Engelmann Spruce (*Picea engelmannii*)-Subalpine Fir (*Abies bifolia*) Forests

Spruce-fir forests are common throughout the Northern Hemisphere at high latitudes or high altitudes. Many of the world's 34 species of spruce and 50 species of fir grow together in various combinations somewhere amidst their ranges. In North America, the combination of Engelmann spruce and subalpine fir is the most extensive, and can be found in the Rocky Mountains from the Yukon Territory to New Mexico, and in the Coast Ranges and Cascades from British Columbia to California (Figure 127). Countless mountain landscapes are richly decorated with these two species—often providing the frame for photographs of mountain scenery. They even bring distinctive color to the compositions, as their cones are often as colorful as the flowers with which they grow (Figure 128). Even though there are differences in the ecologies of these two species, it is amazing how similar their ranges are. Of course, there are plenty of places where one species will occur without the other, especially at the edges of the ranges.

Figure 127. Engelmann spruce–subalpine fir forest. The combination of Engelmann spruce and subalpine fir is the most extensive spruce–fir forest type found in North America. It occupies much of the subalpine forest in eastern Washington.

Figure 128. Maturing cones of subalpine fir (left) and Engelmann spruce (right) often add lively color to an otherwise evergreen forest.

In eastern Washington, it is difficult to find one species without the other. Even if such a place is located, the other species will no doubt be nearby. Spruce-fir forests dominate all but the wettest subalpine forests in our region (Figure 3, Figure 4). The vegetation zone is named for subalpine fir, the more shade-tolerant of the pair, but the spruce is also shade tolerant and can regenerate in the understory of all but the darkest forests within its range.

Engelmann spruce and subalpine fir do not tolerate warm temperatures very well, but they can endure temperatures as low as –50° C (–58° F). As a result, they form extensive forests in the high, cold mountains throughout western North America (Figure 129). They also are tolerant of very wet conditions, including riparian areas and the swampy ground near beaver ponds or other wetland features (Figure 130). The wet conditions near streams allow these species to descend to elevations where it would otherwise be too hot or dry. In steep mountain topography, stream drainages are often drainages for cold air as well, allowing cold mountain air to pour down into the lowlands. The largest specimens of the two

Figure 129. A spruce–fir landscape near the Stuart Range in the Wenatchee Mountains is just one of many mountain vistas framed by either one (or both) of these species.

Figure 130. Englemann spruce and subalpine fir can reach great sizes on moist soils. A swamp encircling a beaver pond along Icicle Creek supported former record specimens of both species.

species are found within the cool and moist conditions of these lower elevation sites, where snowfall is lower and growing seasons are much longer (Figures 131 and 132). Many other species find these conditions optimal as well, and such stands often contain ten or more tree species.

Living in snowy environments forces trees to adapt their architecture to deal with the physical stresses of being covered by wet, heavy snow. Many of our high-elevation pines, such as whitebark pine or limber pine (*Pinus flexilis*), develop

Figure 131. Subalpine firs do well in a variety of cold and wet conditions. This record-sized speciman is enjoying these conditions in the cold air drainage of a valley bottom, where the smaller snowpack allows for an extended growing season.

flexible, rubbery twigs that simply flop over to dump any accumulated snow. The crowns of spruces and firs often form tall spires that naturally shed snow with their short branches. Subalpine fir is one of the world's most extreme examples of this characteristic, with mature tree crowns often being only a few meters wide (Figure 133). Harsh environmental conditions near treeline restrict arborescent growth forms and many species are reduced to krummholtz. Both spruce and fir branches in contact with the ground are able to take root. This strategy, called ***layering*** is quite useful in alpine environments where seedling survival is limited

Figure 132. Record-sized specimens of Engelmann spruce occur where cold air drainages allow them to grow at elevations normally below their ranges.

(Figure 134). During the long winters at this elevation, trees are subject to constant physical stress from strong winds, desiccating air, and abrasion by ice crystals. The protective blanket of winter snowpack is often their only refuge—any twigs emerging above soon fall victim to the extreme exposure. To cope with such conditions, trees can use their own structures to protect the growing portion of the plant. Individual plants can live for centuries by growing downwind through layering, using older parts of the plant to take the brunt of the harsh winds (Figure 135).

Figure 133. Alpine woodlands in the Pacific Northwest receive some of the highest snowfalls recorded on Earth. The spire-like crown form of subalpine fir is perfectly shaped to shed this potentially burdensome load.

Disturbance in these wet and cold environments is most commonly a stand-replacing event, and often provides the only opportunity for shade-intolerant trees to enter the developmental sequence. Stand development is predictable, and thus the developmental stage is correlated with stand age. Growth rates in pure spruce-fir forests are universally slow—height growth normally averages just a few centimeters per year. Trees 10–20 cm (4–8 in) in diameter are frequently 50 to 150 years old, and trees over 30 m (98 ft) tall are often 250 to 350 years old

Figure 134. Layering of subalpine fir allows the species to proliferate in some our harshest mountain landscapes.

Figure 135. Downwind movement of a krummholtz Engelmann spruce allows the actively growing portion of the plant to receive protection by the older parts of the plant. Note the dead wood to the right indicates the position of the plant centuries earlier. Prevailing winds are from right to left.

Figure 136. An old subalpine fir. Even on moderately productive sites, 200 years or more are required for tall trees such as this to develop.

Figure 137. A great diversity of height and diameter classes of the shade-tolerant subalpine fir indicates an old-growth forest, even if the tallest specimens are only 15–20 m (49-66 ft) tall.

(Figure 136). Both spruce and fir can survive for decades, even centuries, as suppressed understory trees—alive, but with extremely little annual growth.

Many mature and old spruce-fir forests contain a residual component of the original cohort of pioneer trees. These residual pioneer trees, usually western larch or lodgepole pine, are often more than a century older than the shade-tolerant cohort of spruce and fir underneath. In any case, by the time spruce-fir forests develop a rich diversity of sizes within the shade-tolerant cohort (vertical diversification), they are very old, regardless of tree size (Figure 137).