Subcanopy microclimate and fuel moisture research at the Canadian Forest Service

Fuel Treatment Efficacy & Landscape Resiliency Research & Knowledge Sharing Event

March 1, 2023

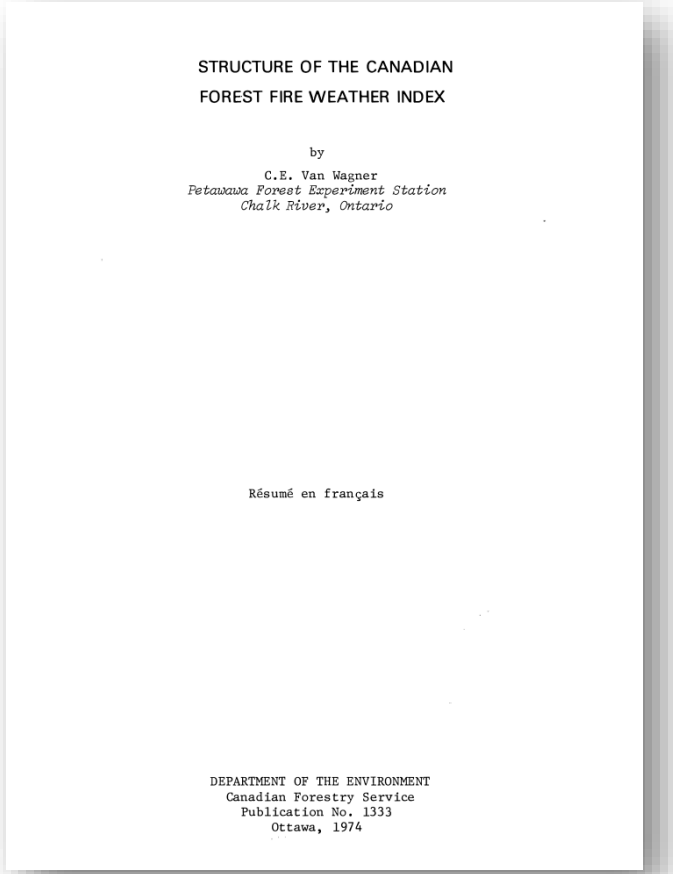
Derek van der Kamp

Canada

Context

Fire Weather Index System (1984):

- Designed to represent midafternoon fire danger within a “generalized pine forest”
- Intended to give uniform results for the entire country



STRUCTURE OF THE CANADIAN
FOREST FIRE WEATHER INDEX

by

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Chalk River, Ontario

Résumé en français

DEPARTMENT OF THE ENVIRONMENT
Canadian Forestry Service
Publication No. 1333
Ottawa, 1974

Context

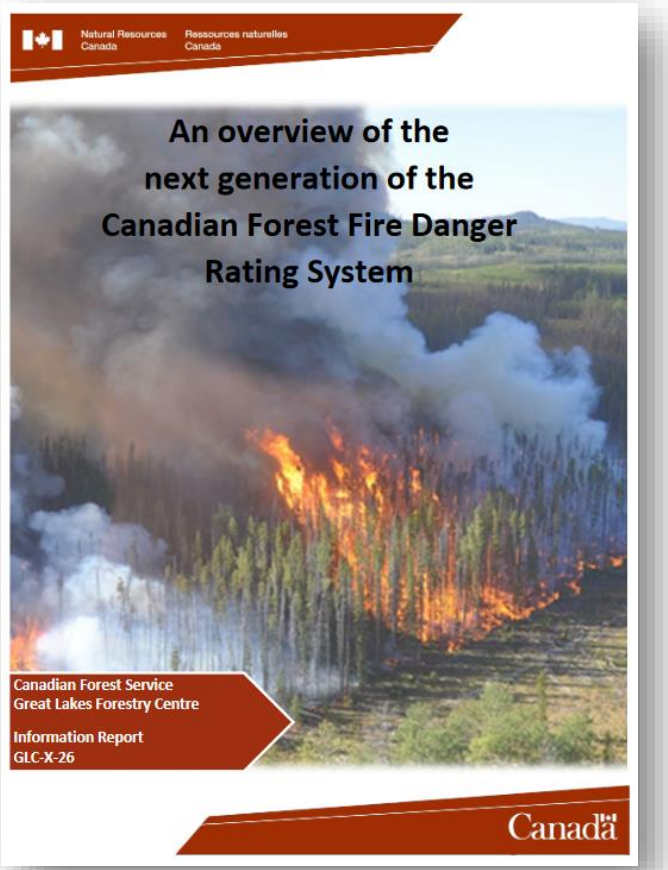
Next generation Canadian Forest Fire Danger Rating System:

