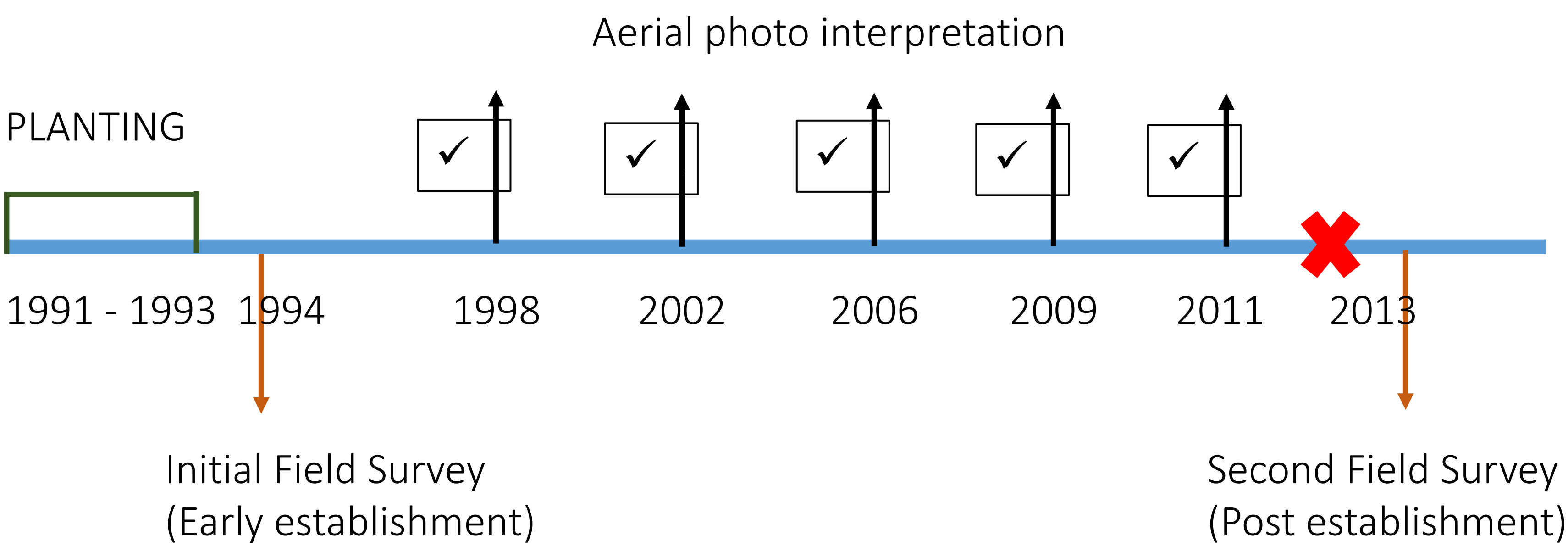
Randomly sampled 92 properties (317 trees) from these original 254 (Simpson and McPherson, 1998)

Methodology: Data collection



Methodology: Survival analysis

- Kaplan-Meier survival curve using the ‘interval’ package in R with our interval censored data.

