Genecological Responses in Western Conifers to Climate Changes Over the Past Two Millennia

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Vegetation changes in western North American mountains are assumed to shift up and down in elevation in response to climate change. In addition, local populations are assumed to be optimally adapted to their environments. We review these assumptions in light of recent analyses of forest tree responses to climate changes over the past two millennia.

First, we analyzed well-preserved downed deadwood at 3000 m on Whitewing Mountain in the eastern Sierra Nevada. These were dated to 800-1350 CE and comprised whitebark, western white, sugar, Jeffery, and lodgepole pines, and western hemlock. Excepting whitebark pine, these species are currently 200 m or more lower in elevation; sugar pine is not locally native. Using the joint overlap of the climate spaces for these species, we estimated the climate for the period of sympatry to be warmer (+3.2oC annual minimum temperature) and slightly drier (-24 mm annual precipitation) than present (Millar, Westfall QR 06).

We next examine results from Rehfeldt et al (1999), who analyzed growth relationships in 120 lodgepole pine seed sources with the climate at 60 common garden locations in British Columbia, Canada. They found that the fastest-growing seed source at a location was from a warmer location and that growth of most seed sources was greater at a warmer location than the local one, suggesting that the populations not only lag current climate changes, but they did not fully adapt to the Little Ice Age climate (Westfall, Millar FEM 04).

Next, we compared tree-ring growth between living trees with those that died in three eastern Sierran limber pine stands following a persistent drought during the 1980s. Both the mean and GARCH-modeled interannual variance in growth was greater in the dead trees than the living during the 18th and 19th centuries, but mean growth was greater in the living during the 20th. Moreover, the dead trees were less responsive than the living to increasing winter precipitation under high minimum temperatures, implying that these populations have undergone adaptation to current climate changes (Millar, Westfall CJFR In press).

Finally, we studied recruitment of limber and bristlecone pines in the White Mountains, in eastern California. Limber pine is recruiting in much greater numbers than bristlecone above current treeline, which is dominated by bristlecone, and about 300 m above current limber pine treeline. Recruitment peaked during the 1980s and was associated with higher minimum temperatures and a low phase of the Atlantic Multidecadal Oscillation (Millar, Westfall AGU 06). In addition, recruitment was insensitive to minimum temperature under low winter precipitation, but increased with increasing minimum temperature under high precipitation.

Thus we find that episodic, threshold, and reversible changes are more common responses to climate in mountain ecosystems than are linear or gradual changes. Such responses will complicate conservation planning.