Trees and Sustainability through Design

As designers, we're accustomed to thinking of trees in terms of their visual, sculptural, and aesthetic qualities—how they define a space, the interest they bring to a site as the seasons change, their contribution to the spirit of a place. But while the trees in our designs are accomplishing these objectives, they're also working to provide crucial ecosystem services. And many of their environmental contributions address California's most difficult challenges, including conserving energy, improving the quality of our air and water, and reducing greenhouse gas levels.

Thoughtful design can maximize the ecosystem services trees are providing, making our cities greener, healthier, and more sustainable. In many cases, with knowledge of the underlying mechanisms, small adjustments to siting or species choice can have significant impacts on the environmental contribution of trees and can be accommodated invisibly into a design.

Energy Conservation

Energy use is of critical concern in California, where our growing population means ever-growing demands on our overtaxed energy infrastructure. In addition, the production of energy creates both air pollution and greenhouse gases, both of which we would like to reduce.

How do trees reduce energy use? First, by directly shading buildings and paved surfaces, they reduce the amount of heat that is captured and stored and therefore the demand for cooling. Second, through the process of evapotranspiration they use up solar energy that would otherwise go to heating the air. Finally, by blocking cold winter winds they reduce the infiltration of outside air into buildings.

Wise design choices can affect all of these processes.[i] When possible, make siting decisions with energy conservation in mind. In hotter climates, this might mean planting trees on the west and east sides of buildings—the sides the sun warms most strongly. Shading paved surfaces—streets and parking lots—will reduce heat absorption. In colder, windy areas, trees can be used to block prevailing winter winds. At the larger scale, a dense, expansive tree canopy will help reduce the urban heat island effect and lower city temperatures. [ii]

Species choice is as important as location. In general, larger species that will grow to arch over and shade rooftops provide greater energy conservation benefits. Using large trees in parking lot designs can quadruple the shade benefits offered by small trees. The evergreen vs deciduous character of a species should also be kept in mind:

Evergreens on the southern sides of buildings, for example, can increase energy use by blocking the warming rays of the sun in winter.

Air Quality

Although in recent years we have seen significant improvements in our air quality, much work remains to be done before Californians have the pristine air to breathe that they deserve.

How do trees help clean the air? Both directly and indirectly. The leaves of trees have a direct effect when they absorb or intercept air pollutants, including small particulate matter and the components of smog. As mentioned above, trees planted in strategic locations around buildings help conserve energy, reducing emissions onsite and pollutants from power plants supplying energy. Finally, trees can be planted to shade parked cars, lowering temperatures and reducing evaporative emissions—an astonishingly significant source of the pollutants that cause smog.[iii]

How can we maximize the air quality contributions of trees through design? First, keep energy conservation in mind as described above. Trees planted to reduce energy use also reduce the levels of air pollutants produced at the power plant.[iv] Second, maximize shade over parked cars.[v] Third, make wise species choices: Pollutant absorption and interception are related to leaf surface area, so larger-leafed species do the most work.[vi]

Climate Change

California is playing a leading role in the fight against global climate change by pledging to reduce our greenhouse gas emissions levels significantly over the next few decades.

How do trees help? They pull carbon dioxide directly from the air (a claim no existing strategy can make) and transform it into living matter—trunks, branches, roots, leaves, and flowers. And here again the energy conserving role of trees has an indirect effect—as energy use is reduced from shade, so too are greenhouse gas emissions onsite and from power plants.

How can design influence the climate change impacts of trees? Once again, designing for energy conservation will reap great benefits as it avoids the production of greenhouse gas emissions onsite and at the source. In extreme climates, this contribution can be even greater than the amount of carbon dioxide sequestered by the trees. In addition, two aspects of species choice are critical: size and longevity. The largest species of trees will sequester up to 30 times more carbon dioxide than small species.[vii] When trees die and decay they return their carbon dioxide to the atmosphere, so long-lived species will have a longer-lasting benefit. Finally, the greater the number of trees, the greater the benefit.

Stormwater Management

Californians have struggled with the problem of water for a long time. In some regions, we simply don't have enough. In other areas with older infrastructure, sometimes we have too much, and heavy rains overwhelm stormwater systems, resulting in raw sewage being dumped in our waterways. And everywhere, non-point-source pollution—runoff from storms and irrigation that picks up pollutants from our streets and lawns and carries it into our waterways—is a significant problem.

How can trees help manage our water problems? Trees capture rain as it falls on their leaves and branches, allowing it to evaporate and reducing the burden on stormwater treatment systems. The soil around the trees can store and filter even more runoff, cleaning the pollutants out of the water as it passes through and allowing time for it to percolate and recharge the groundwater. A dense tree canopy and root system also help slow erosion, reducing sediment levels in streams.

