Forest Sciences

Prince Rupert Forest Region

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Stand Structure and Height Growth Patterns of Mature, Mixed-Species Forest Stands in the ICH Zone

Research Issue Groups:

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Extension

This extension note is the second in a series on the forests of the Interior Cedar-Hemlock (ICH) zone of northwestern B.C. As discussed in the original extension note (LePage 1995), the ICH zone is one of the more complex biogeoclimatic zones in the province and mixed-species forests are typical throughout. Within the Prince Rupert Region, young to mature ICH stands can contain an intimate mixture of up to nine tree species: western hemlock, western redcedar, lodgepole pine, hybrid spruce (*Picea glauca* x *sitchensis*), subalpine fir, paper birch, trembling aspen, black cottonwood and willow. Following a disturbance, the large variety of potential parents in the area provides a tremendous opportunity for species interaction and competition throughout the development of a new stand. This extension note will examine the structure and height growth patterns of a mature (135 years), mixed-species stand that developed on a mesic site after a catastrophic fire. The study stand is located in the Hazelton variant of the moist cold subzone (mc2) of the ICH, approximately 16 km west of Kispiox village. Three large stand structure plots were established and a total of 1,070 trees were measured. Destructive stem analysis techniques were used to determine height growth patterns over the life of the trees.

In mixed-species forests, height stratification or "layering" is a commonly recognized structural attribute. Height strata are typically divided into five layers or crown classes: 1) **emergent** - individuals that extend far above the main canopy, 2) **dominant** - trees with crowns that extend above the general level of the main canopy, 3) **co-dominant** - trees with crowns that form the main canopy, 4) **intermediate** - trees that are shorter than the main canopy but with crowns that extend up into the co-dominant layer and 5) **suppressed** - trees with crowns that are entirely below the general level of crown cover. This vertical stratification is evident in most of the mature, mixed-species stands found in the ICH zone.

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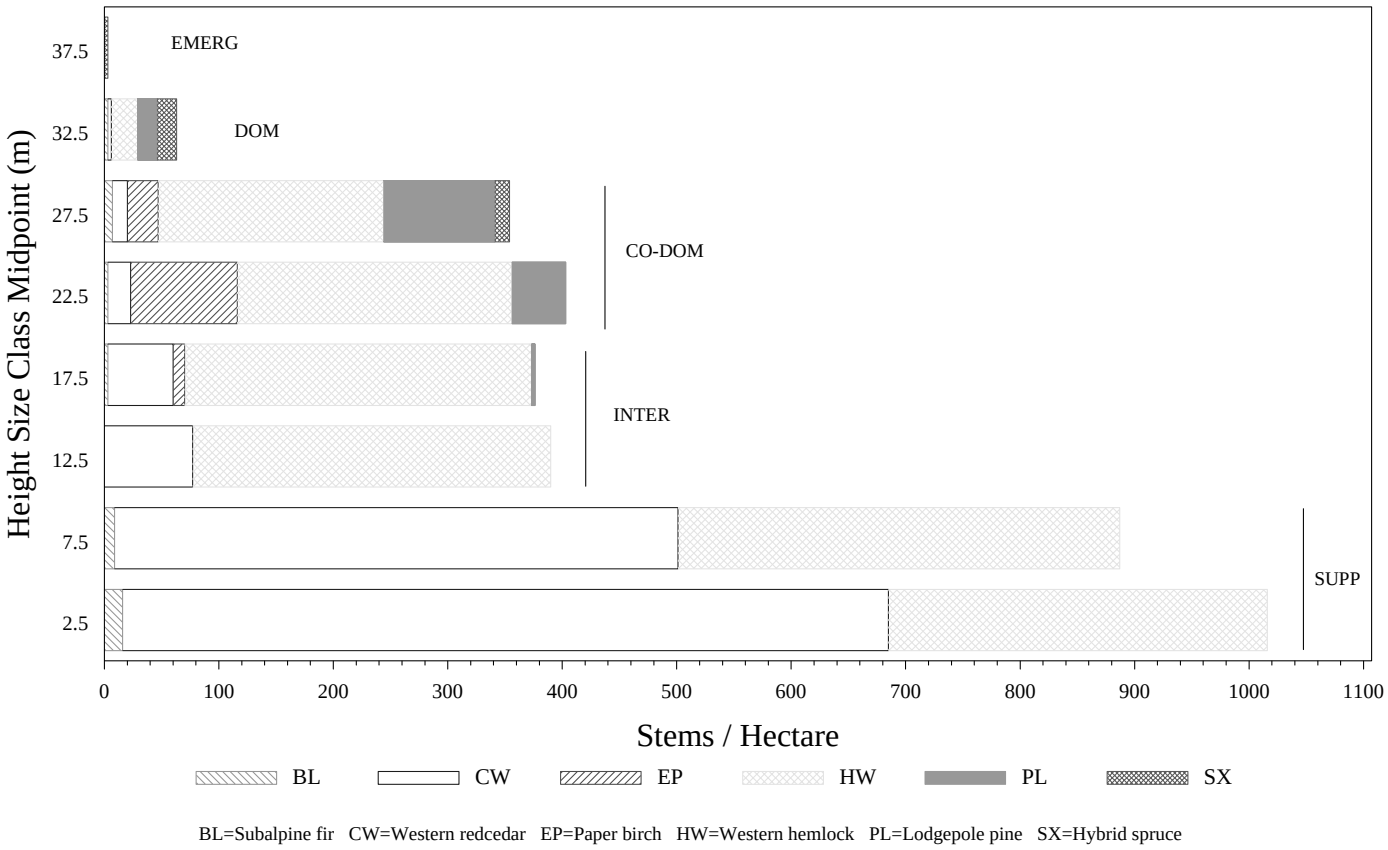

