



FACING THE FUTURE

The FACTS II (Aspen FACE) Newsletter

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David F. Karnosky and Janet M. Pikkarainen, Editors

Aspen FACE is a highly successful project for global change research. Over 100 scientists and students contributing to the project have written over 100 scientific papers and Aspen FACE remains at the cutting edge of forestry and ecological research.

*Principally supported by the U.S. Department of Energy's Office of Biological and Environmental Research, the Aspen FACE (Free Air CO₂ Enrichment) project is located on USFS property 10 miles west of Rhinelander, Wisconsin. Since 1998, the project has been examining the impacts of elevated atmospheric carbon dioxide (CO₂) and tropospheric ozone (O₃) on the structure and functioning of a northern forest ecosystem dominated by trembling aspen, North America's most widely distributed trees species. The Aspen FACE project became part of DOE's distributed facility in 2003. The Aspen FACE facility is run by Michigan Technological University with MTU's Dave Karnosky as Director. All major decisions at the Aspen FACE facility are made by the Steering Committee which includes Dave Karnosky, Kurt Pregitzer (MTU), Neil Nelson (U.S. Forest Service), Kevin Percy (Canadian Forest Service), and Alistair Rogers (Brookhaven National Laboratory). Dr. Mark Kubiske is an ex-officio member of the Steering Committee and coordinates science at the site. **Note:** Previous issues of the newsletter are available at the Aspen FACE web site <http://aspenface.mtu.edu>*

Retired Aspen FACE Principal Investigator Dr. Richard Dickson Visits Aspen FACE

Retired USFS Principal Tree Physiologist, Dr. Richard E. Dickson, visited Aspen FACE on July 26, 2006. Now living in southern Illinois on his family's old farmstead with his wife Carol, Richard was one of the original set of principal investigators who conceived and developed the Aspen FACE project. Richard had a wonderful eye for detail and spent days looking over the shoulders of our contractors during the construction of Aspen FACE, finding and correcting several problems before they jeopardized the experiment. An award-winning scientist who worked with the USFS for nearly his entire career, Richard is a walking encyclopedia of tree physiology and he still maintains his strong interest in our Aspen FACE project.



Rich International Culture at Aspen FACE

Aspen FACE continues to attract scientists from around the world. Pictured (L to R) are four international scientists including Joseph Darbah (Ghana), Markus Löw (Germany), Johanna Riikonen (Finland), and Johan Uddling (Sweden). Joseph Darbah is working on his Ph.D. degree with Dave Karnosky (MTU) and Mark Kubiske (USFS). He has been conducting gas exchange measurements and examining the impacts of the greenhouse gases on seed yields and seed quality. Markus Löw is working with Dave Karnosky and Neil Nelson (USFS) on ozone flux of two aspen clones. Johanna Riikonen has recently returned for her second year to Aspen FACE. She is examining stomatal frequency of birch trees growing in the various treatments. Johan Uddling has been working for the past few years with Dr. David Ellsworth (University of Michigan) on sap flow sensing for birch and aspen at Aspen FACE to examine the



impacts of these greenhouse gases on canopy level transpiration.

Thorsten Grams (Germany – below left) is examining various aspects of competition at Aspen FACE and will compare his findings at Aspen FACE with his previous results from beech and spruce experiments in Europe, including the famous Kronsberg Forest ozone project on mature trees.



Anu Sober (Estonia – right) returned this year for her 8th year at Aspen FACE. She is working with Dave Karnosky, Mark Kubiske and Neil Nelson on leaf level water dynamics for aspen and birch at Aspen FACE.

Carlo Calfapietra (Italy) is working with Tom Sharkey (UW-Madison) and Dave Karnosky on the molecular aspects of VOC emissions under our various greenhouse gas emissions. Carlo has extensive experience from the POPFACE experiment in Italy.



NRS Director Rains Visits Aspen FACE

U.S. Forest Service Northern Research Station Director Michael Rains and Assistant Directors, Bob Bridges and Tom Schmidt, toured Aspen FACE on August 22, accompanied by Aspen FACE Director Dave Karnosky (MTU) and Mark Kubiske, Neil Nelson, and Eric Gustafson of the Rhinelander Lab. The Northern Research Station encompasses the former North Central and Northeastern Research Stations and covers 20 states in the Midwest and Northeast, including the USDA Forest Service, Forestry Sciences Laboratory in Rhinelander.



