Optimizing Landscape Tree Placement to Conserve Energy for Heating and Cooling Residential Structures

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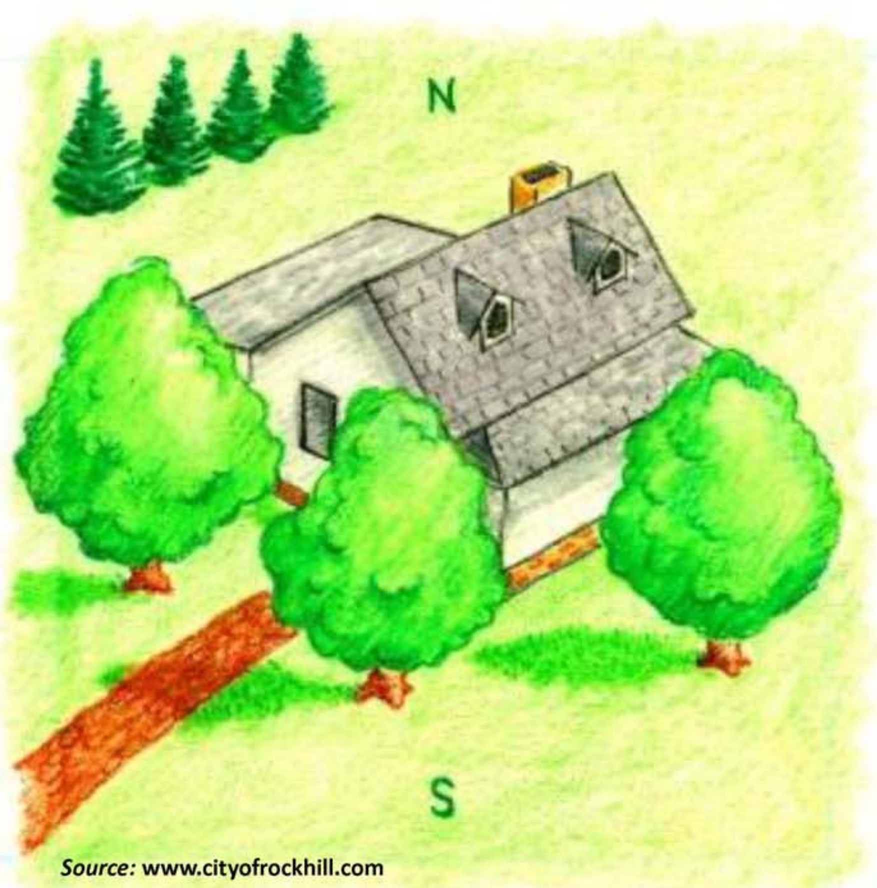
Abstract

Landscape trees can help reduce energy consumption by shading homes in summer and by blocking winds in winter. Because most modern homes have automated climate control, homebuilders and homeowners often do not give much thought to using trees to conserve energy. As a result, trees often end up being planted in sub-optimal locations for energy conservation. We conducted a series of computer simulations to study the effects of tree form (size and shape) and tree placement (distance and direction from house) on energy consumption. We then examined existing landscape trees around recently constructed homes in three cities of contrasting climate (Minneapolis, MN; Charlotte, NC; and Orlando, FL). From the simulations, we learned that a large tree on the west aspect of a structure could decrease annual energy costs by up to 160 kWh (valued at $18) in southern cities with longer cooling seasons. In contrast, the same tree on the south aspect could increase annual energy costs by up to 134 kWh (cost of $15) in northern cities with longer heating seasons. When we modeled existing landscape trees in the three U.S. cities, we found that large-stature deciduous trees provided average annual energy savings per parcel of 14 kWh (MN), 25 kWh (NC), and 44 kWh (FL). By spatially reconfiguring these trees in a simulator, we were able to optimize the placement of over 70% of the trees and more than double the annual energy savings. These results suggest that homebuilders and homeowners are not taking full opportunity to save energy with landscape trees and that more outreach is needed to improve landscaping decisions.

How do trees conserve energy?



