Coastal Douglas-fir Seral Stage Differentiation from a Microclimatic Point of View

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Introduction

Seral stages of a forest stand can be differentiated by many factors such as the age of the overstory vegetation and the types and diversity of the flora and fauna. Another group of factors that can be used to help characterize the differences between seral stages are soil and above-ground microclimatic variables. A microclimate study was conducted to determine what climatic elements could be used to detect differences in the seral development; the study was a component of the Canadian Forest Service's Coastal Forest Chronosequence research program which is studying the effects of converting old-growth Douglas-fir (*Pseudotsuga menziesii*) to managed forests.

The key objective of this study was to characterize the microclimatic differences between the four different seral stages (R - regeneration, I - immature, M - mature, and O - old growth) using a limited microenvironmental monitoring system on three southeastern Vancouver Island study sites (as described in Trofymow et al. 1997). One replicate of each seral stage was located at each site and all seral stages were in close proximity at any given site. The results presented represent the initial characterization of the microclimatic differences based on three years of collected weather data. The data collected during this period indicate a generally warmer and drier microclimate at two of the sites when compared to Environment Canada 1961-1990 climatic normals for the region. The third site tended to be warmer and wetter than the climatic normals.

Methods

Microclimate monitoring stations were established in each of the four seral stages on the three study areas. These stations were located in the center of the intensive study plots. The stations measured air temperature and relative humidity at 1.3 m, soil temperature, and water potential at the duff-soil interface, and soil temperature and water potential at 30 cm depth. Stations located in the regeneration sites also collected solar radiation and rainfall data. Two replicates were made for each soil measure, with one replicate in the center subplot and the other made on one of the western edge subplots. Campbell Scientific dataloggers were used to monitor, collect, and summarize the information. Each sensor was sampled once per minute. Data summaries were compiled every four hours and once per day at midnight. These summaries include mean, maxima, minima, and standard deviations for most measurements and totals for solar radiation and rainfall, where appropriate. All temperature measurements were made using thermistor sensors. Gypsum blocks were used to measure soil water potential.

Data collected from the climate network were integrated into a database for further analyses. For the initial analysis, a series of multiple range tests was applied to help determine whether there were statistically significant differences in environmental variables with seral stage. While several methods were initially investigated, the Tukey's studentized range test was selected for comparative purposes due to its robustness, particularly with unequal data series. The database has been analyzed as a pooled set as well as by site and season. This discussion will focus primarily on the analysis of the pooled seasonal data sets.

Results and Discussion

Pair-wise analysis of the various measured climatic elements indicated that there were statistically significant differences between the four different seral stages at the 95% confidence level even though the R^2 values were very low (Table 1). The root mean square error (RMSE) is presented as it provided a better measure of the expected accuracy of the predicted results in the units of measure. The data estimates fall within the

TABLE 1. Seral stage grouping using Tukey's studentized range test.

Pooled Data	Alpha=0.05				
Element	Grouping	R^2	RMSE	# of Obs.	Pr > F
Avg. 1.3m. Air Temperature[1]	R M I~O[2]	0.02	6.2	11188	0.0001
Avg. Interface Soil Temperature	R I~M O	0.03	5.5	11662	0.0001
Avg. -30cm Soil Temperature	R I M O	0.06	3.9	10916	0.0001
Max. 1.3m Air Temperature	R M I~O	0.06	7.5	11407	0.0001
Max. Interface Soil Temperature	R I~M O	0.07	6.0	11614	0.0001
Max. -30cm Soil Temperature	R I M O	0.06	3.8	11479	0.0001
Min. 1.3m Air Temperature	R~I M~O	0.01	5.4	11211	0.0001
Min. Interface Soil Temperature	R~I M O	0.02	4.9	11616	0.0001
Min. -30cm Soil Temperature	R I M O	0.03	3.9	10936	0.0001
Max. Interface. Soil Water Potential[3]	R I M O	0.04	4.1	11881	0.0001
Max. -30cm Soil Water Potential	R M I~O	0.03	4.2	11881	0.0001

[1] Air and soil temperatures were measured in °C.
[2] Groupings joined with ~ are not significantly different.
[3]Soil water potential was measured in bars with higher values indicating drier soils.
Seral stage abbreviations: R = regeneration, I = Immature, M = Mature, O = Old Growth.

annual variation expected for the area under study. In most cases, there is a statistically significant difference between the different aged stands. Of interest are the environmental elements that show little difference with seral stage. In particular, the mean values for the deep soil water potentials show few significant difference among any of the age classes.

Further analysis of the pooled data broken down by season indicates a less obvious set of distinctions among age classes for the environmental variables (Table 2). For most variables the regeneration stands are statistically distinct from the other age classes, but for many climatic elements the differences between immature, mature, and old-growth stands varies depending on the season. The regeneration stands are most likely separated from the other age classes due to the very open nature or complete lack of overstory vegetation which intercepts both incoming radiation and precipitation. For the other age classes the resulting microclimate is likely to depend on the nature of the crown cover and understory vegetation, as they will regulate both incoming radiation and precipitation and also outgoing transpiration.

TABLE 2. Seral grouping by season.

By Season	Tukey's studentized range test groupings			
Element	Spring	Summer	Fall	Winter
Avg. Air Temperature[1]	R~M I~O M~O[2]	R I M~O	R~O I~M M~O	R M I~O
Avg. Interface Soil Temperature	R I~M I~O	R M I~O	R~I~M~O	R I~M I~O
Avg. -30cm Soil Temperature	R I~M O	R I~O M	R I~M~O	R~M I O
Max. Air Temperature	R M I~O	R I M O	R I~M~O	R I M O
Max. Interface Soil Temperature	R I~M I~O	R I~O M	R I~M I~O M~O	R I~M I~O
Max. -30cm Soil Temperature	R I~M~O	R I~M I~O	R I~M M~O	R I M O
Min. Air Temperature	R~I I~M M~O	R I M O	R~M R~I I~M O	R~I~O M
Min. Interface Soil Temperature	R I~M~O	R I~M O	R I~O M~O	R I~M O
Min. -30cm Soil Temperature	R I~M O	R I~O M	R~I I~M M~O	R~I~M M~O
Max. Interface Soil Water Potential[3]	R~M~O I~M	R~M I O	R I M O	R~M I M~O
Max. -30cm Soil Water Potential	R~M I~M O	R~M I~O	R I M O	R I~M~O

[1]Air and soil temperatures were measured in °C.
[2]Groupings joined with a ~ are not significantly different.
[3]Soil water potential was measured in bars with higher values indicating drier soils.
Abbreviations used in table: Avg. = Average, Max. = Maximum, Min. = Minimum, m = metre.
Seral stage abbreviations: R = regeneration, I = Immature, M = Mature, O = Old Growth.

The results suggest it is possible to distinguish the microclimatic differences among age classes of stand given a sufficient length of record and spatial replication. In addition, these distinctions among age classes vary throughout the year.

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