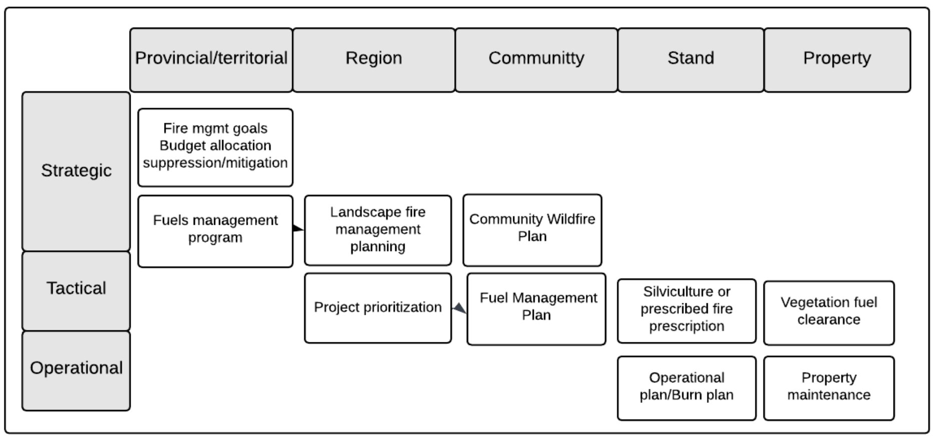
Update on some fuels-related research initiatives at Pacific Forestry Centre, Natural Resources Canada

Fuel Treatment Efficacy & Landscape Resiliency Research & Knowledge Sharing Event, Feb 28 – March 1, 2023. Univ. of B.C.

Review of Fuel Treatment Decision Aids and Research Needs

Decisions about fuels management are made a range of spatial and temporal scales from provincial programs, to landscape management, to property level fuel treatments. We are reviewing fuels management through the lens of decision making to identify gaps and inform our future research in this area. We would welcome input.



Fuels management decisions span a range of spatial & temporal scales

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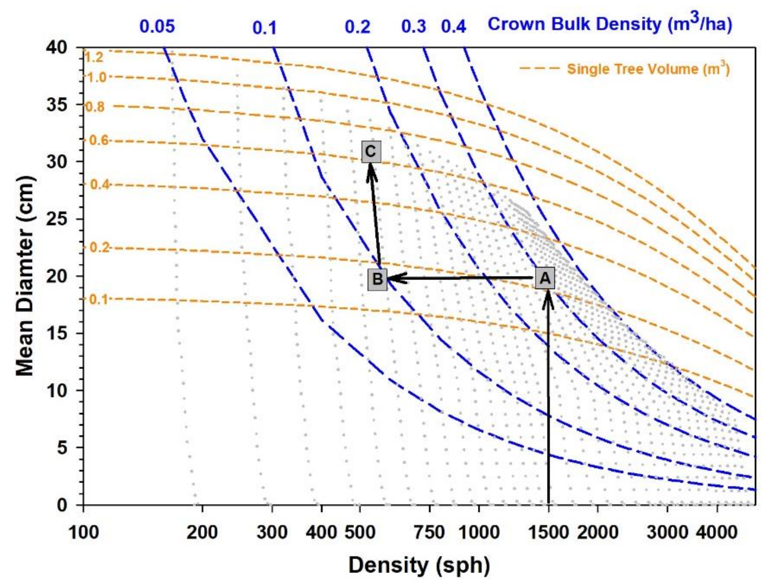
Developing Stand Management Diagrams to Inform Fuel Treatment Prescriptions

Stand Management Diagrams (SDMD) portray the relationship between stand density and single tree and/or stand level characteristics such as volume or biomass as well as self thinning trajectories at any density. There is an upper limit on maximum tree size at any density that is often referred to as the -3/2 power law of self thinning. SDMD have been used to develop thinning prescriptions for timber management. We are developing SDMD for interior BC tree species based on stand projections from TIPSY that incorporate Crown Bulk Density and Crown Base height to inform fuel treatment prescription development.



SDMD portraying relationship between density, quadratic mean diameter, CBD and average tree volume. Thinning example for a stand with 1500 stems per hectare. Self thinning trajectories are in grey.