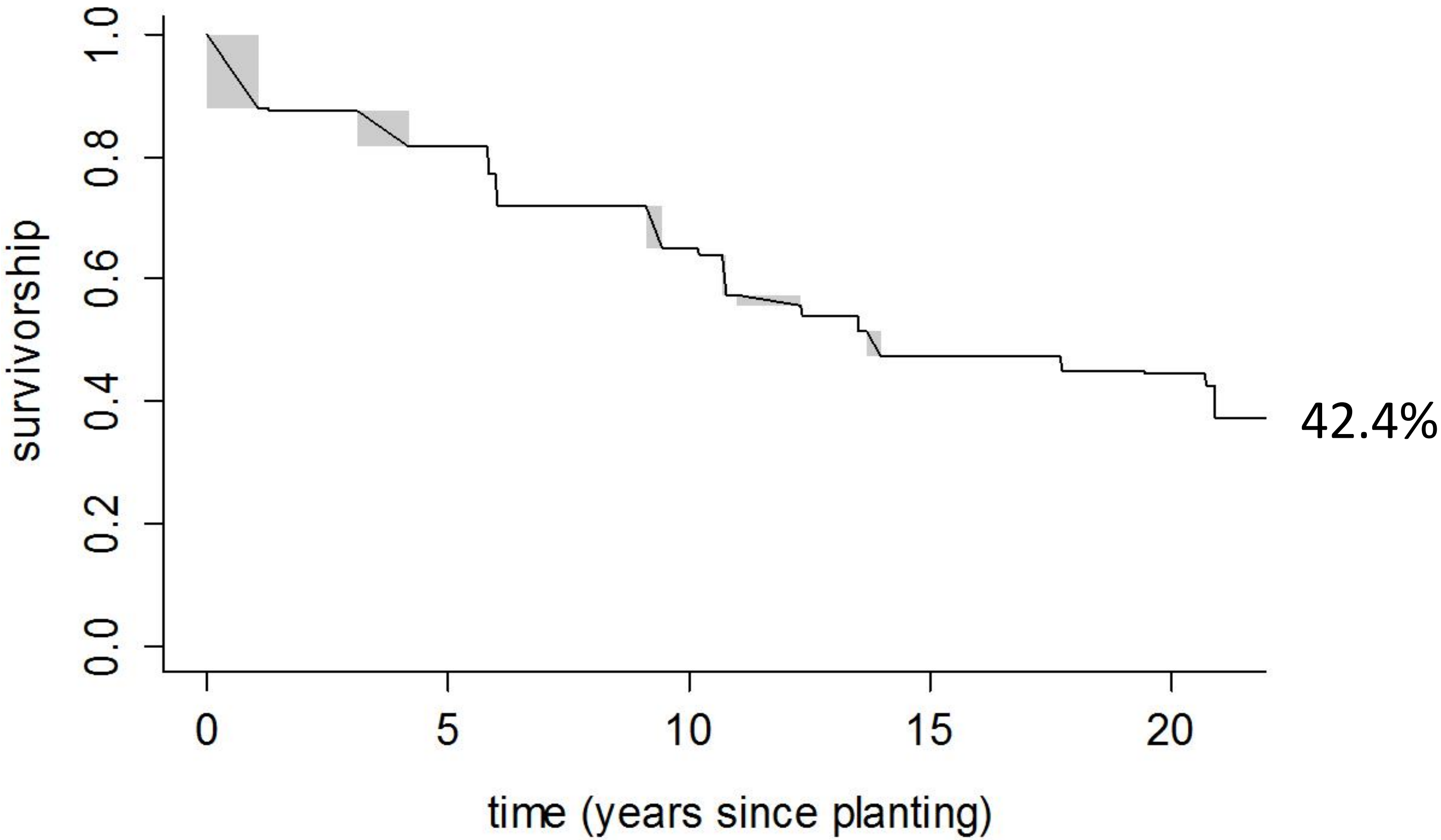


Methodology: Building energy simulation

