

Subalpine Meadows: A Promising Indicator of Global Climate Change

By Andrea Woodward and June Rugh

As one of a number of projects funded by the NPS Global Change Program, the University of Washington Cooperative Parks Study Unit (UW CPSU) has chosen to study tree establishment in subalpine meadows. Studies underway at Olympic and Mount Rainier National Parks include two that examine the relationship between climate and tree establishment; others focus on establishment after fire, seedling establishment in relation to substrate, and soil development as a result of tree establishment. It is hoped that these projects will give park managers tools to understand and interpret for the public the dynamics and consequences of change in subalpine areas, as well as the vital role these areas play in detecting global climate change.

Background

Climatic variation is integral to the Earth's history, with changes generally occurring on the scale of centuries or millennia. However, atmospheric changes following the Industrial Revolution--specifically, the atmospheric concentrations of CO₂ and other greenhouse gases--may produce rates of global climate change unprecedented since the last Ice Age. One aspect of this change involves the earth's mean surface air temperature, which already has increased approximately 0.6 C. since 1880 (Hansen and Lebedeff 1988) and is predicted to rise 1 to 5 C. during the next century (Schneider 1989). Although seemingly small, this increase would have far-reaching consequences; significantly, it is of the same magnitude as the 3 to 5 C. change in

average temperature that occurred between the height of the last Ice Age and the present (Schneider 1989). Precipitation patterns are expected to change as well; however, the complexity of the hydrologic cycle makes prediction in this area more difficult.

It is intuitively clear that this changing climate will affect the biosphere, including the distribution of vegetation. One way to conceive of the effect of global change on vegetation distribution is to think of plant communities as grouped into vegetation zones appearing as distinct bands along elevational and latitudinal gradients (a useful idealized scheme; Peters 1990) and then imagine these zones shifting to new locations. There is, in fact, evidence that distribution of tree species has altered in response to changing climate in the present century (Franklin et al. 1971), as well as over the period following the last Ice Age (Brubaker 1988). However, such vegetation changes are much more complex than the migration of intact plant communities, or the shifting of vegetation zones to higher elevations and latitude in response to warmer climates; crucial factors include disturbance history, substrate availability, seed source, current conditions and the adaptations of individual species. In some places, trees may eventually be replaced by meadows, if conditions change to favor meadows.

Moreover, the accurate *detection* of vegetation change presents a tough challenge. First, to discern significant changes within the high variability of biological systems

requires large sample sizes over time and space. Second, the processes of biological change operate on diverse time scales. For example, while tree establishment in subalpine meadows may happen on a scale of years, their presence might not be noticeable for decades due to the slow growth typical of higher altitudes. In contrast, redistribution of species in the adjacent montane zone depends on disturbance frequency, which generally is measured in centuries. Finally, it can be hard to find a distinct division between one vegetation zone and another because where zones meet, the vegetation types characteristic of each zone can overlap.

Such problems associated with detecting vegetation change can be avoided by studying the subalpine, an area uniquely suited to the study of global climate change. Here, where meadows are punctuated with clumps of trees, there is a distinct line between vegetation types. Also, the process of tree establishment in subalpine meadows is sensitive to climate, particularly to the winter snowpack of the Pacific Northwest. Finally, the subalpine allows researchers to examine the effect of climate patterns on vegetation on a yearly basis (by correlating annual weather patterns with tree age), rather than having to rely solely on the larger patterns of climatic trends.

In order to seize the unique opportunity to study vegetation in relation to climate provided by the subalpine zone, the UW CPSU is cooperating on several research projects.

In both Mount Rainier and Olympic National Parks we have established transects from forests into meadows and aged trees along these transects. At Olympic NP, study sites are arrayed along a precipitation gradient from the wettest to driest regions. From these studies we hope to learn how regional and local climate patterns affect the distribution of trees and meadows in the subalpine.

Management Implications

Vegetation change in the subalpine areas of national parks has important consequences for management. Typically, subalpine meadows are popular with park visitors because of their wildflowers and vistas, and many park facilities have been created to accommodate this demand. If these meadows start to shrink, park managers will need to decide how to handle greater concentrations of people in

these already fragile areas. If subalpine meadows disappear altogether, the adjacent facilities will need to be redesigned or relocated.

To envision and interpret such transformations in the face of predicted global climate change is a major challenge within NPS. Biological changes that appear to proceed slowly, in human terms, will be difficult to accept if they accelerate in the future. A primary aim of the current global change research in subalpine areas is to assist park staff in making informed management decisions as parks are impacted by these changes, and in gaining public support for those decisions.

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References

- Brubaker, L.B. 1988. Vegetation history and anticipating future vegetation change. In *Ecosystem Management for Parks and Wilderness*, edited by Agee, J.K. and Johnson, D.R., pp.41-61, FUniv. of Washington Press, Seattle.
- Franklin, J. F., W.H. Moir, G.W. Douglas, and C. Wiberg. 1971. Invasion of subalpine meadows by trees in the Cascade Range, Washington and Oregon. *Arctic and Alpine Research* 3:215-224.
- Hansen, J. and S. Lebedeff, 1988. Global surface air temperatures: update through 1987. *Journal of Geophysical Research Letters* 15:323-326.
- Peters, R.L. 1990. Effects of global warming on forests. *Forest Ecology and Management* 35:13-33.
- Schneider, S.H. 1989. *Global Warming*. San Francisco, California, Sierra Club Books.

At least 70 years separates these two views of Mount Angeles in Olympic NP. The top photo was taken between 1915 and 1920. The lower view, taken in 1986, shows tree establishment in areas that formerly were meadow.

