Western hemlock (*Tsuga heterophylla*)

As one of our most shade-tolerant tree species, western hemlock is abundant in nearly all old forests in western Washington (Figure 82). Although it is often overlooked when growing with its much larger associates – Douglas fir, Sitka spruce, or western redcedar – western hemlock can occasionally reach impressive dimensions. It has been recorded to 78.0 m tall, 290 cm in diameter, and with a volume of 121 m^3 (Figure 11). Even though it only represents a fraction of the wood volume in old-growth forests, it nearly always represents more than half of the foliage (Figure 83). Accordingly, western hemlock controls the understory light environment in these old stands. A mature hemlock tree casts a very dense shade, only allowing shade-tolerant plants to persist.

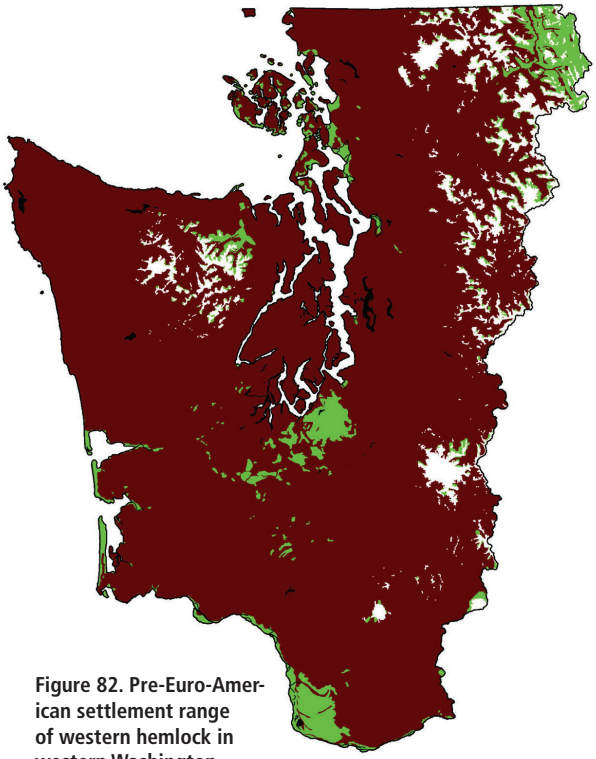

Figure 82. Pre-Euro-American settlement range of western hemlock in western Washington.

Like Sitka spruce, western hemlock seedlings are mostly limited to elevated woody substrates (Figure 84). Large logs can present the same problems for a young hemlock seedling as for spruce, and successful seedlings can form similar rows of trees as they grow along the length of a log (Figure 85).

Besides stumps and logs, a third woody substrate exists that Sitka spruce does not typically exploit. Large Douglas fir trees often have a wide skirt of bark that

forms at their base (Figure 86). Douglas firs produce large amounts of bark during their lifetime, which accumulates at the base of the tree as it sloughs off. Because it is elevated and continually accumulating, it has reduced competition from other plants and roots. Bark decays very slowly, so this skirt of organic substrate makes the perfect growing medium for a young hemlock seedling. In old-growth Douglas fir forests it is common to see a big old tree with its ***minion*** – groups of small hemlocks clustered around the tree base (Figure 87).

Even though western hemlock is one of our most shade-tolerant tree species, it still needs a gap or other opening to ascend into the canopy. Like most shade-tolerant tree species, western hemlocks can persist in dark forest understories for decades, even centuries, without growing much (Figure 88). These small, ***suppressed*** trees often develop an umbrella shape, in an attempt to capture as much light as possible. In many cases, these suppressed trees are often nearly the same age as large hemlocks growing nearby that had better opportunities when younger. If an opening in the canopy occurs, such as when a large tree falls over, the small tree may be able to ***release***, responding by increasing its growth in the new light environment. Usually, however, the light gap will be closed by neighboring trees or other trees present in the understory. In most old-growth forests, upper canopy western hemlocks have experienced repeated periods of suppression and release.

Figure 83. An old-growth Douglas fir/ western hemlock stand at Mount Rainier National Park. Apart from some moss on the branches and a few ferns on the forest floor, all of the green in the photo is western hemlock foliage.