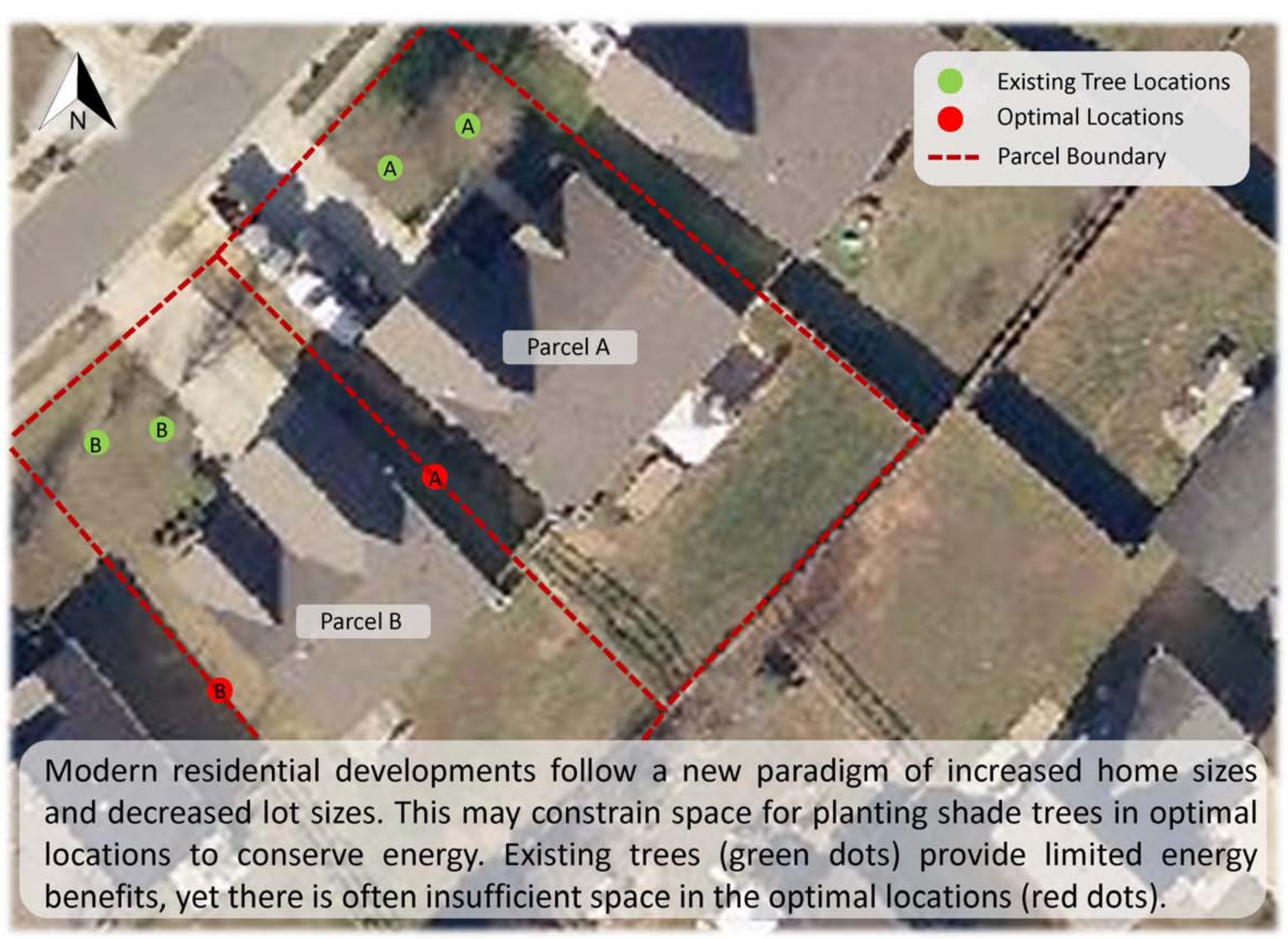
The Conventional Tree Placement Strategy

Summer Shade
West-side trees block sunlight in the late afternoon and east-side trees block sunlight in the morning.

Winter Warmth
Deciduous trees planted around the house allow sunlight through to warm the house.

Winter Windbreak
Evergreen trees planted on the northwest side of the house block chilling winter winds.

