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Title: Sean Michaletz Directors Post Doc Fellow Report

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Sean Michaletz Directors Post Doc Fellow

Abstract

Predicting climate change effects on plant function is a central challenge of global change biology and a primary mission of DOE. Although increasing temperatures and drought have been associated with reduced growth and increased mortality of plants, accurate prediction of such responses is limited by a lack of process-based theory linking climate and whole-plant physiology. This inability to predict forest mortality can cause significant biases in climate forecasts. One way forward is metabolic scaling theory (MST), which proposes that physiologic rates – from cells to the globe – are governed by the rates of *resource distribution* through vascular networks and the kinetics of *resource utilization* by metabolic reactions. MST has traditionally not considered rates of *resource acquisition* from organism-environment interactions, but it has an ideal mechanistic basis for doing so. As a first step towards integrating these processes, Sean has extended MST to characterize effects of temperature and precipitation on plant growth and ecosystem production. Sean's post doc fellowship aimed to address a remaining shortcoming in that the new theory does not yet consider the physical processes of resource acquisition, and thus cannot mechanistically predict plant performance in a changing climate.

Background and Research Objectives

Sean developed and evaluated a new MST for predicting climate change effects on plant function from individual to global scales. He extended the MST to include physical processes of vascular network hydraulics, leaf heat transfer, and leaf photosynthesis, which together control the acquisition rates of key metabolic resources in plants. The theory was evaluated and refined using plant growth, mortality, and resource flux data from two DOE water and temperature manipulation experiments and the new DOE Next Generation Ecosystem Experiment-Tropics. Next, the theory was parameterized with existing climate and plant trait data to predict plant performance for evaluation against globally-distributed data obtained from an independent literature review. Data-based sensitivity analyses was used to identify key plant traits that mediate plant responses to temperature and drought. Ultimately the theory will be used with the DOE's next generation Earth System Model ACME to forecast climate change effects on plant performance and feedbacks.

Scientific Approach and Accomplishments

Sean collected combinations of photosynthesis temperature response, leaf thermal traits, thermal IR camera leaf temperature time series, and cellulose d18O samples at multiple sites spanning very diverse ecosystems. Field data collection was undertaken at sites including DOE BER SUMO experiment at LANL; Rocky Mountain Biological Laboratory, Colorado; Moxi, China; DOE BER NGEE Tropics; and NSF/DOE BER Sevilletta National Wildlife Refuge. Sean is currently processing these data to inform the improvement of the MST.

Sean has been co-mentor and collaborator of Zhenhong Xu, PhD student from Fudan University in China who was at LANL working with LANL staff scientist Chonggang Xu. Sean coached this student on scaling analyses of global wood decomposition rates, and helped write a manuscript which has been submitted to Nature (and appears to be under review).

While at LANL Sean submitted five co-authored grant applications to NSF-DEB and one co-authored application to DoD/EPA/DOE, and was a reviewer for an application to National Science Foundation – Division of Environmental Biology. Sean also reviewed over 27 submissions to peer reviewed journals along with 1 book chapter. He gave 10 invited presentations, and submitted 20 papers to peer reviewed journals.

Impact on National Missions

This research integrates for the first time the key mechanisms governing acquisition, distribution, and utilization of metabolic resources by plants. The result is a general, process-based theory for understanding and predicting climate change effects on plant performance at multiple scales, from cells to the globe. This theory substantially improves our ability to predict future vegetation dynamics and their feedbacks to climate, and integration of the theory with DOE-ACME earth system model will contribute substantially to DOE's mission for future climate prediction.