Urban Tree Planting and Greenhouse Gas Reductions – Discussion Paper

Greg McPherson, Ph.D.
USDA Forest Service
Center for Urban Forest Research
Davis, CA

March 7, 2007

Several stories have appeared recently in popular news outlets suggesting that trees are not a solution in the fight against global warming. In a report from Reuters ("Trees take on greenhouse gases at Super Bowl", 30 January 2007), Dr. Ken Caldeira, a Carnegie Institute climate scientist, was reported to say, "It's probably a nice thing to do, but planting trees is not a quantitative solution to the real problem." Dr. Philip Duffy of Lawrence Livermore National Laboratory said, "If you plant a tree (CO_2 reductions are) only temporary for the life of the tree. If you don't emit in the first place, then that permanently reduces CO_2." Dr. Caldeira had made similar arguments previously in an op-ed in the *New York Times* ("When Being Green Raises the Heat, 16 January 2007).

A *New Scientist* article ("Location is key for trees to fight global warming," 15 December 2006) reports results from a study by ecologist Dr. Govindasamy Bala of Lawrence Livermore National Laboratory. The model developed by Bala and colleagues indicates that, while trees planted in tropical regions have a clear net cooling effect, trees planted in mid-latitudes may absorb so much heat from the sun that they actually contribute to warming.

These stories fail to capture the complexity of the role that city trees play in fighting global climate change. Trees reduce carbon dioxide in the air, thereby reducing the warming "greenhouse" effect of the gas, in two main ways. First, as they grow, they take carbon dioxide out of the air and transform it into roots, leaves, bark, flowers, and wood. Over the lifetime of a tree, several tons of carbon dioxide are taken up (McPherson and Simpson 1999). In fact, trees are the only known feasible way to remove carbon dioxide from the atmosphere. Even if we were able to switch immediately to fuel sources that do not emit carbon dioxide, the current levels in the air are higher than at any time in the past 400,000 years, according to the UN's International Panel on Climate Change, and because of the long "lifetime" of carbon dioxide, will remain so for decades or even centuries.

Second, by providing shade and transpiring water, trees lower air temperature and, therefore, cut energy use, which reduces the production of carbon dioxide at the power plant. Two-thirds of the electricity produced in the United States is created by burning a fuel (coal, oil, or natural gas) that produces carbon dioxide—on average, for every kilowatt hour of electricity created, about 1.39 lbs of carbon dioxide is released (eGRID 2002). It is certainly true, as Dr. Duffy states, that not emitting carbon dioxide in the first place is a good strategy. Lowering summertime temperatures by planting trees in cities is one way to reduce energy use and thereby reduce carbon dioxide emissions.

To address the other claims made above: *Are carbon dioxide and other greenhouse gas reductions from tree planting temporary?* In a sense, yes, greenhouse gas reductions are temporary if trees are removed and not replaced. To achieve long-term reductions, a population of trees must remain stable as a whole. This requires a diverse mix of species and ages so that the overall tree canopy cover remains intact, even as individual trees die and are replaced. Although sequestration rates will level off once an urban tree planting project reaches maturity, the reduced emissions due to energy savings will continue to accrue annually. Dead trees can be converted to wood products or used as bioenergy, further delaying, reducing, or avoiding greenhouse gas emissions.

Dr. Caldeira suggests in the Super Bowl article that tree planting projects are "risky." They may appear more risky than reducing emissions by building solar or wind farms because the tree-related climate benefits are less easy to document and because the 50- to 200-year life span of a tree seems less permanent than a new power plant. This uncertainty can be offset by legally binding instruments such as contracts, ordinances, and easements that guarantee tree canopy in perpetuity. And, of course, trees and alternative energy sources are not mutually exclusive—both have a place in reducing carbon dioxide emissions.