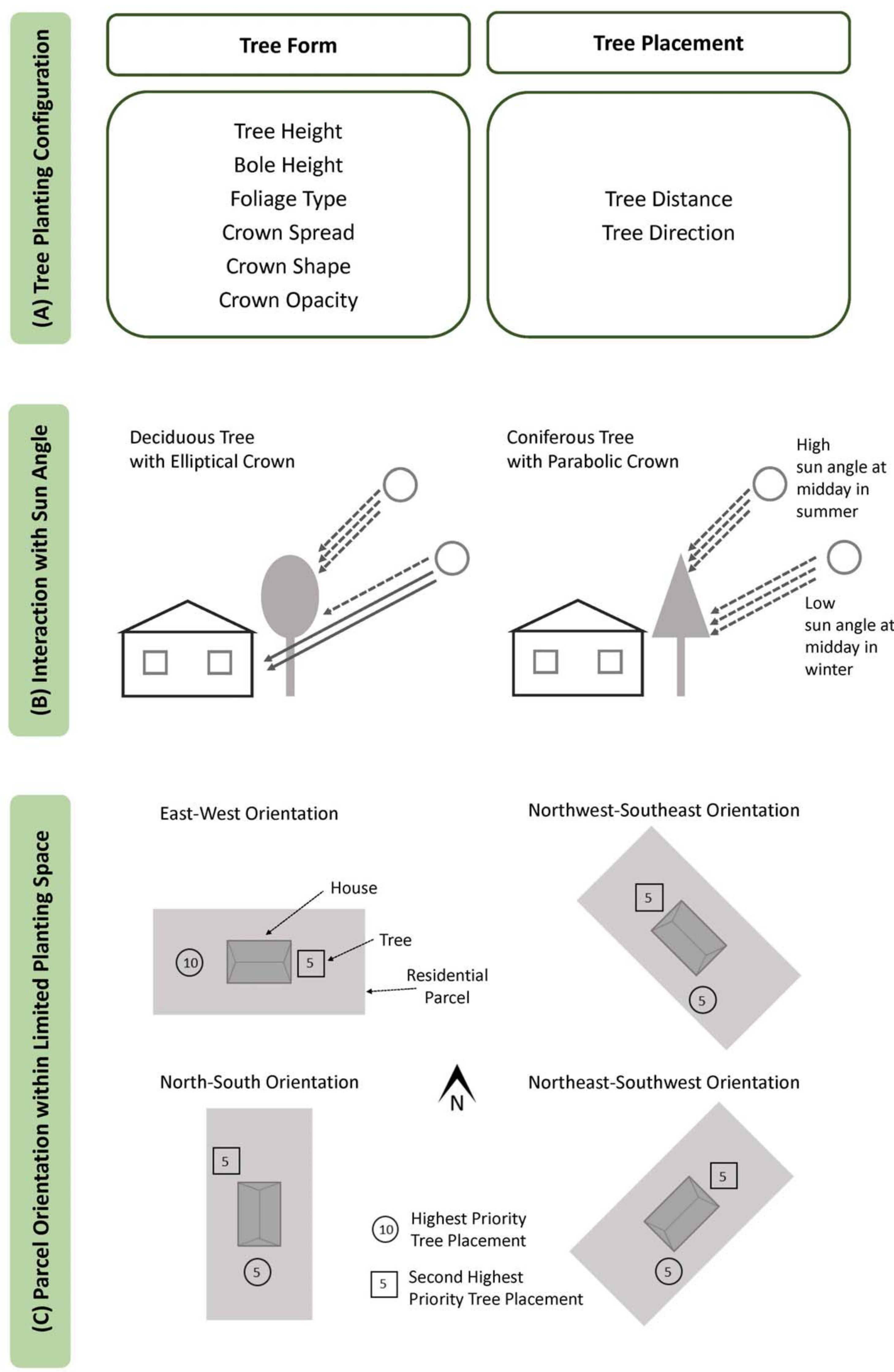
Where can we plant trees for energy conservation?



Modern residential developments follow a new paradigm of increased home sizes and decreased lot sizes. This may constrain space for planting shade trees in optimal locations to conserve energy. Existing trees (green dots) provide limited energy benefits, yet there is often insufficient space in the optimal locations (red dots).