Figure 1. Height distribution by 5 m height size class for all live stems, by species.

In the study stand, hemlock exists in all but the emergent crown classes and in terms of number of stems, dominates all but the suppressed layer (Fig. 1). Hybrid spruce are found only in the emergent, dominant and upper portions of the co-dominant canopy layers. Lodgepole pine are located primarily in the dominant and co-dominant crown classes. A few individuals are still present in the upper portions of the intermediate stratum, however, their crowns are very small and they appear to be dying out. Paper birch occupies a similar canopy position to the pine with the majority of the trees in the co-dominant layer and a few individuals in the upper portions of the intermediate stratum.

Although only a few subalpine fir are present, they are vertically well dispersed and can be found in all but the emergent canopy class. Western redcedar dominates the lower crown classes with over 87% of the trees located in the suppressed class. The remaining redcedar are distributed throughout the intermediate and co-dominant classes with a few individuals reaching the dominant level. Although none were sampled in the three reconstruction plots in this study, trembling aspen and black cottonwood are common in the ICH zone and can be found scattered throughout most mature forests. Aspen are usually found in the upper co-dominant and lower dominant layers, similar to pine and birch. Cottonwood, usually restricted to wetter micro-sites, are found only in the dominant and emergent classes.

When mature ICH stands are viewed from the ground, the height stratification patterns are usually clouded by the presence of western hemlock. As mentioned earlier, hemlock occurs in all stratum, from suppressed up to dominant, and their deep crowns provide a virtually continuous canopy cover. Most of the other species are found primarily in one or two crown classes, however, the wide range of hemlock heights visually obscures this vertical separation and distinct layers in the forest canopy are not easily recognized. When hemlock are

removed from the picture, the layering becomes much more apparent (Fig. 2).

Competition between individuals is recognized as the primary mechanism driving stand development (Oliver and Larson 1990; Larson 1992). In the study stand, two of the most important attributes affecting this competitive interaction are the characteristic height growth patterns and shade tolerance of each species. There are four basic height growth patterns recognized by most silviculturists: **1**) rapid juvenile growth followed by a slowdown (*pioneer species*), **2**) slow initial growth followed by a 'grand period' of growth and then another period of slow growth (*sigmoidal*), **3**) good growth during all stages of development (*fast linear*), and **4**) slow growth during all stages of development (*slow linear*) (Larson 1992).

Western redcedar and western hemlock are both considered very shade tolerant species and capable of surviving for extended periods of time with minimal growth. When given adequate resources, however, their growth rates can improve significantly. The redcedar and hemlock in the suppressed and intermediate canopy classes are subject to high levels of competition for all resources and tend to follow the slow linear growth pattern (Figs. 3, 4). Those trees that are able to grow into available space in the canopy are subject to less competition, have more available resources and grow at much superior rates, typically following the sigmoidal growth pattern (Figs. 5, 6). The height growth patterns of the co-dominant redcedar and the dominant and co-dominant hemlock show that they are still in the 'grand period' of growth and have not yet begun to slow down.

