Changes in Overstory Structure and Composition in Coastal Forest Chronosequences

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Introduction

Natural disturbance and harvesting over the last 100 years have created a mosaic of successional stages in British Columbia (BC) often adjacent to undisturbed old-growth areas. These sites present a unique opportunity to study changes in forest stand structural attributes and to what extent old-growth conditions are restored during forest succession. By studying several successional stages occurring in close proximity on similar sites, effects associated with stand development may be separated from those caused by site variability.

The primary objective of this study was to quantify overstory structure and composition changes associated with forest succession. This abstract reports findings in Coastal Western Hemlock (CWH) zone forests on four east (CWHxm - Coastal Western Hemlock very dry maritime) Douglas-fir (*Pseudotsuga menziesii*) dominated and four west (CWHvm - Coastal Western Hemlock very wet maritime) western hemlock (*Tsuga heterophylla*) dominated Vancouver Island chronosequence sites (for more details on study sites and methods see Trofymow et al. 1997). Each site contains stands of four ages. Age since disturbance was established in 1990: R - regeneration (3-9 years), I - immature (32-43 years), M - mature (66-99 years), and O - old growth (>200 years). Regeneration and immature stands were established following harvesting and slashburning.

Methods

At all eight sites, triangular main plots were laid out by establishing three subplot centers 30 m and 120^{o} apart from a center benchmark. Within each main plot, three of the four subplots were randomly chosen for sampling (center benchmark and three subplots). At each subplot mensuration measurements of overstory trees and snags (dbh, height to live crown, and total height) by species were made. Overstory was defined as any tree greater than 1.3 m high (breast height). Tree biomass was estimated using published biomass regression equations for coastal BC tree species (Blackwell 1993). Snag biomass was estimated using only the bolewood equation for each species present.

The number of live stems/ha was summarized by dbh class, height class, and crown depth class. Dbh was stratified into 11 classes based on 10-cm increments. Height class was stratified into 12 classes based on 5-m increments. Crown depth (height to live crown) class was stratified into 9 classes based on 5-m increments. Stem basal area/ha was summarized using the same dbh classes used for the number of live stems/ha. The numbers of snags/ha, snag biomass, and live stem biomass were summarized by dbh size classes.

Results and Discussion

Results of the study showed that diversity of overstory structure and composition in coastal forests increases with stand age and that the CWHvm is more structurally diverse than the CWHxm (Table 1).

Within the CWHvm, density followed the order R>I>M>O. Densities in the CWHxm were lower in R plots than I and M plots indicating, for this subzone, differences in the establishment regime (natural vs. artificial). The total number of stems/ha in the CWHxm (2494) exceeded that of CWHvm (1541). With the exception of R plots, density across seres was greater in CWHxm than in CWHvm (Table 1).

Douglas-fir (Fd) (average stems/ha 57%) dominated R, I, and M plots of the CWHxm. Western hemlock (Hw) (average stems/ha 56%) and minor amounts of western redcedar (*Thuja plicata)* (Cw) (average 19%) dominated most seral stages within CWHvm sites. This difference in dominant species was expected given climatic differences

TABLE 1. Selected summary statistics of overstory structure and composition for chronosequence plots.

	LIVE STEMS PER HECTARE										STEM BIOMASS Mg/ha									
	CWHvm					CWHxm					CWHvm					CWHxm				
SP	R	I	M	O	ALL	R	I	M	O	ALL	R	I	M	O	ALL	R	I	M	O	ALL
ALL	2143	1899	1114	1006	1541[a]	1698	4180	2930	1166	2494[b]	3.5	232.2	463.7	687.3	346.6[a]	0.6	142.0	422.8	586.0	287.8[a]
	(196)	(187)	(471)	(433)	(194)	(638)	(1038)	(594)	(386)	(422)	(1.8)	(20.3)	(24.7)	(222.5)	(80.2)	(0.6)	(17.8)	(89.0	(51.7)	(61.7)
FD	168	201	0	0	93[a]	1082	2387	1814	430	1429[b]	1.8	54.6	0.0	0.0	14.1[a]	0.6	129.3	393.3	565.1	272.1[b]
	(104)	(150)	(0)	(0)	(46)	(625)	(516)	(591)	(34)	(285)	(1.4)	(46.6)	(0.0)	(0.0)	(11.7)	(0.6)	(21.6)	(79.0)	(47.9)	(58.8)
HW	1114	1199	543	650	877[a]	95	700	473	580	462[b]	1.3	139.2	419.4	340.3	225.0[a]	0.0	9.0	23.8	14.4	11.8[b]
	(234)	(115)	(123)	(291)	(114)	(95)	(383)	(723)	(295)	(151)	(0.4)	(40.4)	(36.5)	(81.2)	(46.3)	(0.0)	(6.6)	(23.1)	(4.9)	(5.7)
CW	700	361	3	132	299[a]	286	1092	426	47	463[a]	0.2	9.4	0.3	325.0	83.8[a]	0.0	3.7	4.6	5.8	3.5[a]
	(467)	(106)	(3)	(68)	(124)	(191)	(657)	(377)	(25)	(195)	(0.2)	(2.7)	(0.3)	(177.1)	(51.8)	(0.0)	(3.4)	(2.5)	(2.9)	(1.2)

