April 2021

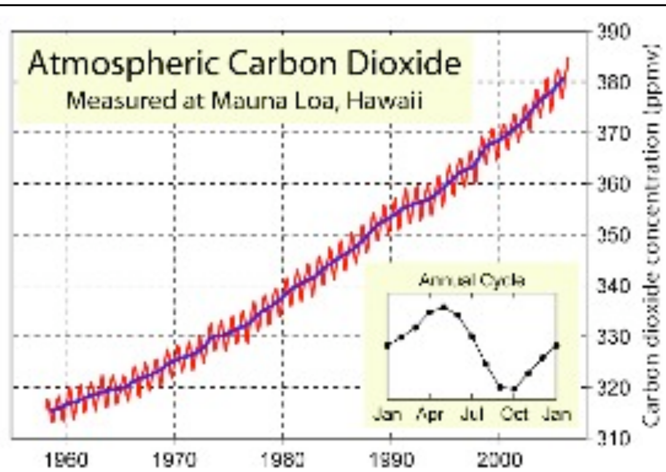
Reading - Carbon Sequestration

Center for Urban Resilience

Module 3 – Lesson 8 Narrative: *Carbon Sequestration*

As we have learned throughout this module, ecosystems are complex systems with energy and materials as inputs. The outputs include goods and services, but can also include pollution – especially those pollutants released into the air. The combustion processes of modern industrial cities include many pollutants. Most of them have carbon as a central component and include carbon dioxide and methane. Carbon dioxide also known by its chemical formula CO_2, is one of the most challenging pollutants to control, as it is a principle product of all combustion processes. Whether the engine is fueled by coal, oil, diesel – or even hydrogen, CO_2 is an unavoidable pollutant. Air pollution is a real health hazard and a threat to healthy ecosystems. In a big city like Chicago, data collected by health researcher scientists suggest that as many as 3,500 premature deaths are caused by air pollution each year. Clearly, air pollution is a serious problem.

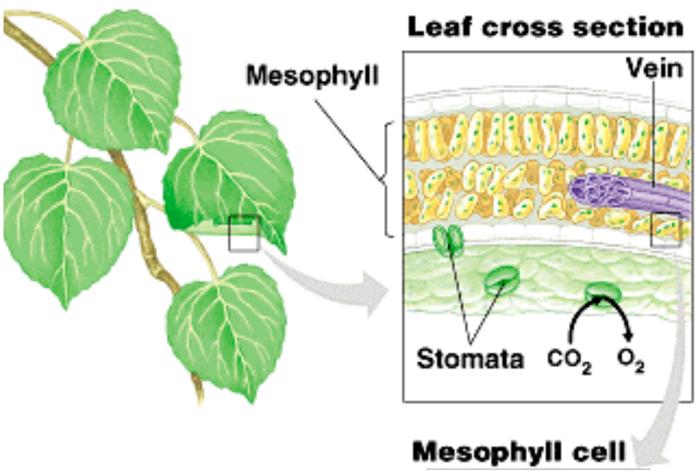
However, at relatively low levels, pollutants such as CO_2 are a natural, critical and important part of our ecosystem. CO_2 helps to warm our atmosphere and it is a fundamental chemical for plant metabolism. Plants and other organisms metabolize CO_2 and transform it into more complex molecules such as carbohydrates. These complex forms of carbon are the foundation for the food webs of all ecosystems. In healthy ecosystems, carbon production and use is in balance. In cities the excess production of carbon – especially CO_2, disrupts the balance and becomes a health hazard. Excess CO_2 leads to the Greenhouse Effect and ultimately to global climate change. The key to healthy urban ecosystems is the control of the excess CO_2. But, how can this be done? Well, trees provide us with part of the solution to this daunting challenge.



Top left: Mauna Loa Volcano in Hawaii is the sight of some of the most sophisticated measurements of atmospheric CO_2 anywhere in the world. The Atmospheric and solar observatory has been collecting ecological and earth science data for decades.
Bottom left: This graph depicts the atmospheric CO_2 for a span of forty years. As you can see, the trend has been steadily upward. The red line tracks the seasonal variation and the blue line is the yearly average. Typically, CO_2 levels in healthy ecosystems average about 300 parts per million by volume (ppmv). Current levels are exceeding 380 ppmv. This additional carbon loading is most likely the result of human industrial practices and contributes to global warming.

When carbon molecules are taken up by trees, the result is lower total amounts of CO_2 in the atmosphere. We call this specialized form of uptake *carbon sequestration*. Sequestering carbon is one of the most beneficial functions that trees perform in urban neighborhoods. Trees take up CO_2 through specialized openings in their leaves called stomata. Once the CO_2 enters the leaf, it is quickly metabolized into carbohydrates that the plant uses for food. In fact, these plant foods are utilized by humans as well. When we harvest vegetables and fruit for our own consumption, we are indirectly using the capacity of plants to sequester carbon.

Choosing the right trees to plant in a city is a big challenge for urban ecologists. Some trees grow rapidly and therefore, sequester carbon more efficiently. However, trees that grow quickly are often very susceptible to wind storms and must be replaced more often. Also remember, that when trees die, they break down and release their carbon back into the atmosphere. Many scientists make the technical assumption that about 10% of all of the carbon sequestered by a tree will be released through decomposition and by the plant's own metabolism. In this lesson, we experiment with different planting plans that use different mixes of tree and shrub species. We investigate the advantages and trade-offs among the different species.



Top left: Drawing of a leaf in cross-section. The stomata can be seen on the underside of the leaf where they serve as portals for gases to enter and leave the plant. Gases such as CO_2 flow into the plant and water vapor and oxygen flow out. The higher percentage of the landscape planted with vegetation, then the more efficient the sequestration of carbon becomes.
Bottom left: A tree-lined street in Boston looks beautiful and the trees help clean the air. "These street trees remove three tons of harmful air pollutants each year, including sulfur dioxide, particulate matter, and ozone that contribute to respiratory and cardiovascular disease," *says Sherri Brokopp of the Urban Ecology Institute and Boston's Urban Forest Coalition. U.S. Forest Service researchers Richard Birdsey and Linda Heath calculate that Forest carbon sequestration currently captures about 200 million metric tons of CO_2, which represents nearly 12% of the total greenhouse gases generated by American each year. According to their calculation, thirty healthy trees can offset the carbon generated by a relatively fuel efficient automobile driving 12,000 miles per year.*