Michael Rains, USFS NRS Director, visits the Aspen FACE project with USFS colleagues (L to R) Mark Kubiske, Bob Bridges, Neil Nelson, Tom Schmidt, Eric Gustafson, and David Karnosky.



Michael Rains, USFS NRS Director (left), and Neil Nelson, USFS Project Leader (right), listen to Mark Kubiske (USFS) discuss the logistics of CO₂ generation.



Michael Rains comments on the dense canopy in the elevated CO₂ ring. Leaf area index has remained above control levels over the 9 years of the experiment.

Recent Aspen FACE Tours



On October 3, 2006, U.S. Forest Service Deputy Chief Hank Kashdan toured the FACE site with Dr. Neil Nelson, USFS Project Leader and Aspen FACE Steering Committee Member, and Tom Schmidt, Assistant Director of the Northern Research Station.



On October 4, 2006, the Inter-Regional Ecosystem Management Coordinating Group (IREMCG) toured the FACE site, led by Drs. Mark Kubiske and Neil Nelson, USFS.

FIA Ozone Bioindication Workshop Held at Aspen FACE

The US Forest Service program Forest Inventory and Analysis (FIA) ozone bioindicator program collaborated with the FACE research staff to use the Harshaw facility for ozone injury training in July 2006. The FIA ozone bioindicator program conducts annual surveys to assess the amount and severity of ozone induced foliar injury on ozone-sensitive native species growing under field conditions and ambient exposures. Specimens, many collected locally, were grown in 40 liter pots filled with native soils and placed in either an ozone or a control ring in late June. Species included black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), green ash (*Fraxinus pennsylvanica*), common milkweed (*Asclepias syriaca*), spreading dogbane (*Apocynum androsaefolium*), Indian hemp (*Apocynum cannabinum*), blackberry (*Rubus alleghaniensis*), snowberry (*Symphoricarpos albus*) and big leaf aster (*Aster macrophyllus*). By late July, foliar injury symptoms were already being expressed on many species. All species, except aster, were displaying light to severe foliar injury in the ozone ring at the end of August. None of the potted specimens in the control ring exhibited ozone injury in 2006.

The Harshaw FACE site was an excellent training site for the FIA bioindicator survey staff who came from around the Great Lakes region and included Dr. John Witter, University of Michigan (third from right in photo below). Others who attended were: Jennifer Stoyanoff (U. Michigan), Paul Mueller (Lumberjack-Wisconsin), Gary Cummings (Minnesota DNR), Ed Jepsen (NC Region Ozone Coordinator-Illinois), Brent Hummel (USFS Missouri), Melissa Powers (Kansas Forest Service), Dr. William Lovett (Nebraska Forest Service-U. Nebraska), Aron Flickinger (Iowa DNR), and Dr. Mike Kangas (North Dakota).

In addition to the potted specimens, many of these species, plus elderberry (*Sambucus canadensis*), grow naturally within the rings. Harshaw provided FIA staff an opportunity to observe a range of ozone injury symptoms on a variety of bioindicator species under relatively realistic field conditions. (Story by Ed Jepsen - Wisconsin Department of Natural Resources Air Management Program – front center of photo)





Alistair Rogers Joins Aspen FACE Steering Committee

Dr. Alistair Rogers, a scientist in the Environmental Sciences Department, Brookhaven National Laboratory, has joined the Aspen FACE Steering Committee. Dr. Rogers has long studied the mechanisms that underlie whole plant and ecosystem responses to global change, with a focus on carbon and nitrogen metabolism. For the past three growing seasons, Dr. Rogers has examined aspen foliar biochemistry at Aspen FACE as a partner in the POPGENICS project. Dr. Rogers replaces Dr. George Hendrey whose early pioneering design work helped Aspen FACE get established. We all thank George for his tremendous contributions to Aspen FACE and we welcome Alistair to the Steering Committee.

