Energy and Air Quality Improvements Through Urban Tree Planting

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Abstract: A brief overview of our carbon guidelines and parking lot/air quality work.

Numerous benefits are associated with urban trees. Two important and interrelated benefits are reduced space conditioning (cooling and heating) energy use, and improved air quality. Urban trees have a moderating effect on extremes of climate by reducing solar irradiance, air temperature and wind speed. Reduced energy use results in fewer emissions of carbon dioxide (CO_2), hydrocarbons and other pollutants. Besides these "avoided" emissions, trees provide the additional benefit of removing CO_2 from the atmosphere and storing it as biomass (wood is about 50% carbon).

Credits for ozone related pollutants are currently actively traded in many regions, and trading in greenhouse gas (GHG) emission allowances and/or emission reduction/ sequestration credits are sure to follow. These benefits from urban trees could be used to fund urban forestry programs that produce them. In the case of air quality, this would allow emitters with expensive reduction options (e.g. industry) to offset their emissions by financing lower cost reductions possible from urban tree programs. The purpose of this paper is to present preliminary results of ongoing research to evaluate the net cost of reducing emissions with urban forestry.

1. Can parking lot trees improve air quality?

Ozone is a serious air pollution problem in most large U.S. cities. In the Sacramento County metropolitan area, motor vehicles are a major source of ozone precursors, contributing approximately 59 tons per day (tpd)(68% of total) nitrogen oxides (NOx) and 59 tpd (49% of total) anthropogenic hydrocarbon (HC) emissions.

While the bulk of HC emissions are from tailpipe exhaust, approximately 9.7 tpd (16%) are from evaporative emissions that occur during daytime heating of fuel delivery systems of **parked vehicles**. Evaporative emissions, as well as exhaust emissions during the first few minutes of engine operation (primarily NOx), are sensitive to local microclimate.

Many municipalities in the West also have parking lot shade tree ordinances, which require that parking lots be designed to achieve 50% tree canopy cover within 15 years of construction. While originally viewed by ordinances as an aesthetic amenity, parking lot trees may provide important environmental benefits. *In the pilot study described here, we posit a relationship between tree cover, parking lot microclimate and vehicle emissions (Mcpherson et al. 1999, Scott et al. 1999).*

Experiment Overview

Microclimate measurements were taken to quantify the moderating influence of tree canopy on parking lot microclimate via shading and evaporative cooling from leaves. These estimates were used to calculate potential temperature-dependent **emissions reductions from parked vehicles** using the California Air Resources Board MVEI7G model.

Measurements

Two automated weather stations and instrumented passenger cars were located in unshaded and shaded portions of a parking lot in Davis, CA for a week in August 1997. Air temperature, solar and net radiation, wind speed and direction, and vehicle cabin and fuel tank temperatures were measured. Shaded surface area was approximately 30%, and canopy density was sparse and variable due to leaf drop.

Peak daytime air temperatures at the shaded parking lot averaged 1 to 2°C cooler than the unshaded site. Temperature differences here are considered conservative due to the relatively sparse tree cover. *Fuel tank temperatures of the shaded car were 2 to 4°C cooler than fuel tank temperatures of the unshaded car.* Larger temperature differences between fuel tanks of shaded and unshaded cars, compared to air temperature differences between shaded and unshaded lots, indicate that direct shading of the vehicle influenced fuel tank temperature (hence HC evaporation rates) as much as, or more than, the aggregate effect of trees on air temperature. *Average vehicle cabin temperature was 26°C cooler in the shaded vehicle for the period 1300 to 1600 PST.*

Emissions Modeling

Observed air temperature regimes at the Davis parking lot were used to design "base case" and "treatment" cases for hypothetical changes in parking lot tree canopy. These temperature regimes were used as input to the MVEI7G model to simulate vehicle emissions in Sacramento County. ROG emissions (reactive organic gases) were reduced by 2% (0.85 tpd) for an increase in canopy cover from 8% to 50%. NO_x emissions from cooler engine starts were reduced by 0.1 tpd (0.2%).