Thoughtful design can increase the performance of the urban forest.[viii] One of the most critical factors is matching species choice to rainfall patterns. In regions like California, where rain falls mostly in the winter, broadleaf evergreen species will have the greatest impact. Rainfall capture rates are related to the total surface area of the leaves, so larger-leafed species will trap and hold the most water.[vi] A dense, continuous canopy will provide the greatest protection against erosion. Areas with heavy pollutant loads, such as driveways and parking lots, can be sloped to drain towards the trees and their soil, rather than into gutters and storm drains. Structural soil can make this even more efficient—capturing more runoff, removing more pollutants, supporting urban infrastructure such as sidewalks and parking lots, *and* improving tree health and growth.[ix]

Water for irrigation, in some areas of California, is in very short supply, but residents of these regions shouldn't be cut off from the many environmental and other benefits trees provide due to their water needs. In these places, careful species choice is critical.[x] In addition, landscaped areas, including those with trees, are a great place to make use of stormwater or recycled "gray water"—water reclaimed after being used for washing, laundry, or other purposes.[xi]

Three things to remember:

(1) When siting trees, make sure they will have enough room above and below ground to grow and be healthy. Although large trees provide the greatest benefits, a small tree is a better fit for a small space

(2) Be meticulous in your choice of nursery stock. Nothing has a greater effect on a tree's health and longevity than its condition when it goes into the ground

(3) Plan for tree maintenance. Early care and proper pruning will mean significantly reduced long-term maintenance, greater health, and therefore greater benefits into the future.

It was once thought that designing with the environment in mind required sacrificing aesthetic or artistic vision. In truth, many small, often invisible choices can have great ecological impacts. By keeping the mechanisms by which trees provide ecosystem services in mind, we can make wise design decisions that support urban ecology and make our cities more sustainable, while maintaining the integrity of our work.

Sources for more information:

- A web-based tool called i-Tree Design allows you to quantify the benefits of the trees in your designs and to compare alternative scenarios. Just enter the address of the project, draw in any nearby buildings, and enter information about the trees. The energy conservation, air quality, stormwater, and greenhouse gas benefits will be estimated. www.itreetools.org/design
- The Urban Ecosystems and Processes team (formerly the Center for Urban Forest Research) of the US Forest Service has great information on the benefits of trees and ways to maximize them. http://www.fs.fed.us/psw/programs/uesd/uep/
- Nature Within (University of Washington) has reports on many of the less quantifiable benefits of trees: http://www.naturewithin.info
- The California Urban Forests Council is a good starting place for information and resources about the urban forest: http://www.caufc.org/
- Invest From the Ground Up Campaign: http://www.investfromthegroundup.org

---

[i] The Urban Ecosystems and Processes team has published a series of community tree guides (http://www.fs.fed.us/psw/programs/uesd/uep/tree_guides.php) with great tips for tree planting and care.
[ii] Center for Urban Forest Research (2002) Green plants or power plants? http://www.fs.fed.us/psw/programs/uesd/uep/products/3/cufr_148.pdf
[iii] Scott KI, Simpson JR, McPherson EG (1999) Effects of tree cover on parking lot microclimate and vehicle emissions. Journal of Arboriculture 25:129–142.

[v] Center for Urban Forest Research (2002) Where are all the cool parking lots? http://www.fs.fed.us/psw/programs/uesd/uep/products/3/cufr_151.pdf
[vi] Center for Urban Forest Research (2004) The Large Tree Argument. http://www.fs.fed.us/psw/programs/uesd/uep/products/cufr_511_large_tree_argument.pdf
[vii] Center for Urban Forest Research (2010) Tree carbon calculator, v 31. http://www.fs.fed.us/ccrc/topics/urban-forests/ctcc/
[viii] Center for Urban Forest Research (2003) Is all your rain going down the drain? http://www.fs.fed.us/psw/programs/uesd/uep/products/cufr_392_rain_down_the_drain.pdf
[ix] Downing Day S, Dickinson SB (eds) (2008) Managing stormwater for urban sustainability using trees and structural soils. Virginia Polytechnic Institute and State University, Blacksburg, VA
[x] The WUCOLS Guide offers valuable regional suggestions for trees and other landscape plants based on their water needs: Costello LR, Jones KS (1994) Water use classification of landscape species (WUCOLS). UC Cooperative Extension, San Francisco.
[xi] EPA (2011) Water recycling and reuse: the environmental benefits. http://www.epa.gov/region9/water/recycling/