Subalpine fir is also considered to be very shade tolerant and can grow in the understory as highly suppressed advance regeneration for periods exceeding 100 years prior to being released. Following this typical height growth pattern, subalpine fir have been found in the ICH that exceed 350 years of age. In the study stand, however, where subalpine fir established soon after the disturbance (see extension note #12), initial height growth was rapid and subsequent growth remained excellent for almost 100 years before slowing down (sigmoidal pattern, Fig. 5). This type of growth pattern has been previously noted in amabilis, grand and noble fir, but not in subalpine fir. Although most subalpine fir still occupy an upper canopy position, their height growth rate has slowed considerably in the last 40 to 50 years.

The shade intolerant species, such as birch, spruce and pine, are currently found only in the upper canopy layers (co-dominant and dominant). The high numbers of dead stems of these species in the stand indicate that those individuals unable to keep up to or above their neighbours soon died out. The height growth of birch followed the pioneer pattern, developing rapidly but slowing around 40 years of age as the other species in the stand reached the same

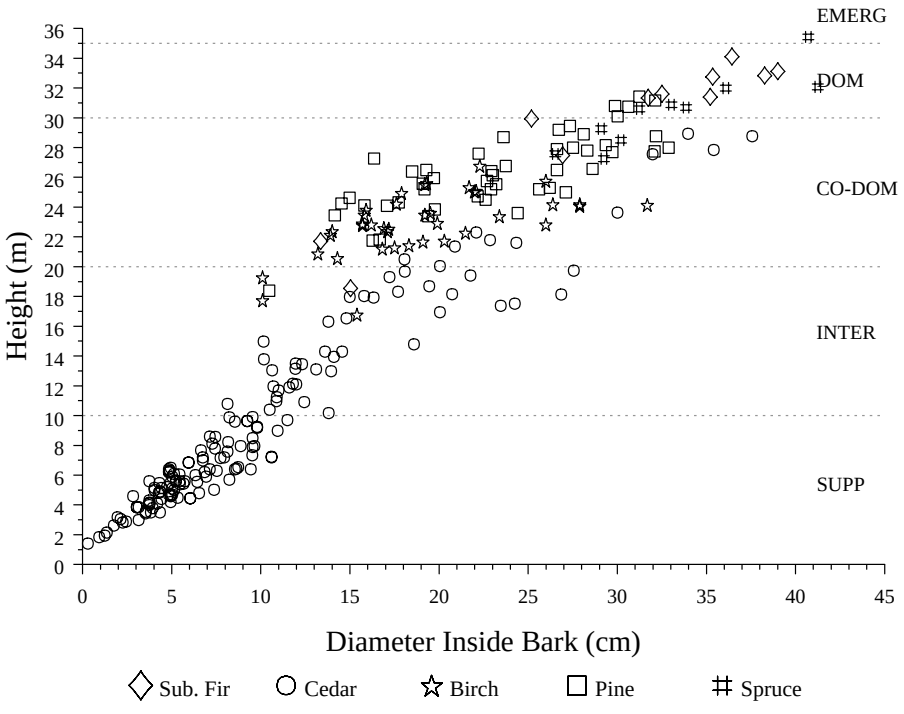

Figure 2. Scatter plot of total height versus diameter inside bark (@1.3 m) for all sample trees excluding western hemlock.

height and reduced the amount of available light (Fig. 5). The remaining birch in the stand are now well below the main canopy and continuing to die out. The height growth of pine in the co-dominant and dominant layers also follows the pioneer pattern (Figs. 5, 6). Initial growth was very rapid but has dropped off in the co-dominant layer over the last 50 years as the neighboring trees grow up and increase light competition causing the lower portions of the crowns to die back. In the dominant layer, the pine follows the same pattern, however, growth has only begun to slow down in the last 20 years (Fig. 6). Spruce in the co-dominant and dominant layers show pioneering growth patterns similar to the pine, with rapid initial growth and subsequent slowdowns (Figs. 5, 6). The co-dominant spruce have been above the other species in the layer for the last 40 years while those in the dominant layer are still growing alongside the dominant pine.