Figure 84. A Douglas fir log covered with moss and abundant western hemlock seedlings.

Figure 85. Western hemlock seedlings colonizing an open area with the help of a nurse log.

Figure 86. The common sight of a large skirt of bark at the base of an old Douglas fir tree. Note hemlock seedlings using bark as a growing substrate.

Many of the clues that reveal the age of Douglas fir trees, such as bark characteristics or epicormic branches, are often absent in western hemlock. Since old western hemlock trees often have bark similar to much younger trees, the bark appearance gives few clues to tree age. Due to western hemlock's high shade tolerance, the branch-pruning seen in Douglas fir may not occur. Epicormic branches are often not present, even in trees several centuries old (Figure 89). Branch size, however, does change predictably through time. Hemlock trees less than 150 years old typically have very small, but numerous, branches (Figure 90). The presence of large (> 10 cm) branches on a western hemlock is usually an indication of an older tree (Figures 89 and 91).

Hemlocks often do not appear in a stand until the second century, as outlined in the ideal stand development scenario presented earlier. Even at 200 years in many stands, depending on disturbance intensity and proximity to seed sources, hemlocks have yet to grow into the upper canopy. The presence of hemlocks of different sizes in a Douglas fir forest, including canopy trees, is therefore an excellent indication of an old-growth forest.

Even in coastal forests, where western hemlocks can sometimes be the oldest trees, a mixed structure stand will still take considerable time to develop. For example, a coastal stand that is blown over, burned, or clearcut, can come back to a pure hemlock canopy (Figure 13). The same patterns of development will occur under the idealized scenario presented earlier, substituting western hemlock for Douglas fir. Vertical diversification will still take time to develop.

Figure 87. Douglas fir *minion*. Western hemlock seedlings growing on shed bark accumulated at the base of the tree.

Hemlock dwarf mistletoe

A distinctive characteristic – mostly unique to western hemlock in western Washington – are mistletoe infections. Mistletoes are parasitic plants that grow in the canopy of many tree species. The leafy mistletoe popular at Christmastime is a member of the genus *Viscum* found on hardwood trees in Europe. Crowns of our native oak, (*Quercus garryana*), become infected with another leafy mistletoe of the genus *Phoradendron*. In contrast, dwarf mistletoes are small, leafless mistletoes that often infect the twigs in the outer crowns of trees (Figure 92). Many members of the *Pinaceae*, including Douglas fir, western larch, and several of our pine and fir species become infected with dwarf mistletoes of the genus *Arceuthobium*. In western Washington only one species is common: *Arceuthobium tsugense*, which is mostly limited to western hemlock crowns.

These parasitic plants possess a unique seed dispersal mechanism: the seeds are explosively discharged when ripe and coated with a sticky covering that can adhere to the leaves or stems on which they land. Depending on wind conditions and the location of the plant within the tree crown, the seeds can sometimes travel 10-12 m away from the parent plant. While impressive, this is a limited distance when compared to other mechanisms of seed dispersal. Occasionally the sticky seeds will adhere to a bird and be transported to another tree.

Figure 88. A 210 year-old hemlock that is scarcely 2 m tall in the south Cascades. Such suppressed trees form an umbrella shape — producing only a few leaves each year.

As a parasite, the mistletoe makes use of sugars produced by the host tree, reducing their availability for tree growth. Hormones produced by the mistletoe cause excessive, but deformed growth of the tree in the vicinity of the infection. This often results in broom formation – dense areas of foliage and branches which appear as star-shaped formations on branches (Figure 93).

Because of the relatively slow manner in which this species propagates itself, hemlock dwarf mistletoe is, with some exceptions, generally only found in older forests. The most common exception to this general rule is when infected hemlocks are the residual trees in a developing stand. The mistletoe is in a perfect position to rain down seeds onto the new cohort of trees. This scenario is most common along the coast, in areas where wind was the disturbance agent. After a catastrophic wildfire, the few surviving hemlock trees will not usually persist long enough to infect the next generation of hemlocks, which may not establish for a century or more under the new Douglas fir canopy.

