The Mother Tree
PROJECT

This document was referred to in the field sampling methods, and there should be a link to it on our website: [CFIC and CFS] Canadian Forest Inventory Committee and Canadian Forest Service. 2008. Canada's National Forest Inventory: Ground Sampling Guidelines. Version 5.0. Ottawa. http://www.worldcat.org/title/canadas-national-forest-inventory-ground-sampling-guidelines/oclc/606580128

A few notes about site selection....

Site selection criteria included: mature stands with at least one-third of the basal area in Douglas-fir; medium moisture regime; and similar topography, species mix, stand structure and tree age distribution across a 20-ha block. We established agreements with the licensees operating in the chosen locations to apply our five experimental logging treatments and maintain the area as long-term (decades) research sites.

A few notes about our sites....

The research sites are in mature forests (age 82-123 years) across a 900 km climate gradient in interior British Columbia, Canada, from near the southern distribution of Interior Douglas-fir in BC near Cranbrook (49.21° N,115.37°W), to its northernmost extent near Fort St James (54.65°N, 124.43°W (Table 1; Fig. 1). Each location along the gradient represents a unique set of climatic conditions where Interior Douglas-fir grows. As a comparison to the interior location, one coastal location was chosen in the Malcolm Knapp Research Forest near Maple Ridge (49.32°N, 122.54°W).

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The interior study locations are in various biogeoclimatic (BEC) subzones of the Interior Douglas-fir (IDF), Sub-Boreal Spruce (SBS), and Interior Cedar-Hemlock (ICH) zones and occur in the Thompson-Okanagan, Kootenay-Boundary, Cariboo, and Omineca Forest Regions. The coastal site is in the Coastal Western Hemlock (CWH) zone on the south coast of BC. At each location the three replicate sites are within the same BEC zone except at the Alex Fraser Research Forest where one replicate is in the IDF and the other one in the ICH zone. Four sites occur in the IDF zone which dominates low-mid elevation valleys and rolling terrain in southern interior BC and is characterized by warm, dry summers, a fairly long growing season and cool winters (Meidinger and Pojar 1991). The IDFxh (Interior Douglas-fir very dry hot subzone), where one Peterhope replicate occurs, is the driest IDF subzone in the province. The SBS zone, where our highest latitude site (John Prince) occurs, dominates the landscape of BC's central interior. The SBS climate is continental with relatively warm, moist, short summers, moderate annual precipitation and cold, snowy winters. The ICH zone, where the remaining interior sites are located, occurs at mid to low elevations and the climate is continental with warm, dry summers and cool, wet winters. The ICH is the most productive zone in interior BC and has the highest tree diversity of any zone in the province. The CWH zone occurs at low to mid elevations along the entire BC coast, mostly west of the coastal mountains. It receives the most rainfall of any BEC zone in BC. Summers are cool but hot spells can occur, and winters are mild.

Climatic data for our 23 sites was extrapolated from ClimateNA, by inputting latitude, longitude and elevation, and choosing the 1980-2010 dataset (Wang et al. 2016). Of our interior sites, the two mid-elevation locations in the interior wet belt of the Kootenay-Boundary region receive the most precipitation (868-1059 mm yr^{-1}), with about one-third falling during the growing season. The coastal site receives an average of 2701 mm of precipitation annually. At the other extreme, our two driest locations receive about 390 mm of precipitation annually. Precipitation falling as snow ranges from 140 mm yr^{-1} at our climatically driest sites to 420 mm yr^{-1} at the wettest. Mean annual temperature of the interior locations ranges from 2.3^{o} C to 7.7^{o} C, and is 8.0^{o} C for the coastal site. Drought during the growing season is an important climatic growth limiting factor throughout the interior locations, especially in the IDF zone. Frost constrains growth and survival of susceptible seedling species in all of the interior subzones where our sites occur (Braumandl and Curran 1992; Lloyd et al. 1992; Steen and Coupe 1997; Delong et al. 1993). The average frost-free-period on the interior sites ranges from 84 days at the highest latitude site to 152 days at the lowest elevation, southern site, and is 172 days at the coastal site. Summer heat: moisture index (SHM), (mean warmest month temperature/(mean summer precipitation/1000) is highest for the Thompson-Okanagan and low elevation West Kootenay site (81-88). Sites at higher elevations and further north have a lower SHM (51-68), and the SHM of the coastal site is 25.

