



FACING THE FUTURE

The FACTS II (Aspen FACE) Newsletter
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David F. Karnosky and Janet M. Pikkarainen, Editors



USFS Administrative Tour

The Aspen FACE site hosted a visit of some 36 senior USFS administrators on October 6, 2003 as part of the USFS Chief's Review of the East. Following a catered lunch, Mark Kubiske (USFS) welcomed the group to the site and Dave Karnosky (MTU) gave a brief overview of the Aspen FACE site accomplishments. Subsequently, Bill Mattson (USFS), Wendy Loya (MTU), Karnosky and



Kubiske made presentations at various rings. Among the participants

were Dr. Linda Donoghue, Director of the North Central Research Station, Deputy USFS Chief and Director of Research and Development Dr. Robert Lewis, Associate Chief of the USFS Sally Collins, USFS Region 9 Regional Forester Randy Moore, and USFS Northern Stations Global Change Program Director Rich Birdsey.



Aspen FACE in the News

On May 16, 2003, the Aspen FACE project was featured in a story entitled "World's largest climate change experiment" in a national radio program entitled "The Osgood File." A transcript of the broadcast is available at: http://wbz1030.com/siteSearch/osgood_story_136124212.html



Karnosky Takes Part in DOE and EPA Tasks

Dave Karnosky, Aspen FACE Director, (a) presented a seminar at the US DOE Global Change Education Program in Portland, Oregon (June 11), and (b) served on the National Technical Advisory Committee (NTAC) of the National Institute for Global Environmental Change in Washington, DC (August 12-13). In addition, Dave has been heavily involved in writing the latest EPA Ozone Criteria Document, as he was asked to take the lead role on the "Genetics" and "Ecosystems" sections of the document, which is due out later this year.

Percy Heads IUFRO Task Force on Carbon Sequestration

Kevin Percy, member of the Aspen FACE Steering Committee, is heading the International Union of Forest Research Organizations (IUFRO) Task Force on "The Role of Forests in Carbon Cycles, Sequestration and Storage". The Task Force is publishing a series of science-policy summaries representing the view of foresters about carbon sequestration in the world's forests. The Task Force web site is: <http://iufro.boku.ac.at/iufro/taskforce/tfcsnlftcs.htm>

John King's Group

John King reports that he has received new support (\$22,952) from the USDA Forest Service North Central Research Station to support Lingli Li (MTU Ph.D. candidate) who is investigating how CO₂ and O₃ affect the chemistry and decomposition of leaf litter. She is characterizing decay rate constants for individual chemical constituents and developing models of the decomposition process. Jack Chapman, M.S. student, continues his work on fine root chemistry and decomposition.

The Aspen FACE Steering Committee

The Aspen FACE project is coordinated by a five-member Steering Committee that provides overall research direction and major decision making. The Committee meets periodically and conducts an annual meeting in conjunction with the annual investigator meeting. The five members include: George Hendrey (Brookhaven National Lab), Dave Karnosky (Michigan Tech), Mark Kubiske (USFS), Kevin Percy (Canadian Forest Service), and Kurt Pregitzer (Michigan Tech).

A pioneer in open-air fumigation technology, **George Hendrey** and his Brookhaven National Lab team engineered the CO₂ and O₃ dispensing, monitoring systems, the mechanical and electronics control boards, and computer software that operate the Aspen FACE site. George and his team remain actively involved in FACE system development and have worked on FACE projects across the U.S. as well as in Switzerland and Panama. George can be contacted at hendrey@bnl.gov and has a web site at http://www.bnl.gov/des/Files/GHendreyFull_cv-.pdf.

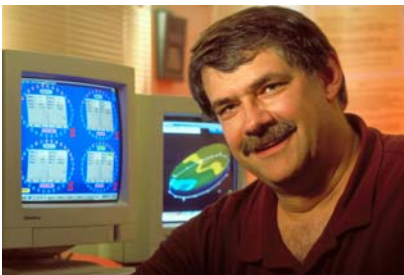


Director of the Aspen FACE project, **Dave Karnosky** coordinates day-to-day activities of the site. In addition, he and his students and post doctoral fellow have conducted research on gas exchange, canopy dynamics, seasonal phenology, *Melampsora* rust occurrence, and gene expression. Dave has studied the effects of global change and greenhouse gases on forest ecosystems for the past 30 years and has been actively involved in the development of the last two Ozone Criteria Documents as a consultant to the US EPA. Dave can be contacted at karnosky@mtu.edu and has a web site at

<http://www.forestry.mtu.edu/faculty/karnosky/>.



