# Shade Mapping Tree Species

## Tree Planting Recommendations for Optimizing Tree Shade

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## Land Acknowledgement

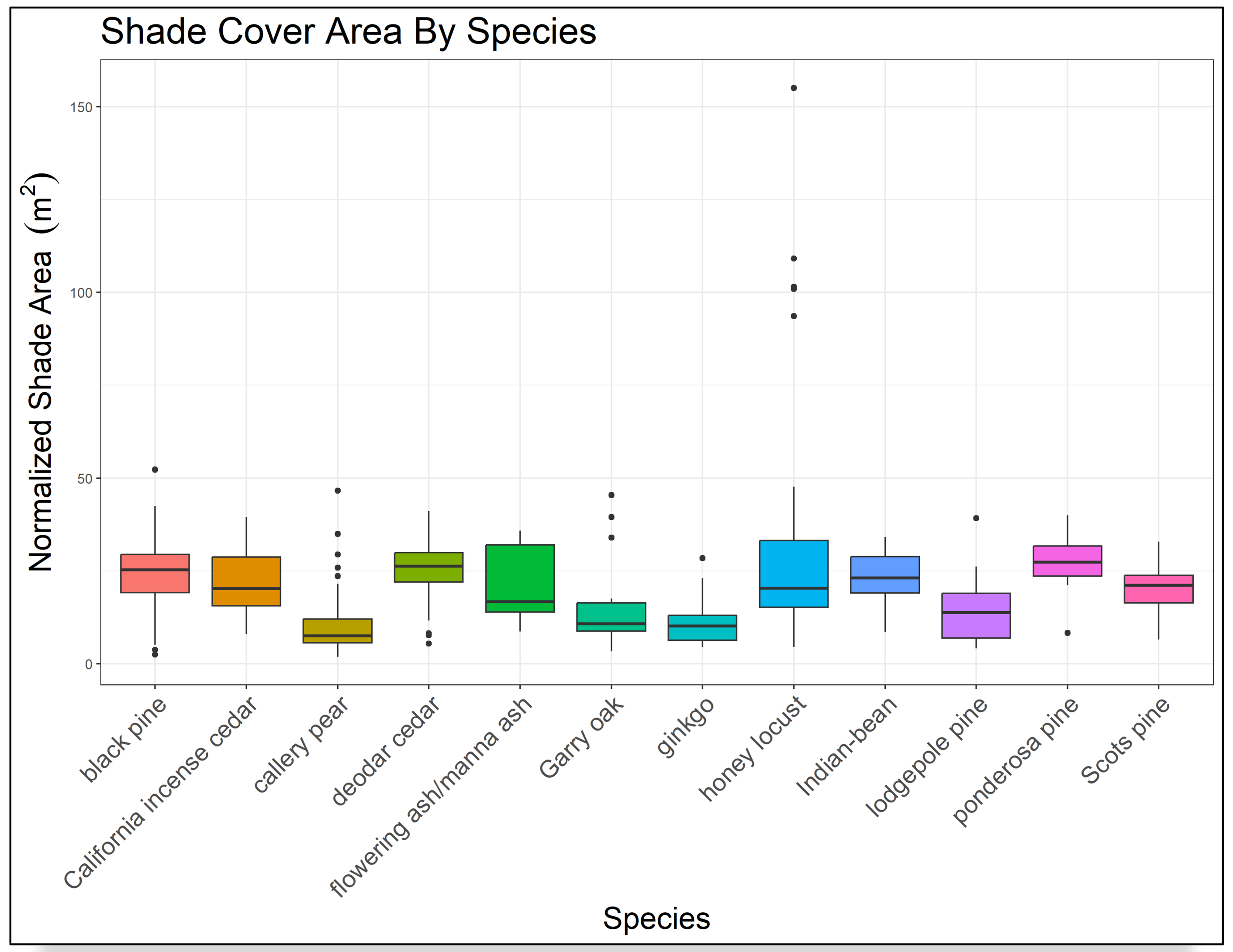
This study takes place on UBC's Point Grey campus on the ancestral unceded territory of the xʷməθkʷəy̓əm (Musqueam) People. We acknowledge the traditions and culture of the Musqueam and all other Indigenous Peoples who have long been the stewards of this land. We are grateful for the opportunity to conduct research in the Forest Sciences Centre in Vancouver.