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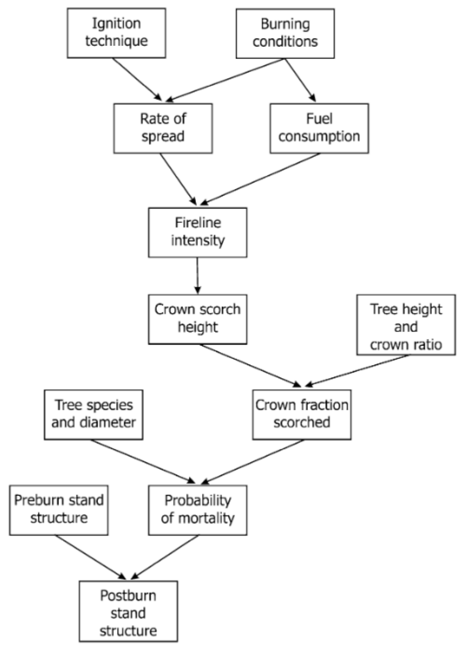
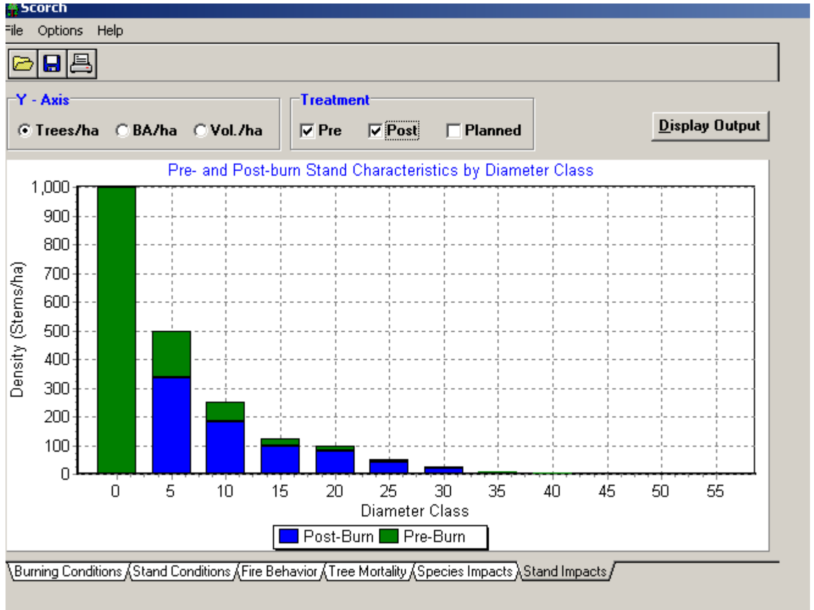
Reengineering SCORCH – Predicting Prescribed Fire Impacts on Stand Structure

We developed the model SCORCH to predict fire impacts on tree mortality and stand structure as part of the EMBER (Ecosystem Maintenance Burning and Restoration) project in the East Kootenays a number of years ago. The model uses some similar relationships as FOFEM (First Order Fire Effects Model), however out model is applied at the stand rather than single tree level, and we attempt to represent variability in fire intensity due to ignition patterns. We relate fire weather to fire intensity, crown scorch height, tree mortality, and impacts on stand structure (mortality and residual stems by species and diameter class). A user enters stand and fire weather prescription information and gets an estimate of impacts on stand structure. Prescription parameters need to be adjusted iteratively to arrive at a desired post-fire condition. SCORCH is several operating systems out of date. We will be updating the model to run online.



SCORCH model inputs, processes, outputs



Projected mortality (green) and post fire stand structure for an example scenario.

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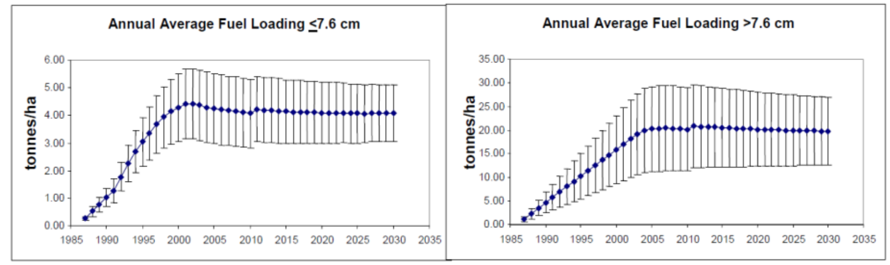
Development of an FVS- BC Fuels and Fire Effects Model

Canadian fire management agencies are carrying out prescribed fire and fuels management programs to maintain or restore fire dependent ecosystems, and to reduce the fire risk to communities. There is a need for decision support tools to: a) predict fire behavior, scorch, and tree mortality for different prescriptions and stand conditions and b) simulate fire behavior potential over time with or without prescribed fire and fuel management.

