# Plant Responses to Ozone

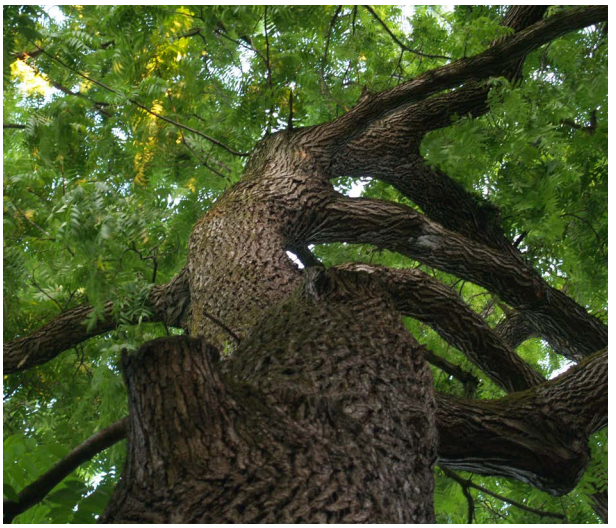
This project has collected data about ozone damage to plants that have been used to describe ozone impacts on agricultural and natural ecosystems, screen plants for ozone tolerance, and to set national ozone standards, ultimately protecting U.S. crops, forests, and other vegetation.

## Who cares and why?

In this field plot, ozone-sensitive snap beans in the middle row show signs of premature deterioration and stem and leaf loss compared to ozone-tolerant snap beans in the far right row. Photo by Kent Burkey.

In the layer of the atmosphere closest to the Earth's surface, ozone is a gaseous air pollutant created when sunlight reacts with chemical compounds in vehicle exhausts, industrial emissions, and chemical solvents. Ozone can severely damage plants and is a serious concern for farmers, forest and plant nursery managers, park managers and visitors, landscapers and gardeners, and consumers across the U.S. Ozone-sensitive plants include major crops (e.g., barley, bean, cotton, grape, oat, peanut, potato, soybean, tomato, and wheat) and many important tree species (e.g., aspen, birch, cottonwood, Ponderosa pine, black cherry, white ash, sycamore, and yellow poplar). Chronic exposure to ozone injures the leaves of sensitive plants and can reduce plant growth, quality, seed production, and tolerance to insects, pathogens, weather, and other stress factors. Current estimates suggest that ozone causes three to five billion dollars in crop loss annually. Considerable visible damage has also been noted among native plants in wilderness areas and recreational areas. Damage to plants in both managed and natural settings can lead to poor soil and water quality and can affect organisms that rely on plants for food, shelter, and other uses. By collaborating across multiple disciplines and states, researchers can get a more complete picture of the factors involved in ozone damage. Scientific data will help estimate economic costs, project future impacts, set air quality regulations, and protect U.S. crops, forests, and other plants.

## What has the project done so far?



With funding from the USDA Plant Genome Program, NE-1030 researchers have analyzed genes in black cherry, green ash, and black walnut trees (above, photo courtesy of Minh Kiet Callies, Flickr) to understand how different hardwood tree species respond to ozone.

Since the project started in 1995, NE-1030 researchers have become international leaders of cooperative work on ozone damage to plants. By bringing together scientists with diverse knowledge and experience, this project has led to unique approaches to studying—and preventing—ozone damage. Over the past five years, NE-1030 scientists have described many different molecular and environmental characteristics that influence ozone levels in the air. For example, NE-1030 studies have shown that warmer soils can accelerate ozone damage to beans. Reliable data collected through NE-1030 studies have helped scientists develop models that accurately predict and assess ozone damage. These models have been adopted by regulatory agencies around the world and used to set appropriate ozone level standards. NE-1030 research has also led to more accurate calculations of the economic cost of ozone damage

to plants by providing information about changes in ozone levels based on time of day and season. Furthermore, scientists have shown that economic damage estimates should include reduced nutritional value in addition to reduced crop yield. Taking a major step towards breeding ozone-tolerant plants, NE-1030 scientists have examined the molecular basis of ozone toxicity in a variety of plants. To share results and recommendations from these studies, NE-1030 members have developed handouts, websites, and digital media and have led classroom instruction, interactive presentations, and training sessions for many groups, including teachers and Master Gardeners.

## Impact Statements

Measured ozone levels and damage, providing early detection of ecosystems under ozone stress, thereby helping to tackle problems quickly and successfully.

Collected reliable scientific data used to set State and National Ambient Air Quality Standards for ozone to protect crops, forests, and other plants and sustain the goods and services they provide.

Developed more accurate estimates of the economic impact of ozone damage to plants, helping agencies like the U.S. EPA compare the costs and benefits of various ozone control strategies.

Gained acceptance of ozone regulations by showing the severity of damage to plants.

Shared locally relevant information on ozone air pollution and control strategies, leading to informed communities and voters and encouraging behaviors that promote better air quality.

Demonstrated potential ways to improve the ozone tolerance of cultivated plants through genetics and to improve the sustainability of U.S. agriculture.

To study the impacts of ozone on the nutritional qualities of plants, rabbits were fed forage grown under elevated ozone levels. Researchers found that high ozone levels decreased digestible dry matter intake, suggesting that ozone air pollution can have negative impacts on animals that eat plants. Photo courtesy of Carl Mueller, Flickr.

## What research is needed?

Researchers need to quantify the effects of ozone in terms of interactions with climate change factors (e.g., temperature), plant pathogens, and biodiversity. More work is also needed to quantify the effects of ozone on the nutritional qualities of forage consumed by animals. In national parks and other natural ecosystems, researchers need to assess how ozone impacts aesthetics and visitors' enjoyment. For cultivated plants, continued genetic research is needed to improve the ozone tolerance—and thus yield and quality.

## Want to know more?

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Compiled and designed by Sara Delheimer