MTU's Global Change Summer Teacher Institute Boasts Another Successful Year

Twenty-one teachers from California, Connecticut, Maryland, Ohio, Michigan, and Wisconsin attended a five-day summer institute titled "Global Change" this past summer at Michigan Tech University. The institute was hosted by MTU's Ecosystems Science Center and partially funded with an NSF grant. MTU faculty and research scientists Kurt Pregitzer, Andrew Burton, and Kate Bradley co-taught the course with Dr. Bill Holmes from University of Michigan and Dr. Erik Lilleskov of the USDA North Central Research Station Forest Sciences Lab. The institute was designed to prepare teachers to engage middle and high school students in a

real-world study of the effects of global change on ecosystems, including the impacts of climate change, elevated carbon dioxide and ozone levels, nitrogen saturation, acid rain, and invasive



species. The teacher participants spent a day touring the FACE research site, which proved to be a highlight of the week. Teachers had lots of positive things to say about the institute and the FACE field trip:

- * I liked listening to the experts and getting a ton of resources for my classroom.
- * The BEST! A great culmination to a lot of knowledge.
- * The field trip to the FACE site was absolutely fabulous! It was a great opportunity to see something like this that I never imagined could exist. Kurt's presentation was excellent and so interesting. It was great to see that research is being done to better understand effects of increased carbon dioxide and ozone on plants, but also to solve problems. (Story by Joan Schumaker Chadde, MTU)

Canopy-level Transpiration Study Calibrated

University of Michigan scientists, Drs. David Ellsworth and Johan Uddling (R), conducted calibrations of their Aspen FACE sap flow sensors for estimating canopy-level transpiration. The calibration was done on clone 271 aspen trees in an adjacent O₃ gradient study being conducted by Aspen FACE Director Dr. David F. Karnosky. The group also conducted birch calibrations with naturally occurring paper birch trees near the Aspen FACE rings. The team has been conducting canopy-level transpiration studies in conjunction with Dr. Mark Kubiske over the last several growing seasons. The work was largely supported by the U.S. DOE NIGEC Program.



University of Colorado Scientists Study VOC Emissions

Drs. Russell Monson (L in photo) and Todd Rosenthal (R in photo), University of Colorado scientists, spent two weeks in mid-July conducting an intensive VOC emissions monitoring campaign. They were joined by graduate students Nicole Trahan (photo below right) and Patrick Veres. The team set up an impressive array of equipment including a Proton Transfer Reaction (PTR) Mass Spectrometer and a Rapid Response Isoprene Sensor to analyze isoprene emissions. Aspen are large isoprene emitters in North America. This research is a collaborative effort with Dr. Thomas Sharkey, University of Wisconsin-Madison.



Another Successful USFS Respiration Campaign

Dr. John Hom, Assistant Director, USFS Northern Research Station Global Change Program – photo on left, and his crew recently completed another successful stem respiration campaign in mid-July at Aspen FACE. The team sets up a maze of wiring, tubing, and cuvettes at several heights for trees and collects their data from a custom-designed trailer work station. The system is unique in that the series of cuvettes allow for simultaneous and continuous respiration measurements for numerous trees and at several heights along the stem. John was joined by Dr. Steve Roberts, San Diego State University, and John's Technical Assistant Matt Patterson (center photo).



Ron Teclaw and Warren Heilman Receive Aspen FACE Recognition

Ron Teclaw and Dr. Warren Heilman (photo insert) (USFS) both received service awards at the December 6, 2005 Aspen FACE Annual Investigator's Meeting in Green Bay, Wisconsin. Ron and Warren have established and maintained the Aspen FACE micrometeorological network which was augmented tremendously in 2005 by equipment in all 12 Aspen FACE rings. The new equipment was purchased in part by the USFS and in part by the USDA NRI Program via Dr. John King's (North Carolina State University) competitive grant to study our site's water balance. Our micrometeorological network now generates something like 2,256,828 measurements per day from 1,032 micromet sensors. Ron (right in photo) is shown receiving his award from Aspen FACE Director David F. Karnosky (MTU).



Aspen FACE on Minnesota Public Radio

Bob Kelleher, Minnesota Public Radio, visited Aspen FACE scientists Drs. Neil Nelson (USFS) and Dave Karnosky (MTU) on July 11, 2006 for his story on “Forest experiments track causes and effects of global warming.” The story can be accessed at <http://minnesota.publicradio.org/display/web/2006/06/19/aspenwhiteface/>. This is Bob’s second story on Aspen FACE in the past four years. In the photos, Bob is shown interviewing Neil Nelson and taking photos in an Aspen FACE ring.



