Taking the Pulse of Mountains: Ecosystem Responses to Climatic Variability

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Abstract:

An integrated program of ecosystem modeling and field studies in the mountains of the Pacific Northwest (U.S.A.) has quantified many of the ecological processes affected by climatic variability. Paleoecological and contemporary ecological data in forest ecosystems provided model parameterization and validation at broad spatial and temporal scales for tree growth, tree regeneration and treeline movement. For subalpine tree species, winter precipitation has a strong negative correlation with growth; this relationship is stronger at higher elevations and west-side sites (which have more precipitation). Temperature affects tree growth at some locations with respect to length of growing season (spring) and severity of drought at drier sites (summer). Furthermore, variable but predictable climate-growth relationships across elevation gradients suggest that tree species respond differently to climate at different locations, making a uniform response of these species to future climatic change unlikely. Multi-decadal variability in climate also affects ecosystem processes. Mountain hemlock growth at high-elevation sites is negatively correlated with winter snow depth and positively correlated with the winter Pacific Decadal Oscillation (PDO) index. At low elevations, the reverse is true. Glacier mass balance and fire severity are also linked to PDO. Rapid establishment of trees in subalpine ecosystems during this century is increasing forest cover and reducing meadow cover at many subalpine locations in the western U.S.A. and precipitation (snow depth) is a critical variable regulating conifer expansion. Lastly, modeling potential future ecosystem conditions suggests that increased climatic variability will result in increasing forest fire size and frequency, and reduced net primary productivity in drier, east-side forest ecosystems. As additional empirical data and modeling output become available, we will improve our ability to predict the effects of climatic change across a broad range of climates and mountain ecosystems in the northwestern U.S.A.