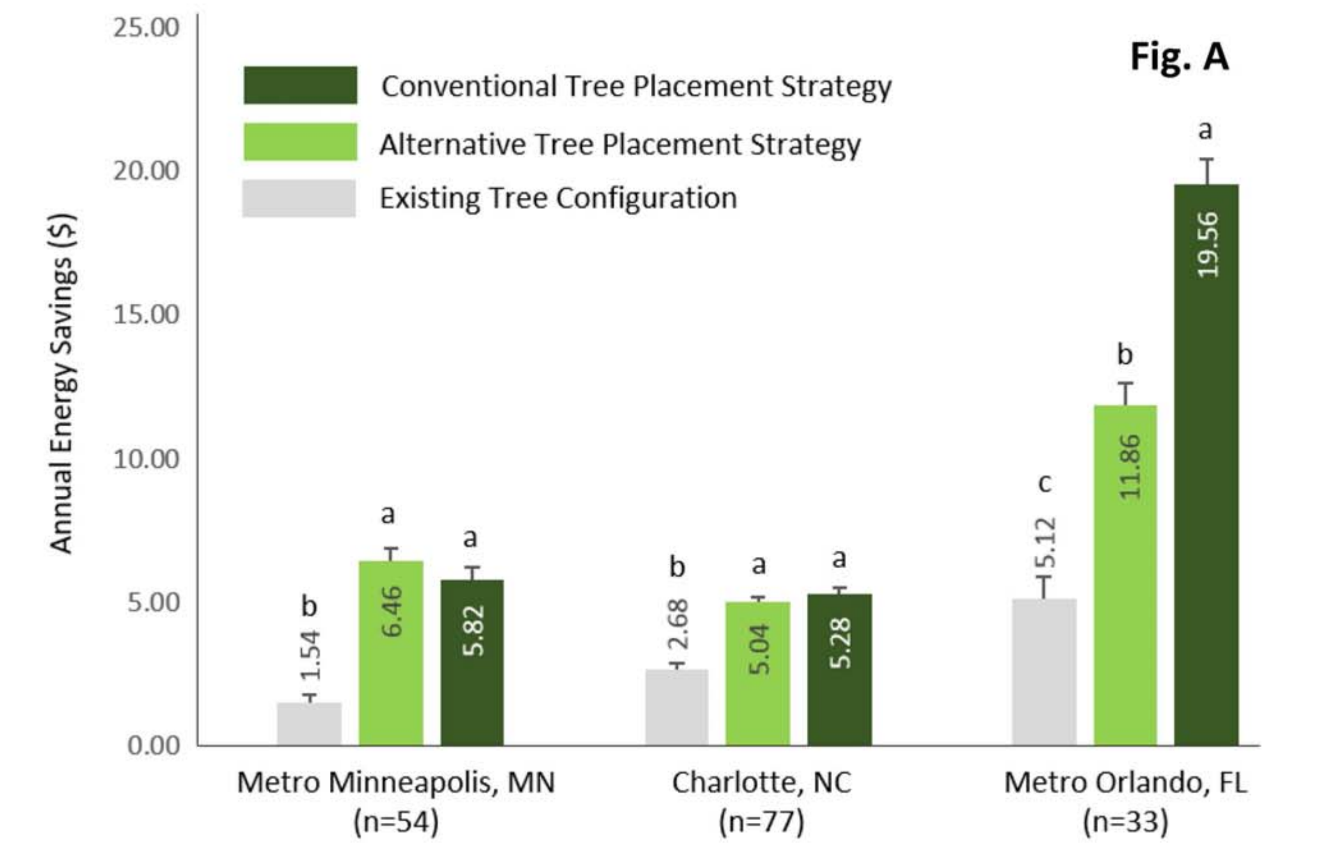
What factors did we consider for optimizing tree placement?

We used a computer simulation program to examine how **(A) tree form and tree placement**, interacting with daily and seasonal variation in **(B) sun angle**, influence shade cast upon building surfaces, and consequently how this impacts energy consumption of a building in a dense residential development where **(C) limited space** is available for tree planting. We then virtually repositioned trees based on **(C) parcel orientations** using the **Alternative Tree Placement Strategy** that we developed.

