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# Regeneration, Growth and Productivity of Trees Within Gaps of Old-Growth Forests on the outer coast (CWHvh2) of British Columbia

## Introduction

Central to the issue of harvest feasibility on the outer BC coast (CWHvh) is the question of whether sites, once harvested, can be regenerated, and whether the time period for replacement and subsequent growth is economically and environmentally acceptable. Since low productivity sites have not been harvested in the past, there is a lack of data to answer this question. We tried to provide an answer by assessing regeneration following natural disturbances. Small scale gap disturbances are the norm within old-growth stands. If regeneration is not a problem in gaps, then we have some evidence that regeneration should not be a problem upon implementation of our management practices. The objectives of this study were: (1) to develop baseline information on the mechanisms and the patterns of regeneration across a sequence of forest types; (2) to assess regeneration success with respect to productivity; and (3) to estimate future growth and productivity.

## Study sites and methods

Data was collected from canopy gaps in five different site series near Prince Rupert representing a gradation of productivity and drainage. Gaps were located in five site series: i) [04] HwSs-Lanky moss, ii) [01] CwHw-Salal, iii) [11] CwYc-Goldthread, iv) [12] PlYc-Sphagnum, and v) [32] Sphagnum bog (Figure 1). Five gaps per site series were sampled in the Diana Lake transect and three gaps per site series were sampled in the Smith Island transect. Plot size varied from $100m^2$ in site series 04 to $50m^2$ in site series 01 and 11, and $25m^2$ in site series 12 and 32. For all trees, saplings, and seedlings, height, diameter and rooting substrate were measured. Stem analysis was carried out on all trees and saplings (>1.3 m tall). Five randomly selected seedlings (< 1.3 m tall) of each species were cut at the root collar and collected for analysis. For the Diana Lake transect, one dominant canopy tree of each species was sampled near each gap. The dominant trees were felled and sections cut every 0.5 m to 5.3 m in height and every 1 m thereafter. At the Lachmach Channel site, we sampled 5 faller created gaps in a 23 year old partial cut. For the preliminary analyses, only the age and height for the Diana Lake transect are presented.

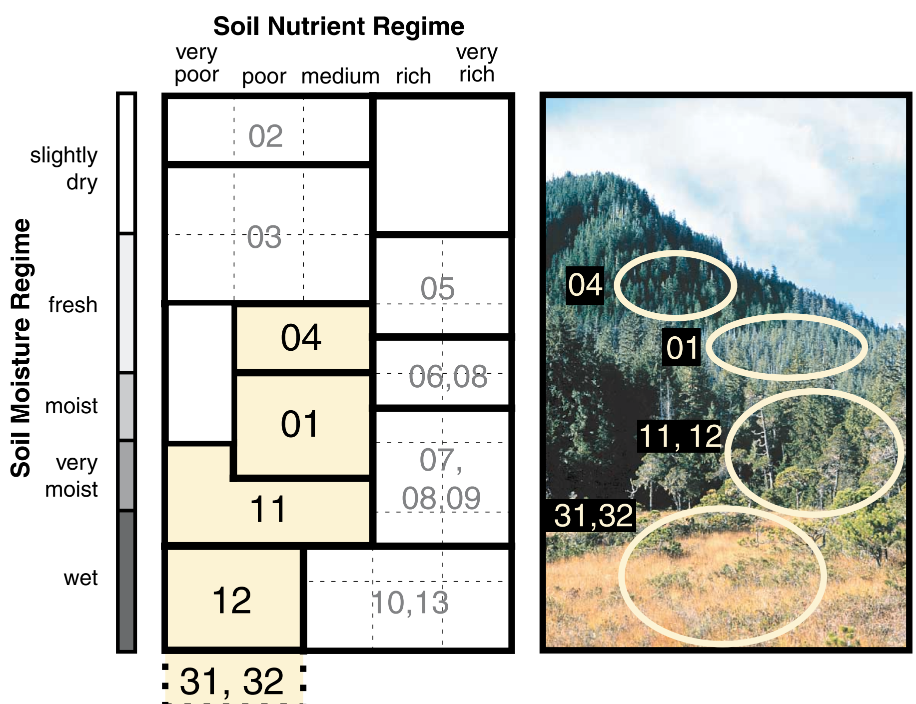


Figure 1. Position of the five series on the edatopic grid and on the landscape at the Diana Lake site.

