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The future of US forest function under changing environment, disturbance, and forest management

Christina Staudhammer, William Kleindl, Chiung-Shiuan Fu, Ankur Desai, Michael Dietze, Paul Duffy, Matthew Marsik, Christy Rollinson, Courtney Schultz, Greg Starr, and Paul Stoy
(cstaudhammer@ua.edu)

Managed forests play an important role in global biogeochemical and carbon cycling, and management practices influence forest structure and productivity, as well as climate, hydrology, and biodiversity. However, while forest management is one of the most extensive and continual drivers of ecosystem dynamics, little is known about how forest management decisions influence forest ecology across regional to continental scales. We seek to expand understanding of these mechanisms across the United States by answering the question: What is the relative importance of management, climate, disturbance and edaphic factors in determining change in forest ecosystem composition, structure, and function across scales from stands to the continent?

In a first phase of this project, we mapped management approaches across forests of the US Southeast and Pacific Northwest and modified the Ecosystem Demography 2 (ED2) Model to generate estimates of C, water, and forest structure characteristics under various management and climate scenarios. This initial phase used two large forest domains with different forest structure, disturbance, climate and management regimes: the Southeastern US [SEUS] and US Pacific Northwest [PNW].

We used datasets on land cover, forest change and disturbances, linking ownership and management with historical trends in phenology of forests subject to different management approaches. A Random Forest classifier was built to classify management types using both Spectral Entropy calculations and a summarized output data stack from Breaks For Additive Season and Trendanalysis (BFAST) of MODIS Enhanced Vegetation Indices. Using a 10-fold cross validation method), the SEUS map had 89% overall accuracy, while the PNW map 91% overall accuracy.

Theoretical frameworks related to the modeling of management and disturbance at large spatial scales were added to ED2. To improve computational efficiency, a new approach was derived to represent spatially extensive disturbances (management, fire, pests) as a spatially implicit process by modeling not just the fractional area of different land cover classes but also a matrix describing their probabilities of adjacency. This new approach showed that the adjacency information could be used to propagate spatial disturbances, and that the adjacency matrix could be dynamically updated. We also developed a generalisable approach to represent forest insects and pathogens (FIPs) by aggregating FIP species into functional groups based on their impacts on plant ecophysiology. To support management in ED, we developed a functional type framework for regionally-specific forest management practices.

This allowed us to answer questions about the interaction of climate, management, and disturbance at regional scales, analyze non-linear scaling of these interactions, and contribute to theories linking forest structure to function at the macroscale. Adoption of these mechanisms into earth systems models by incorporating forest management and disturbances into a scalable model will allow for better predictions of the effects of changing management policy, disturbance regimes, and climate on forests across the continental US.