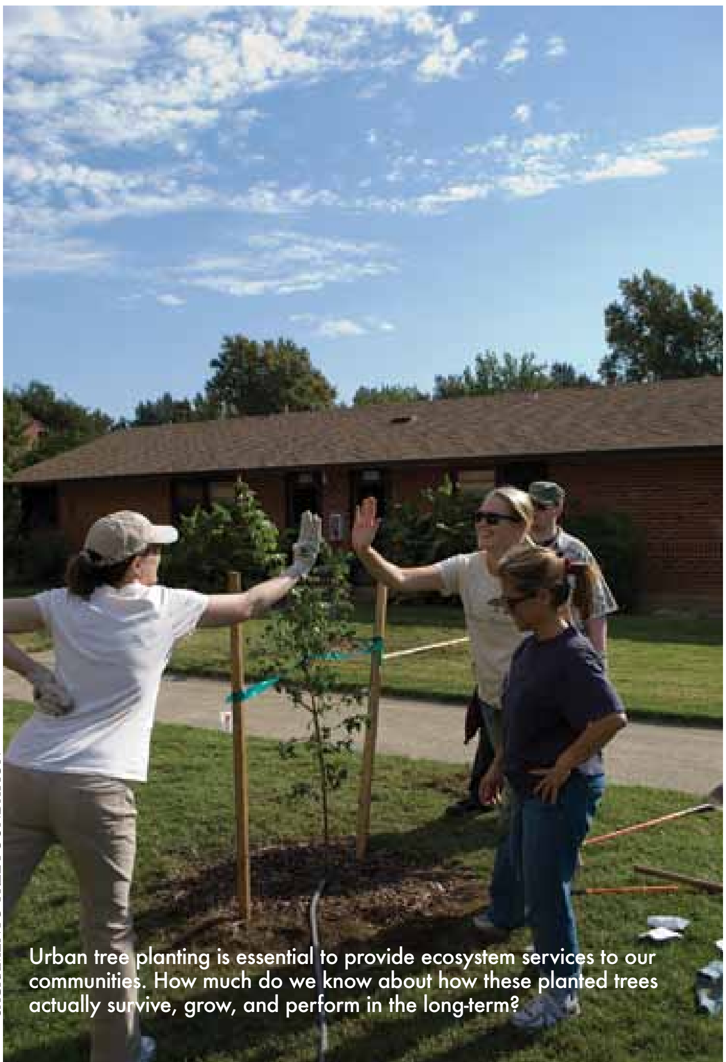
Does Tree Planting Pay Us Back? Lessons from Sacramento, CA

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

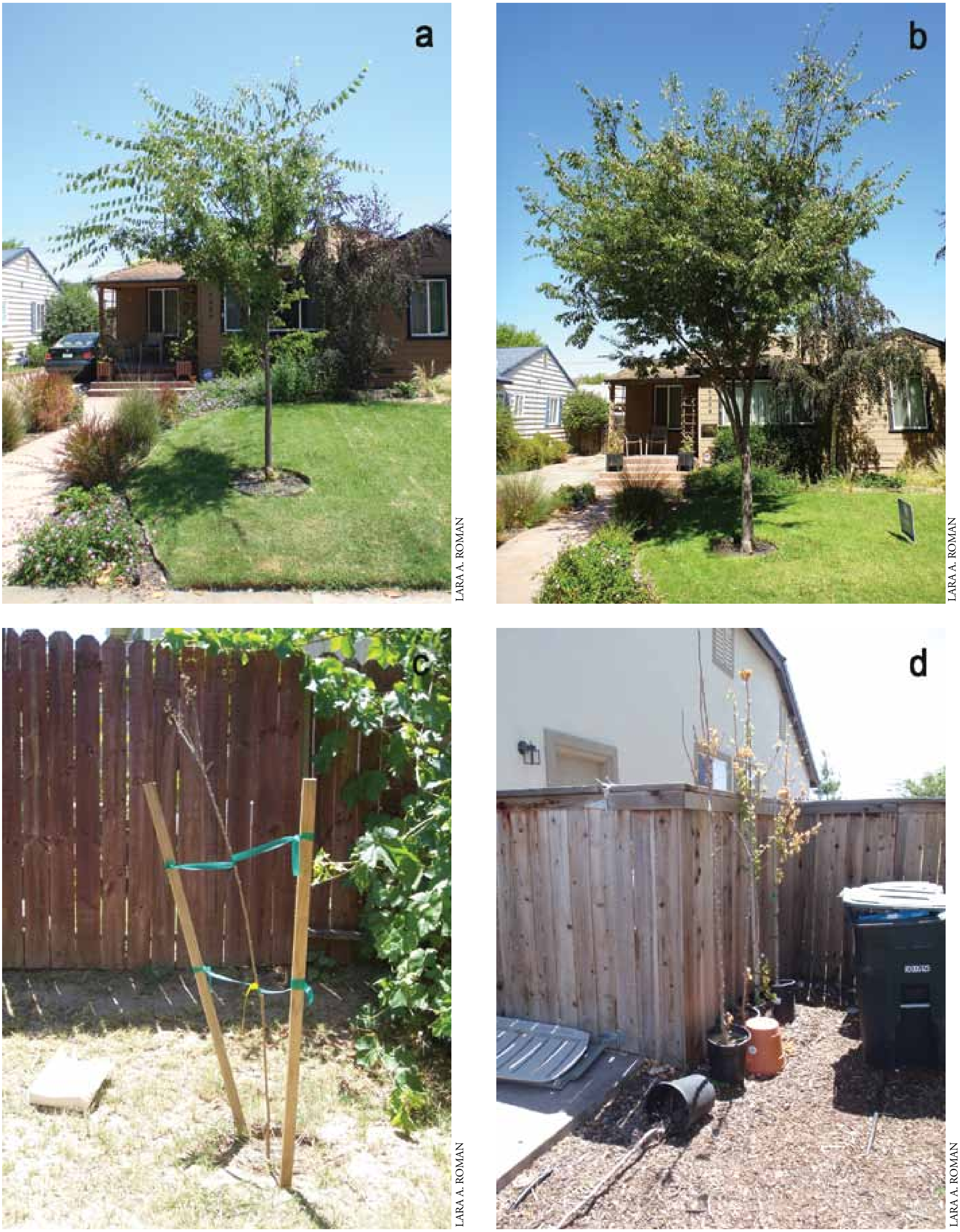
Urban tree planting is essential to provide ecosystem services to our communities. How much do we know about how these planted trees actually survive, grow, and perform in the long-term?