# Results (preliminary)

The gaps in the four site series have increasing light environments from the lowest in gaps of site series 04 (productive), to highest in site series 01 (unproductive zonal) and 11 (bog forest). This light gradient is a function of the height and density of the trees surrounding the gap. Gaps of site series 04 are surrounded by a forest of full crown closure with trees 40-50 m tall. Gaps of site series 01 and 11, are surrounded by open forests without crown closure with trees 20-25 m tall and 15 m tall, respectively. Gaps of site series 12 are openings in a forest having widely dispersed trees.

Within all gaps, both seedlings and trees are much older than would be expected from their size. The mean seedling age (< 1.3 m tall) was > 30 years, and some were > 100 years (Table 1). Seedlings are not only growing under the saplings but also under a heavy cover of *Vaccinium* up to 1.5 m tall. The mean age of trees (> 1.3 m tall) was > 100 years (Table 2). It took well over 100 years for the trees in the gap to reach approximately 4.5 m for site series 04, 3.5 m for site series 01, 3.0 m for site series 11, and 2.5 m for site series 12. However, the spread in ages within gaps was very large. In general, the youngest ages within the gaps were > 50 years, with the oldest 200 to > 400.

Table1. Age comparisons for site series 04, 01, 11 and 12 for seedlings (< 1.3 m height) growing in canopy gaps. Values are given for each plot in the Diana Lake transect.

| Site series | Plot | Age (years) | | |
|---|---|---|---|---|
| | | mean | SD | range |
| 04 | 1 | 29 | 12 | 11-57 |
| 04 | 2 | – | – | – |
| 04 | 3 | 39 | 31 | 11-102 |
| 04 | 4 | 26 | 15 | 4-56 |
| 04 | 5 | 21 | 10 | 7-42 |
| 01 | 1 | 48 | 18 | 30-86 |
| 01 | 2 | 57 | 31 | 18-122 |
| 01 | 3 | 44 | 25 | 12-115 |
| 01 | 4 | 38 | 16 | 13-77 |
| 01 | 5 | 23 | 13 | 7-66 |
| 11 | 1 | 33 | 25 | 2-97 |
| 11 | 2 | 45 | 17 | 14-85 |
| 11 | 3 | 47 | 24 | 12-113 |
| 11 | 4 | 54 | 32 | 19-118 |
| 11 | 5 | 45 | 20 | 7-96 |
| 12 | 1 | 48 | 24 | 24-117 |
| 12 | 2 | 79 | 37 | 27-162 |
| 12 | 3 | 54 | 26 | 16-107 |

Table 2. Age and height comparisons for site series 04, 01, 11 and 12 for trees (> 1.3 m height) growing in canopy gaps. Values are given for each plot in the Diana Lake transect and number of trees are per $50m^2$.

| Site series | Plot | Number of trees | Age (years) | | | Height (m) | | |
|---|---|---|---|---|---|---|---|---|
| | | | mean | SD | range | mean | SD | range |
| 04 | 1 | 7 | 161 | 115 | 39-357 | 7.20 | 6.67 | 1.40-20.80 |
| 04 | 2 | 12 | 150 | 39 | 77-227 | 4.53 | 3.62 | 1.33-15.80 |
| 04 | 3 | 14 | 128 | 63 | 52-308 | 4.03 | 3.67 | 1.35-17.90 |
| 04 | 4 | 8 | 193 | 45 | 88-267 | 4.72 | 2.88 | 1.43-10.42 |
| 04 | 5 | 9 | 129 | 109 | 27-465 | 4.67 | 6.22 | 1.35-25.80 |
| 01 | 1 | 14 | 148 | 91 | 46-374 | 3.67 | 4.21 | 1.39-17.20 |
| 01 | 2 | 11 | 181 | 112 | 69-425 | 5.28 | 4.11 | 1.92-13.50 |
| 01 | 3 | 26 | 145 | 70 | 68-414 | 2.99 | 2.34 | 1.51-13.48 |
| 01 | 4 | 57 | 71 | 15 | 50-115 | 2.48 | 1.48 | 1.40-10.74 |
| 01 | 5 | 22 | 120 | 69 | 49-253 | 3.58 | 3.08 | 1.47-12.40 |
| 11 | 1 | 31 | 125 | 28 | 77-197 | 2.80 | 1.39 | 1.39-7.13 |
| 11 | 2 | 35 | 143 | 66 | 56-456 | 3.00 | 2.10 | 1.42-10.95 |
| 11 | 3 | 33 | 133 | 86 | 47-504 | 2.98 | 1.70 | 1.44-6.98 |
| 11 | 4 | 23 | 163 | 93 | 82-440 | 3.18 | 2.22 | 1.37-10.73 |
| 11 | 5 | 26 | 153 | 54 | 73-306 | 3.32 | 2.38 | 1.41-10.70 |
| 12 | 1 | 48 | 129 | 40 | 48-216 | 1.98 | 0.67 | 1.30-3.59 |
| 12 | 2 | 52 | 131 | 47 | 72-231 | 2.29 | .85 | 1.39-4.39 |
| 12 | 3 | 52 | 118 | 34 | 60-189 | 2.82 | 1.80 | 1.36-7.80 |