Infrastructure Changes at Aspen FACE

Michels Power from Appleton, Wisconsin has been awarded the bid to change the poles supporting the vertical vent pipes and the center poles in each Aspen FACE ring. We are replacing our existing 35 ft. poles with 65 ft. poles. To facilitate the work, Aspen FACE employees, Scott Jacobson and Tribin Holbrook, have been taking the vertical vent pipes down (photo top center) and the USFS team, led by Ron Teclaw, has been dismantling micrometeorological equipment from the poles. The pole replacement project team met at Aspen FACE on September 20, 2006 with Michigan Tech’s lead capital projects engineer Jim Heikkinen (photo top left). Weather permitting, the plan is to have all existing poles replaced by the middle of December, 2006. Scott and Tribin will then work through next spring to reinstall the vertical vent pipes in preparation for our May, 2007 startup.





Elevated Walkways Being Raised

Swager Communications, the contractors who originally designed and installed the elevated walkway system in each Aspen FACE ring, has been raising the walkways to allow continued access to the upper canopy of our trees. Don Swager (left) and his able crew has had to install additional support scaffolding, adjust walkway heights an average of 2 m, and install the ladder and climbing buddy systems to access the walkways. The project is progressing as scheduled and should be completed within a few weeks.

Editor's Note: Some walkways will be temporarily inaccessible during the work as additional ladder assemblies were needed.

2006 Measurements Campaign in Full Swing

The annual height and diameter measurements campaign is at full swing at Aspen FACE. All core trees in the experiment are measured each year and this is getting to be quite a challenge with trees in several rings being well over 10 m tall. This season's measurements crew is shown in the photo - L to R: Dave Karnosky (MTU), Anita Foss (USFS), Joseph Darbah (MTU), Ray Lange (USFS), Emmanuel Opuni-Frimpong (MTU), Paula Marquardt (USFS), JoAnne Lund (USFS), Ron Zalesny (USFS), Adam Wiese (USFS). Not shown: Dan Baumann and Bruce Birr (USFS).



Aspen FACE Featured at International Meetings

Dr. Kevin Percy (photo - CFS and Member, Aspen FACE Steering Committee) presented a talk entitled "Using multifactor global change experiments to answer big science questions" at the Ecological Society of America (ESA) meeting in Memphis, Tennessee on August 6-11, 2006. The presentation was coauthored by Dr. David Karnosky (MTU) and David Layzell (Queen's University, Ontario, Canada).

Drs. David Karnosky and Kevin Percy also jointly presented an invited talk entitled "Climate change, air pollution and carbon sequestration" at the IUFRO Research Group 7.01 22nd Biannual Meeting in Riverside, California on September 10-16, 2006. Ben Felzer (Woods Hole) was a coauthor. Joseph Darbah (MTU graduate student) presented a paper entitled "Impacts of [CO₂] and [O₃] on paper birch reproductive fitness" at the same meeting. Coauthors were Dave Karnosky, Mark Kubiske (USFS), Neil Nelson (USFS), Elina Oksanen (Univ. of Joensuu, Finland), and Elina Vapaavuori (Finnish Forest

Research Institute).

Dr. Anu Sober (University of Tartu, Estonia) presented a poster entitled "Diurnal and seasonal changes in transpiration, stomatal conductance, and hydraulic conductance in aspen and birch: The "Aspen FACE" (Free-Air CO₂ and Ozone Enrichment) study" at the American Society of Plant Biologists (ASPB) meeting entitled "The Biology of Transpiration: From Guard Cells to Globe" at Snowbird Mountain Resort, Utah on October 10-14, 2006. The presentation was coauthored by Joseph Darbah, Katre Kets (University of Tartu, Estonia), Johanna Riikonen (University of Kuopio, Finland), Neil Nelson, Mark Kubiske, and Dave Karnosky.

People at Aspen FACE



**Keith Lewin, Senior Research Engineer
Brookhaven National Laboratory**

Editors: What is your position at BNL?

Keith: My position title at BNL is Senior Research Engineer. My responsibilities include serving as the Principle Investigator on three DOE funded projects: Operations Management at the FACTS-1 FACE Research Facility at Duke University, Engineering and Operations Support to all FACE research projects, and Eddy-Covariance Flux Tower and Tracer Technology Support to the AmeriFlux Program.

Editors: What is your role in Aspen FACE?

Keith: John Nagy, who also works at BNL, and I were responsible for designing and specifying most of the control system hardware and software used at Aspen FACE.

We provide engineering and operations support to the Aspen FACE site operators, steering committee, and other researchers working at the site.

Editors: How long have you been involved in Aspen FACE?

Keith: I have been involved with Aspen FACE since we began working on the design in late 1995 or early 1996.