## Introduction

Street trees can lower surrounding air temperatures by up to 7°C (Armson et al., 2013), simply due to consistent shade and evapotranspiration. These lowered temperatures have a direct effect on the quality of life in urban neighborhoods, and can lower the energy consumption of nearby shaded buildings by reducing their use of air conditioning (Pandit & Laband, 2010). Tree shade is an excellent way to address increasing temperatures and frequent heat waves under future climates. This project will provide recommendations for optimal tree planting on UBC's Vancouver campus that maximize shade area and efficiency.

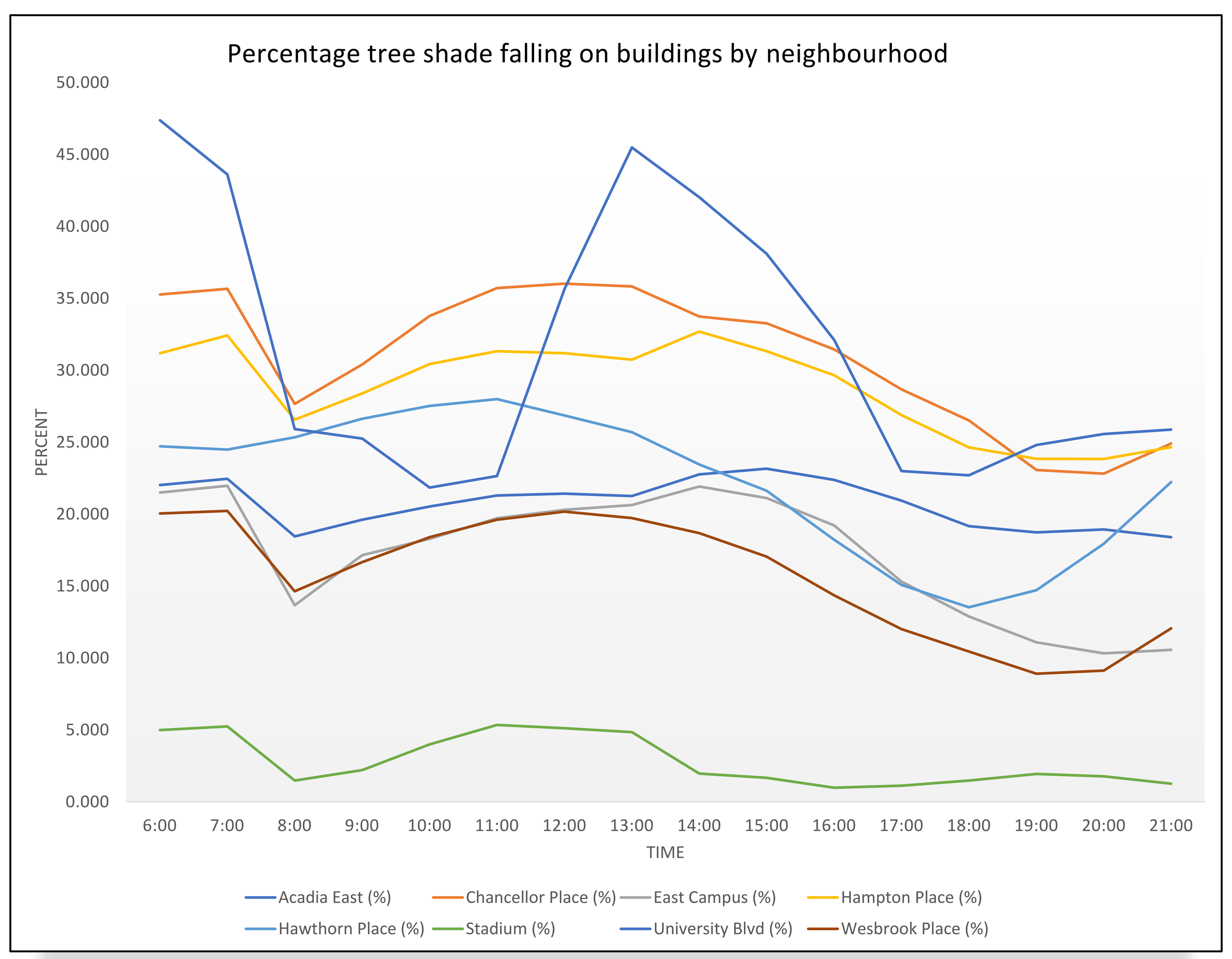
## Methods

- R packages Rayshader (Morgan-Wall, 2025) and suncalc (Thieurmel, 2025) were used to model shade from trees over the course of a single day.
- One simulation was run in 30-minute intervals on 463 individual trees.
- Another simulation was run in one-hour intervals on the trees of each neighbourhood on campus.
- Each simulation began with a LiDAR point cloud of the features of interest.
- These were used to create Canopy Height Models (CHMs) to serve as elevation matrices.
- Elevation matrices were modelled for shade using the solar altitude and azimuth at a given time to provide light direction.
- Mean daily shade area was calculated for each of the 463 trees studied.
- Hourly and mean daily shade were calculated for each neighbourhood.
- The percentage of total tree shade area that fell on buildings was calculated for each neighbourhood, then compared with tree position maps to determine optimal planting configurations for shading buildings.