The 23 replicate sites have a medium (mesic-submesic) moisture regime, are south or west facing, and are in a mid-slope position. Slope gradient is relatively gentle ($\leq$ 30%) except at one Redfish Creek replicate where slopes are 40-60%. Soil textures vary but in general the texture of the dominant B horizon is coarser in the ICH zone (sandy loam) than the IDF (silt loam, sandy clay loam or loam), and finest in the SBS (clay loam or loam). Soil texture at the coastal location varies from sandy loam, silt loam to loam. Coarse fragment content of the dominant B horizon ranges from about 25 to 50 percent. The predominant soil orders are Luvisols and Brunisols in the IDF zone, Podzols and Luvisols in the SBS, and Podzols in the ICH and CWH.

2.2 Data collection and sampling

2.2.1 National Forest Inventory plots

2.2.1.1 Overview

Pre-harvest field data was collected in 2017/18 according to the 2008 National Forest Inventory (NFI) ground sampling guidelines (CFIC and CFS 2008). Tree data was collected within circular 0.04 ha (r=11.28 m) plots, and other data within smaller nested plots. The plots were located near the centers of the 4 ha treatment units. A total of 113 plots were established and measured. The plot centers were marked on georeferenced maps prior to the field visit to avoid bias in selecting the plot location.

2.2.1.2 Large tree plot

Each large live conifer and broadleaf tree ($\geq$9 cm DBH and >1.3 m tall) occurring within the 0.04 ha plot was tagged at the base and stem mapped (i.e., distance and azimuth from plot center were measured). Species was recorded and measurements were taken of diameter at 1.3 m height (DBH) (nearest 0.1 cm), height (nearest 0.1 m), height to crown top (nearest 0.1 m), height to live crown base (nearest m), and damage/condition. Each dead tree or stump ≥ 9 cm DBH and >1.3 m tall was assessed for species, mortality cause, and whether intact, broken or cut, and it was measured for DBH and height. The tree measurements were used to describe the stands and for calculation of C stored in large trees (Mg ha^{-1}).We used increment cores to determine the age of one live undamaged codominant or dominant trees of each major tree species (≥20% of stand basal area) for use in site index calculations. Cores were taken at 1.3 m height and accepted if within two years of the pith.

2.2.1.3 Small tree plot

A circular 50 m^2 plot (r=3.99 m), centered on the 0.04 ha plot, was used to measure small trees (<9 cm DBH and >1.3m tall); shrubs >1.3 m tall; and stumps ≤1.3 m tall and ≥ 4 cm diameter. The trees were assessed for species and status (live/dead), and DBH and height were measured. Species, height class, basal diameter class, and status were recorded for individual shrub stems that met the minimum height requirement. Each stump meeting the size requirements was assessed for species and one of five decay classes (BCMOFR and BCMOE 2010; Appendix 1) and measured for height, and top inside and outside bark diameter. The measurements of small trees and stumps were used to describe the understory of the stands and for calculation of C stored in small trees (Mg ha^{-1}).

2.2.1.4 Coarse and small woody debris

Coarse woody debris (CWD) (>7.5 cm diameter) was measured along two perpendicular 30-m transects intersecting each other at the NFI plot center. Pieces were classified as either round or odd-shaped. The round pieces were measured with large calipers for diameter (nearest 0.1 cm) at the point of intersection with the transect line. Tilt angle (angle from horizontal) was measured with a clinometer to the nearest degree. Odd-shaped pieces were measured for horizontal length and vertical depth at the point of intersection with the transect line. For both categories of CWD, species was recorded (where reliable) and each piece was assigned to a decay classes (same classes as used for stumps) based on characteristics of the entire piece. The number of pieces of small woody debris (SWD) (1.0 - 7.5 cm diameter) that intersected the transect line were counted by diameter class on a 5-m section at the end of each CWD transect (total 20 m per NFI plot). The diameter classes were 1.1-3.0, 3.1-5.0 and 5.1-7.5 cm. The average decay class of SWD was recorded for each transect. The measurements were used to calculate C storage and volume per hectare of CWD.

2.2.1.5 Substrate

Substrate type (organic, buried wood, decayed wood, bedrock, rock/cobble, mineral soil, or water) was recorded every 2 m along each CWD transect (total 30 stations per NFI plot). Substrate depth to mineral soil, bedrock, sound wood or other obstacles was recorded for organic and buried wood substrates. Sample stations were moved to the side of the transect if they landed on tree boles or decay class 1 or 2 logs. Substrate type and depth was used in calculation of C (Mg ha^{-1}) in the forest floor.