“improvements in modelling of the effects of fuel treatments such as mechanical thinning and pruning on fire behaviour”

“…a new Fuel Moisture System (FMS) will provide a means to directly estimate the moisture content of important fuel layers in a range of different stand types at different times throughout the day”

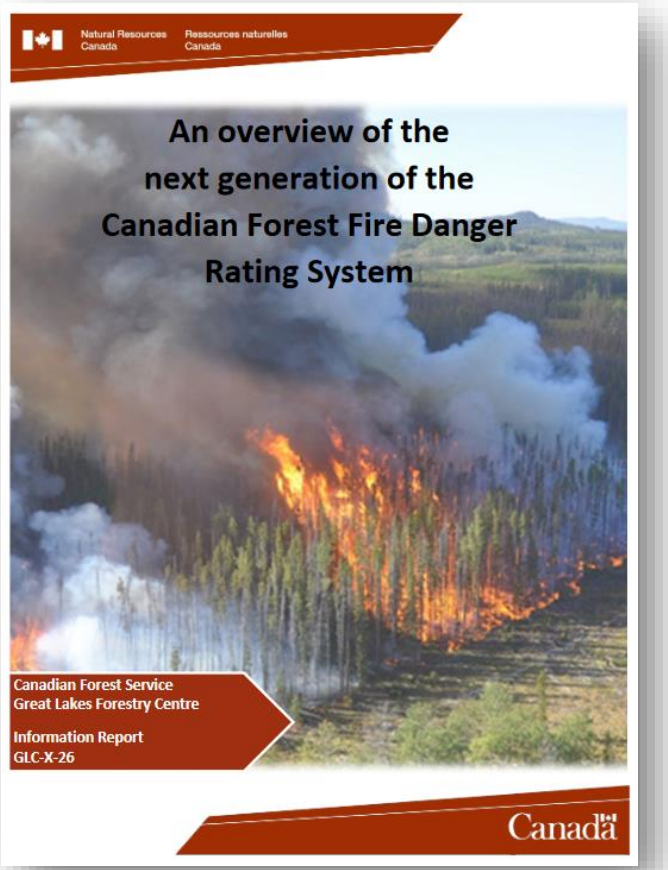
“New fire spread rate models will decouple from the reliance on ISI (Initial Spread Index) and rely, more directly, on estimates of actual fine fuel moisture content and actual windspeed”

“Includes flexibility to change stand structure (e.g., crown base height, canopy bulk density, stand height, forest floor cover type) and fuel loading. Stand structure can be modified by natural disturbance or fuel treatment”



Context

- Building a suite of microclimate models
- driven by stand type, terrain, and nearby standard weather station data
- Microclimate conditions drive fuel moisture models and rate of spread models
- Different fuel moisture models: grass, elevated, peat
- Core FWI indices remain



Subcanopy microclimate database

- ~ Dozen different studies across Canada (most with multiple sites)
- Paired with nearby open weather station
- Over a range of forest and canopy cover
- Hosted as an R data package
- Allows us to train and evaluate models
- Always looking for more partners!