Mark Kubiske, Project Leader for the USDA Forest Service North Central Research Station, is the newest member of the Steering Committee, having replaced former member Jud Isebrands last year.



Mark is well known for his thorough examination of gas exchange dynamics in the canopy and the impacts of elevated CO₂ on them. Mark and his team also coordinate annual growth measurements at our site. In addition, Mark oversees sample collection and site access needs by the entire Aspen FACE science team. Mark can be contacted at mkubiske@fs.fed.us.

Kevin Percy is a Senior Scientist with the Natural Resources Canada, Canadian Forest Service-Atlantic Forestry Centre in Fredericton, New Brunswick, Canada. Kevin has been examining the role of leaf surface wax alteration by elevated CO₂ and O₃ in pest interactions at the Aspen FACE site. This work was featured in Kevin's 2002 *Nature* paper. Kevin is also actively seeking the best O₃ measurement dynamic (i.e. SUM06, W126, AOT40, etc.) and micrometeorology parameters to predict our growth responses at our site. Kevin can be contacted at kpercy@nrcan.gc.ca.



Kurt Pregitzer, Professor of Forest Ecology at Michigan Tech, spearheads belowground research and carbon budget development research at the Aspen FACE site. He and his



colleagues have had long-term support from the US DOE's Program for Ecosystem Research for examining belowground aspects of forest tree responses to elevated CO₂ and O₃. A pioneer in innovative root research, Kurt was the inventor of the minirhizotrons which are now used around the world for examining root growth and fine root turnover. Kurt recently completed a two-year assignment with the USFS to develop the ecosystem productivity project at the North Central Experiment Station at Houghton, Michigan. Among recent accomplishments, Kurt and his team have just had a carbon isotope paper accepted in *Nature* for their FACE work. Kurt can be contacted at kspregit@mtu.edu and has a web site at <http://www.forestry.mtu.edu/faculty/pregitzer/>.

N15 Labelling Study (Provided by Bill Holmes, University of Michigan)

As part of the collaborative belowground research of Don Zak (UM) and Kurt Pregitzer (MTU), the ^{15}N tracer experiment



commenced in June with the goal of determining how changes in plant growth under elevated CO_2 and O_3 influence N dynamics and storage. The movement of ^{15}N into plant roots, mycorrhizae, microbial biomass, soil organic matter, and leachate will be measured three times this season and once next year. The research teams from UM, MTU, USFS, and Argonne National Lab have coordinated their sampling to minimize the sampling impact on the site and to enable integration of results from different labs.

The ^{15}N addition and initial soil/root sampling was coordinated by Bill Holmes (UM), Erik Lilleskov (USFS), Wendy Loya (MTU), and Alex Friend (USFS). The work was conducted with the help of a large crew, including Jana Gastellum, John Hassett, and Michelle Martin from UM and Angela Johansen, Dan Muth, Rob Wall, Adriane Lenshek, Bethany Baibak, Adam Gahagan, and Kim Larsen from MTU.

Following a pre-enrichment soil/root sampling, soils in all rings were enriched with trace amounts of ^{15}N -ammonium chloride in the form of a dilute solution dispensed using backpack sprayers. The solution was rinsed off plants and into soil with water dispensed from a truck-mounted water tank and pumped through garden hoses. The soil/root sampling will be repeated 1 week, 1 month, and 4 months following addition in order to quantify short-term dynamics of tracer N. Tracer N in aboveground biomass components will be measured as part of the next plant harvest.

