STATEMENT OF

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Good morning Mr. Chairman and other Members of the Committee. I am Dr. Paul J. Hanson. I hold the position of Distinguished Research and Development Scientist at Oak Ridge National Laboratory. I also serve as the Chief Scientist for the Department of Energy's Program for Ecosystem Research. I appreciate the opportunity to discuss the Department of Energy, Office of Science's support for environmental research.

My comments will (1) highlight advances in climate change science gained through past and current support of terrestrial ecosystem research, (2) summarize conclusions of the scientific community about the need for next-generation experiments and measurements, and (3) describe the importance of the DOE National Environmental Research Parks as a protected land resource.

The Office of Science is an essential supporter of fundamental research for understanding environmental effects associated with the application and use of energy technologies. Recent research in this area has focused on developing an understanding of how climatic and atmospheric changes can modify the form and function of terrestrial ecosystems.

Office of Science research has clarified and quantified the dominant role of the terrestrial carbon cycle in moderating atmospheric greenhouse gas concentrations. This achievement has been accomplished through sustained support of landscape-scale carbon, water, and energy exchange measurements in important global biomes.

The Office of Science also encourages and enables large-scale innovative experiments operating over multiple years. Long-term support of elevated carbon dioxide (CO_2) exposure studies in a range of ecosystems is one example. Those studies have demonstrated enhanced terrestrial carbon uptake into both plant biomass and soil carbon pools. The uptake capacity is reduced, however, when nutrient limitations or water stress become key constraints. Terrestrial components of the global carbon cycle must be known to calculate fossil fuel use impacts on global greenhouse gas accumulation in the atmosphere.

Long-term and large-scale precipitation manipulations designed to induce severe drought have revealed a tremendous contrast between the resilience of trees in wet eastern ecosystems and the vulnerability of trees in dry western environments.

Warming studies, both completed and ongoing, demonstrate a complex mixture of responses, including extended annual growth periods and enhanced nutrient mineralization resulting in increased plant growth. Such arguably beneficial responses are contrasted with warming-induced losses of important greenhouse gases to the atmosphere (CO_2 and methane) and the acceleration of drought conditions.

The Office of Science has also pioneered studies to apply state-of-the-science technologies, molecular analyses, and genetic methods to the evaluation of ecosystem-scale responses to climatic and atmospheric changes.

Notwithstanding progress to date, new and more complex research is still needed to improve our understanding of fundamental mechanisms surrounding carbon release from long-term biological storage pools and the vulnerability of species in the face of rapid climate change. The absence of such mechanisms within ecological models undermines our current ability to provide policy-relevant predictions of both climate change impacts and future greenhouse gas trajectories from those ecosystems.

Long-lived organisms and virtually all ecological communities that we recognize today will experience unique climates in the future. Therefore, controlled experiments, which allow us to manipulate a wide range of environmental conditions, are the preferred method for characterizing ecosystem responses and feedbacks.

Recent scientific committees and workshops concluded that available experimental data are insufficient to address the complexity of climate change impacts and feedbacks associated with terrestrial ecosystems (e.g., Dickinson et al. 2008, Ehleringer et al. 2006, Hanson et al. 2008, NRC 2007). Existing studies have not used a sufficiently wide range of temperatures and CO_2 concentrations, nor have multi-factor manipulations been attempted in key ecosystems.

Important environmental drivers to be studied in new combinations and at multiple treatment levels include temperature, water availability, atmospheric CO_2 concentration, and rising sea level in the case of low relief, coastal ecosystems. The scientific community has concluded that future experiments will be most realistic and useful if they are (1) conducted at ecosystem scales; (2) address multi-factor environmental changes; (3) include multi-level treatments; and (4) integrate with process modeling during conceptualization, operation, and following the completion of experiments.

New research to understand climate change impacts must be conceptually relevant to many ecosystems, and therefore provide mechanistic outputs translatable across ecosystems. New research on carbon cycle feedbacks from ecosystems should prioritize spatially extensive high-latitude ecosystems and tropical forested regions with a correspondingly large potential to impact the Earth's climate (e.g., boreal and arctic biomes, and wet tropical forests of Latin and South America, Africa, and southeast Asia).

The DOE National Environmental Research Parks are distributed across the United States in a wide variety of ecosystems, from deciduous and pine forests in the east to arid ecosystems in the west. These research parks provide protected land areas appropriate for conducting climate change manipulations and for measuring ecosystem functions under changing environmental conditions. DOE-managed federal lands represent an important resource for research. For example, the National Ecological Observation Network of the National Science Foundation has identified the Oak Ridge Reservation as a core wild land site for their planned long-term measurements of environmental change. Long-term observations of pine mortality on the Los Alamos Reservation have also provided insights into plausible climate change implications (i.e., drought exacerbated under climate change may force mortality of important species).

Several globally extensive biomes associated with priority carbon cycle feedback questions (defined above) are not, however, represented within DOE's NERP network. In those cases, it will be necessary for DOE to partner with other land owners (such as other federal agencies, states, and private landholders) to develop and conduct the necessary experiments and measurements to advance the science of climate change.

To conclude:

By funding multidisciplinary science at national laboratories and universities, the DOE Office of Science plays a dominant role in the support of terrestrial ecosystem studies to understand the fate and function of global land surfaces and their role in the Earth system. The scientific community looks to the Office of Science for guidance and necessary support to enable complex next-generation experiments and measurement systems.

Only through the development of an integrated understanding of multiple, interacting environmental effects can the scientific community generate appropriate prognostic models to inform Congress and the public about the capacity of our ecosystems to provide goods and services for society under projected rapid rates of climate change.

Thank you for the opportunity to provide testimony. I am pleased to answer any questions.

<u>References:</u>

Dickinson RE, Meehl GA, et al. (2008) *Identifying Outstanding Grand Challenges in Climate Change Research: Guiding DOE's Strategic Planning*. A report of the DOE/BERAC Workshop, 25–27 March 2008, Crystal City, Virginia available at http://www.sc.doe.gov/ober/berac/Grand_Challenges_Report.pdf

Ehleringer J, Birdsey R, Ceulemans R, Melillo J, Nösberger J, Oechel W, Trumbore SE (2006) *Report of the BERAC Subcommittee Reviewing the FACE and OTC Elevated* CO_2 *Projects in DOE*. White paper report submitted to the U.S. Department of Energy, 16 October 2006, 23 p. available at http://www.sc.doe.gov/ober/berac/FACE_2006_report.pdf

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National Research Council of the National Academies (NRC) (2007) *Understanding Multiple Environmental Stresses: Report of a Workshop.* Committee on Earth-Atmosphere Interactions: Understanding and Responding to Multiple Environmental Stresses, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies, The National Academies Press, Washington, D.C., 142 p.

DOE WWW Resources:

- DOE, Office of Science
  - http://www.sc.doe.gov
- Climate and Environmental Sciences Division
  - http://www.sc.doe.gov/ober/CCRD_top.html
- Program for Ecosystem Research (PER)
  - http://www.sc.doe.gov/ober/CCRD/per.html
- Terrestrial Carbon Processes (TCP) program
  - http://www.sc.doe.gov/ober/CCRD/tcp.html
- National Environmental Research Parks
  - http://www.nerp.ornl.gov/index.html
- National Ecological Observatory Network (NEON)
  - http://www.neoninc.org/domains/appalachians

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