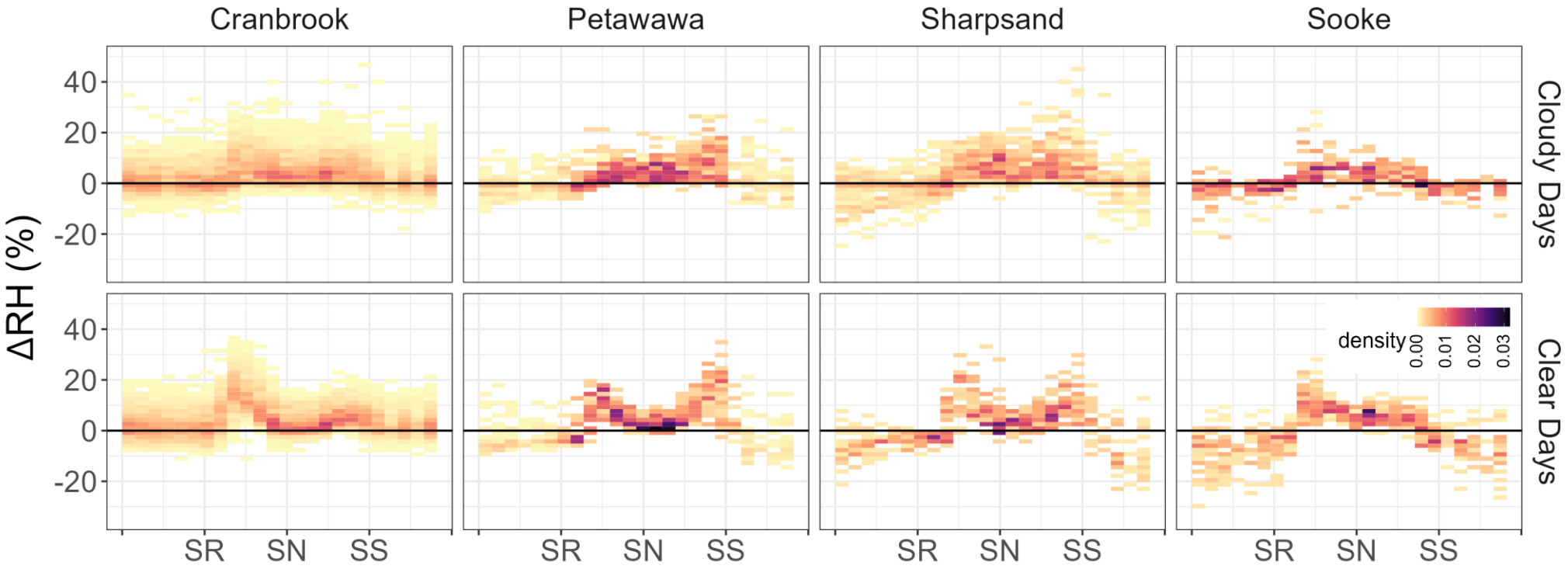
Suite of microclimate models

- Temperature/Humidity differences
- Solar radiation reduction
- Wind reduction

Temperature/humidity differences

- Model differences between open and subcanopy temperature/humidity based on:
  - Time of day
  - Open weather conditions
  - Canopy cover

Temperature/humidity differences



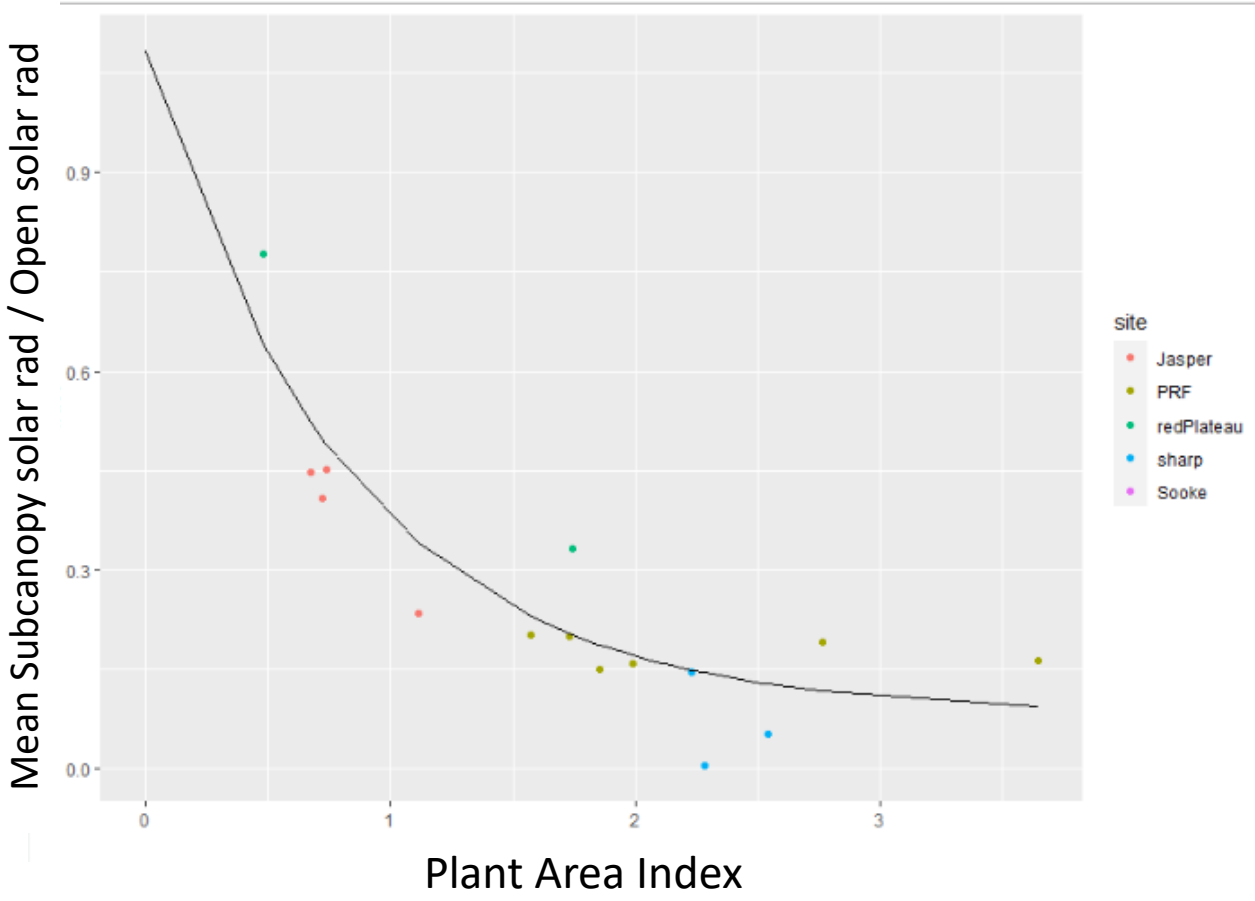
- Diurnal trends study-specific (microclimate of open site?)