	SNAGS PER HECTARE										SNAG BIOMASS Mg/ha									
	CWHvm					CWHxm					CWHvm					CWHxm				
SP	R	I	M	O	ALL	R	I	M	O	ALL	R	I	M	O	ALL	R	I	M	O	ALL
ALL	0	1210	350	111	418[a]	0	393	599	119	278[a]	0.0	23.6	34.4	22.0	20.0[a]	0.0	5.1	15.3	16.1	9.1[a]
	(0)	(674)	(89)	(59)	(190)	(0)	(145)	(271)	(41)	(89)	(0.0)	(14.2)	(16.6)	(10.7)	(6.1)	(0.0)	(1.8)	(2.9)	(9.9)	(2.8)
FD	0	0	0	0	0[a]	0	297	525	37	215[b]	0.0	0.0	0.0	0.00	0.0[a]	0.0	4.5	13.1	14.6	8.1[b]
	(0)	(0)	(0)	(0)	(0)	(0)	(114)	(295)	(9)	(87)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(1.7)	(2.7)	(8.9)	(2.6)
HW	0	997	247	69	328[a]	0	74	64	74	53[a]	0.0	19.3	28.7	12.8	15.2[a]	0.0	0.5	0.5	0.9	0.5[b]
	(0)	(618)	(80)	(34)	(168)	(0)	(61)	(64)	(50)	(23)	(0.0)	(13.1)	(16.7)	(5.1)	(5.4)	(0.0)	(0.4)	(0.5)	(0.7)	(0.2)
CW	0	180	5	36	56[a]	0	0	0	5	1[b]	0.0	3.8	0.2	8.2	3.0[a]	0.0	0.0	0.0	0.3	0.1[a]
	(0)	(74)	(5)	(27)	(25)	(0)	(0)	(0)	(5)	(1)	(0.0)	(1.5)	(0.2)	(6.0)	(1.6)	(0.0)	(0.0)	(0.0)	(0.3)	(0.1)

	STEM BASAL AREA m^2/ha									
	CWHvm					CWHxm				
SP	R	I	M	O	ALL	R	I	M	O	ALL
ALL	0.45	57.01	69.13	127.89	63.62[a]	0.05	39.66	78.57	82.54	50.20[a]
	(0.29)	(4.60)	(2.99)	(40.76)	(14.14)	(0.05)	(4.76)	(8.15)	(4.57)	(8.70)
FD	0.30	12.18	0.00	0.00	3.12[a]	0.05	36.41	69.28	75.96	45.43[b]
	(0.26	(10.42)	(0.00)	(0.00)	(2.61)	(0.05)	(5.63)	(4.28)	(5.48)	(7.79)
HW	0.12)	31.77	60.48	49.79	35.54[a]	0.00	2.50	7.03	3.89	3.35[b]
	(0.05)	(8.73)	(6.41)	(10.00)	(6.55)	(0.00)	(1.80)	(6.84)	(1.32)	(1.68)
CW	0.01	2.68	0.14	73.90	19.18[a]	0.00	0.75	1.88	2.45	1.27[a]
	(0.01)	(0.90)	(0.14)	(35.25)	(10.99)	(0.00)	(0.73)	(1.02)	(1.17)	(0.44)

Notes:
R = regeneration. I = immature. M = mature. O = old growth.
All = all species (Fd,Hw,Cw,Ba,Dr,Tx,Ss,Pw) and or seres combined.
CWHvm = Coastal Western Hemlock very wet maritime biogeoclimatic unit.
CWHxm = Coastal Western Hemlock very dry maritime biogeoclimatic unit.
Standard error in parentheses. Subzone means followed by different letter are significantly different ($p<0.05$).

between the CWHxm and CWHvm (Green and Klinka 1994).

Tall trees >35 m were found only in M and O seral stages. Comparison of the number of stems by height class showed that more than 50% of all trees were <5 m (height class 1) regardless of species or subzone. The number of trees >35 m (height class 8) were on average greater in the CWHvm (94 stems/ha) compared with the CWHxm (42 stems/ha).

Similar trends were observed for the total number of stems by crown depth class as those observed for dbh and height class. More than 67% of all stems present were found in crown depth class 1 (<5 m). Stems present in crown depth class 5 and greater (>20 m) were found only in M and O plots, representing 1% and 4% of the stems in each sere, respectively.

Average stem biomass increased as a function of stand age and was greater in the CWHvm than the CWHxm. When seral stages were compared between subzones, stem biomass was always greater in the CWHvm. In the CWHvm, Cw stem biomass increased dramatically from M plots (0.3 Mg/ha) to O plots (325 Mg/ha). As these forests age, Cw becomes a more significant component of the stand given its longer life history compared with the shorter-lived Hw.

Total number of snags/ha was greater in the CWHvm (418) than the CWHxm (278). In the CWHvm, snags/ha followed the order of I>M>O, and were dominated by Hw (78%) and Cw (14%). In the CWHxm, snags/ha (Fd 77%) follow the order M>I>O. The presence of more small diameter snags in younger seral stages represents early mortality through natural thinning. The higher number of snags in M plots in the CWHxm likely corresponds with later mortality of Fd. The majority of snags were <12.1 cm dbh, 84% in CWHxm and 75% in CWHvm respectively. Very few snags were >60 cm dbh in either subzone and represented <3% of all snags present.

Snag biomass in the CWHvm (20 Mg/ha) was double that measured in the CWHxm (9 Mg/ha). Lower snag density and biomass in the CWHxm may be explained by the greater frequency of stand-replacing and surface fires, which have historically removed a greater proportion of the larger trees which could be recruited as snags (Green et al. 1998).

As expected, total basal area for all species combined increased with seral stage. In both subzones, Hw basal area increased from R to M plots, but decreased in O plots. As discussed for stem biomass, this may be related to the shorter life history of Hw. Total average stem basal area in the CWHvm (63 m^2/ha) was greater than in CWHxm (50 m^2/ha).

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