Influence of Urban Tree Canopy on Single-Family Residential Structure Energy Consumption at the Community Scale in Hutchinson, Minnesota

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Executive Summary

BACKGROUND

Hutchinson, Minnesota, a central Minnesota community of approximately 14,000 residents is in the transition area between Minnesota's ecological subsections of the Big Woods and the Minnesota River Prairie, an area characterized by prairie winds, cold winters and hot summers. In 2011, a stratified and randomized tree survey was conducted to determine the community's vulnerability to canopy loss due to the likelihood of an emerald ash borer infestation. This subsequent study focused on the potential impact that urban tree canopy (UTC) loss could have on the community-level consumption of energy for residential heating and cooling.

METHODS

Calculating tree canopy

A sample of single family detached residential structures was established based on the stratified random tree survey conducted in 2011 (Figure 1). Urban tree canopy was measured across Hutchinson by first digitizing the tree canopy from aerial photo imagery. Then, percent of UTC was calculated by various shapes and at multiple distances from each of the sampled homes. Percent UTC was calculated at the property parcel and at 100 foot increments out to 1500 feet (Figure 2).

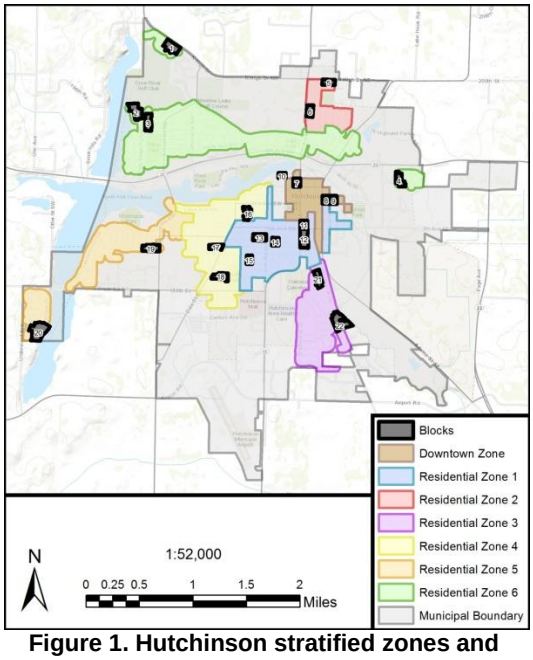

Figure 1. Hutchinson stratified zones and randomly sampled blocks with the study area.

Normalize energy consumption

Monthly natural gas and electricity consumption data was acquired for each of the sampled homes over a three year period. Billing data along with daily temperature and long-term degree days were processed to calculate a weather-adjusted index or Normalized Annual Consumption (NAC) of heating and cooling consumption.

Control for house characteristics

Housing characteristics were gathered from the McLeod County (Minnesota) Assessor and used as control variables in the ANOVA analysis. Amount of conditioned space, heating system type, house age, and height of home were all

found significant to heating energy use.

RESULTS: TREES SAVED ENERGY

Digitized urban tree canopy data at multiple scales was correlated with weather adjusted normalized energy consumption data while controlling for a variety of housing characteristics. Tree canopy throughout neighborhoods and adjacent to homes contribute to energy reduction. In the Upper Midwest windy climate of Hutchinson, Minnesota the greatest savings were realized in winter. In this heating dominated climate, neighborhood trees reduce the speed of winter winds that reach homes. Lower wind speed against a house reduces the amount of heat loss through air exchange.

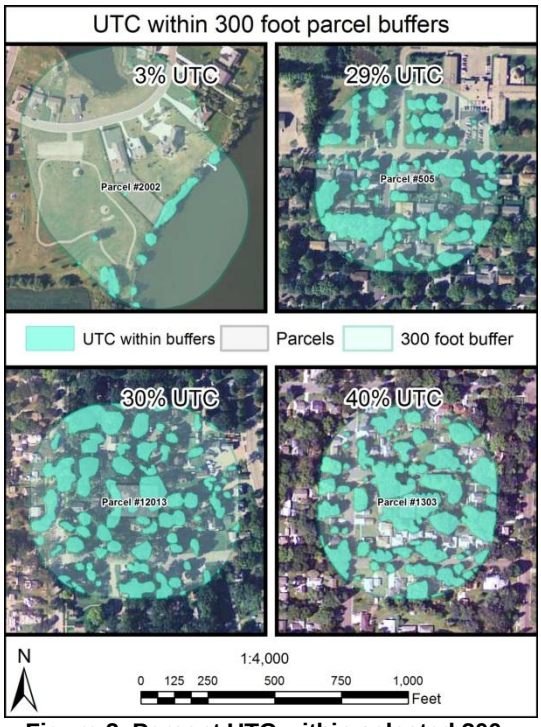

Figure 2. Percent UTC within selected 300 foot parcel buffers.

Additionally, trees reduced summer energy consumption by providing shade. Tree shade reduces the amount of heat entering a home directly through windows by solar radiation and by reducing the amount of heat stored in pavement. Neighborhood trees provide microclimate cooling through evapotranspiration.

More tree canopy = Lower heating bills

Homes influenced by more tree canopy (at least 10%) used less energy for heating. This relationship was significant ($p<0.05$) when tree canopy was measured at 400 feet from the property parcel and at every 100 foot increment out to 1500 feet ($p<0.05$). Houses without improvements to siding or windows after 1998 showed a significant benefit from tree canopy starting as close as 100 feet from the parcel ($p<0.05$). The strongest correlations between tree canopy and heating energy use were found at 100 foot increments from 500 to 1100 feet from the parcel ($p<0.01$). Although the highest correlations were found at great distances from the parcel, based on the various shapes and buffer types analyzed, tree canopy near the parcel also has a sizable role in reducing heating energy use. Based on the changing steepness of the slope at various distances, an increase in tree canopy farther from the home shows the most benefit.

More tree canopy = Lower cooling bills

Homes with more tree canopy used less energy for cooling. The relationship between tree canopy and cooling energy use was significant at

and near the parcel ($p<0.05$). The relationship also showed slight significance at 900 to 1500 feet from the parcel ($p<0.10$).

Impact of house characteristics

Larger homes used more energy for heating than smaller homes. Homes with forced air used less energy for heating than homes with hot water heat. Newer homes used less energy than older homes. Taller homes used more energy for heating than shorter homes. The cooling energy use control variables did not show a strong significant relationship.

Predicting the impact of UTC change on energy use

The impact of a percent change in UTC was interpolated from within significant slope relationships to predict the percent change in energy consumption for communities similar to Hutchinson, Minnesota. For wind shielding benefits at the community scale, a 1% change in UTC was predicted to have a 1.1% change in heating energy use. For microclimate modification at the community scale, a 1% change in UTC was predicted to have a 2.2% change in cooling energy use. For shading related benefits at the community scale, a 1% change in UTC was predicted to have a 0.7% change in cooling energy use. Although the percent change is higher for cooling energy use, since the heating season is so long, the greatest benefit from urban tree canopy in communities similar to Hutchinson is for winter season energy reduction.

COMMUNITY SCALE OPPORTUNITY & OBLIGATION

Community trees reduce home energy consumption in both winter and summer. The scale of potential benefits is beyond the property boundaries of individual home owners. Saving energy with urban trees is a community scale opportunity and obligation.

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