Growth of Douglas-fir, western hemlock and Engelmann spruce in relation to location and microclimate in openings created using a strip shelterwood system

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Introduction
The primary objectives of the shelterwood regeneration method is to retain an overstory canopy to shelter regeneration from harsh or limiting environment factors such as frost, high temperatures and high levels of solar radiation. However, this approach also provides continuous cover to assist in meeting visual, habitat and biodiversity objectives. With the shelterwood system overstory trees are removed individually or in groups to provide sufficient light and to remove other limitations to the establishment of regeneration. In gaps created using group or strip shelterwood methods, there is substantial spatial variation in microclimatic conditions and this can result in substantial variation in establishment and growth of seedlings. Gradients in light, soil and air temperature, soil moisture and other factors can lead to substantial variation in survival and growth within gaps which will have differential effects depending on the requirements and tolerances of the tree species. When using the shelterwood regeneration method in mixed Interior Cedar Hemlock zone stands in B.C., it is particularly important to understand how location within gaps can influence microclimate and how this relates to the establishment and growth of different species. For the purpose of this extension note, we examine the growth of three species with contrasting shade tolerances (Douglas-fir, western hemlock and Engelmann spruce) based on their location within gaps and associated microclimatic conditions at a site in the Interior Cedar-Hemlock moist warm biogeoclimatic subzone (ICHmw2) near Nakusp, B.C.

The Study
In 1994, a study was initiated by the Forest Sciences Section of the Nelson Region at Burton Creek 50 km south of Nakusp, B.C. (49°57’ N, 117°53’W). Two small (50 m wide by 150 m long) clearcuts were created in a mixed stand dominated by Douglas-fir, western redcedar, and western larch on a circum mesic site. The long axis of each clearcut goes east-west. In the spring of 1995 seedlings of each of ten species (Douglas-fir, western larch, Engelmann spruce, western redcedar, western hemlock, white pine, ponderosa pine, lodgepole pine, subalpine fir, and paper birch) were planted in rows oriented north-south across each block. Planting rows extend 20 m into the uncut stand south and north of each clearcut. Three replicate rows were established for each species in each of the two cutblocks. Based on the previous data on light and soil moisture levels, 12 gap environments were defined and the microclimate of those gap environments is being measured (starting in 2007) using sensors attached to dataloggers. Light, air temperature, soil temperature and soil moisture sensors are located at -12.5, -7.5, -2.5, 2.5, 10, 20, 30, 40, 47.5, 52.5, 57.5, and 62.5 m from the south edge. Additional information on the design and implementation of this project is provided by Delong et al. (2000).

Results
Preliminary results show strong spatial patterns of transmitted light, soil moisture and air temperature inside these openings. Light (transmittance) is highest at the center of the openings and decreases towards the edges and into the intact stand; north edges have light levels similar to those at the center while at the south edge light levels are lower than at center (Figure 1). Soil moisture stress was high under the canopy and immediately adjacent to gap edges but is lowest in the area located between 5 m and 25 m distance from the south edge (Figure 2). This reduction in moisture stress is thought to be related to both shading from the adjacent stand and longer spring snow retention in this southern portion of the gaps. Temperatures below 5\(^\circ\) C and above 30\(^\circ\) C occurred most frequently at the center and towards the north side of the opening (Figure 3).

Of the three species, western hemlock grew better than Engelmann spruce under the intact canopy. Douglas-fir was substantially suppressed in understory environments. While western hemlock was the fastest growing species in the southern its growth declines in the northern portion of the gaps (Figure 4). The best growth of Douglas-fir is at 40 m from the south edge (10 m from the north edge) where it also grows better than western hemlock and Engelmann spruce. While there are only small differences in light levels between the center and the areas
immediately adjacent to gap edges (2.5 and 47.5 m), substantial reductions in growth of trees adjacent to the edges appears to be related to soil moisture stress in this portion of the openings.

Figure 1. Light transmittance (diffuse) varies with distance from the south edge of the gaps at Burton Creek (Year 2007; the south edge of the 50 m wide clearing is at 0 m and the north edge is at 50 m).

Figure 2. Box plots showing soil moisture stress (> 0.2 Mpa) for each gap environment (Year 2007). Horizontal lines side the bars is median and mean is represented by a ‘+’.

Figure 3. Air temperature patterns in the two cutblocks at Burton Creek during 2007.
Conclusion
For all species, patterns in growth are consistent with and closely related to patterns in microclimate. Moreover, species show variation in growth that reflects their environmental requirements and tolerances. Ongoing measurement and data analysis is examining growth and physiological responses of all 10 species planted at Burton Creek and their relationship to location in the openings and microclimate.

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Reference

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