Site series 04 showed definite, although variable, patterns of release of trees within gaps. There were instances of a gradual ingress and release of most trees within a plot, and patterns where trees were suppressed for 100+ years but exhibited strong release to become the dominants within the gap. In such cases, two height cohorts were created, one of a few dominants, and another of a large number of shorter saplings which represent ingress into the gap. The pattern of ingress and release exhibited for site series 04 was also generally exhibited for site series 01, although the degree of release was not as dramatic and showed more of a steady increase. Despite similar ages between site series 01 and 04, and the former having greater light availability in the gap, trees in site series 01 were shorter and the double height cohort pattern of site series 04 was weaker. One or two trees may dominate, but generally, all the regeneration was increasing in height at similar rates. For site series 11, the pattern of release was much more subdued. Most trees had fairly steady, constant, and slow growth. This site series receives more light in the understory than either site series 01 or 04, so the light levels of the pre-gap understory would not increase as much as would happen in site series 04. This more constant light level would explain the gradual increase in height growth exhibited by most trees in the bog forest. Further, much of the light during the growing season is diffuse thus increasing the similarity between open grown and open-canopy cover conditions. The light conditions for the bog woodland are different than the three previous site series. Here, the situation is not really classic gap dynamics since the trees are so widespread that the conditions more resemble full light levels. Despite the increased light availability, height growth was slow, reflecting the site quality. The maximum height was 7.80 m, yet the ages range in the hundreds of years.

## Discussion

Three main points are emphasized. The first is that regeneration in canopy gaps is not a problem. Since experience in site series 04 suggests that regeneration under clearcut conditions is not a problem, than by extrapolation, it appears that regeneration should not be a problem under management scenarios for site series 01 or 11, despite the prevalence of a heavy *Vaccinium* cover. However, this statement is made under the condition that the hydrological conditions of the site is not altered under a clearcut scenario. The second point is that although there is a lot of regeneration, the establishment and growth within these gaps is extremely slow. The gap trees are hundreds of years old. The lack of trees < 1.3 m in the past 50+ years shows a very large regeneration delay. The tall and heavy *Vaccinium* cover may be part of the explanation, but even in site series 04, which does not have the associated cover of ericaceous species, there also is a lack of trees < 1.3 m in the past 50 years. It takes well over 100 years for saplings to grow 2-5 m high. The third point is the recognition of the variation in height development (and probably species development as well, which will be analyzed in the coming year) within the gaps. Even within one site series gap sizes differ, the size, density, and pattern of the trees surrounding the gaps differ, the seed source differs, and the substrates within the gap differs. All of these factors, as well as others, combine to form varied gap dynamics which can not be generalized.

These three points lead to some preliminary management concerns. It appears that, if hydrological conditions do not change, regeneration is achievable upon clearcutting on site series 01 and 11. However, if some sort of variable retention harvesting system is used with dependence on natural regeneration, then forest managers must allow for a very long regeneration delay. Even in the productive site series 04, the regeneration is much older than initially thought. Finally, if an aggregate retention system (the traditional patch cut) is implemented followed by planting to overcome the regeneration delay, we have to recognize that we are still simplifying the natural system. Even within the concept of creating gaps, the variability of growth rates is large. Research is needed to assess whether the simplification of regeneration within gaps will have any negative impact upon biodiversity concerns.

## Reference

Chourmouzis, C. and G. J. Kayahara. 1998. Regeneration dynamics of old-growth forests on the north coast of British Columbia. Northwest Science 72:57-59.

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