Solar radiation reduction

- Solar radiation, AKA shortwave radiation, AKA solar energy, AKA solar irradiance, can play large role in fuel moisture
- Rarely measured/reported at fire weather/ECCC stations
- Developing:
  - Methodology for estimating above-canopy solar radiation based on standard fire weather observations
  - Simple model for estimating solar radiation reduction as function of canopy cover

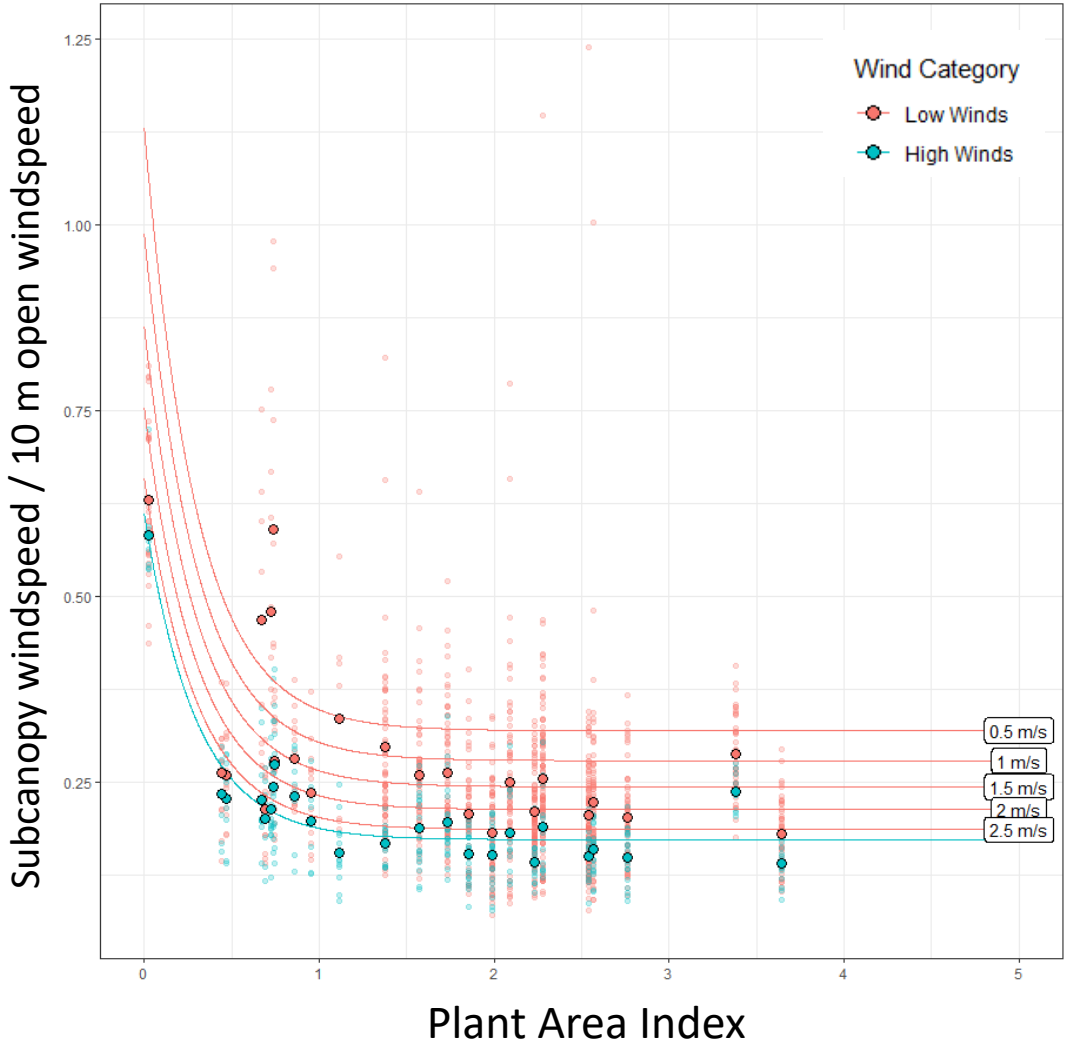
Solar radiation reduction

- Using subcanopy microclimate database to develop an empirical model connecting reduction and canopy density



Subcanopy wind adjustment

- Fit based on data from microclimate database
- Takeaway – For wind speeds > 10 km/hr, within moderate or dense canopies:
  - 1 m winds ~20% of open 10m winds



Subcanopy wind adjustment

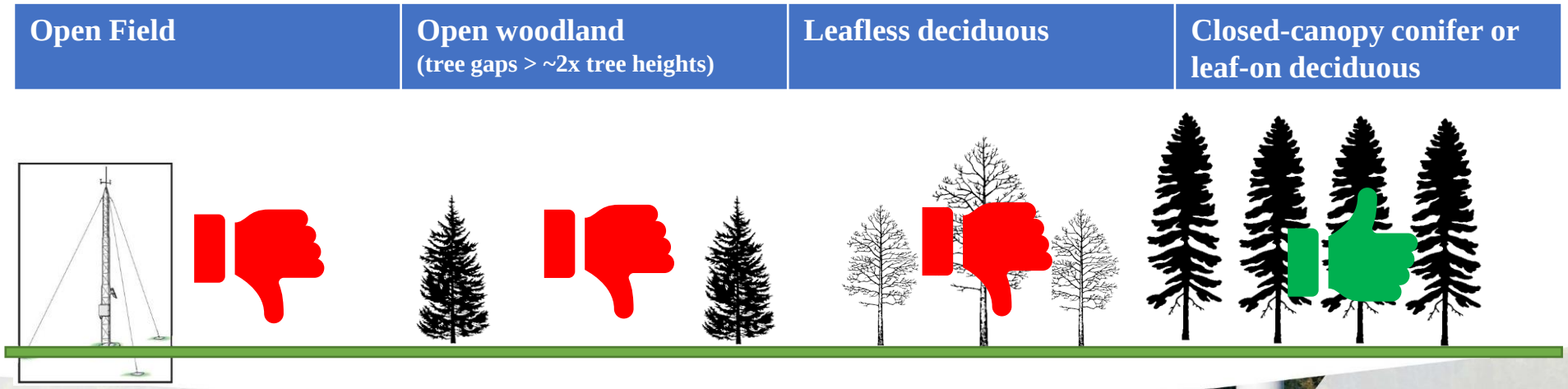
Open Field	Open woodland (tree gaps > ~2x tree heights)	Leafless deciduous	Closed-canopy conifer or leaf-on deciduous	@ a wind-exposed forest edge
0.62 for short grass 0.55 for tall grass	~0.3-0.4	0.25-0.40	0.2	0.3

Subcanopy 1m windspeed / 10 m open windspeed

Fine fuel moisture modelling (litter & grass)

- Stick with the general approach that's "under the hood" of the Fine Fuel Moisture Code, but:
- Drive the new model with actual subcanopy conditions
- Explicitly model impact of solar radiation on litter moisture

When does the **FFMC** apply?