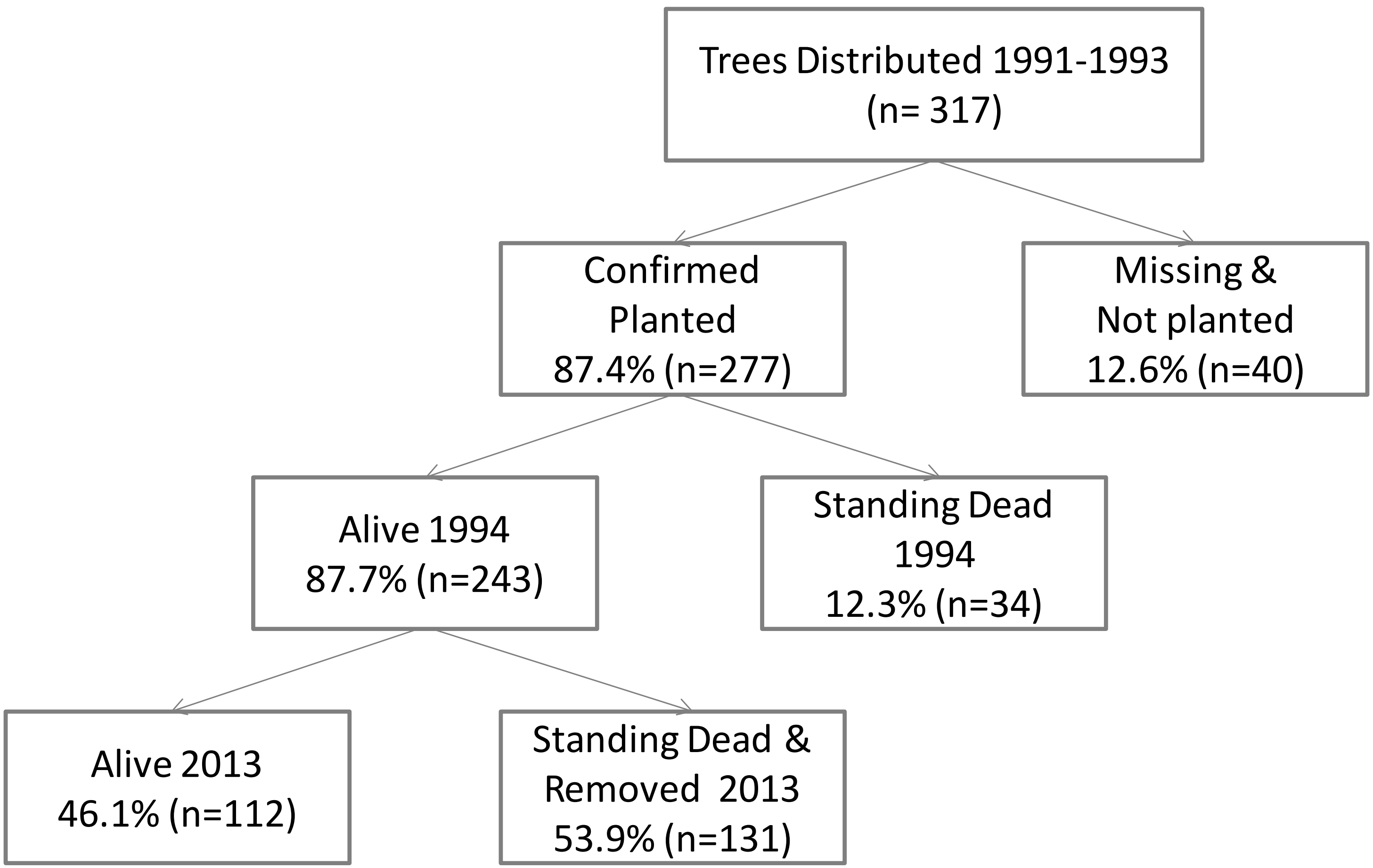
- Shadow Pattern Simulator (SPS)
- Micropas – building energy simulation model

