Changes in Ecosystem Mass and Carbon Distributions in Coastal Forest Chronosequences

J.A. Trofymow, Pacific Forestry Centre, Canadian Forest Service, Natural Resources Canada, 506 West Burnside Road, Victoria, British Columbia, Canada, V8Z 1M5

and

Bruce A. Blackwell, B.A. Blackwell and Associates Ltd., 3087 Hoskins Road, North Vancouver, British Columbia, Canada, V7J 3B5

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Natural Resources Canada
Canadian Forest Service
Pacific Forestry Centre
506 West Burnside Road
Victoria, British Columbia
V8Z 1M5
Canada

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Introduction

Knowledge on quantities and changes in distribution of biomass and carbon occurring as a result of conversion of old-growth to second-growth forests is fundamental to understanding how forestry impacts site C balance and thus global atmospheric C levels. Developing such knowledge is especially relevant in coastal British Columbia (BC) where the national biomass inventory has identified BC as having the highest biomass contents, and hence the highest C, in Canada (Bonnor 1985).

The primary objective of this study was to quantify ecosystem mass and C contained within living, detrital, and soil components. This abstract reports findings from measurements of mass and C in Coastal Western Hemlock (CWH) zone forests (Meidinger and Pojar 1991) on four chronosequence sites (VWS, VWN, KOK, NAN) on the east side of Vancouver Island (CWHxm), and four chronosequence sites (REN, RGC, NIT, KLA) on the west side of Vancouver Island (CWHvm) (Trofymow et al. 1997); each site contains stands of four ages [R - regeneration (3-9 years), I - immature (32 - 43 years), M - mature (66 - 99), and O - old growth (245 - 445 years , except for RGC which was 176)]. All R and I plots and most M plots were of harvest origin and had been slash burned, although M plots at KOK and KLA were of stand-destroying wildfire origin. Origin of the old-growth stands was unknown.

Methods

At all eight sites, triangular plots were defined by establishing three subplot centres 30 m and 120^{o} apart from a centre benchmark. Using the line intercept method, three 50-m transects connecting the subplots were used to measure coarse woody debris (CWD); the transects were also used to estimate percent cover of different forest floor substrate classes. The plot and subplot centers also defined centres of 5- or 10-m radius plots for measurement of all standing live and dead stems and sampling centres for understory vegetation, fine woody debris, forest floor, and soils. Mensuration measurements of overstory trees (dbh, height to live crown, and total height) by species were made and tree biomass determined using published biomass regression equations for coastal BC tree species (Standish et al. 1985). Coarse root estimates included in the live biomass were derived using equations based on overstory biomass (Kurz et al. 1996). From each of three trees of each species in each plot, an entire upper canopy branch and breast-height bole core were collected for chemical analysis of foliage, twigs, wood, and bark. Living understory biomass and fine woody debris (<1 cm in diameter) were destructively sampled in four 1.0-m^2 quadrats, one per subplot, samples dried, weighed, and combined by plot for chemical analyses. Samples of each size, species, and decay class of CWD on each transect were taken for density and chemical analyses. Three forest floor samples were collected per subplot for bulk density determination. These were then weighed, sieved, and combined by subplot for chemical analyses. Detrital mass and C includes snags, fine and coarse woody debris, and forest floor. Mineral soils were sampled in each subplot at three depths for bulk density and sieved prior to chemical analyses. Live medium roots (2-8 mm) sieved from the forest floor and soil were weighed and the mass was included with the live biomass. Live fine roots (<2 mm) were not extracted and are included in the soil. Total C content was determined for each component by multiplying %C for each component sampled by its total mass. Mass and C inventories were calculated for each plot.

Results and Discussion

For the same seral stage, the mass of living and the mass of detrital components were greater for west side (815 Mg/ha) versus east side (521 Mg/ha) sites. Living biomass accumulation followed the order O>M>I>R for both east and west sites. With the exception of R plots, the highest quantities of living biomass (>75%) were contained in overstory trees. Detrital biomass accumulations were more variable and followed the order O>R>M>I in the west and O>M=R>I for the east. Coarse woody debris accounted for the greatest proportion (>60%) of detrital biomass.

Figure 1 illustrates the subzone and sere effects on total C distributions within living, detrital, and soil pools. Within the same seral stage, total C content was greater in the west (261-799 Mg C/ha) than east (111-513 Mg C/ha). With seral stage, C content increased primarily due to accumulation in living and detrital pools. For O plots, living and detrital pools accounted for 89% of total ecosystem C in the west, 63% in the east. Greater accumulation of C in the west than in the east is likely attributable to slower decomposition and lower fire frequency on west-side sites where the climates are moister and cooler than the warmer drier climates in the east (Meidinger and Pojar 1991). In the Pacific Northwest fire return intervals in the dry Douglas-fir forests are estimated at 230 years (Agee 1993) versus 300-600 years for moist *Abies amabilis* forests (Hemstrom 1982).

With the exception of R plots, living biomass C content was greatest for overstory trees and in the same seral stage tended to be higher in west-side (19-532 Mg C/ha) than in east-side plots (9-417 Mg C/ha). Understory C accounted, on average, for 20% of live biomass in R plots and 1% or less in I, M, and O plots. On average, bolewood accounted for 70% of the C present in trees. One O plot in the CWHvm1 contained close to 546 Mg C/ha in bolewood.