Though modest, projected ROG reductions were equivalent to projected hydrocarbon emission reductions for existing Sacramento Metropolitan Air Quality Management District control measures for graphic arts, ethylene oxide sterilizers, alternative fuel stations and waste burning (totaling 0.89 tpd). Projected NOx emission reductions (0.1 tpd) were equivalent to reductions projected from the district's light-duty vehicle scrappage program (0.1 tpd).

What's Next?

Parking lots occupy about 10 percent of the land in our cities, and besides their air quality impacts, can be significant sources of heat, water pollutants, and visual blight. Mitigating these pollutant "hot-spots" with tree shade is a Cool Communities strategy. While many jurisdictions have implemented ordinances over the last 15 years that require shading of paved areas by trees, little has been done to assess their effectiveness. Consequently, we have begun research in Sacramento to investigate:

a) if requirements for parking lot shade are being met,

b) how existing parking lot tree shade ordinances can be amended to increase their effectiveness,

c) what the potential is to plant and manage trees and provide stormwater treatment for parking lot runoff as retrofit measures for existing lots, and

d) what is the potential to reduce overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas?

2. Carbon Dioxide Reduction Through Urban Forestry–Guidelines for Professional and Volunteer Tree Planters

This Forest Service General Technical Report (McPherson and Simpson 1999) is a tool for utilities, urban foresters, arborists, municipalities, consultants, non-profit organizations and others to determine the effects of urban forests on atmospheric carbon dioxide (CO_2) reductions. It provides a quantitative tool that allows decision-makers to incorporate urban forestry into their efforts to protect our global climate. This information can be used to:

- report current or future CO_2 reductions through a standardized accounting process
- evaluate the cost-effectiveness of urban forestry programs with other CO_2 reduction measures
- compare benefits and costs of alternative urban forestry program designs
- produce educational materials that quantify potential CO_2 reduction benefits and provide guidelines on tree selection, placement, planting, and stewardship.

The four chapters and appendices provide basic information to calculate CO_2 reductions through urban forestry programs.

Chapter 1: Urban Forests and Climate Change

Chapter 1 presents readers with background information on global climate change and the role of urban forests as one strategy for reducing atmospheric CO_2 concentrations. The implication of global climate change on communities is described, and our current knowledge regarding urban forestry as a CO_2 reduction measure is reviewed.

Chapter 2: Program Design and Implementation

Chapter 2 provides information on the design and implementation of urban forestry programs specifically aimed at reducing atmospheric CO_2. We share lessons learned from previous programs that have succeeded and failed, as well as general guidelines for selecting and locating trees to maximize energy and CO_2 reduction benefits. Current information on tree planting and stewardship techniques is presented as well as sources of technical assistance.

Chapter 3: General Information about These Guidelines for Calculating CO_2 Reductions from Urban Forestry Programs

Chapter 3 presents a general description of methods and assumptions for calculating CO_2 reductions from urban forestry programs. The chapter objectives are to (1) familiarize you with the data collection and calculation process, (2) help you determine what data are required and how it can be obtained, and (3) explain certain key modeling assumptions.

Chapter 4. Illustrative Examples

Chapter 4 provides case studies of how to apply these guidelines. In one example, estimates of future CO_2 reductions for a proposed utility-sponsored program are described. The second example reports future reductions from an existing planting in a residential neighborhood.

Appendices

The Appendices contain information that you will reference while applying the guidelines. They also contain more detailed information on techniques used to develop the guidelines.

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Building Cities of Green

Proceedings of the 1999 National Urban Forest Conference

Seattle, Washington
August 31 - September 3, 1999

Edited by:
Cheryl Kollin
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Special thanks to Gary Moll, Deborah Gangloff, Donna Steward, and Peter Kilpe for their invaluable assistance in production, design, and proofreading.

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Cover Design: Adequate Graphics: adequate@worldnet.att.net
Proceedings Design: RABA Technologies, Columbia, MD