The Forest Vegetation Simulator (FVS) North Idaho variant was recalibrated as FVS-BC to model uneven aged stands in central and southern interior BC. The Fuel and Fire Effects (FFE) l extension to FVS simulates fuel dynamics and potential fire behaviour over time, in the context of stand development and management.

We have worked with ESSA for a number of years to implement surface fire behavior equations, a crown fire initiation model (CFIM) and crown fire spread equations with the FVS Fire and Fuels Extension (FFE) and FVS-BC. The fire behaviour modeling scheme was chosen so that fire behaviour could be predicted as a function of variable, physical fuel properties (surface fuel load, crown base height, crown bulk density) as well as wind speed and FWI System moisture codes. The physical fuel properties are modeled in FVS-BC and FFE from the initial stand conditions (tree list), surface fuel data, and fuels treatment (if any), usually at a 5 year time step. This provides an alternative way to represent fire behavior to the 16 fixed fuel types in the Canadian Fire Behavior System over a longer planning period. Users can evaluate the immediate and long term effects of prescriptions and estimate when further treatment may be required to maintain desired stand conditions, and/or fire behaviour potential. These equations/models have been incorporated as an option into the FFE but further testing is required with field data. Further work is also be needed to validate/calibrate the fuel dynamics models.



Projected fuel accumulation following MPB attack in 20 stands with FFE

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Predicting Ember Yield and Transport

There are a number of physical models including CFD (computational fuel dynamics) models such as FIRETEC that can represent ember transport quite well if the ember characteristics are known. However, the yield or ember production factor (e.g. number, size/mass of embers / kg fuel consumed) is a key uncertainty in modeling ember flux into the Wildland Urban Interface. We have developed acoustic methods to recover data on ember yield from in-fire camera video footage taken from within about 15 experimental fires. We are planning new experiments in NWT in 2023 focussed on measuring ember yield and characteristics in crown fires. Fuel treatment likely reduces ember production through reduction in crown fuel load, fire intensity and probability of crowning, as well as transport distance, however this is poorly understood. We are looking for opportunities to assess ember yield from high intensity fires in thinned stands in future years.

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Conifer Pyrometrics (CP) System:

Empirical fire behaviour modelling in conifer forests

- Linked empirical modelling system with graphical visual dashboard (FuelGraph-CP) shows fire behaviour across a range of wind speeds
  - Predicts fire type: **surface fire** (SF), **passive crown** (PC), **active crown** (AC); and **rate of spread** (ROS) in conifer stands
- Available now as a bridge between FBP/CFIS systems and NG-CFFDRS
- Starts with **crown fire initiation** (Fig.1) to determine threshold conditions for crown fire in a given conifer stand
  - CFI model based on <u>wind speed</u> (ws, km/h), stand-adjusted litter <u>moisture content</u> (mc_{SA}, %; uses FFMC and optional stand attributes), <u>fuel strata gap</u> (FSG, m; adjusted live crown base height), <u>surface fuel consumption</u> (SFC, kg/m^3; can be estimated, e.g. with FBP equations).
  - In fuel treatments, e.g., FSG and SFC can be manipulated for testing treatment scenarios, along with mc_{SA}
- CFI model is based on empirical analysis of > 120 experimental fires (~0.1-4 hectares) in Canadian conifer stands on level ground (Fig. 2)
- At lower wind speeds or conditions when **surface fire** is predicted, surface RSO (sROS) model is based on 54 surface fires, using a modified ISI input (stand-adjusted moisture content ISI, ISI_m)
- When PC or AC fire behaviour is predicted, uses Van Wagner's (1977, 1993) criterion for active crowning (CAC), based on ws and crown bulk density (CBD); leads to a 'stair-step' ROS function in open stands (Fig.3) and more abrupt ROS transition in closed stands
- Can be easily compared with FBP System (standard fuel type) predictions in FuelGraph-CP (Fig. 3)
- Based heavily on boreal & sub-boreal pine-spruce forests; use in other forest types (e.g. Douglas-fir) may need calibration
- FuelGraph-CP includes additional calculation tools to estimate inputs.