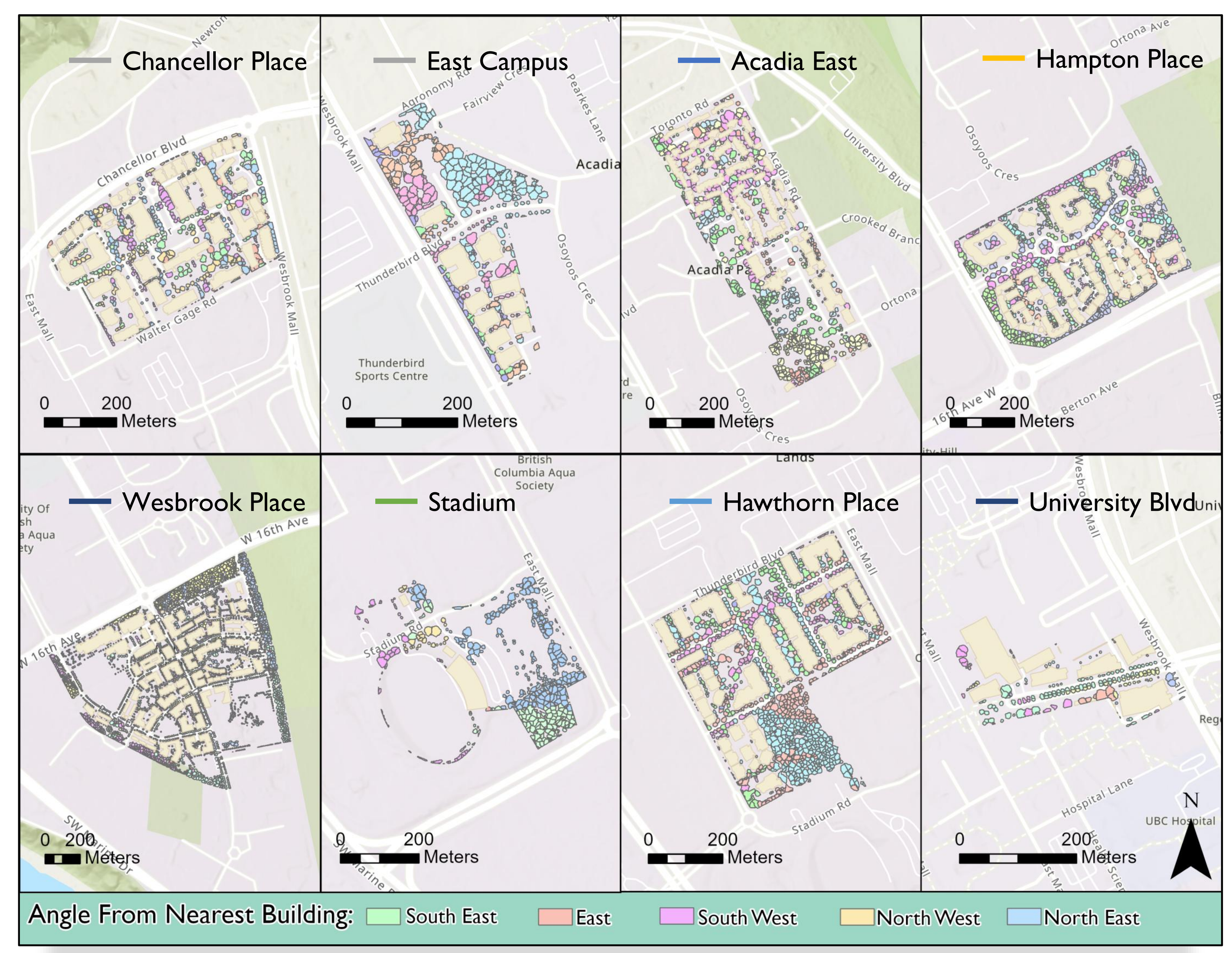



*Shade area offered by the 12 most common species of climate change resilient trees on UBC Vancouver Campus. Ponderosa pine, deodar cedar, and black pine offer the highest median shade cover. It can be seen that the individual trees that offer the most shade cover on campus are all honey locusts.*


*Hotspots of shade cast by climate change resilient tree species, along with 3D comparisons of high and low shade areas. The trees and shadows found in the example hotspot are much larger than those in the example low-shade area.*




*The percentage of total tree shade that falls on buildings for each neighbourhood on UBC Vancouver campus throughout one day. University Blvd has the highest maximums, while Chancellor Place maintained consistently high percentages.*




*In order to compare tree planting configuration between neighbourhoods, each tree was assigned a colour representing its angle relative to the nearest building. Trees in University Blvd are planted in a thin strip to the south of and in close proximity to most buildings.*

## Conclusions

- Ponderosa pine, deodar cedar, and black pine are recommended for planting around neighbourhoods on UBC campus to improve shade coverage.
- The comparison map shows that high shade area hotspots contain taller, wider trees, supporting the results of the species level shade analysis.
- Honey locusts, while having a lower median, had the highest mean shade cover extent. A larger sample size of honey locust could provide further insight.