Ozone-induced Hydrogen Peroxide Accumulation and Peroxisomal Proliferation (Progress report from Elina Oksanen, University of Kuopio, Finland)

Ozone is one of the most powerful oxidants known, and the primary damage is largely confined to the leaf mesophyll, where ozone dissolves into the wet surface of the exposed cell walls. The toxicity of ozone in plant cells is mediated through the

formation of reactive oxygen species (ROS) including hydrogen peroxide (H_2O_2). Unsaturated lipids and proteins in the apoplast and plasmalemma are the obvious targets for ozone and ROS. Under environmental stress (such as ozone) production of exacerbate H_2O_2 has been observed in chloroplasts, mitochondria, peroxisomes, plasma membrane, and in the apoplast. Thereafter, excess H_2O_2 can be converted to water and molecular oxygen spontaneously or by catalase, or detoxified through action of various peroxidases or ascorbate-glutathione pathway. Catalase is found mainly in peroxisomes, which therefore play a significant role in defence against ozone stress.

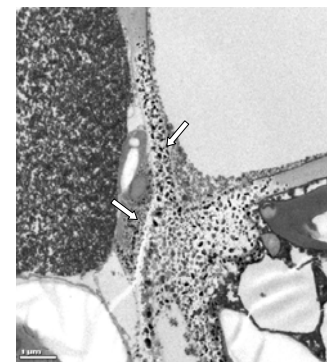


In a study conducted at the Aspen FACE site in 2001, we examined (1) the extent aspen and birch leaves exposed to elevated ozone and/or CO_2 in the field show the signs of oxidative stress (H_2O_2 accumulation) within the mesophyll cells, and (2) whether or not H_2O_2 accumulation is connected to structural damage and increase

in detoxifying peroxisomes. Thereafter, (3) ozone-induced proliferation of peroxisomes were linked to transcript levels of catalase, converting H_2O_2 to water and molecular oxygen.

To localize subcellular accumulation of H_2O_2 leaf pieces were incubated under vacuum with CeCl_3 solution. During incubation Ce^{3+} ions react with H_2O_2 forming electron dense (black) cerium perhydroxide precipitates (Figure, white arrows), which were visualized in electron microscopy analysis.

We were able to locate ozone caused H_2O_2 accumulation within the leaf mesophyll, and relate oxidative stress with structural injuries in aspen and birch. In the relatively tolerant aspen clones 216 and 271, H_2O_2 precipitation was restricted to the apoplasm, and no structural injuries could be found within the cells. In ozone sensitive aspen clone 259 and birch, H_2O_2 accumulation continued from cell wall and plasma membrane to cytoplasm and adjacent chloroplasts (Fig 1), and damage in plasma membrane was apparent. In chloroplasts, however, accumulation was found only in ozone-exposed leaves, not in the presence of elevated CO_2 . In aspen clone 259, cytoplasmic and chloroplastic H_2O_2 accumulation was accompanied by reduced chloroplast size and increased thylakoid injuries in ozone exposed leaves. In birch, on the other hand, ozone caused H_2O_2 accumulation within cells was observed in conjunction with reduced starch grain and increased thickness of cell walls, indicating increased defence against ozone stress. In addition, increased transcript level for catalase was demonstrated to be related to ozone induced proliferation of peroxisomal population in the tolerant clones 216 and 271.



Ozone caused oxidative burst (H_2O_2 production, black precipitation) in sensitive aspen clone 259, extending from cell walls to cytosol and adjacent chloroplast



Early Snow Hits Aspen FACE

An early snow blanketed the Aspen FACE site on October 1, 2003. While the snow melted within the day, it and the associated cool nights of the same week have frozen the maple leaves. Aspen and birch foliage has thus far remained physiological active.



Evan McDonald Takes New Position

Evan McDonald, a long-time fixture at the Aspen FACE project and member of Mark Kubiske's USFS project, has taken on a new position in Hancock, Michigan. Evan will be working one-half time with the Keweenaw Land Trust and the other half time on as a University of Wisconsin employee working with Dr. Eric Kruger on scaling Aspen FACE results to a regional level via modelling.

