Local Air Quality Management Helpdesk, March 2010

What impact do trees have on air pollutant concentrations?

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmospheric environment. The ways in which trees affect air quality are through:

- Temperature reduction and other microclimatic effects
- Removal of air pollutants
- Emission of Volatile organic compounds (VOCs)

Additional effects can also be through:

- Tree maintenance emissions
- Energy effects on buildings

1. **Temperature Reduction and microclimatic effects:** Tree transpiration and tree canopies can affect air temperature, radiation absorption and heat storage, wind speed, relative humidity, turbulence, surface albedo, surface roughness and consequently the evolution of the mixing-layer height. Such changes in local meteorology can have an affect on local pollutant concentrations in urban areas. Urban trees are generally associated with contributing to cooler summer air temperatures, however in some instances they may have the opposite effect causing an increase in air temperature. Where tree stands consist of scattered tree canopies, radiation can reach and heat ground surfaces; at the same time, the canopy may reduce atmospheric mixing, preventing cooler air from reaching the area. In such cases, tree shade and transpiration may not compensate for the increased air temperatures due to a reduction in overall mixing. However reduced air temperature as a result of tree planting is believed to improve air quality because emissions of many pollutants and/or ozone-forming chemicals are temperature dependent.

2. **Removal of Air Pollutants:** Trees can remove gaseous air pollution either through uptake via leaf stomata or the plant surface. Once inside the leaf, gases diffuse into intercellular spaces and may be absorbed by water films to form acids or react with inner-leaf surfaces. Recent research suggests that the planting of trees along the sides of roads could reduce...
NO₂ concentrations in addition to providing amenity value \[^1\]. Trees can also remove pollution by intercepting airborne particles. Some particles can be absorbed into the tree, though most that are intercepted are retained on the plant surface. The intercepted particle is often re-suspended to the atmosphere, washed off by rain, or dispersed through leaf fall. Consequently, vegetation is thought to be only a temporary retention site for many atmospheric particles.

3. **Emission of Volatile Organic Compounds (VOCs):** Trees can also have an adverse effect on air quality through the emission of volatile organic compounds (VOCs). VOCs in combination with oxides of nitrogen (NOx), can contribute to the production of other pollutants, especially ozone and particles. However, under low nitrogen oxide concentrations (e.g., some rural environments), VOCs may actually remove ozone. Because VOC emissions are temperature dependent and trees generally lower air temperatures, increased tree cover can often lower overall VOC emissions and, consequently, ozone levels in urban areas. VOC emission rates however also vary by species e.g. sycamore (Platanus spp.), poplar (Populus spp.) and oak (Quercus spp.) have some of the highest standardised isoprene emission rates, and therefore the greatest relative effect among genera on increasing ozone. However, due to the high degree of uncertainty in atmospheric modelling, results are currently inconclusive as to whether these genera will contribute to an overall net formation of ozone in cities (i.e. ozone formation from VOC emissions are greater than ozone removal).

4. **Tree Maintenance Emissions:** Because urban trees often receive relatively large inputs of energy, primarily from fossil fuels, to maintain vegetation structure, the emissions from these maintenance activities need to be considered in determining the ultimate net effect of urban forests on air quality, e.g. equipment used, vehicles, shredders, chippers and leaf-blowers may all contribute to concentrations of CO₂, VOCs, carbon monoxide, nitrogen, sulphur oxides, and particulate matter).

5. **Energy Effects on Buildings:** Additional effects of urban trees can be through energy conservation from buildings. Trees reduce building energy use by lowering temperatures and shading buildings during the summer, and blocking winds in winter. However, they can increase energy use by shading buildings in winter, and may increase or decrease energy use by blocking summer breezes. Thus, proper tree placement near buildings is critical to achieve maximum building energy conservation benefits. When building energy use is lowered, pollutant emissions from power plants are
also lowered. While lower pollutant emissions generally improve air quality, lower nitrogen oxide emissions, particularly ground-level emissions, may lead to a local increase in ozone concentrations under certain conditions due to nitrogen oxide scavenging of ozone.

The cumulative and interactive effects of trees on meteorology, pollution removal, and VOC and power plant emissions determine the overall impact of trees on air pollution.