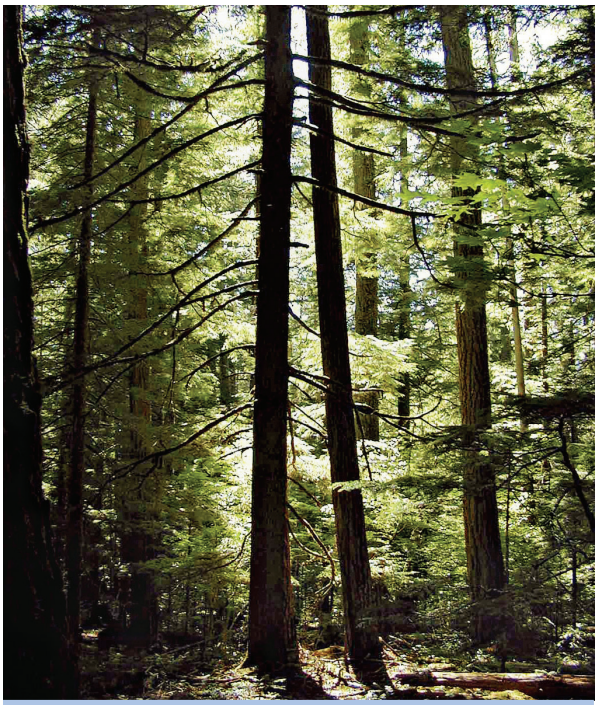

Figure 89. A 300 year-old hemlock in a 400+ year-old Douglas fir/western hemlock forest in the south Cascades. The extreme shade-tolerance of this species allows it to maintain its original branches close to the ground

Longevity and death

Throughout much of its range in western Washington, western hemlock will be susceptible to decay

Figure 90. Post-Euro-American settlement hemlocks rarely have branches > 10 cm, regardless of trunk size. Wood production is devoted to height growth and trunk enlargement, well into the second century.

Figure 91. Branches > 10 cm in diameter usually indicate an older hemlock, regardless of the trunk size.

Figure 92. A male hemlock dwarf mistletoe plant infecting a branch at 50 m above the ground. Female plants explosively discharge seeds which can occasionally fly 10 m or more away from the parent tree.

Figure 93. A mistletoe broom. Hormones within the mistletoe cause excessive growth in the hemlock in the vicinity of the infection. Such dramatic infections are usually only found in old forests.

Figure 94. A section of pure western hemlock within a 400+ year-old Douglas fir/western hemlock forest. Such sights are usually the result of the Douglas fir being killed off by disease.

fungi and will likely die before reaching 300 years of age. This is true in nearly all forests below 1,000 m in elevation. The tree does not produce decay-resistance extractives in its heartwood, and the warmth and moisture of these low elevation sites is ideal for fungal growth.

Both Douglas fir and western hemlock are subject to a wide array of different decay fungi, several of which will attack one species and not the other. Particularly on poor sites, one will occasionally encounter sections of an old-growth Douglas fir/western hemlock forest in which all of the Douglas firs have died. In these situations, a limited area of pure hemlock forest might be found (Figure 94).

Because fungi are limited in their effectiveness at high elevations, such as the upper Pacific silver fir or mountain hemlock zones, western hemlock in these locations routinely reaches ages of 800+ years, even up to 1,200 years (Figure 95, Figure 11).

Figure 95. A section of forest that is several thousand years-old near Glacier Peak in the north Cascades. If the frequent avalanches do not kill the trees, many can survive for more than 1000 years.

Extremely old western hemlock forests, such as those on the coast or in the North Cascades, are also susceptible to one of our only outbreak insects – the hemlock looper (*Lambdina fiscellaria*). This moth has been known to defoliate small sections of pure hemlock stands from time to time. Given that most old hemlock stands are already infected with hemlock dwarf mistletoe, the results of a looper infestation can be particularly unsightly (Figure 96).

Figure 96. A pure hemlock stand in the north Cascades killed by the hemlock looper. The added stress of these dramatic mistletoe infections probably made the trees more susceptible to the defoliation.