Editors: How does this study compare to the other FACE experiments you have been involved in?

Keith: Aspen FACE has the largest number of treatment plots, and has the most complex fumigation system, since we are fumigating with both CO₂ and O₃. It also has the most uneven canopy, which affects the spatial and temporal uniformity of the treatments. The control software and much of the hardware is identical to that at other FACE experiments BNL has designed, so many of the operations issues we see at Aspen FACE are similar to what we see at other FACE sites.

Editors: Did you ever expect to be looking at the second decade of these studies?

Keith: We have always designed the FACE systems to be long term research facilities. Some of our prior systems were used for agricultural crop studies which lasted for more than 10 years, so I am not surprised that a study following tree growth and development would continue into a second decade. The control hardware was selected with the expectation that the experiment would continue for 15 to 20 years.

Editors: What sorts of wear and tear do we need to be particularly careful with as we approach the start of our second decade at Aspen FACE?

Keith: After 10 years of operation, all components are showing their age to some extent. We need to closely monitor safety-related items such as pressure regulators, relief valves and piping to avoid any danger to site occupants and the environment. We also need to keep a watchful eye on the many analyzers and sensors in use around the site. Many researchers, and ultimately national and international policy decisions, will rely on the information these instruments provide, so we have to make sure they continue to provide accurate information as they age.

Editors: Have there been any unusual problems to diagnose at Aspen FACE?

Keith: Field installations seem to lend themselves to unusual problems, and troubleshooting a system as complex as Aspen FACE from 1,500 miles away is always a challenge. One of the more memorable problems I had to diagnose at Aspen FACE was the sudden loss of CO₂ flow to one plot, with no obvious cause and no problems at any of the other plots. After we had eliminated all of the "normal" reasons for a flow restriction, the only plausible explanation left was the presence of a foreign object in the CO₂ supply line leading to that plot. The CO₂ supply lines had been sealed for 8 years, and had by this time carried thousands of tons of food-grade CO₂, so we couldn't imagine what could still be in the pipe that would be large enough to restrict the CO₂ flow and strong enough to resist the 200 psi pressure trying to push it through the regulator. When Jaak removed the regulator, he found a piece of corrugated cardboard lodged against the inlet. Our only explanation is that it either was left in the pipes when the system was assembled and took that many years to work its way down to a point where it caused a problem, or that it had been introduced into the sealed system along with a load of CO₂. If it was the latter, you have to wonder what makes it into the carbonated beverages we drink, because the soda and beer companies use the same quality of CO₂ as we do at Aspen FACE.

Editors: What has been your biggest challenge with Aspen FACE?

Keith: My biggest challenge with Aspen FACE has been to understand and remotely troubleshoot the ozone supply system. We do not use O₃ at any other FACE site supported by BNL, and there are unique issues with measuring, producing, distributing, and controlling ozone, a gas that cannot be stored, reacts with many materials, including itself, and is toxic to humans and plants at parts per billion concentrations. You always have to be thinking about unforeseen consequences of your design and operations decisions. There is little room for error, and so many things that can go wrong.



David "Daver" B. Karnosky
Michigan Technological University

Editors: How long have you been involved with Aspen FACE?

Daver: I have probably been involved almost since the conception of the idea. Actually, I think it was the summer of 1996, when my dad asked me to come down to help him with the initial setup of the site, so I think that basically counts as since the beginning.

Editors: What sorts of activities have you been involved with in Aspen FACE?

Daver: You know, I've done a little bit of everything. One of the first memories I have was when Wendy Jones (MTU Site Operator) and I brought the walkways out to the rings and installed them. I think we'd been at it for about an hour, and my dad came over with this scowl on his face because it didn't appear that we had moved very many pieces of the walkway yet. We stopped what we were doing, and told him that the pieces were really quite heavy. He gave us this funny look, and told us that we needed to pick up the pace. We told him he should try moving one of these. He lifted one with our help, and then realized we weren't lying about the weight. Even with his help, it still took most of the day to get all of the pieces moved to the rings. I believe we broke the bed of one of the MTU vans that day.

When we realized that the plenum pipe was really too big to step over several times a day, Asko Noormets (former MTU Graduate Student) and I built steps for them. Asko and I also rebuilt one of the sheds after it burned down. Scott Jacobson and I cut the original slits in the vertical vent pipes in most of the rings. I believe that I dug the holes for at least half of the trees that were planted in the rings with a chainsaw-auger, and I also planted some those trees as well as part of a team of MTU and UW-Madison students. I've also done some of the weed and pest control by mowing and backpack-spraying. I also was an operator for a couple of months one summer. Scott also had me helping a bit with some of the troubleshooting when I was doing the operating, but I wasn't quite as proficient with that.

