GRAHAM SUSTAINABILITY INSTITUTE
UNIVERSITY OF MICHIGAN

Catalyst Grant Final Project Report

Project title

Modeling Socio-ecological Adaptation to Climate Change in Temperate Forests

Project team

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Summary

Our interdisciplinary team of researchers from social and natural science and engineering fields investigated the following *actionable question*: **How can information about human behavior improve climate impact models to inform decision-making regarding adaptation**? A critical first step in investigating this question was identifying knowledge gaps and information needs. We pursued the following objectives: (1) inventory the various ways that humans have been represented in models of climate impacts on terrestrial ecosystems; (2) evaluate these approaches for their potential application in forest systems; and (3) assess climate impact information needs among land management and socio-economic development organizations and agencies that seek to assist forest managers and forest-dependent communities with adaptation planning. We pursued these objectives by synthesizing published research and research-in-progress and by engaging decision-makers in discussions of current and potential future information needs. Our geographic focus was the U.S. Great Lakes and Pacific Northwest regions, where sophisticated downscaled climate models project increasing wildfire, insect, disease, storm and drought-related stress in forests due to shifts in precipitation and temperature.
Our research team has *expertise from multiple disciplines*, including natural resource sociology, environmental policy, landscape ecology, engineering and climate science. We represent multiple units at University of Michigan including the School of Natural Resources and Environment, Department of Climate and Space Sciences and Engineering and Department of Industrial Operations Engineering (Co-PI). The Northern Institute of Applied Climate Science (NIACS) was our *engaged partner.* NIACS is a multi-institutional entity that builds partnerships, facilitates research, and synthesizes information to bridge the gap between climate science research and the information and management needs of land owners and managers, policymakers, and members of the public.

Project background and approach

Climate change is one of the world's most pressing challenges, one that will require society to adapt to new and in some cases more hazardous environmental conditions. Forests, which provide critical goods and services to society, will be greatly affected by changes in global precipitation and temperature patterns. The temperate forest biome is of particular concern. In recent years increasing temperatures, drought, insects and diseases, and uncharacteristically large wildfires have caused disturbances in temperate forests across North America, Europe, South America and southern Australia, resulting in forest diebacks beyond the range of what was seen during the last century (Millar & Stephenson, 2015). These so-called "megadisturbances" are expected to worsen under future climate change, releasing large amounts of carbon into the atmosphere, exacerbating human health problems (e.g., asthma) and degrading ecosystem goods and services. As temperate forests occupy approximately 40% of the land area in the countries where they are found, many people will be affected.

Forest management and land use decisions by humans will interact with climate-driven change, exacerbating or ameliorating hazards and risks. However, despite substantial investments in modeling

global climate change and local vegetation response, little work has been done to incorporate knowledge about human influences into models of climate impacts on forests to date. For example, terrestrial biosphere models use climate-change scenarios of biophysical variables to simulate carbon responses driven by plant ecology, phenology, physiology, and biogeochemistry. For human-dominated regions, however, this approach has important and well-known shortcomings. People will modify forest, farm and other land management and land use practices in response to climate change and these responses will interact with ecosystem functions. The ultimate spatial patterns and temporal trajectories of land-atmosphere carbon exchange will depend on combinations of ecological responses and responses by the humans who manage the landscape. Interdisciplinary research that combines ecological dynamics with human behavior is greatly needed to improve models that project climate-related changes to inform long-term forest management and socio-economic development plans.

Our project investigated how information about human behavior can improve climate impact models to inform decision-making regarding adaptation through three objectives:

1. Inventory the various ways that humans have been represented in models of climate impacts on terrestrial ecosystems
2. Evaluate these approaches for their potential application in forest systems
3. Assess climate impact information needs among land management and socio-economic development organizations and agencies that seek to assist forest managers and forest-dependent communities with adaptation planning.

