FINAL REPORT
FOREST SERVICE GRANT NO. 94-G-131

Issued to: ACRT, Inc.

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Project Name: The Effect of Vegetation on Residential Energy Use in Ann Arbor, Michigan

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Project abstract (as defined by initial proposal and contract):

The Effect of Vegetation on Residential Energy Use in Ann Arbor Michigan

Grant Number 94-G-131, Final Report

Abstract: Computer models have shown that proper placement of trees around climate-controlled buildings can significantly contribute to energy conservation by lowering cooling requirements in summer months and heating requirements in the winter. A study conducted in a residential neighborhood of Ann Arbor, Michigan uses electric and natural gas utility company records to examine energy demand for homes in three areas with distinctly different levels of tree stocking. Field measurements quantify the density of vegetation which casts shade directly on homes, and aerial photo interpretation is used to evaluate potential wind shielding offered to individual homes by vegetation and adjacent buildings. Statistical analysis of data indicates that variability of structures, including different levels of insulation, infiltration, and efficiencies of space-conditioning appliances mask the effects of vegetation on energy use. Analysis is further complicated by a wide range of energy use habits of individual homeowners. However, trends are observed which suggest that proper placement of trees with regard to seasonal solar gain and wind patterns may yield substantial savings of energy. Improper placement of trees may yield a significant increase in net levels of energy used for space conditioning.

Project objectives:

Energy conservation continues to be a major concern for most utility companies and consumers. The oil embargo of the 1970's highlighted the limited supply of natural resources that serve as sources of energy. Continued concern for the environment, including global climate change, has renewed interest in energy conservation and efficiency.

Combustion of fossil fuels emits carbon into the atmosphere. There is considerable debate surrounding the degree to which increased carbon in the atmosphere contributes to global climate change, but the fact that atmospheric carbon dioxide is rapidly increasing cannot be disputed. International demand that the United States recognize its role in creating this problem has led to the Clinton administration's Climate Change Action Plan. This plan calls for rolling back greenhouse gas emissions to 1990 levels by the year 2000.

Tree conservation, planting and maintenance can play a multi-faceted role in energy conservation and control of atmospheric carbon dioxide. All trees store or "sequester" carbon, and vigorously growing natural forests act as carbon sinks. Depletion of tropical rain forests has resulted in a loss of carbon storage capacity and a release of large amounts of stored carbon. In addition to providing carbon storage, properly placed trees in developed areas can provide cooling shade which results in less electricity required to operate air conditioners. Therefore less fossil fuel is burned at power plants and less carbon enters the atmosphere. Reducing peak energy demand benefits utility companies and lowers utility bills to homeowners. Trees also indirectly contribute to energy conservation through shading of hard scape and dark surfaces, such as parking lots, which absorb sunlight and re-radiate the energy as heat. In addition to providing shade, trees move water vapor into the air through transpiration, which also reduces air temperature making trees particularly effective at diminishing urban heat islands.

In winter months, properly placed trees can reduce residential energy use by slowing and diverting cold winds. Most studies on the use of vegetation as wind breaks have focussed on rows of trees arranged to intercept prevailing winds, but trees need not be arranged in a shelterbelt formation to provide protection from winter winds. Indeed, shelterbelts are usually not possible in an urban or suburban setting due to space constraints. Tree canopies over homes provide protection by collectively slowing wind speeds and reducing infiltration of cold air into houses through gaps in caulking, weatherstripping, or insulation. The height and density of tree canopies determine the amount of slowing and turbulence created in directional winds.

Improperly placed trees can be detrimental to energy conservation, particularly in northern climates where trees to the south of buildings block beneficial solar gain during winter months. The placement of trees must consider the net impact on both heating and cooling requirements of buildings to achieve optimum levels of energy conservation.

The suggestion that trees can contribute to energy conservation is supported by previous research. A limited number of studies have been based upon on-site data collection while a greater number have been conducted primarily with computer generated models. The potential for energy savings is dependent on regional climate. Studies conducted in the southwestern United States have focused primarily on reducing energy use for cooling. Northern climates prove to be more complex in terms of energy conservation. Shade-produced energy savings during the cooling season can be more than offset by higher energy requirements for heating during winter months. In addition to shade, wind becomes an important factor in northern climate space-conditioning requirements. This study conducted in Ann Arbor, Michigan was designed to take an important step in developing a methodology to investigate the effect of urban trees on energy use.