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



Examples of tree status from yard tree monitoring: a tree that survived in 2009 (a) and 2012 (b), a standing dead tree in 2008 (c), and trees that were never planted (d).

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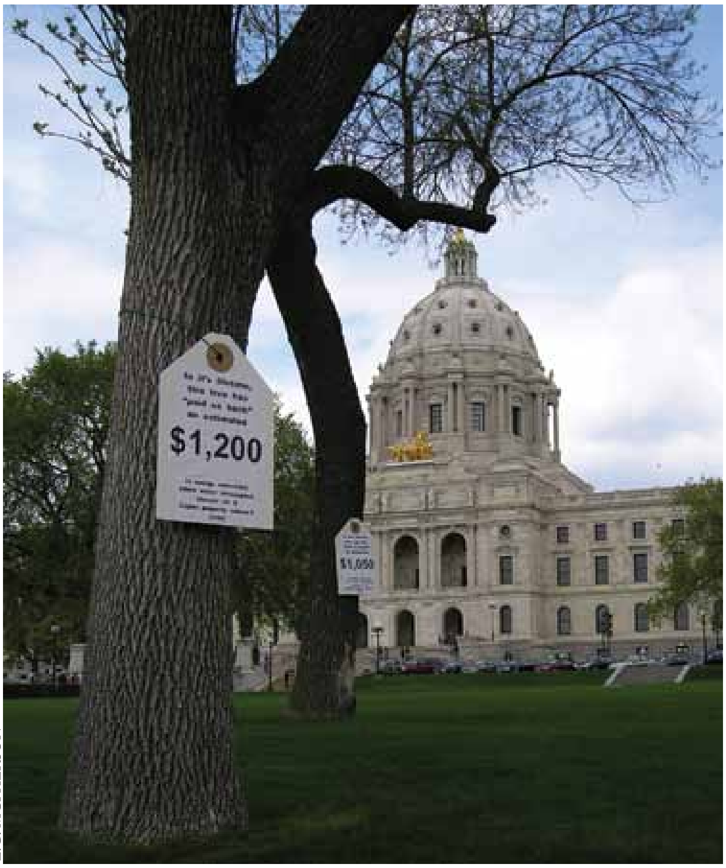
locations. To the best of our knowledge, these studies are the first to document long-term survival of residential yard trees; most previous urban tree survival studies have been concerned with street trees, generally focused on the establishment phase (Roman and Scatena 2011).

These studies also examined biophysical and socioeconomic factors associated with tree survival. In the establishment phase, higher tree survival was associated with properties with stable home ownership, drought-tolerant species, and having ordered relatively fewer trees. Stable homes—owner-occupied properties that did not have foreclosures or home sales—were also tightly linked with better maintenance. Only 23% of trees had maintenance that followed the program's basic guidelines for watering, staking, and mulching; nearly all of these trees with good maintenance were on stable properties. Drought-tolerant species also had higher survival. Species that have lower water-use demand are especially relevant in Sacramento, which has a Mediterranean climate with seasonal drought. Furthermore, water-shortage issues in California are worsening with climate change. Number of trees delivered also mattered; properties that ordered too many trees showed higher mortality, possibly because residents' care for an individual tree is reduced.

