First Discussion Paper

One goal of the work by Peterson and Peterson (2001) was to examine how *Tsuga mertensiana* forests will respond to climate change along gradients of latitude and elevation. At the regional scale examined, the authors conclude that the warmer climate expected by global warming are likely to decrease growth rates for this species in Oregon, while conditions farther north would favor growth. As Miller and Halpern (1998) show, this is an oversimplification of the processes that are likely to affect forest communities, especially regarding seedling establishment, in the face of global warming. In the following discussion, I consider the implications of Miller and Halpern's analysis regarding tree establishment only in the subalpine zone where *T. mertensiana* was most dominant and the relevance of their findings to the Peterson and Peterson study.

Both studies found that fluctuations in climate have strong effects on tree growth, both in the establishment of seedlings and on the growth of mature trees; depth of snowpack and timing of melt are key factors affecting the length of the growing season, soil moisture availability, and the subsequent establishment and growth of *T. mertensiana*. However, while Peterson and Peterson found that growth in mature trees responded positively to warmer and drier conditions in Oregon, Miller and Halpern found that seedlings responded favorably to these conditions only on north-facing slopes. On south-facing slopes, growth of seedlings (establishment) occurred during cooler, wetter conditions.

This result is not surprising. Site conditions can vary dramatically on north vs. south facing slopes, and seedlings, especially pioneers, face unique challenges including wide fluctuations in soil moisture availability, a shallow root system, and overexposure to sun. The pattern of vegetation in the subalpine community seen at site C in the Wenatchee mountains illustrates the concept of site amelioration as related to topography. On the south side of the site, conditions were very dry with few trees; soil water availability was clearly limited. If the climate were to cool, bringing more precipitation, the site would become more favorable for seedling establishment. At the summit, establishment was in clumps, suggesting that a few pioneering individuals had facilitated subsequent establishment due to their ameliorating effects on wind and snow. On the north side, trees seemed limited only by competition with each other, indicating few limitations on soil moisture availability.

These studies suggest that*T. mertensiana* may respond to climate change in a predictable way once established, but that the initial establishment of seedlings will depend on a much more complex interplay of other environmental factors such as topography and autogenic processes that help ameliorate harsh environmental conditions in the subalpine zone.Predicting how *T. mertensiana* forests will move in response to global warming, we could expect that the initial establishment of juveniles would occur first on slopes favored by climatic trends at that time. The forest may indeed migrate along the latitudinal and elevational gradients suggested by Peterson and Peterson, but initial establishment would be dependent on aspect as described by Miller and Halpern. A section written for the Peterson and Peterson paper would be as follows.

While these results illustrate growth patterns for mature *T. mertensiana*, recent studies have shown that factors influencing growth in seedlings are dependent on the interaction between climate and topography. In seedlings, climatic effects serve to ameliorate harsh subalpine conditions, the effects of which differ by site aspect (Miller and Halpern 1998). This would suggest that as forests begin to shift in response to climatic warming, initial establishment of seedlings will be largely dependent on topographic position.

References

Peterson, D.W. and Peterson, D.L. 2001. Mountain hemlock growth responds to climatic variability at annual and decadal time scales. Ecology 82(12) 3330-3345.

Miller, E.A. and Halpern, C.B. 1998. Effects of environment and grazing disturbance on tree establishment in meadows of the central Cascade Range, Oregon, USA. Journal of Vegetation Science 9:265-282.