

## Introduction

The main objective of the Green Prescription (GreenRx) project was to add to the current knowledge base by exploring relationships between neighborhood tree canopy and a variety of health-related behaviors and health outcomes in three age groups (adults, teens, and children) of an urbanized population in the Sacramento, California, region. The current study fills a gap in the existing research by focusing specifically on exposure to tree canopy as opposed to a more general measure of vegetation. The researchers hypothesized that greater neighborhood tree canopy would be associated with more physical activity, lower body weight, higher neighborhood social cohesion, better general health status, and lower prevalence of obesity-related chronic diseases, asthma, and mental/emotional disorders.

## Data

Two main data sources were collected for urbanized areas of the Sacramento region:

1. Land cover data with 1m resolution, developed from a combination of LiDAR and aerial orthophotography data.
2. California Health Interview Survey (CHIS) data for adults (ages 18 and older), teens (ages 12-17), and children (ages 11 and older).

The tree canopy data generated for this study constitute the most detailed and accurate dataset produced for Sacramento and with a user's accuracy of 92% for the "tree" classification, far surpasses the accepted threshold for forestry research of 80%.

## Methods

Land cover data were used to calculate the amount of tree canopy as a percentage of the total area within 50, 100, 250, and 500m airline buffers of each participant's geocoded home address. Bivariate correlations between tree canopy variables and potential CHIS outcome variables were calculated to identify appropriate buffer sizes for the tree canopy variables and to identify a set of outcome variables to be used for regression modeling. Regression models were then developed for each CHIS outcome, and models were adjusted for potential confounding variables.

## Results

For adults, greater tree canopy was statistically significantly associated ( $p < 0.05$ ) with lower prevalence of overweight/obesity, more leisure vigorous physical activity, better self-reported general health, lower prevalence of asthma, and better neighborhood social cohesion. Greater tree canopy was weakly associated with lower prevalence of high blood pressure ( $p = 0.10$ ) and lower prevalence of type 2 diabetes ( $p = 0.12$ ). Tree canopy was not associated with other types of physical activity or with distress over the past 30 days.

For teens, greater tree canopy was statistically significantly associated ( $p < 0.05$ ) with lower prevalence of overweight/obesity, better self-reported general health, and a lower score on the depression scale. Tree canopy was not associated with physical activity or prevalence of asthma.



For children, greater tree canopy was statistically significantly associated ( $p < 0.05$ ) with lower prevalence of overweight/obesity and better parent-reported general health. Greater tree canopy was weakly associated with lower prevalence of ADHA ( $p = 0.16$ ). Tree canopy was not associated with physical activity or prevalence of asthma.

Predictive modeling was used to estimate health outcomes for two different hypothetical scenarios – one where the average participant has 18 percent tree canopy in their neighborhood buffer, and a second where the average participant has 28 percent tree canopy in their neighborhood buffer. The most sensitive adult outcomes were type 2 diabetes and obesity, which both are predicted to be nearly 20 percent lower in the greater tree canopy scenario. These were followed by vigorous physical activity, which is predicted to be over 10 percent higher, while overweight/obese and asthma are predicted to be roughly 10 percent lower.

The most sensitive teen outcomes were the body weight outcomes, with body mass index percentile predicted to be nearly 13 percent lower, overweight/obesity to be over 23 percent lower, and obesity to be almost 15 percent lower in the greater tree canopy scenario. For children, the most sensitive outcomes were ADHD, which is predicted to be nearly 28 percent lower in the greater tree canopy scenario, and obesity, which is predicted to be nearly 25 percent lower. These were followed by overweight/obese, which is predicted to be over 16 percent lower, while asthma is predicted to be over 11 percent lower.

## Discussion

The findings of this research provide an exploratory overview of associations between neighborhood tree canopy and a variety of physical activity behaviors and health outcomes in an urban population in the Sacramento region. The research took advantage of very high resolution LiDAR and imagery data to derive tree canopy variables and the large sample size and extensive coverage of the CHIS data.

For all age groups, the body weight models consistently provided the strongest associations with tree canopy in the direction expected from previous studies. General health was also consistently better for all age groups, in line with prior expectations. While most of the study results were consistent with prior findings and initial expectations, there were a few notable exceptions. Mental/emotional health models produced mixed findings by age group, though the literature suggests a strong connection between access to green space and better psychosocial health for all age groups.

It was expected that increased physical activity was the mechanism linking increased tree canopy to lower body weight, but this largely was not the case (with the exception being that for adults, vigorous physical activity explained a small amount of the tree canopy – overweight/obesity relationship). However, the weak associations between higher tree canopy and lower adult prevalence of high blood pressure and type 2 diabetes were consistent with the tree canopy – overweight/obesity findings.

Tree canopy associations with asthma varied by age group, with the only significant finding being a negative association for adults. The literature on tree relationships with asthma is mixed and suggests a very complex relationship. Our model is likely to be over-simplistic, as the available data did not allow

us to account for the amount of outdoor or indoor pollutant exposures, the types of trees found near the home, or micro environmental conditions affecting ventilation and exposure.

### **Limitations**

All data used for the analysis were cross-sectional – that is, they represent only a single observation of tree canopy data and health behaviors/outcomes. The exploratory nature of this research led to the use of a large number of statistical tests (i.e. multiple comparisons), increasing the likelihood that any significant finding was due to chance alone. All CHIS data are self-reported, and thus are subject to several types of bias.

### **Implications**

Despite the exploratory nature of the present study, the findings suggest numerous connections between urban tree canopy, health-related behaviors, and health outcomes. These findings, in combination with other published research, provide health-related justification for the need to maintain and increase the size and quality of urban forests, street trees, and other urban vegetation.