SUMMARY

The results of this study indicate that the developmental patterns of mixed-species ICH stands are best related to individual height-growth characteristics and competitive interaction between those individuals. The extensive variation in growth rates, both within and between species, is the main factor influencing the development of distinct canopy layers within the stands. While lodgepole pine, hybrid spruce, western redcedar and paper birch developed in height along characteristically predictable lines, western hemlock followed a number of different growth patterns and could be found in all canopy positions. This extensive variation in height growth pattern and subsequent crown depth has the effect of visually obscuring the stratification patterns. Subalpine fir did not follow typical growth patterns. While usually

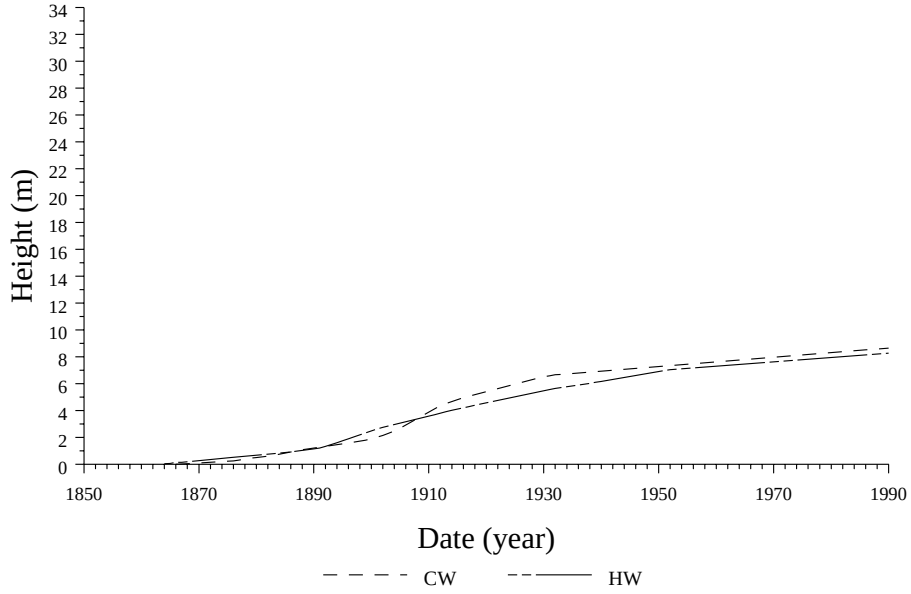

Figure 3. Mean height growth pattern, by species, of trees in the suppressed canopy layer.

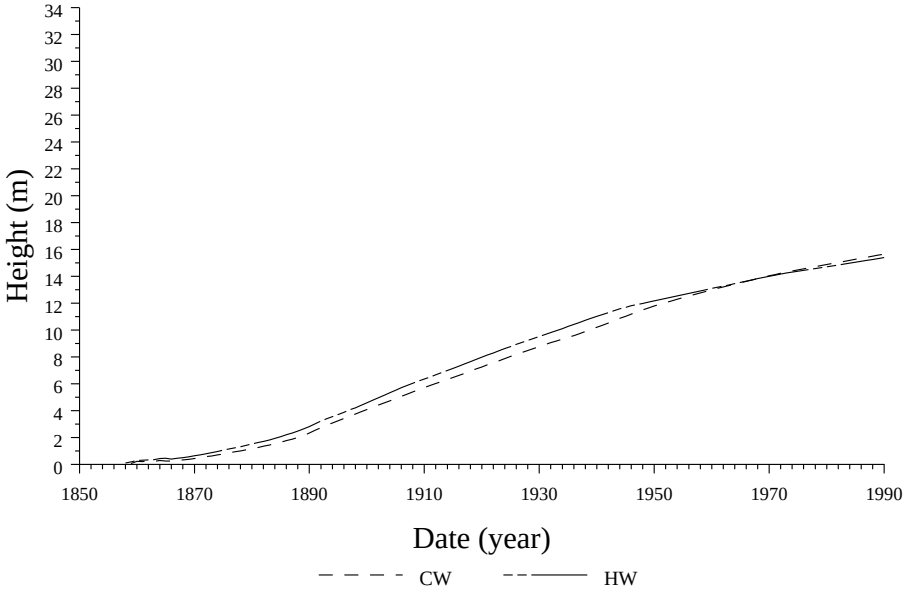

Figure 4. Mean height growth pattern, by species, of trees in the intermediate canopy layer.

