Introduction to the Coastal Forest Chronosequence Project

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Introduction

The coastal forests of British Columbia (BC) contain stands that have the highest recorded live tree biomass (1100 Mg/ha) and are amongst the most productive and biologically diverse in Canada. As new values for forests have evolved, so have domestic and international scrutiny of logging of these forests increased. In response to this issue, the Canadian Forest Service, Pacific and Yukon Region, initiated the Coastal Forest Chronosequence (CFC) project to study the changes caused by converting coastal old-growth to second-growth forests in the Coastal Western Hemlock (CWH) zone (Pojar et al. 1991) of southern Vancouver Island. Questions to be addressed by the experiment were: (1) How does conversion impact species and forest structural diversity? (2) How does diversity recover in older second-growth stands? (3) How does conversion affect ecosystem carbon levels and cycling? and (4) How does conversion affect ecosystem nutrient capital and hence potential site productivity?

This paper serves to introduce the CFC project for the presentations that follow in this proceedings. More detail on the site selection process; introduction to the ecology, physiography, geology, and climate of the study area; and the layout, location, and description of each plot are available in an establishment report (Trofymow et al. 1997). Methods for some studies are summarized in papers from the first CFC project workshop (Marshall 1993).

Approach

On Vancouver Island, as of 1989, harvesting had converted approximately 40% of the total land area to managed forest, with much of this harvest concentrated in forests on the east side of the island (BC Ministry of Forests 1991). Significant areas of unharvested old growth remain, often in a mosaic of forests of various successional stages. Potential sites containing stands of various successional stages were located through interviews with foresters, and electronic and manual searches of forest cover maps. Plot establishment was completed in 1992 on ten sites (Figure 1): five sites in Douglas-fir (*Pseudotsuga menziesii*) dominated stands on the dry leeward east side of Vancouver Island in very dry variants of the CWH zone (CWHxm1&2) (VWS - Victoria Watershed South, VWN - Victoria Watershed North, KOK - Koksilah, NAN - Nanaimo River, LOON - Loon Lake); and five sites in western hemlock (*Tsuga heterophylla*) dominated stands on the wetter windward west side of the island in very wet variants of the zone (CWHvm1) (REN - Renfrew, RGC - Red/Granite Creek, NIT - Nitinat, KLA - Klanawa, OZZ - Mt. Ozzard). Each site contained a suite of seral stands—a chronosequence—representing four stages of stand development: R - regeneration (3-9 years), I - immature (32- 43 years), M - mature (66-99 years), and O - old growth [176 (RGC), remainder 245 to >450 years] (stand age in 1990). Chronosequences were selected so that stands within a site were in an area 5 km x 5 km or less and on similar slope, elevation, and aspect. Most second-growth stands selected were of harvest origin and burned, though mature stands at three sites were of wild–fire (KOK, KLA) or landslide origin (OZZ). Disturbance history of the old-growth plots was unknown.

Site Environmental and Soil Attributes

The following is a summary of the methods and results of analyses of site environmental and soil attributes of the coastal forest chronosequences (Trofymow *et al.* 1997). Results were summarized both by site and by seral stage.

Methods

The environmental characteristics of each plot—including biogeoclimatic zone and site association