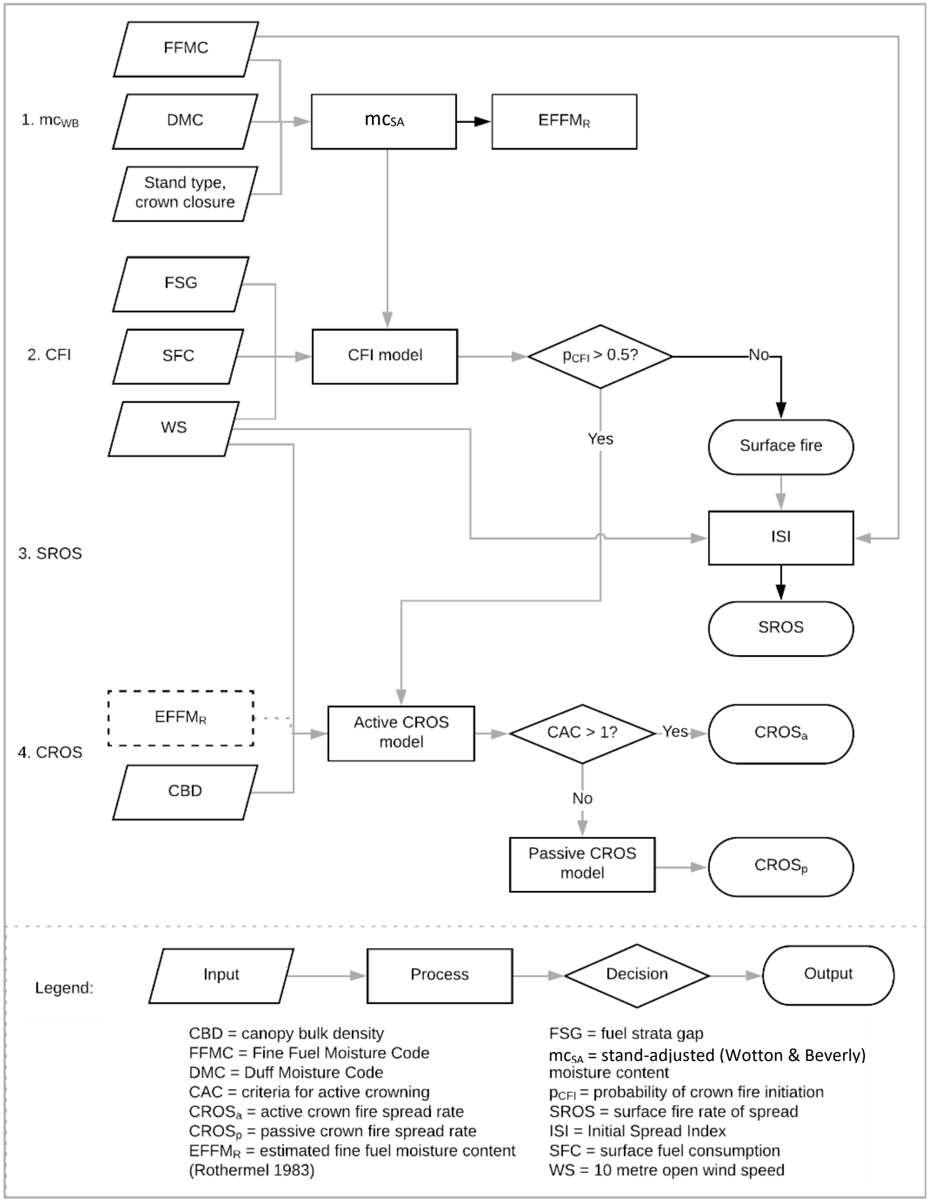

Figure 1. CCP flowchart showing inputs and process flow. Note that new sROS model uses ISIm, a refitted ISI model that incorporates stand attributes via the mc_{SA}.