Our project is *advancing scholarship* by contributing to conceptual and quantitative models of human-natural system interactions in the context of changing climate and methods for projecting climate impacts that derive from both human behavior and biogeophysical processes. Understanding adaptation behavior among land managers is especially important because it is through land management actions that adaptation policies shape ecological conditions. Improved models will increase decision-makers' abilities to anticipate how people may modify land management and land use practices in response to climate change and shape these responses with policy. The primary potential societal impact of our research is that it will enhance knowledge and methods for investigating how humans may modify forest, farm and other land management and land use practices in response to climate change, and how these responses will interact ecosystem responses. This knowledge is critical for promoting the sustainability of ecosystem goods and services and minimizing impacts of climate change on society. This knowledge is also needed to inform policy to facilitate human adaptation to climate change.

Outputs

Our project resulted in several outputs that contribute to scholarly work and support decision-making:

1. Our first output was an annotated bibliography of published and in-progress efforts to incorporate human behavior to models of climate impacts.
2. Our second output was a typology of methods for projecting climate impacts that incorporate information about human behavior and that may be suitable for forest systems.
3. Our third output was a preliminary set of climate change projection needs identified by the organizations and agencies we engaged in discussions.

Outcomes

The outputs of our project will contribute to several positive changes, or outcomes, in the area of climate change adaptation:

1. Our work will enhance understanding of decision-makers' information needs regarding climate impacts on forests and how these needs can be addressed with more sophisticated models that incorporate human behavior.
2. Already, this improved understanding is helping our research team develop a set of informed research questions and objectives to guide the development of a longer-term research project on climate change and human response in forest systems.
3. Another outcome has been the collaborative relationship that we have developing with NIACS that we anticipate will lead to socially-relevant climate research on in the future.

Findings

1. In our annotated bibliography of published and in-progress efforts to incorporate human behavior to models of climate impacts (Output 1) we identified 17 examples of climate impact models that integrate human behavior. We paid special attention to research on behaviors that land managers engage in to respond to climate change and how these behaviors interact with climate impacts across space and time. To identify source material for the bibliography, we solicited input from scholars with expertise that spanned diverse fields of research related to climate and vegetation modeling. We supplemented bibliographic information with standardized summaries of 1) the objective (e.g., research questions) related to modeling efforts documented in the publication; 2) the specific modeling approaches used; 3) how human behavior was incorporated in the climate impact models; and 4) the study system.
2. In our typology of methods for projecting climate impacts that incorporate information about human behavior and that may be suitable for forest systems, we identified two broad categories of models, and four specific types of models. Our summary report of the annotated bibliography identifies the shared themes (e.g., common modeling approaches) as well gaps in published research on climate impact models that incorporate human behavior that could be incorporated into subsequent versions of the typology as the literature expands.
3. Our preliminary set of climate change projection needs identifies gaps in information that practitioners would like from models. We created a database of researchers and research groups involved in relevant projects and long-term initiatives, conducted phone interviews with 11 of these individuals to gather information about their climate projection needs (Output 3). We are currently analyzing the transcripts of these interviews and synthesizing insights from the interviews with the typology of methods for projecting climate impacts, as part of the development of a “Perspectives”-style research paper that will be submitted towards the end of the fall.

References

Millar, C. I., & Stephenson, N. L. (2015). Temperate forest health in an era of emerging megadisturbance. *Science, 349*(6250), 823-826. doi:10.1126/science.aaa9933

Evaluation

The project was successful in producing the three anticipated outputs. Although the outcomes will take longer to realize, the bibliography and typology will have immediate use in the background section of a grant proposal that the team plans to develop, and the inventory of practitioners needs will inform the broader impacts that we will propose to achieve in that proposal. We also shared the bibliography and typology with the practitioners we interviewed about their information needs.

We found that the field of modeling climate impacts in ways that represent human behavior is underdeveloped. Published works documenting such efforts were scarce, as were efforts in progress. Perhaps for this reason, we were not as successful as we had hoped consulting with scholars about how to refine our typology in the organized conference session. Only two scholars showed interest in participating the organized session at the International Symposium on Society and Natural Resources in Sweden in June and only a handful of scholars were interested in meeting at the Resilience Alliance conference in Sweden in August. We expect to receive more constructive feedback on the typology at future paper presentations and through reviews of our manuscript submission.