Forest floor and coarse woody debris C were higher in all seral stages in the west (27-49 Mg C/ha) compared with similar stages on the east (84-178 Mg C/ha), such that total detrital C was some 30-40% lower in the east than in the west. Detrital C was highest in O plots and declined only slightly following harvest in R plots. The lowest amount of detrital C was found in I plots, which coincides with the period of high biomass accumulation. Increasing accumulations of detrital C in M plots is likely a function of continued overstory biomass accumulation and increased mortality associated with self-thinning. In the west, detrital C accumulations substantially increased from mature to O plots; whereas, for the east, accumulations were similar.

Mineral soil C quantities were much higher in the west (91-128 Mg C/ha) than in the east (47-60 Mg C/ha) although soils were generally shallower and rockier for west side sites. Soil C pool accounted for 11% of total ecosystem C in west O plots compared with 9% for the east O plots. For R plots soil C accounted for 53% of the total ecosystem C in the east and 35% in the west.

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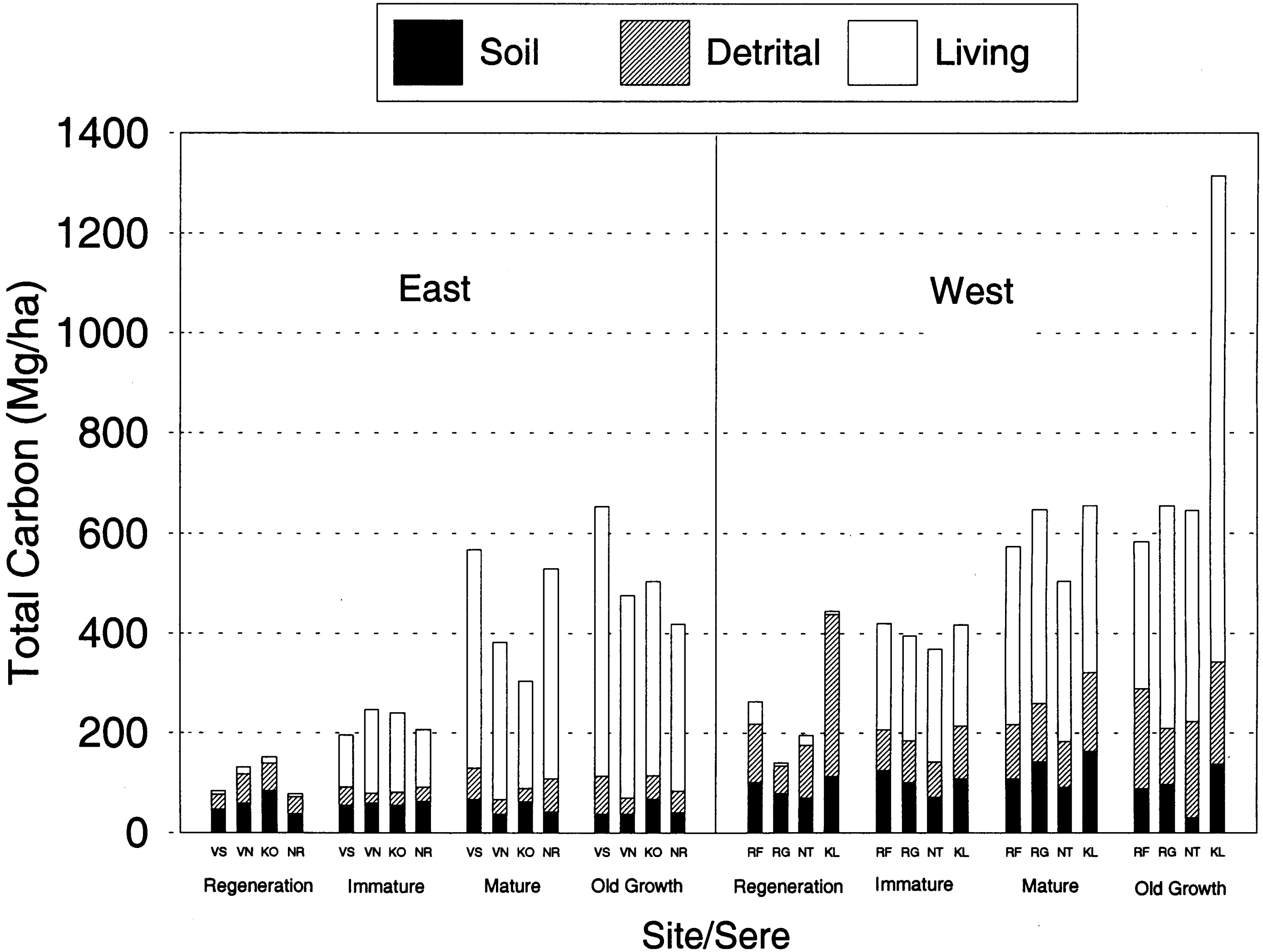

Figure 1. Living, detrital, and soil carbon for each plot, grouped by site and seral stage within the CWHxm (east) and CWHvm (west) biogeoclimatic subzones.