Empirical Crown Fire Reanalysis and the Conifer Pyrometrics System

DDB Perrakis, ME Alexander, MG Cruz, CC Hanes, SW Taylor, DK Thompson, BJ Stocks

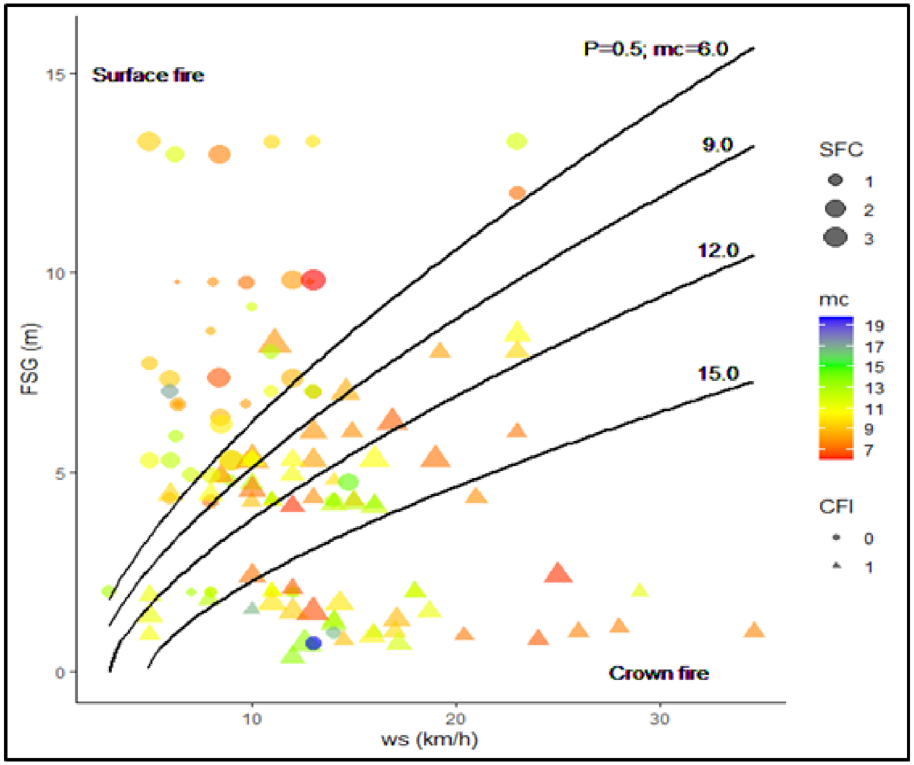

Fig 2. Reanalysis of combined records from > **120 experimental fires** in Canadian conifer forests (1960-2019)

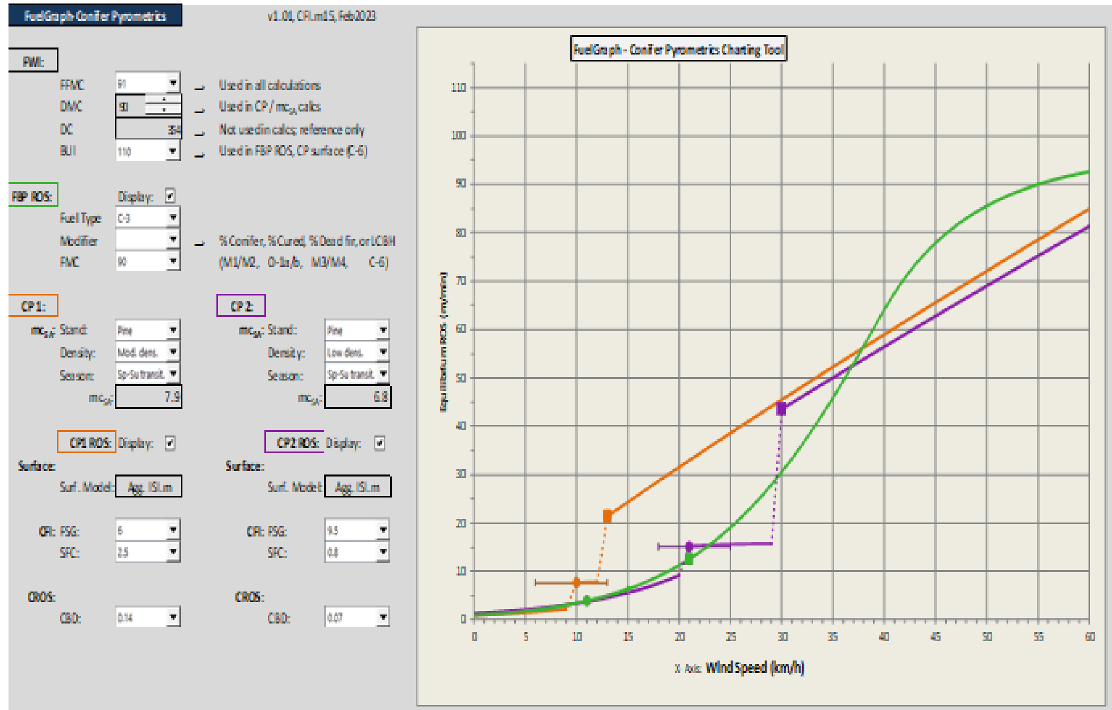

Fig 3. FuelGraph dashboard allows scenario-building and 'gaming' of fuel and fire weather scenarios, including hazard reduction treatments.

CP scenarios (orange, purple) can easily be compared with base FBP predictions (green).

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