Eastern Deciduous Forest Responses to Climatic Change Drivers: An Upland-Oak Forest Case Study

Paul J. Hanson,[1] Stan D. Wullschleger,[1] and Jeffrey S. Amthor [2]

[1]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

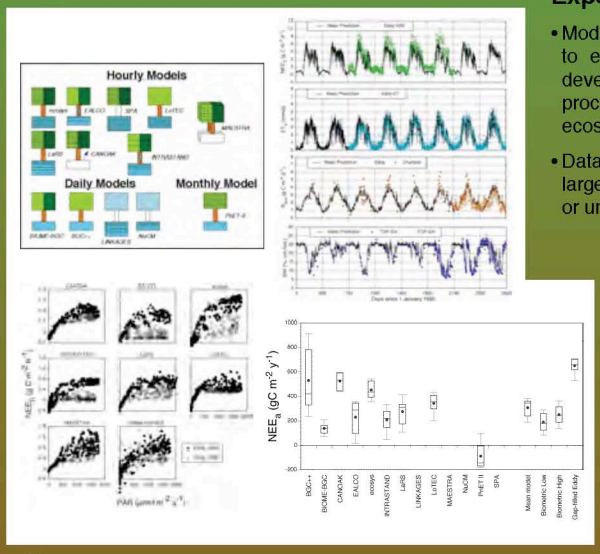
[2]U.S. Department of Energy, Office of Science, Germantown, Maryland

Introduction

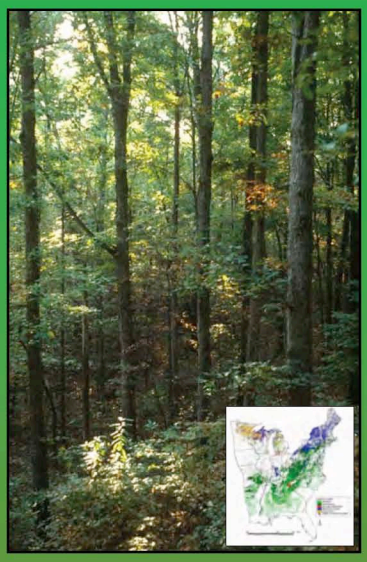
- Mechanistic ecosystem models represent the scientific community's primary method for evaluating complex multi-scale responses to climatic change and are the logical tool for testing hypotheses about ecosystem responses to specific scenarios of change.
- In this poster we provide examples of the abilities and limitations of ecosystem models to handle current environmental variations for upland-oak forests of the eastern United States and discuss their use for predicting forest responses to future climatic conditions.

Inter-model Comparisons

- Current ecosystem models for deciduous forests are equipped to reproduce short-term physiological responses for average historical environmental conditions, but have more difficulty capturing responses to past extremes (e.g., severe drought).
- An ensemble mean of multiple model outputs was shown to produce robust near-term predictions for a case-study upland-oak forest, and such an approach is likely to benefit model simulations conducted in support of other decision making processes.



Reference:
Hanson PJ, Amthor JS, Wullschleger SD, Wilson KB, Grant RF, Hartley A, Hui D, Hunt ER Jr., Johnson DW, Kimball JS, King AW, Luo Y, McNulty SG, G. Sun, P. Thornton PE, Wan S, Williams M, Baldocchi DD, Cushman RM (2004), Oak forest carbon and water simulations: model intercomparisons and evaluations against independent data. *Ecological Monographs* 74(3):443-489.



Upland-Oak Forests

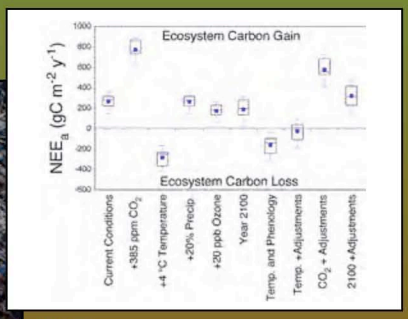
- The upland-oak forest of Walker Branch Watershed in eastern Tennessee and associated vegetation have been studied and modeled in the context of climatic change.
- The experimental site and vegetation are representative of temperate deciduous forests that comprise about 40% of current forest lands in the United States. Such forests are among the most productive natural ecosystems, store substantial amounts of carbon, are a key source for steady supplies of clean water, are a repository of plant biodiversity, and provide important habitat for a wide range of animals.

Ecosystem Modeling Needs

- Although many models have been developed to simulate carbon, water, and energy exchange between forests and the atmosphere, comparatively few mechanistic models are equipped to simulate long-term productivity changes and mortality patterns that are of primary interest to decision makers.
- Models designed to predict plant succession typically have insufficient mechanistic rigor to incorporate the key physiological adjustments by plants and ecosystems revealed from experimental work.

Experimentally Informed Modeling

- Model simulations are only as good as experimentally derived knowledge of plant and ecosystem responses to environmental change. The ability of plants to acclimate to environmental change over time, the development of internal feedbacks from biogeochemical cycles, and changes in the seasonality of ecosystem processes all represent indirect, experimentally observed responses that must be incorporated into ecosystem models.
- Data for an upland-oak forest indicated that existing model codes need to incorporate "lessons learned" from large-scale experimental manipulations of temperature, elevated CO_2, ozone, and precipitation to avoid over- or under-predictions of long-term ecosystem responses.



Reference:
Hanson PJ, Wullschleger SD, Norby RJ, Tschaplinski TJ, Gunderson CA (2005) Importance of changing CO_2, temperature, precipitation, and ozone on carbon and water cycles of an upland oak forest: incorporating experimental results into model simulations. *Global Change Biology* 11:1402-1423.

Summary

- A key goal of the U.S. Climate Change Science Program is to understand the potential consequences of global change for ecological systems. Few ecosystems, however, have been adequately studied in sufficient detail to derive policy-relevant conclusions directly from experimental data.
- Results from experiments and modeling of upland-oak forests indicate that ecosystem forecasts relevant to decision making must include relevant process information and be based on rational scenarios of future climatic change if they are to logically address effects of future environmental changes.

Acknowledgments

Funding for this work was provided by the U.S. Department of Energy (DOE), Office of Science, Biological and Environmental Research (BER), as a part of the Program for Ecosystem Research (PER) and the Terrestrial Carbon Processes (TCP) Program. Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for DOE under contract DE-AC05-00OR22725. This project addresses research needs and questions outlined in Chapter 8 (Ecosystems) of the 2003 Strategic Plan of the U.S. Climate Change Science Program.