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Greenhouse Warming and Landscape Care

• Kevin T. Smith

Climate change is one of the few truly planetary processes that influence the assessments and actions of governments and of everyday citizens. Principles and practices of ecological landscaping fit well with concern about the effects of climate change.

Models of complex weather patterns indicate that as the planet increases in overall temperature, global patterns of circulation in the atmosphere and in the oceans change as well. These changes in large-scale patterns can influence local precipitation, the timing of budbreak and frosts, and the frequency of extreme weather events. We know that climate change is nothing new and there is evidence of extreme change prior to the development of modern society.

"Greenhouse warming" distinguishes global change caused by human activity from long-term climate cycles that are independent of human activity. Concern for greenhouse warming has centered on "greenhouse gases." Greenhouse gases make life possible on earth by trapping some of the heat produced by solar energy that reaches the earth's surface.

The current greenhouse warming problem stems from the release of huge amounts of greenhouse gases such as carbon dioxide (CO_2) from the burning of fossil fuels as well as other gases from animal agriculture and other industrial sources. The term "carbon footprint" refers to the direct and indirect release of CO_2 to meet some need. This increased production of greenhouse gasses is coupled with the decreased capture of CO_2 and reduced storage of carbon in living trees and soil due to deforestation, forest fires, and other changes in land use.

Photosynthesis by land and marine plants takes CO_2 out of the atmosphere, using solar energy to make chemical bonds to form sugar. The sugar is then the fuel and the raw material for plant biosynthesis of organic compounds, compounds that contain carbon. This is the fundamental support for most of the world's food webs.

Although most organic compounds will be rapidly broken down by organisms and the CO_2 released back into the atmosphere, some organic compounds are stored or sequestered for long periods of times. Stored carbon does not contribute to greenhouse warming or to the carbon footprint. For the terrestrial environment, much organic matter is stored in woody plants and soils. Ecological techniques that promote healthy landscape plants can have the additional benefit of increasing that stored carbon.

The amount of carbon stored in the wood of healthy trees and shrubs can be increased by tree care practices that reduce wood decay. Wood decay can be reduced by decreasing the frequency and severity of tree wounding. Wounding provides the opportunity for infection by wood decay fungi and their associated microorganisms. Repeated wounding can breach the boundaries of the compartmentalization process, resulting in injured trees.

Compartmentalization resists the spread of infection and results in less decay and increased carbon storage. Proper pruning practices that remove the target branch and leave the stem uninjured favor healthy compartmentalization. Although ecological landscaping techniques should aim to reduce the amount of decay in living trees, the decay of woody mulch and even woody debris can support communities of healthy soil microorganisms.

Most textbooks present soil as a

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Wood decay has reduced the amount of carbon stored in the center of this red oak stem.

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physical mix of clay, silt, and sand with a little humus (decayed organic matter). This model is good for predicting some soil properties such as porosity and permeability. In contrast, an ecological approach presents soil as *alive*, with the living roots, microorganisms, and micro fauna all playing key roles in plant nutrition. Much of the carbon stored by plants is below ground in the root system and is not readily visible. Healthy roots in natural environments release carbon macromolecules into the soil that improve soil texture and that support communities of beneficial microorganisms. These communities alter the chemical forms of essential elements, making them more available for plant uptake and growth.

Ecological landscaping techniques can increase the storage of carbon directly through encouraging the development of healthy root systems and living soil and indirectly through reduced consumption of energy-intensive landscape treatments. Meeting the goal of healthy root systems can involve physical and biological soil amendments, especially for impoverished urban soils. The carbon added to the soil through the addition of organic amendments also increases carbon storage. The slow breakdown of that organic matter can help fuel the development of healthy communities of soil microorganisms.

Probably the landscape treatment with the largest carbon footprint is nitrogen fertilization. Although our atmosphere is rich in nitrogen gas, that essential element is taken up by plants in other forms such as nitrate. Most nitrogen fertilizer is produced by an industrial process that consumes large amounts of electricity. Development of that process was a tremendous boost to modern agriculture. The rapid response of landscape plants to nitrogen fertilizer encouraged its use, which rapidly became widespread. Now, fertilization of landscapes with industrial nitrogen is one of the most common practices in traditional landscaping. In addition to the large carbon footprint, the rich succulent growth encouraged by nitrogen fertilization can also be prone to attack by pests and pathogens. Some of these problems can be reduced through increased pesticide use, which unfortunately also increases the carbon footprint.

Mycorrhizal root of red oak showing the sheath of beneficial fungus, proliferation of root tips, and aggregation of soil particles.

An unintended consequence of nitrogen fertilization is the suppression of natural communities of microorganisms in healthy soils. These communities can take nitrogen gas and produce nitrate and other forms to fertilize landscape plants. Nitrogen and phosphorous fertilization also suppress the formation of healthy mycorrhizae. Mycorrhizae are symbiotic associations of plant roots and beneficial fungi. The fungus component greatly increases the surface area of the function root system of the plant and is more effective than the plant alone at taking up certain essential elements such as phosphorous. Mycorrhizae naturally form in most families of higher plants, especially trees and woody shrubs. Healthy mycorrhizae and natural communities of soil microorganisms reduce the need for industrial fertilizers. Reduced fertilizer use lowers the carbon footprint of the landscape through reduced energy consumption in the formation and transportation of the manufactured materials.

New commercial products and techniques are being developed to meet the goals of healthy plants and soils while reducing the carbon footprint. Some will be more effective than others, depending on specific circumstances. Research on the relationships within the biological webs of planted landscapes can provide options and guidance on what we should do to enhance the role of ecological landscaping in reducing greenhouse warming. Although the contribution may seem small with respect to the total problem of climate change, ecological techniques can make alternative approaches available for effective, efficient, and sustainable landscaping.

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Photos by Kenneth R. Dudzik, USDA Forest Service