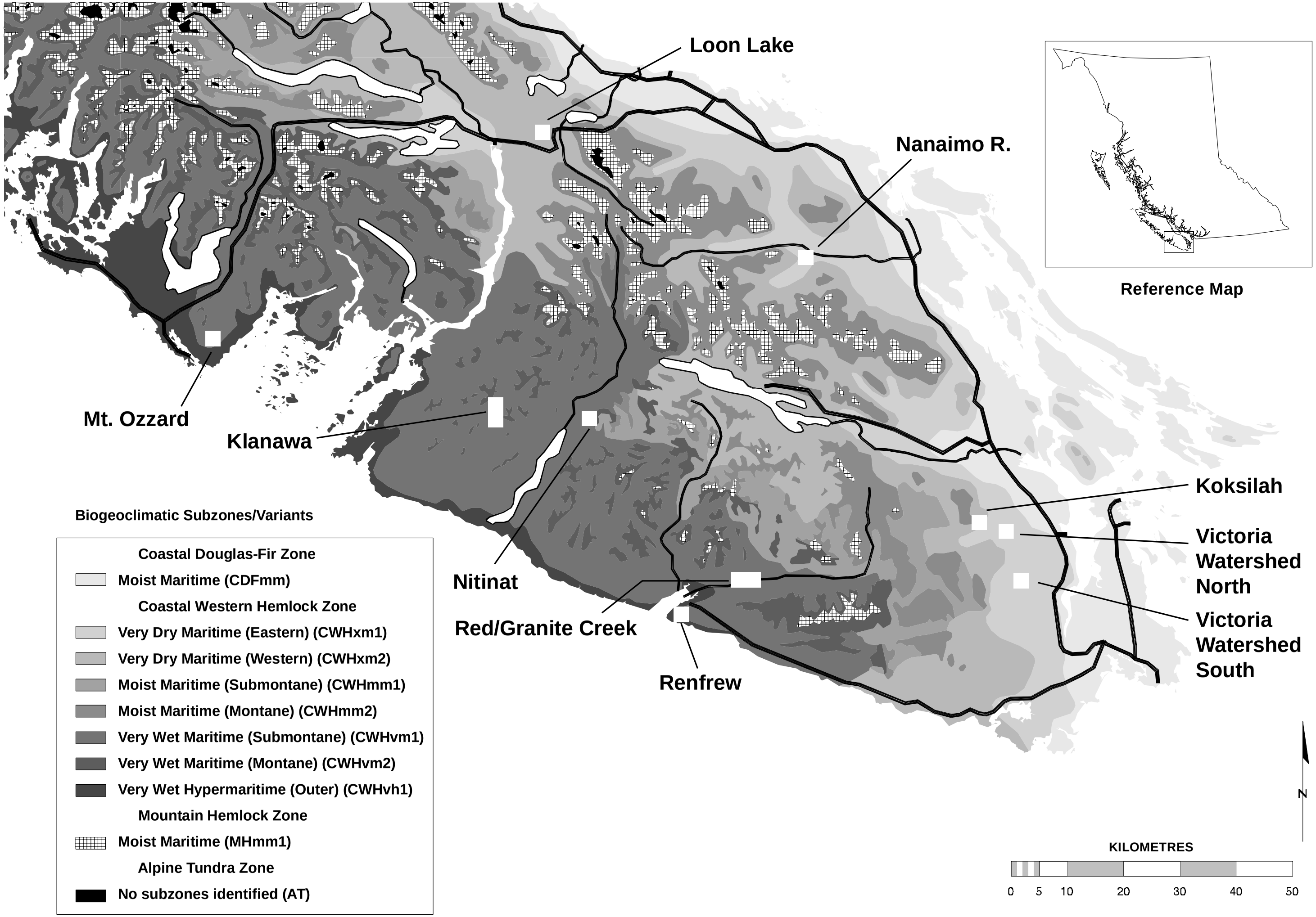

Figure 1. Location of Coastal Forest Chronosequence sites in relation to the biogeoclimatic subzones of southern Vancouver Island.

(Pojar et al. 1987), location, elevation, aspect, slope position, exposure, surface shape, trophotope, hygrotope, terrain, soil classification, and soil summary characteristics—were recorded on site description forms. Means and ranges of environmental variables were calculated for each site and seral stage. Individual plot data were summarized (tabulated) by site and by seral stage.

Soil Great Groups were identified according to the Canadian System of Soil Classification (Agriculture Canada Expert Committee on Soil Survey 1987). The following soil characteristics were described: forest floor classification, horizon types and depth, soil texture, drainage, root size and distribution, and soil colour by depth. As part of the total ecosystem carbon and nutrient distribution survey, mineral soils were sampled by depth, volumes were recorded for bulk density determinations, and samples were collected for nutrient analysis. Total oven dry, <6 mm and <2 mm dry mass were determined. Sub-samples were taken to determine soil texture, soil colour, pH, %C, %N, %P, %S, cation exchange capacity, %Fe + Al, and exchangeable Ca, Mg, and K. Zero to 30 cm mineral soil chemistries (pH, C/N ratio, cation exchange capacity, %C, %Fe + Al, Total N kg/ha, and Ca + Mg + K) for each plot were tabulated by site and by seral stage.

Samples of forest floor organic matter (LFH) were collected; volumes were recorded in the field and samples were analysed for nutrients. Variables measured on these samples included total oven dry mass, pH, %C, %N, %P, and %S. Surface organic horizon (LFH) chemistries (pH, C/N ratio, %C, Total N kg/ha) for each plot were tabulated by site and by seral stage.

Results

Summary tabulation of the plot data by site (chronosequence) location (Table 1) indicated greater variability in environmental and site conditions among sites than among seral stages at each site. Summarized across geographical locations, each seral stage is highly diverse for environmental and site conditions.

The site data reflect differences in climate and terrain between the two sides of Vancouver Island. The biogeoclimatic units on the west side have a generally wetter, cooler, and milder climate than those of the east side. The chronosequences on the east side of the island are generally higher in elevation than those on the west. Slope gradients are greater in the west side chronosequences. Wind is a near-universal exposure factor on the west side, while it is uncommon and local on the east. The west-side chronosequences are mainly on colluvial material; the east-side chronosequences are on morainal material. Brunisolic soils occur on the east side but not on the west.

Soil chemical analysis (Table 2) showed a sharp difference between the east-side and the west-side chronosequences, apparently related to climate. The east side has higher pH in both LFH and mineral soil (difference greater in LFH); lower nitrogen in both LFH and mineral soil (difference greater in mineral soil); lower %C and higher C/N ratio in mineral soil; lower %Fe + Al; higher cations (Ca, Mg and K), and lower cation exchange capacity; and lower total nitrogen. All of these observations were significant at the 5% level (t-test comparisons of east versus west sites).