Aspen FACE Photo in U.S. Strategic Plan

A photo of the Aspen FACE site (p. 182; Figure 8-5) and its caption (p. 172; Figure 8-5...) were used in the "Strategic Plan for the U.S. Climate Change Science Program" which provides the vision and strategic plan for the U.S. Climate Change Science Program. The report is published at <http://www.climatechange.gov/Library/stratplan2003/final/ccspstratplan2003-all.pdf>. (Note: page numbers may vary in different computers)

Aspen FACE New Publications

Kurt Pregitzer's team has just had the following article accepted in *Nature*:

Loya, W.M., K.S. Pregitzer, N.J. Karberg, J.S. King, and C. Giardina. 2003. Reduction of soil carbon formation by tropospheric ozone under elevated carbon dioxide. *Nature* 425:705-707.
Great work!

Davey, P.A., S. Hunt, G.J. Hymus, E.H. DeLucia, B.G. Drake, D.F. Karnosky, and S.P. Long. 2003. Respiratory oxygen uptake is not decreased by an instantaneous elevation of [CO₂], but is increased with long-term growth in the field at elevated [CO₂]. *Plant Physiology* (In Press)

Mankovska, B., K. Percy, and D.F. Karnosky. 2003. Impact of greenhouse gases on epicuticular waxes of *Populus tremuloides* Michx.: Results from an open-air exposure and a natural O₃ gradient. *Ekologia* (In Press).

Percy, K.E., R. Jandl, J.P. Hall, and M. Lavigne. 2003. Forests and the global carbon cycle: Sources and sinks. IUFRO Task Force on "The Role of Forests in Carbon Cycles, Sequestration and Storage."

Web site: <http://iufro.boku.ac.at/iufro/taskforce/tfcsnltfcs.htm>

Sharma, P., A. Sober, J. Sober, G.K. Podila, M.E. Kubiske, W.J. Mattson, J.G. Isebrands, and D.F. Karnosky. 2003. Moderation of [CO₂]-induced gas exchange responses by elevated tropospheric O₃ in trembling aspen and sugar maple. *Ekologia* (In Press)

Aspen FACE investigators Dave Karnosky, Kevin Percy, and Janet Pikkarainen have a new book coming out this fall:

Karnosky, D.F., K.E. Percy, A.H. Chappelka, C. Simpson, and J. Pikkarainen. 2003. *Air Pollution, Global Change and Forests in the New Millennium*.

Elsevier Press (In Press) -- Web site for book launch:

<http://www.elsevier.nl/inca/publications/store/6/8/1/0/0/9/index.htm>



People at the Aspen FACE Project



Wendy Jones

Aspen FACE site operator (2000-present)

Editors: Wendy, How did you end up here at the Aspen FACE site?

Wendy: Actually, I have worked at the Aspen FACE site since its early days as when I was an undergraduate student, I worked summers with Dave Karnosky, propagating the clones for the FACE site, setting out the original walkways, planting the rings, and then planting and maintaining the border trees. Then, when I finished my Masters project at Michigan Tech, Dave was looking for someone to replace Scott Jacobson at the Aspen FACE site, so I applied.

Editors: Wendy, I know you handle a lot of duties here. Could you explain a few?

Wendy: Sure, besides working as a site operator, especially during the early and late growing season when our student operators are not here, I am on-site's safety coordinator. With the ozone being a health hazard for employees and with the development last year of the elevated walkway system, safety has come front and center at our site. I also coordinate user information for Dave and I oversee site maintenance. In addition, I coordinate the distribution of our site's CO₂ and O₃ data sets to CDIAC. So far, we have sent them all of our hourly CO₂ data for each ring for the first 5

years of operation. I am close to being able to send them the O₃ data sets. Finally, I have really enjoyed getting involved this year in taking fish-eye photos in each quadrant of each ring every 10 days over the growing season for LAI calculations.

Editors: What is your biggest challenge out here?

Wendy: Well, I would say keeping 50 different scientists and their technicians and students up to speed on safety issues is probably the toughest chore. No one wants to slow down long enough to worry about safety, so it is a challenge.

Editors: What are your goals?

Wendy: At some point, I would like to continue my education and try for my doctorate in forest ecology. In the meantime, I would like to publish the results of my Masters work.



