Predicting Depth and Duration of Winter Snowpack in the Western Cascade Mountains[1]

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A method is described to approximate maximum winter snowpack depths and the snow-free date for high-elevation forests in the western Cascade Mountains of Oregon and Washington, even when it may be impractical to visit the stand during the winter.

Artificial forest regeneration in the Westem Cascade Mountains of Oregon and Washington is, on many sites, made more difficult by uncertainty associated with the winter snowpack. The maritime climate west of the Cascades results in a seasonal pattern in which 70 percent or more of the annual precipitation typically occurs between October and March. Above about 650 meters in elevation, most of the precipitation, which may be as much as 300 centimeters per year, falls as snow. The snowpack may reach depths of 7 meters or more during the winter and, in areas of maximum accumulation, may remain on the ground until August.

Ideally, information on both the depth and duration of the winter snowpack at a particular high-elevation site should be incorporated in regeneration plans. Snow depth, for example, may affect the choice of species because of the differing susceptibility to snow damage of the various montane and subalpine tree species (*6, 10*). To a large extent, the timing of snowmelt at a particular site controls the growing season length and the availability of the site for planting, factors affecting the choice of planting stock and the logistics of planting.

Unfortunately, the limited wintertime accessibility of many high-elevation sites in the western Cascades imposes practical restrictions on the direct measurement of winter snowpack depths and duration. Many stands scheduled for harvest and subsequent regeneration may only be conveniently visited during the snow-free period. The objectives of this paper are to suggest a practical indirect estimate of maximum winter snow depth and illustrate the relationship between the maximum depth and the duration of the winter snowpack.

Maximum Snow Depth

The indirect estimate of maximum snow depth proposed is based on the apparent sensitivity of a common epiphytic lichen to snow burial. That corticolous lichens respond to gradients in various environmental factors upon the boles of trees is well documented (*3, 4*). It has even been suggested that, under some circumstances, the minimum height of lichens on the boles of host trees may be a function of snow depth (*7*). However, no reference was found in which the distributions of epiphytic lichens were used as an indirect estimate of snow depth.

One of the most common epiphytes of the western Cascade Mountains is *Alectoria sarmentosa* Ach., a pendulous yellow-green lichen, which resembles coarse hair. In mature high-elevation forests of the region, it is commonly the major component of an epiphytic community, which may actually outweigh the aboveground portion of the vascular understory (*8*). Its distribution on a host tree typically extends from the top of the tree, on all sides, to relatively near ground level.

The lower distributional limit of Alectoria sarmentosa on the boles of host trees is quite distinct (fig. 1). This distribution pattern results in a dramatic lichen-free zone, which for the boles of trees in a given stand, is almost invariably at nearly the same height, but may vary greatly between stands at different locations. It is suggested that the minimum height of these lichens within a stand provides an indirect estimate of the maximum depth of the winter snowpack at that location.

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Figure 1.—*Pacific silver fir (Abies amabilis (Dougl.) Forbes) stand at about 1,100 meters. The epiphytic lichen, Alectoria sarmentosa, extends down the boles of the trees to within approximately 3 meters of the ground.*

The hypothesized relation between the lower limit of *Alectoria sarmentosa* on the boles of host trees and the depth of the winter snowpack was tested using U.S. Department of Agriculture cooperative snow courses. Six snow courses in the central Cascade Mountains of Washington were visited during the summer of 1975. The minimum heights of *A. sarmentosa* thalli were determined for 10 trees on or adjacent to each of the snow courses. The average minimum lichen height on the trees of a given snow course was compared to the published maximum measured snow depth for that course during the previous winter (*9*). The strong association between snow depths and lichen heights (fig. 2) suggests that *A. sarmentosa* is, in fact, sensitive to snow burial and thus may serve as an indirect estimate of maximum snow depths.

Timing of Snow Melt

Intuitively, it seems that the date at which a site becomes snow-free should be a function of the depth of the winter snowpack. This has been shown to be true for several locations in the subalpine zone of British Columbia (*1*). Data from nine weather stations in the western Cascade Mountains of Washington were used in an attempt to quantify this relationship. For each of the weather stations, the Julian date (number of days since beginning of calendar year) corresponding to the final disappearance of the snowpack was plotted against the maximum snow depth during the preceding winter. Figure 3 represents these data for the weather stations for 1968, 1973, and 1974. These particular years were picked because they appear to represent a more or less typical range of snow conditions for this area of the State. The regression of the Julian date for the beginning of the snow-free period against the maximum depth of the snow suggests that date of snowmelt for a particular location can be predicted reasonably well given information about maximum snow depth.