Objectives met successfully:

The study was completed within the original time frame and within budget. While the results were not conclusive, the study produced a valuable methodology for evaluating vegetation density around buildings relative to energy conservation. The statistical analysis of collected data helped to define new areas of study that are current underway.

Objectives not met:

All of the objectives were met.

How did the project increase the knowledge we have about urban forestry? How did the public benefit?

Much of the research that has been conducted on the effect of trees on energy use has been based on computer models. More emphasis has been placed on the impact of trees on residential cooling demands through direct shade than on the impact of trees on residential heating demands. This study takes a first step toward improving the quality of data used in computer models, and considers the net annual space conditioning requirements of the test homes. By looking at both heating and cooling seasons we seek to optimize the placement and density of vegetation around homes to decrease energy requirements for space conditioning.

The public will benefit directly by lowering their energy costs if trees are properly planted and maintained. The utility companies will benefit by using tree planting for energy conservation as a demand side management tool. Utility companies may also use urban tree planting programs in offsetting their carbon emissions. Trees that provide energy conservation benefits serve the dual role of preventing new carbon from entering the atmosphere and also sequester atmospheric carbon dioxide.

What specific quantifiable results were produced?

Data were collected on building characteristics, energy use, vegetation, and, to a lesser extent, occupant behavior in a residential neighborhood in Arm Arbor, Michigan with three distinct levels of vegetation density. Stratum L had low vegetation density, stratum M was moderate, and stratum H high. Statistical and graphical analyses were performed to examine the effect of vegetation on energy used for heating and cooling in single-family residential buildings.

Strata M and H were similar in building characteristics, while stratum L was different from both other strata. Strata M and H were similar in gas energy use per square foot over all time periods considered. Stratum L had the lowest gas energy use, except for several billing periods in the summer. There was no statistically significant difference in electricity energy use per square foot among strata, except for two minor cases. Differences in patterns of energy use between strata were apparent, although they lacked statistical significance.

Building characteristics are a strong factor in determining energy use, and are likely responsible for the lower average energy use in stratum L. Differences in energy use between strata M and H, which are more similar in building characteristics, may be the result of differences in vegetation. Higher energy use in stratum H in winter was consistent with the higher amount of shade there, and higher electricity use in stratum M in summer was consistent with the lower amount of shade there.

It should be remembered that the variation in energy use was high and there were many factors that affect energy use. This study primarily considered factors in two categories, building characteristics and vegetation, while grouping all other factors, including occupant behavior, as random variation or "noise".

This study is the first step toward a methodology to be used in the field to quantify the effect that vegetation has on residential space conditioning energy use. The techniques were designed to not be intrusive and to require a minimum of time from the homeowners. They did not, unfortunately, provide enough information to reliably correct for some of the most influential factors. The results described here indicate that vegetation is a factor in determining energy use, but stop short of quantifying the strength of the relationship. Please see the attached publication for a full discussion of the project.

How were the result disseminated to the public?

The Ann Arbor News published an article entitled "Tree Houses" that described the project and discussed the potential energy-saving benefits of trees.

A paper entitled "The Effect of Vegetation on Residential Energy Use in Ann Arbor, Michigan" is scheduled to be published in the September, 1996 issue of the Journal of Arboriculture.

If a no-cost time extension was granted for this project, why was it needed?

Not applicable

List the active partners (key individuals or organizations) involved in the project:

R.J. Laverne, Vice President of Urban Forestry, ACRT, Inc.
Geoffrey Lewis, Owner, Arbor Resources Group
Detroit Edison
Michigan Consolidated Gas Company
University of Michigan

How would you evaluate the grant process? What changes, if any, would you recommend?

At the beginning of this project, the administration of the grant was a bit disorganized. That changed dramatically with the arrival of Suzanne del Villar. Ms. del Villar has been very helpful in guiding us through the reporting process. Mr. Robert Neville has also been a very good source of information and assistance. We have benefitted greatly from U.S. forest Service personnel throughout this project. Some of the finest researchers in urban forestry are employed with the Forest Service, and they are always eager to share ideas and information. Drs. David Nowak, Gordon Heisler, and Greg McPherson helped evaluate the methodology and analysis of data for this project, and Dr. Nowak provided a thorough review of our paper prior to publication. ***The urban forestry personnel within the U.S. Forest Service that I have had the pleasure to work with set the standard for efficiency and expertise that the rest of our federal government would do well to emulate.***

Comments:

This report was prepared by:

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