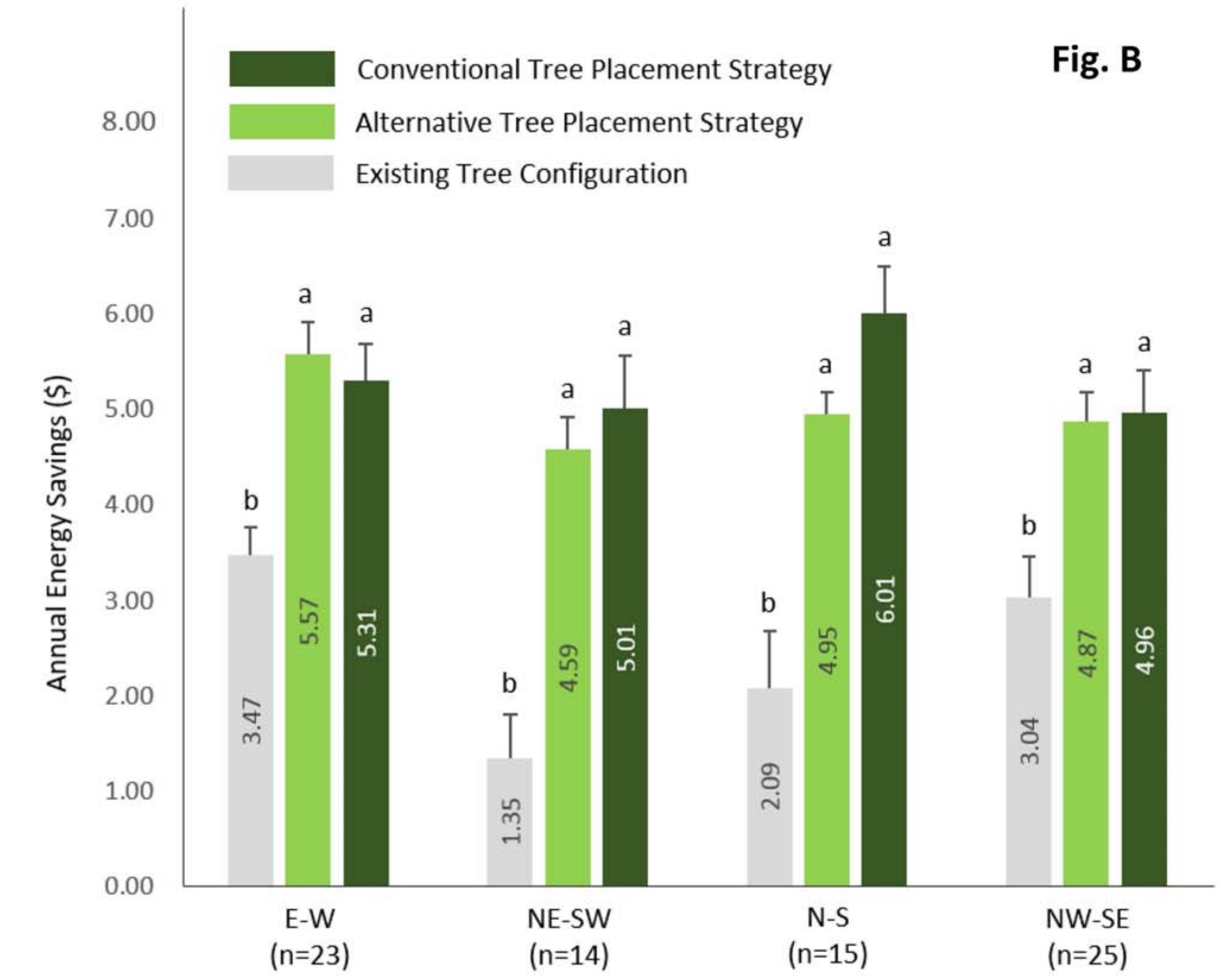


Alternative Tree Placement Strategy
Circles and Squares on the parcels above show the Alternative Tree Placement Strategy applied in Metro Orlando, FL for optimal tree placement of large deciduous trees around a residential structure. Numbers in the circles and squares indicate tree distance in meters from the structure.

How much energy can we save using optimized tree placement?



Annual energy savings per parcel (n) from large deciduous landscape trees in three U.S. cities (mean values labeled). Within a study area, values labeled with different letters are significantly different using Tukey's HSD test.



Annual energy savings per parcel (n) from large deciduous landscape trees in Charlotte, NC by parcel orientation (mean values labeled). Within a study area, values labeled with different letters are significantly different using Tukey's HSD test.

What did we learn?

- Existing trees within parcel boundaries of modern residential developments are often sub-optimally placed for energy conservation benefits (Fig. A).
- Reconfiguring existing trees significantly improved energy savings in simulations (Fig. A).
- Our alternative tree placement strategy was equally effective (Fig. B) to the conventional strategy and more responsive to space constraints on small residential parcels.
- To maximize energy conservation, large-maturing tree should placed based on parcel and house orientations, primarily on the southwest aspect and within 5-10 meters.

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