- Even when accounting for the lower number of trees, University Blvd had highest mean and maximum shade cover efficiency due to the proximity of trees to buildings' south-east faces.
- The optimal planting configuration for shading buildings is trees planted in thin belts along the south and south-east faces of buildings in order to maximize individual contributions of shade from each tree.
- Studies agree that the most efficient method of shading buildings is to plant trees to the south (Ghods, 2023). This is due to the sun's relative southern position in the northern hemisphere.

## Literature


Armson, D., Asrafur Rahman, M., & Roland Ennos, A. (2013). A Comparison of the Shading Effectiveness of Five Different Street Tree Species in Manchester, UK. *Arboriculture & Urban Forestry*, *39*(4). https://doi.org/10.48044/jauf.2013.021

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Morgan-Wall T (2025). *rayshader: Create Maps and Visualize Data in 2D and 3D*. R package version 0.38.11, https://github.com/tylermorganwall/rayshader, https://www.rayshader.com.

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Ghods, M., Aghamohammadi Zanjirabad, H., Vafaeinejad, A., Behzadi, S., & Gharagozlo, A. (2023). Optimizing the shade coverage of trees on a block of residential buildings using GIS and ACO (case study: Semnan, Iran). *International Journal of Environmental Science and Technology*, *20*(1), 489–502. https://doi.org/10.1007/s13762-022-04537-6


Trees could solve the problems if people trying to improve things would only allow them to takeover – *Peter Wohlleben*