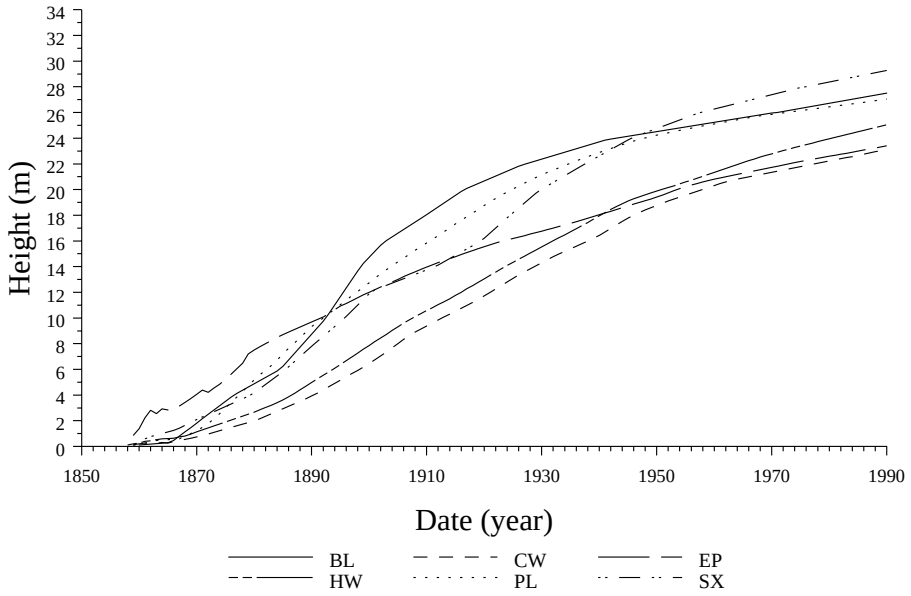

Figure 5. Mean height growth pattern, by species, of trees in the co-dominant canopy layer.

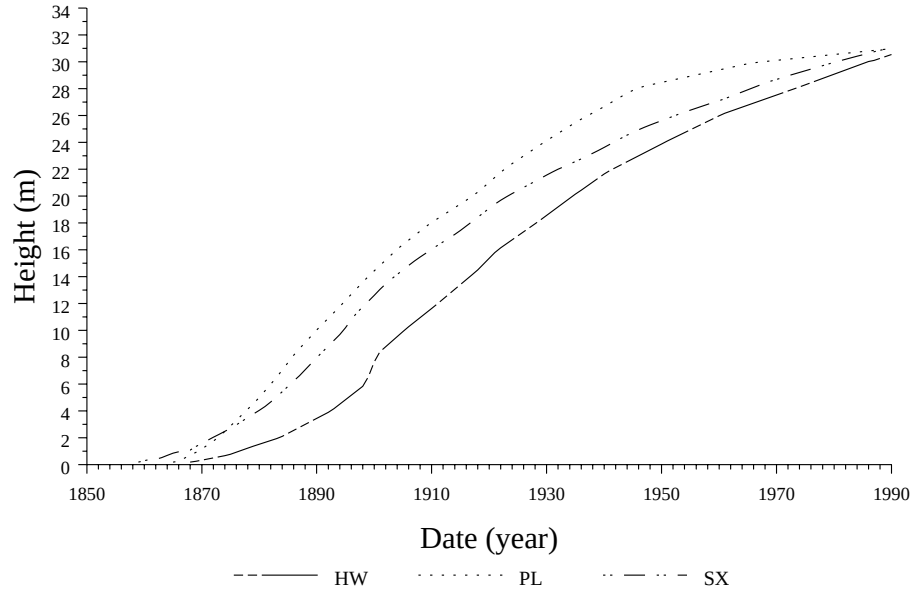

Figure 6. Mean height growth pattern, by species, of trees in the dominant canopy layer.

considered a slow-growing, shade tolerant species that comes up through the canopy after long periods of suppression, the subalpine fir in the study stand established rapidly after the initial disturbance and exhibited a very aggressive, pioneer-like height growth pattern.

Forests commonly have structures that reflect their disturbance history (type and intensity), site quality, the availability of seed or propagules for regeneration and the competitive interaction of those individuals that become established. While the stand chosen for study in this project is typical of many of the zonal ecosystem associations found in the interior cedar-hemlock zone of northwestern British Columbia, differences in any of these factors would likely produce a different mixture of species and therefore a different structure.

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References and Suggested Reading

Larson, B. 1992. Pathways of development in mixed-species stands. p. 3-10. **In**: M.J. Kelty (ed.), The ecology and silviculture of mixed-species forests. Kluwer Academic Publishers. 287 pp.

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