Some developmental trends in the soil chemistry variables along the seral gradient were noted (not illustrated). Cation exchange capacity and total cations show a declining trend with stand age in the east-side plots. In both the east-side and west-side plots, LFH nitrogen appears to decrease in the first few decades, then it peaks in the old-growth stage. Further discussion about differences in ecosystem nutrient contents and soil P chemistry are provided by Blackwell and Trofymow (this issue) and Preston and Trofymow (this issue), respectively.

Studies

A total of 18 studies were carried out during the first five-year period of the project (1992-1997), grouped into studies of ecosystem structure, processes, and biodiversity. Structure studies examined differences in coarse woody debris, overstory, and canopy gap distributions. Process studies included investigations of changes in site biomass, carbon and nutrient levels, transformations of carbon pools, microenvironments, and detrital carbon fluxes. Biodiversity studies included a general insect and disease survey as well as more detailed studies on the abundance and diversity of various groups of soil mesofauna in decaying stumps or forest floor, earthworms, ground dwelling carabid beetles and spiders, ectomycorrhizal

TABLE 1. Summary of selected site attributes (Trofymow et al. 1997).

	Location							
	East side				West side			
Attribute[1,2]	VWS	VWN	KOK	NAN	REN	RGC	NIT	KLA
BGC zone	CWHxm1	CWHxm2 (CWHxm1)	CWHxm2	CWHxm1	CWHvm1	CWHvm1	CWHvm1	CWHvm1
Elevation (m) (mean: range)	303: 240 - 390	382: 260 - 465	631: 590 - 710	440: 430 - 460	206: 130 - 320	172: 80 - 300	227: 85 - 325	155: 120 - 230
Slope (%) (mean: range)	26: 11 - 40	21: 5 - 40	20: 15 - 35	21: 20 - 25	38: 25 - 45	47: 10 - 100	31: 22 - 45	23: 15 - 35
Aspect	NE (NW)	W, N, NE	S	S, SE, SW	W - N	N (E)	SW - W	NW (SE)
Exposure	n/a	n/a	wind	n/a (wind)	wind (n/a)	wind	wind (n/a)	wind
Terrain	morainal (fluvial)	morainal (bedrock)	colluvial	morainal	colluvial	colluvial	colluvial	colluvial
Soil	dystric brunisols	humo-ferric podzols and dystric brunisols	humo-ferric podzols	humo-ferric podzols	humo-ferric podzols	humo-ferric podzols (ferro-	humo-ferric podzols	humo-ferric and ferro-humic podzols
Humus form[3]	mull-like moders (typical moder, zoomull)	humifibrimors	hemihumimors	hemihumimors	orthihemimors	orthihemimors, moders	hemihumimors (moder)	orthi(ligno) humi(hemi)mors

1. Luttmerding et al. 1990.
2. Attributes enclosed in parentheses are from a single plot only.
3. System of Bernier (1968, in Luttmerding et al. 1990) for VWS and VWN; otherwise system of Klinka (1981, in Luttmerding et al. 1990).

TABLE 2. Soil chemistry summary by chronosequence, averaged across all four plots at a site and all four samples within a plot (Trofymow et al. 1997).

	LFH				Mineral soil (0-30 cm)							LFH & mineral
Site	pH	C/N ratio	C (%)	Total N (kg/ha)	pH	CEC (cmol)	C/N ratio	C (%)	Fe + Al (%)	Total N (kg/ha)	Ca + Mg + K (kg/ha)	Total N (kg/ha)
East side												
VWS	4.43	56.23	40.47	231.68	4.54	17.96	58.41	2.68	0.70	1260.15	877.10	1491.83
VWN	4.73	49.41	43.45	286.62	4.58	16.13	120.15	3.30	0.57	511.87	653.91	798.49
KOK	4.90	45.64	40.02	240.34	4.88	17.34	100.21	2.97	0.49	942.00	1440.22	1182.34
NAN	4.37	57.30	42.98	210.00	4.96	9.50	138.20	1.90	0.39	432.59	723.04	642.59
West side												
REN	3.41	48.85	44.13	688.97	4.07	25.85	27.89	4.95	1.74	2548.50	274.49	3273.23
RGC	3.61	42.04	43.80	463.53	4.43	23.66	35.79	4.24	1.83	3351.50	370.44	3815.03
NIT	3.43	70.09	45.55	371.77	4.08	36.90	35.07	7.49	2.29	2003.63	201.43	2375.40
KLA	3.47	44.76	41.85	723.33	4.37	29.47	37.14	6.19	2.76	2841.63	250.55	3494.93

Al = aluminum; C = carbon; Ca = calcium; CEC = cation exchange capacity; Fe = iron; K = potassium; Mg = magnesium; N = nitrogen.

fungi, mushrooms, salamanders, canopy lichens, and vascular plants. Most of the more detailed process and diversity studies were conducted on three intensive study sites on the east island (VWS, VWN, KOK). Preliminary or final results for some studies are summarized in presentations included in this issue. Further studies on ecosystem processes and diversity are planned for sites on the west side of Vancouver Island.

Chronosequence research offers scientists the opportunity to examine, over a period of a few years, long-term changes in forest succession. The knowledge gained from studies on these sites will assist foresters in improving their stewardship of these forests, upon which forest productivity and biodiversity ultimately depend.

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