Discussion

The technique of using minimum *Alectoria sarmentosa* heights as an indicator of maximum snowpack depths has certain limitations. For example, it was found, not surprisingly, that the lichen heights were . more closely related to the previous winter's maximum snow depth than to an average maximum based on several years. This observation may in-

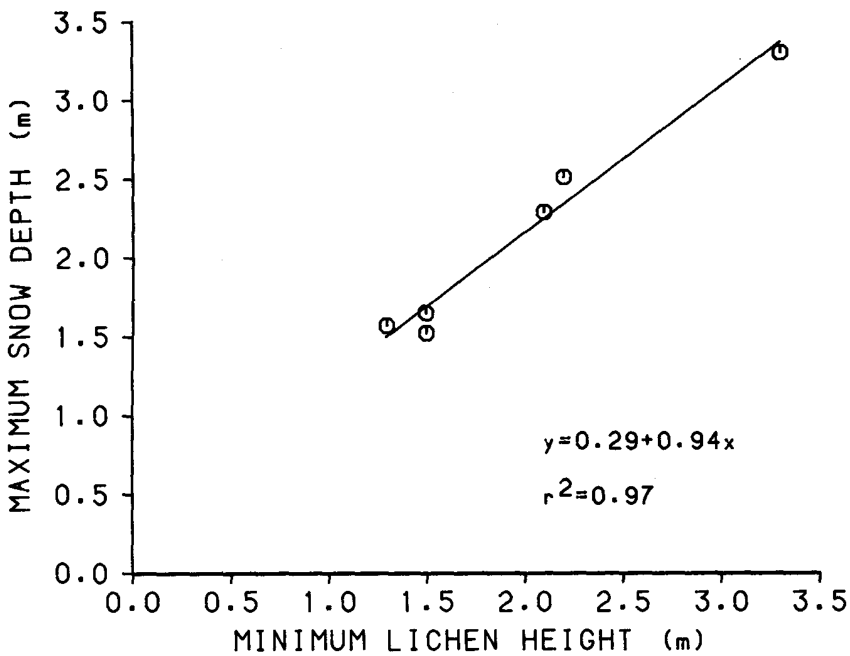

Figure 2.—*Relation between maximum winter snow depth and average minimum lichen heights on tree boles for six U.S. Department of Agriculture snow courses in the western Cascade Mountains.*

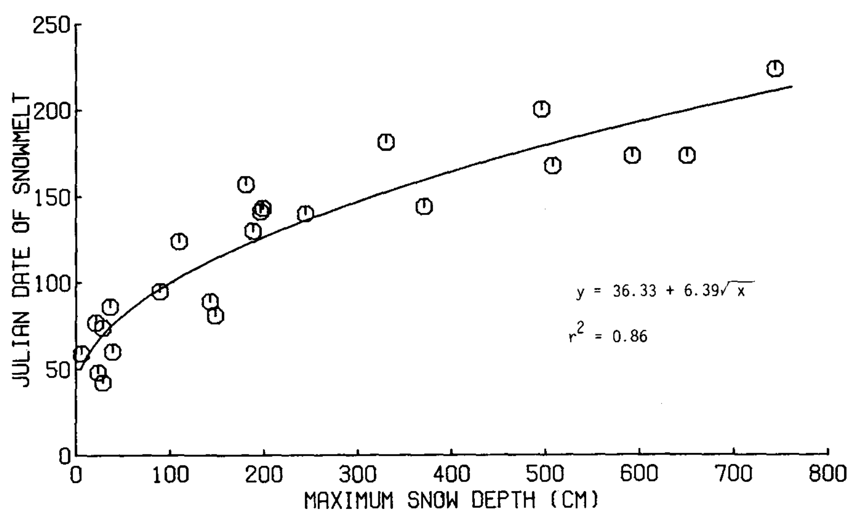

Figure 3.—*Relation between snow-free date and maximum snow depth for nine U.S. Weather Bureau Stations in the western Cascade Mountains. Data are from 3 Different years, representing high, average, and low annual precipitation.*

dicate that, while the lichens are sensitive to snow depth, they quickly recolonize that portion of the lower tree boles that is stripped of lichens during winters with unusually deep snow accumulation.

Also, it is an implicit assumption of the technique that feeding animals do not affect the minimum lichen heights. In high-elevation forests of the western Cascade Mountains, this is a valid assumption (*5*). In forests of other regions with substantial wintering populations of deer, elk, or caribou, the correlation between lichen heights and snow depths can be confounded (*2*).

Similarly, the observed relationship between date of snowmelt and the maximum winter snow depth should be used with an appreciation of possible limitations. While the relation illustrated in figure 3 is probably typical, it is undoubtedly modified by factors such as slope, aspect, and the nature of the overstory canopy.

While the equations given are strictly applicable only to high-elevation forests in the western Cascade Mountains of Oregon and Washington, the basic approach may have application in other regions. Other corticolous epiphytes are known to exhibit sensitivity to snow burial similar to *Alectoria sarmentosa.* For example, a related lichen, *A. glabra* Mot., in subalpine forests of Colorado's Front Range, is apparently sensitive to snow burial (*3*) as are various lichens common to balsam fir forests in New Hampshire.[2]

[2]Personal communication, Gerald Lang, Department of Biology, West Virginia University, Morgantown.

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