Findings

The 22-year post-planting survivorship



The 22-year post-planting survivorship

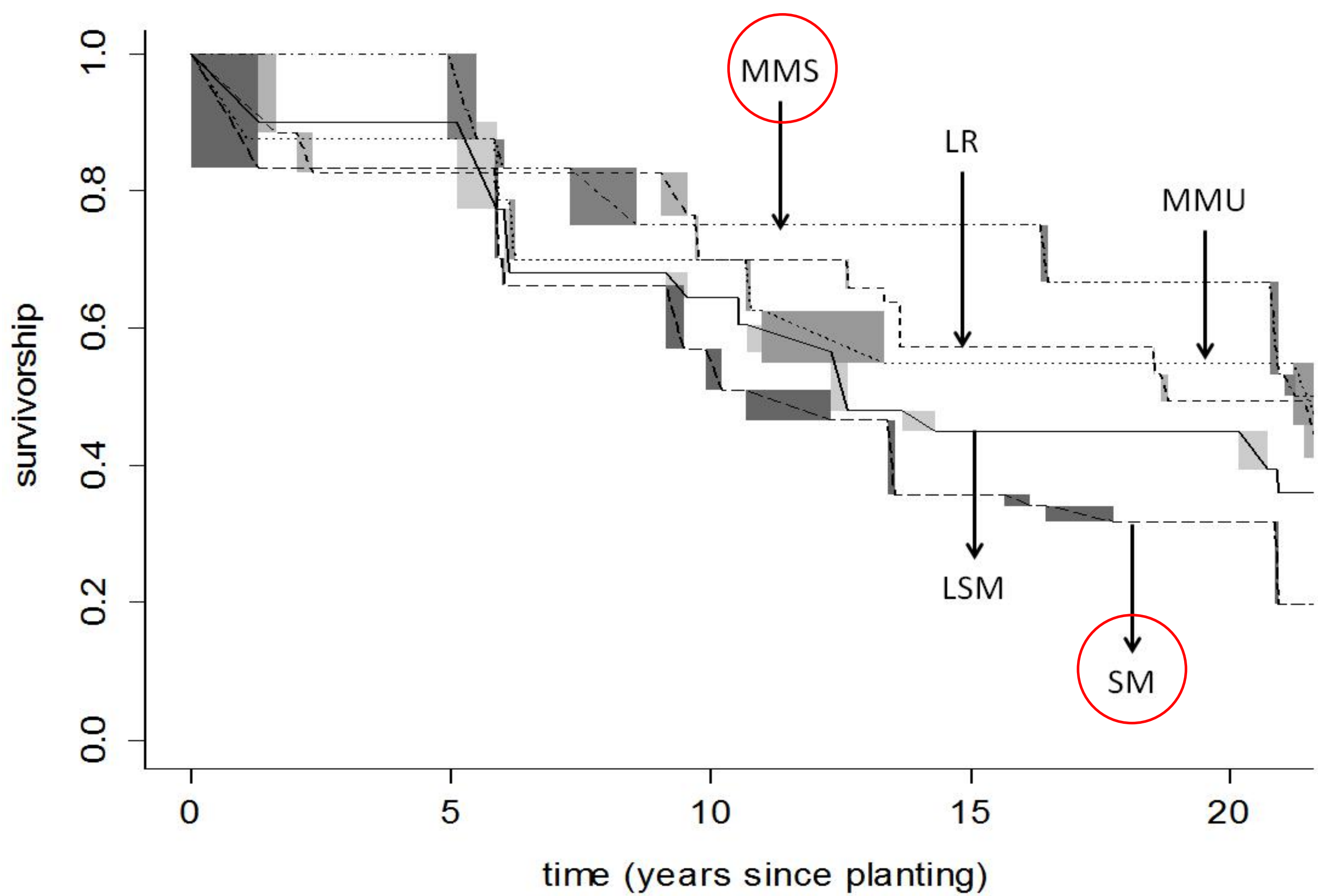


Comparing with early mortality assumptions

- Simpson and McPherson (1998) US Forest Service
  - Tree death and removal would be approximately balanced by tree growth and replacement

In 2013, only 39 trees out of 145 dead or removed trees (26.9%) were replaced in the same location as planted; replacements were much smaller than their projected mature size.

The 22-year survivorship by mature tree size



Energy-saving performance

Comparison of energy savings for all planted trees (shade effect only) b/w projected saving (**30 years**, Simpson and McPherson, 1998) and the 2013 simulated saving (**20-22 years**)

	Initially projected for 2023 30 year post planting		**Simulated for 2013 20-22 year post planting**	
	Per property	Per tree[2]	Per property	Per tree[1]
Mean annual cooling energy	471 kWh 22.0%	153 kWh 7.1%	107 kWh 4.9%	80 kWh 3.7%
Peak demand	0.23 kW 7.1%	0.08 kW 2.3%	0.05 kW 1.6%	0.04 kW 1.2%
Mean annual heating energy	-2.6 MMBtu -5.9%	-0.85 MMBtu -1.9%	-0.5 MMBtu -1.2%	-0.38 MMBtu -0.9%

Findings: Energy-saving performance

Comparable studies		Assumptions	Energy Savings (per property)		Energy savings (per tree)	
Authors (Study year) [Method]	Conditioned Floor Area	Trees	kWh	kW	kWh	kW
Our study [Simulation]	146m^2 (1573ft^2)	Avg. 1.3 "program" trees/property, 20-22 years post planting in all orientations	107 (4.9%)	0.05 (1.6%)	80 (3.7%)	0.04 (1.2%)
Donovan & Butry (2009) [Regression]	139m^2 (1500 ft^2)	Current average tree cover on the south and the west of a house	185 (5.2%)	N/A	82 (2.3%)	N/A
Simpson & McPherson (1998)[1] [Simulation]	146m^2 (1573ft^2)	Average 3.1 trees/ property, 20-30 years post planting in all orientations	471 (22.0%)	0.23 (7.1%)	153 (7.1%)	0.08 (2.3%)
Akbari et al. (1997) [Experiment]	135m^2 (1453 ft^2)	16 trees (eight were 6 m tall and eight were 2.4 m tall)/ property on the west and south walls of a house	396 (29.0%)	0.8 (22.0%)	N/A	N/A
Simpson & McPherson (1996) [Simulation]	139m^2 (1500 ft^2)	Three trees with 7.3-m (24-ft) crown diameter/ property; two on the west, one on the east	513 (34.0%)	0.74 (23.0%)	180 (11.9%)	N/A

Higher tree survival is associated with:

- In the establishment phase (Ko et al., 2015; Roman et al., 2014)
  - ✓Stable homeownership (vs. forecloses, home sales)
  - ✓Better maintenance (highly linked with stable homeownership and owner occupancy)
  - ✓Planted in front yards
  - ✓Having ordered relatively fewer trees
  - ✓Drought-tolerant species
  - ✓Medium-net property values

Higher tree survival is associated with:

- In the overall/ post-establishment phase (Ko et al., 2015)
  - ✓Medium-mature size (vs. small-mature size)
  - ✓Stable homeownership
  - ✓Planted in front yards

Implications for
urban greening planning and policy

Increasing tree survivorship is the key.