I've also done quite a bit of sample collection work as well. Mostly, in those cases, I was just a grunt carrying tools and such. Nowadays, I maintain the Aspen FACE and the POPGENICS web sites and analyze fisheye photos to determine the LAI.

Editors: You have been involved in Air Pollution Workshops and IUFRO Air Pollution meetings with A/V activities. How did you get involved with that and how do you like doing this work?

Daver: I think that it was the IUFRO meeting that MTU hosted in 2000 when I first got heavily involved in the A/V work, as my dad asked me to help out. I had a great time pulling my hair out while trying to keep everything running smoothly for that meeting. Then, in 2004, my dad again asked me to do the A/V work for the Air Pollution Workshop he was hosting in Rhinelander, Wisconsin, USA. Again, I had a blast meeting interacting with all of these scientists and students from all over the world. In the last two years, I worked as the A/V tech at the Air Pollution Workshops in Banff, Alberta, Canada and in Charlottesville, Virginia and at the IUFRO meeting at Riverside, California. Next spring, I have been asked to help out with A/V and web site development for the Guadalajara, Mexico Air Pollution Workshop.

Facilitating A/V with such diverse groups as these can be a real challenge, as scientists from developing countries often have older or sometimes more primitive software and hardware, such as floppy discs or zip discs, which can be a lot of work to try to accommodate. Also, some countries' software often has formatting differences with our equipment which can also be a chore to decipher, let alone get to function properly.

I also enjoy "flying under the radar" as the A/V tech as no one really notices you when things go well, and everyone is able to focus on the science at hand. Of course, there's always something that needs my attention.

Editors: What are you planning to do after graduation?

Daver: Well, first I have to graduate before I worry about that, but seriously, I hope to get into a high school teaching position either Mathematics or English, or both, somewhere. I haven't really figured out where I want to be yet, but I'll worry about that when I get there. I really would also love to land a job coaching either hockey, golf or both at the high school level, as well.

Aspen FACE Publications in Development:

- Holmes, W.E., D.R. Zak, K.S. Pregitzer, and J.S. King. 2006. Elevated CO₂ and O₃ alter soil nitrogen transformations beneath trembling aspen, paper birch, and sugar maple. *Ecosystems* (In Press).
- Karnosky, D.F., J.M. Skelly, K.E. Percy, and A.H. Chappelka. 2006. Perspectives regarding 50 years of research on effects of tropospheric ozone air pollution on U.S. Forests. *Environmental Pollution* (In Press).
- Karnosky, D.F., H. Werner, T. Holopainen, K. Percy, T. Oksanen, E. Oksanen, C. Heerd, P. Fabian, J. Nagy, W. Heilman, R. Cox, N. Nelson, and R. Matyssek. 2006. Free-air exposure systems to scale up ozone research to mature trees. *Plant Biology* (Submitted).
- Kubiske, M.E., V.S. Quinn, P.E. Marquardt, and D.F. Karnosky. 2006. Effects of elevated atmospheric CO₂ and/or O₃ on intra- and interspecific competitive ability of aspen. *Plant Biology* (In Press).
- Majdi, H., K. Pregitzer, A-S. Morén, G.I. Ågren. 2006. Fine root turnover in forest ecosystems. *Plant and Soil* (In Press).
- Percy, K.E., M. Nosal, W. Heilman, T. Dann, J. Sober, A.H. Legge, and D.F. Karnosky. 2006. New exposure-based metric approach for evaluating O₃ risk to North American aspen forests. *Environmental Pollution* (In Press).
- Pregitzer, K.S., D.R. Zak, W.M. Loya, N.J. Karberg, J.S. King, and A.J. Burton. 2006. The contribution of root systems to biogeochemical cycles in a changing world. In: Z. Cardon, J. Whitbeck (eds.), *The Rhizosphere – An Ecological Perspective*. Elsevier, Amsterdam (In Press).

Editor's Note: While working at Aspen FACE this past summer, Markus Löw (Technical University of Munich, Germany) took the panoramic photo below which nicely captures the large size of the Aspen FACE experiment. Thanks! Markus.