Jaak Sober
Aspen FACE site operator (1997-present)

Editors: Jaak, How did you come to end up here in Wisconsin on this project?

Jaak: About 10 years ago, I spent a summer working with Dave Karnosky's open-top chamber study in Alberta, Michigan and I became quite interested in examining the effects of these interacting gases (CO₂ and O₃) and how they affect forest trees. Then, when David's team got their grant (in 1996) for starting the Aspen FACE project, he called me and asked if I would be the lead site operator; I accepted.

Editors: What was it like at the beginning of this huge project?

Jaak: Well, quite frankly, it seemed overwhelming at first as we were developing a system never before used on trees or crops. However, with the tremendous help and experience of the Brookhaven National Lab team, principally George Hendrey, Keith Lewin and John Nagy, we

somehow managed.

Editors: You have seen a lot of serious problems during the 6 years of operation. What do you consider the most challenging?

Jaak: Without a doubt, the worst problems we have faced are the two separate lightning-induced fires which each destroyed a ring-side control and monitoring shed. Probably the worst was the 2001 fire which destroyed the shed at ring 2-3. It first looked like the whole third replicate might be down for weeks but I managed to patch together a bypass of the ring and we were actually up and running for the other 11 rings in a few days.

Editors: Your wife also works here in the summers, right?

Jaak: Yes, Anu has worked for Dave during the summers for most of the past 10 years doing gas exchange, water use efficiency, and nitrogen use efficiency studies, first at the open-top chamber facility in Alberta, Michigan and then here at the Aspen FACE project.

Editors: Are you working on anything new this year?

Jaak: Yes, we have a cooperative study of ozone distribution in the rings this year with Drs. Kevin Percy and Roger Cox of the Canadian Forest Service. We have conducted a whole-growing season study using about 30 passive ozone monitors per ring to thoroughly characterize vertical and horizontal distribution of ozone. We hope to publish these data along with shorter term (6 weeks) O₃ distribution data we collected late in the growing season in 2001.

Aspen FACE in *Science*

The Aspen FACE project was in the minds of members of the National Research Council as they reviewed the National

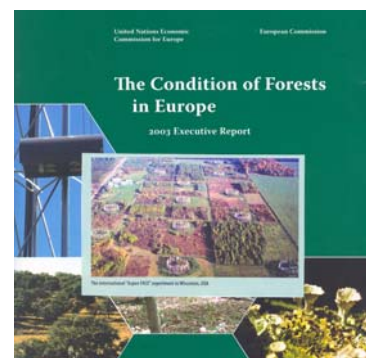


Ecological Observatory Network (NEON) proposal at the request of NSF. NRC recommended that NEON needed "large-scale experimentation, long-term observation, and scientific synthesis that could be carried out only using a net work of nationwide infrastructure and research sites that are optimized for that purpose." Comments from authors of the report indicated that building on studies such as FACE and AmeriFlux to address environmental problems of national scope would be an appropriate approach for NEON to take. Ecological implications of climate change was one of six "critical environmental challenges" listed in the report which can be seen at <http://www.nap.edu/books/0309090784/html/> and which was featured in *Science* (*Science* 301:1828 September 26, 2003). Our Aspen FACE site overview

photo was used in the article.

Aspen FACE in UNEC Report

Kevin Percy and Dave Karnosky prepared an invited synopsis of the Aspen FACE project for the recently published United Nations 2003 Executive Report on "The Condition of Forests in Europe". Again, our Aspen FACE site overview photo was used in the publication.



36th Air Pollution Workshop, April 26-29, 2004

Michigan Technological University and the USFS North Central Research Station will host the 36th Air Pollution Workshop on April 26-29, 2004. Dave Karnosky (MTU) and Mark Kubiske (USFS) will co-host the workshop which will include a tour of the Aspen FACE site. In addition, a pre-workshop symposium, organized by Karnosky and Kubiske, entitled "Impacts of Interacting Air Pollutants on Forests and Crops" will be held on April 26. All activities will be held at the Holiday Inn Express in Rhinelander, Wisconsin. The registration web site for the meeting is:

<http://www.asl-associates.com/apworkshop/formreg.htm>