For long-term survival, mature tree size and home ownership stability were influential. Species with medium-mature size [expected to be 10.6 m (34.78 ft) tall], such as Chinese pistache (*Pistacia chinensis*) and Chinese tallow tree (*Triadica sebifera*), showed the highest survival, while small-sized trees [expected to be 7.6 m (24.93 ft) tall], including Japanese maple (*Acer palmatum*) and crapemyrtle (*Lagerstroemia* hybrid), had the lowest survival. Over 22 years after planting, properties with very unstable home ownership showed lower survival rates.



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Trees pay us back when they survive in the long term.

With both the establishment-phase and long-term analyses, trees planted in front yards survived better than those in backyards, perhaps due to residents taking better care of their front yards as a showcase to neighbors (Larsen and Harlan 2006). Overall, these findings point to the vital role of species selection, tree care, planting location, and home ownership stability for yard tree survival.

Failure to Plant

Sacramento Shade is a yard tree giveaway program that relies on residents to plant their trees. Some distributed trees were never actually planted. Both studies reported a similar planting rate of 84.9%–87.4%. Higher planting rates were associated with socioeconomic factors, such as high educational attainment, stable home ownership, and owner-occupancy.

Growth

Ko et al. (2015b) compared growth observed at 22 years to the original growth projections for five tree classes based on their mature tree size (small, medium, and large) and growth rate (slow, moderate, and rapid growth) at 30 years after planting (Simpson and McPherson 1998). Annual growth rates were consistent with or above those reported from other studies for medium-sized trees, including Chinese tallow tree and Chinese pistache, as well as large-sized trees [expected to be 13.7–16.7 m (44.95–54.79 ft) tall], such as Chinese hackberry (*Celtis sinensis*), London planetree (*Platanus* × *acerifolia*), and red oak (*Quercus rubra*). For small trees, actual growth was below the projections.

Energy-saving Performance

Ko et al. (2015b) assessed the energy-saving performance of Sacramento Shade program trees using tree dimensions measured at 22 years after planting. Per property, the annual cooling energy savings was 107 kWh, considerably less than the savings (471 kWh) initially projected by the U.S. Forest Service (Simpson and McPherson 1998), primarily because tree survival was much lower than the initial assumption (Simpson and McPherson 1998). In the 1994 field survey, an average of 3.1 program trees were observed per property, but only 1.3 program trees were found alive in 2013.

The annual cooling energy savings per tree was 80 kWh (USD $8.05), similar to results from another study of residential shade trees in Sacramento (Donovan and

Butry 2009). The 22-year per-tree savings were lower than those initially projected assuming the 30-year-old mature tree by the U.S. Forest Service (153 kWh) and SMUD (125 KWh); the energy savings may increase as trees grow and reach their 30-year maturity, thus shading more building surface area. On the other hand, energy savings from shade trees may decrease over time as the new residential construction homes became a lot more energy efficient due to continuous improvements in the statewide energy efficiency building code requirements (i.e., CA Title 24).

Discussion

Long-term monitoring of Sacramento Shade trees reveals that increasing survivorship is key to achieving the ecosystem services that planting initiatives strive to achieve. Understanding various socio-ecological factors that affect tree survival helps us develop strategies to increase long-term performance.

Tree species selection is important to achieving long-term performance. Encouraging medium-mature size or rapidly growing large trees appears be effective for maximizing energy-saving benefits because these species provide the greatest amount of shade during their lifetime due to both higher long-term survival rate and larger canopy size. Selecting drought-tolerant trees could increase tree survival, particularly in the establishment phase (McPherson and Albers 2014). Climate-appropriate species selection is becoming more crucial as we enter an era of changing climate (McPherson and Berry 2015). Educating residents about "climate-ready" landscaping is necessary to increase tree survival under climate stress. For example, California ReLeaf's campaign, "Save Our Water and Our Trees," provides simple tree care guidelines to protect trees from impacts of drought and associated watering restrictions.

As yard trees are directly impacted by residents' tree care—or lack thereof—community outreach to raise residents' level of stewardship could play an important role in increasing tree survival. New residents who move into homes with existing program trees may not be aware of the program or of tree care in general. Additionally, homes that are foreclosed may lack watering and other maintenance for many months in a row. This could explain why there is higher mortality on properties with unstable home ownership. Ongoing outreach through e-mail, postage mail, and phone calls to remind residents to engage in proper tree care may be helpful. The Sacramento Tree Foundation has already started conducting systematic phone calls and e-mailed tree care tips to shade tree customers after the Roman et al. (2014) study reported that few residents practiced good tree maintenance.

Studying growth and survival can indicate some harsh realities about tree performance, and we commend STF and SMUD for their dedication to collaborating with researchers to study this issue. Many programs plant trees, but few monitor survival and growth performance. Urban greening programs need to understand the extent and nature of threats to tree survival and strategize to enhance long-term performance.

Conclusion

So, does tree planting pay us back? Yes, it does, but only if the trees are properly selected, planted, and cared for. Maintaining trees is as important as planting trees. Monitoring is essential to adjusting ecosystem services models to more accurately estimate future benefits. Long-term monitoring is a central component of data-driven urban forest planning and management by looking past sheer counts of trees planted and towards long-term performance as a metric of success.

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