2.2.1.6 Microplots

One circular 1 m^2 (r=0.56 m) microplot was established at the ends of each 30 m CWD transect (total four microplots per NFI plot) and here samples were collected for determination of their oven-dry weight which was used in the calculation of C storage (Mg ha^{-1}). All bryoids, herbs, trees/shrubs <1.3 m in height, and fine woody debris (FWD) ($\leq$1 cm diameter) occurring within the microplots were collected in separate paper bags. A 20 x 20 cm sample of forest floor extending from the ground surface to the mineral soil interface was cut out with a knife and stored in a paper bag. At each microplot, the upper 15 cm of mineral soil was collected from holes approximately 10 cm in diameter. At two of the four microplots, mineral soil was collected from 15-35 cm depth, and at one microplot from 35-55 cm depth. The volume of each mineral soil sample was measured in the field by lining the excavated holes with plastic, filling the holes with water, then using a graduated cylinder to measure the water volume for usein calculating bulk density. Each mineral soil sample, including roots and gravel (rocks up to 7.5 cm diameter), was collected in a paper bag. Rocks from the excavated hole that were larger than 7.5 cm in diameter were weighed on a small scale in the field and discarded.

Figure 3. Microplot sampling. The plants, fine woody debris, forest floor, and two layers of mineral soil have been collected.

2.2.1.7 Plant community

The plant community was assessed using two plot sizes. A circular 314 m^2 (r = 10 m) plot was used to estimate percent cover of each tree and shrub species by height class (>10 m (A layer); 2-10 m (B1 layer); and < 2 m (B2 layer)). A circular 100 m^2 plot (r = 5.64 m) was used to estimate percent cover of all conifer seedlings ($\leq$ 1 year old), bryoids and herb species. Percent cover was visually estimated to the nearest 0.1% when less than 1%, to the nearest 1% when 1-10% and to the nearest 5% when 10-100%. The vegetation data was used to calculate biodiversity.

2.2.1.8 Ecological description

The BEC variant of each NFI plot was determined from field maps (https://www.for.gov.bc.ca/hre/becweb/resources/maps/FieldMaps.html). Elevation, slope gradient, aspect, slope position, surface shape (straight, convex or concave), site uniformity (scale of 1 to 5), microtopography (smooth, moderately, strongly or extremely mounded), percent cover of bedrock and cobbles/stones, and other physiographic features were recorded. A soil pit was dug just outside of each NFI plot to $\geq$ 60 cm depth or until an impenetrable layer was reached. Mineral soil horizons were delineated, the depth of each was recorded to the nearest centimeter, and the texture and coarse fragment content of each horizon were estimated. Mineral soil and forest floor were classified to Order (Klinka et al. 1997; Soil Classification Working Group 1998). The physiographic, soils and vegetation data were used to estimate soil moisture regime, soil nutrient status and site series of each NFI plot (Braumandl and Curran 1992; Lloyd et al. 1992; Delong et al. 1993; Green and Klinka 1994; Steen and Coupe 1997).

2.2.2 Wildlife

Wildlife habitat features (i.e., appearance, condition, bark retention, wood condition, and lichen loading) were estimated for each live and dead tree $\geq$ 9cm DBH and > 1.3m height within each 0.04 ha NFI plot (MOF & MOE 2010). Evidence of use (activity/sign) was recorded for each mammal, amphibian and bird species at each plot.

2.2.3 Laboratory procedures

All vegetation, fine woody debris, forest floor and mineral soil samples were oven dried. Immediately after drying, vegetation and fine woody debris samples were weighed then discarded. The dried samples were weighed immediately after drying. The dried mineral soil samples were sieved to separate out roots and gravel (>2 – 7.5 mm diameter) and these components were weighed separately. The forest floor samples were run through an 8 mm sieve and the <8 and $\geq$8 mm portions were weighed separately. Each dried mineral soil and <8 mm forest floor sample was mixed to create a homogeneous product, and a small portion of each product was stored in a labelled sealed plastic bag and sent to the Ministry of Environment Lab in Victoria for analysis of C and nitrogen (N) content. The oven-dried weights and soil C contents were used in the calculation of C (Mg ha^{-1}) and the C and N content used to calculate the C/N ratio.