Will urban tree planting in mid-latitude cities result in zero or even negative climate benefits? Dr. Bala's study in the New Scientist article describes two main ways trees lower temperature: they remove carbon dioxide from the air, reducing the greenhouse effect, and they release water vapor, which increases cloudiness and helps cool the earth's surface. But because tree leaves are dark, they also absorb sunlight, which increases the temperature near the earth's surface. The difference between trees in tropical latitudes and those in mid-latitudes has to do with the difference in how much sunlight forests reflect compared to other possible surfaces, especially during winter. Snow reflects more sunlight back into the atmosphere than forest vegetation, resulting in less heat trapped near the earth's surface. Large-scale tree planting projects that replace highly reflective surfaces with forests will result in more heat trapped near the ground during winter.

In cities, this fact is less relevant. Asphalt, concrete, and roof surfaces account for 50 to 70% of urban areas, with the remaining area covered by trees, grass, and bare soil. The difference in the solar reflectances, or albedos, of the different urban surfaces is small. Vegetation canopies have albedos of 0.15 to 0.30, the albedo of asphalt is 0.10, that of concrete and buildings is 0.10 to 0.35, and the overall albedo in low density residential areas is 0.20 (Taha et al. 1988). In cities, increasing urban tree canopy cover does not appreciably alter surface reflectance, or increase heat trapping.

At the same time, as described above, a number of field and modeling experiments have found that urban trees reduce summertime air temperatures through evapotranspiration and direct shading (Akbari and Taha 1992, Rosenfeld et al. 1998, McPherson and Simpson 2003). This reduces energy consumption and the emissions related to energy generation.

Do tree-planting projects give people a "feel-good illusion that they are slowing global warming?" The climate benefits of trees in mid-latitude cities are not an illusion, although they certainly feel good. Reductions in atmospheric carbon dioxide are achieved directly through sequestration and indirectly through emission reductions. Still, planting trees in cities should not be touted as a panacea to global warming. It is one of many, complementary bridging strategies, and it is one that can be implemented immediately. Moreover, tree planting projects provide myriad other social, environmental, and economic benefits that make communities better places to live. Of course, putting the right tree in the right place remains critical to optimizing these benefits and minimizing conflicts with other aspects of the urban infrastructure.

References

Akbari, H.; Taha, H. 1992. The impacts of trees and white surfaces on residential heating and cooling energy use in four Canadian cities. Energy. 17(2):141-149.

Brahic, C. 2006. Location is key for trees to fight global warming. New Scientist. Dec. 15, 2006. http://environment.newscientist.com/channel/earth/dn10811-location-is-key-for-trees-to-fight-global-warming.html.

Caldeira, K. 2007. When being green raises the heat. New York Times. 16 January 2007. http://www.nytimes.com/2007/01/16/opinion/16caldeira.html?ex=1173502800&en=f38494123b1c3df0&ei=5070

eGRID 2002. Emissions and generated resource integrated database. U.S. EPA, version 2.01.

Gardner, T. 2007. Trees take on greenhouse gases at Super Bowl. Yahoo! News. Jan. 30, 2007. http://today.reuters.com/news/articleinvesting.aspx?type=topNews&storyID=2007-01-30T213403Z_01_N30364530_RTRUKOC_0_US-CARBON-SUPERBOWL-TREES.xml

McPherson, E.G.; Simpson, J.R. 1999. Guidelines for calculating carbon dioxide reductions through urban forestry programs. Gen. Tech. Rep. PSW-171. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

McPherson, E.G.; Simpson, J.R. 2003. Potential energy savings in buildings by an urban tree planting programme in California. Urban Forestry and Urban Greening. 2(2): 73–86.

Rosenfeld, A.H.; Akbari, H.; Romm, J.J.; Pomerantz, M. 1998. Cool communities: strategies for heat island mitigation and smog reduction. Energy and Buildings. 28:51-62.

Taha, H.; Akbari, H.; Rosenfeld, A.; Huang, J. 1988. Residential cooling loads and the urban heat island—the effects of albedo. Building and Environment. 23(4):271-283.