# Free-Air $CO_2$ Enrichment (FACE) Experiment

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**PARTNERS:** Argonne National Lab, Chapman University, University of Illinois-Chicago, University of Illinois at Urbana-Champaign, University of New Hampshire, University of Puerto Rico, University of Tennessee.

**PROJECT WEBSITE:** http://face.ornl.gov/index.html

*The ORNL FACE site was the cover photo for the November 9, 2010 edition of the Proceedings of the National Academy of Sciences.*

*$CO_2$ vent pipes above the canopy.*

*Aerial view of the FACE site.*

*Tower supporting $CO_2$ vent pipes.*

## PROJECT DESCRIPTION

The goal of the Oak Ridge Free-Air $CO_2$ Enrichment (FACE) project is to understand how the eastern deciduous forest will be affected by $CO_2$ enrichment of the atmosphere and the feedbacks from the forest to the atmosphere. This goal is being approached by measuring the integrated response of an intact forest ecosystem, with a focus on stand-level mechanisms.

Stimulation of terrestrial plant production by rising $CO_2$ concentration is projected to reduce the airborne fraction of anthropogenic $CO_2$ emissions. Coupled climate-carbon cycle models are sensitive to this negative feedback on atmospheric $CO_2$, but model projections are uncertain because of the expectation that feedbacks through the nitrogen cycle will reduce this so-called $CO_2$ fertilization effect. We measured the effect of atmospheric $CO_2$ concentration on net primary productivity and related processes in a 12-year FACE experiment in a deciduous Liquidambar styraciflua (sweetgum) forest stand on the Oak Ridge National Environmental Research Park. The FACE facility, comprising five 25m plots, was constructed in 1997 in a sweetgum monoculture plantation that had been established in 1988. This closed-canopy, 18m tall stand offers the opportunity for rigorous tests of hypotheses that address the essential features of a forest stand and how they could influence the responses to $CO_2$. These features include: (1) the closed canopy, which constrains growth responses; (2) full occupancy of the soil by the root system, which constrains the nutrient cycle; (3) the larger scale of the trees compared to saplings in open-top chambers, which changes the functional relationships of carbon cycling; and (4) the longer time scale that can be addressed, permitting studies of soil carbon changes.

## SIGNIFICANCE

The response of natural ecosystems to an increasing concentration of $CO_2$ in the atmosphere is a key component of analyses of the current and potential impact of global change. Efforts to understand how eastern deciduous forests will be affected by $CO_2$ enrichment of the atmosphere have heretofore been addressed by studying components of the forest system (individual small trees, specific processes), but the FACE project takes the critical leap to measuring the integrated response of an intact forest with a focus on stand-level mechanisms. This project was part of the $CO_2$ research network fostered by the Global Change and Terrestrial Ecosystems core project of the International Geosphere-Biosphere Programme. Results from the experiment contributed to the Terrestrial Ecosystem Response to Atmospheric and Climatic Change (TERACC) project, a 5-year initiative integrating experimental data and global change modeling. Results from the FACE project provided a benchmark for coupled carbon cycle climate models

*Autumn color.*

*Litter decomposition bags.*

*Monitoring equipment.*

used in 4th Assessment Report of the Intergovernmental Panel on Climate Change and data sets used by 20 modeling groups, and they are currently being used in a model intercomparison project at the National Center for Ecological Synthesis and Analysis.

**INTERESTING FINDINGS**

Fine-root production was stimulated by elevated $CO_2$, especially deeper in the soil, leading to greater carbon input to soil and greater access to mineral nitrogen. Initial enhancement of net primary productivity was not sustained because of feedbacks through the nitrogen cycle. Stable isotope analysis indicated that nitrogen availability declined faster in plots exposed to elevated $CO_2$, consistent with model predictions. Carbon storage in the soil increased in $CO_2$-enriched plots, including in protected forms. Successional development of the understory community was accelerated in elevated $CO_2$.