- Tree selection
  - Medium mature sized trees and rapidly growing large trees
  - Climate-appropriate / drought-tolerant trees
- Preparing for new challenges (e.g. droughts)
  - California ReLeaf's campaign on smart landscaping guidance
- Community outreach and education
  - Ongoing communication through email, mail, phone calls, labels
  - Strategic intervention (e.g. when home ownership changes)

Save Our Water and Our Trees!

saveourwater.com/trees

Socioeconomic factors matter.

- Motivations for /drivers of tree planting and maintenance
  - Aesthetics, sense of ownership, stewardship, civic engagement etc. (Vogt, 2017).
- Urban tree planting for equity
  - Non-profit tree planting at risk of creating or exacerbating race-based inequity due to system bias (Watkins et al. 2016)
  - Spatial/temporal mismatch b/w biophysical and socioenomic data
  - More attention on vulnerable and underserved communities

https://persquaremile.com/2012/05/24/income-inequality-seen-from-space/

Collaboration with researchers can help data-driven GI planning and management.

Empirically-driven monitoring is essential.

- for accurate quantification of the performances.

http://leaflimb.com/

Long-range, multifunctional approach to tree planting as Green Infrastructure planning is imperative.

- Comprehensive GI planning incorporating socio-ecological dynamics contributes to mitigating and adapting to climate change.

Does Tree Planting Pay Us Back? Lessons from Sacramento, CA

By Yekang Ko, Lara A. Roman, E. Gregory McPherson, and Junhak Lee

The past decade could be called a renaissance of urban forestry, driven by mayoral tree planting initiatives and increased attention on city trees as green infrastructure. The political support for urban greening has been fueled by research that quantifies and projects the ecosystem services of planting initiatives (Young and McPherson 2013). Major cities have been launching "million tree" campaigns, hoping that those trees pay us back.

In the scholarly literature, doubts have been raised as to whether urban tree planting is more fashion than function (Pincetl et al. 2012). We have little understanding of how these planted trees actually survive, grow, and perform, especially in the long term. Concerns have been raised in newspapers and blogs as well, with article titles such as "A million trees? Only if we can keep them around" (Marritz 2012). Here, we present empirical evidence to answer the question: *How are planted trees really doing?* It is only after we have answered this question that we can we judge whether our planting investments are paying off.

SACRAMENTO TREE FOUNDATION

Urban tree planting is essential to provide ecosystem services to our communities. How much do we know about how these planted trees actually survive, grow, and perform in the long-term?

Our evidence centers on 22 years of monitoring with the Sacramento Shade program, which has distributed over 500,000 trees since 1990 to reduce cooling demand, mostly on residential properties (Arrington 2015). This program is a partnership between the Sacramento Tree Foundation (STF) and the Sacramento Municipal Utility District (SMUD). As the largest and longest operating municipal utility-sponsored shade tree initiative in the United States, the Sacramento Shade program has important implications for other tree giveaway programs and major planting initiatives.

In this article, we summarize important findings from three peer-reviewed studies: Ko et al. (2015a; 2015b), which monitored trees planted from 1991 to 1993 for 22 years using field surveys and aerial photo interpretation, as well as Roman et el. (2014), which monitored five years of establishment survival from trees planted in 2007, using field surveys. We then conclude with a call for tree planting programs to consider realistic tree performance expectations and to strategize for enhancing long-term survival based on empirical evidence.

Survivorship

Roman et al. (2014) reported that five-year post-planting survival was 70.9%. Ko and others (2015a; 2005b) found that 22-year survivorship was 42.4%. These survival rates were substantially lower than values used previously to model future tree performance in Sacramento and other cities (Simpson and McPherson 1998; McPherson et al. 2008). In the original model for energy-saving benefits of Sacramento Shade, Simpson and McPherson (1998) assumed that all dead and removed trees would be replaced with new trees. In Ko et al. (2015a), the 2013 field surveys revealed that only 23% of trees lost seemed to have been replaced by younger trees planted in the same

Arborist News, June 2016

Ko, Y, Lee, J., McPherson, E.G., and Roman, L.A. 2015. **Long-term monitoring of Sacramento Shade program trees: Tree survival, growth and energy-saving performance**, *Landscape and Urban Planning* 143:183–191.

Ko, Y, Lee, J., McPherson, E.G., and Roman, L.A. 2015. **Factors affecting long-term mortality for residential shade trees: Evidence from Sacramento, CA**, *Urban Forestry and Urban Greening* 14: 500–507.

Roman, L.A., J.J. Battles, and J.R. McBride, 2014. **Determinants of establishment survival for residential trees in Sacramento County, CA.** *Landscapes and Urban Planning* 129: 22–31

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Thank you and Questions?

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