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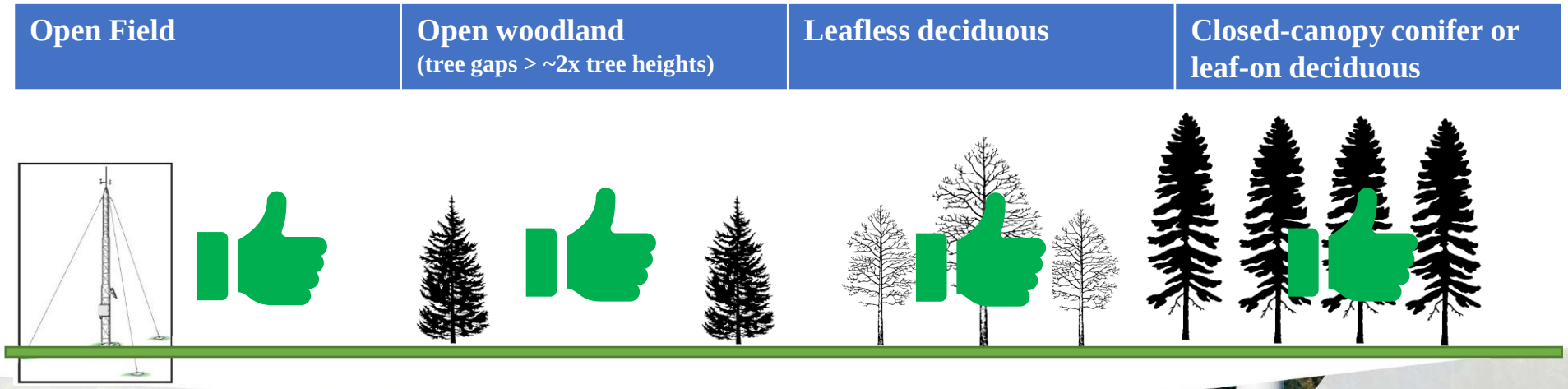
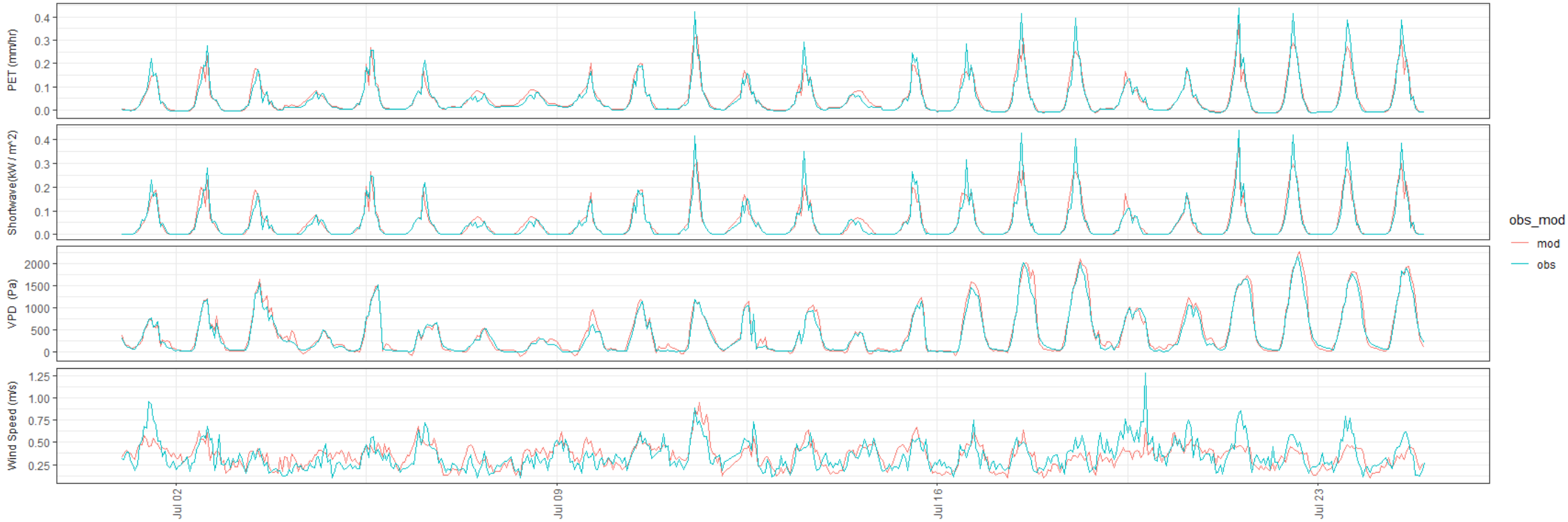


Duff Moisture modelling

- Can use the Penman-Monteith approach to model evaporation from the duff layer
- Evaporation needs solar radiation, vapour pressure deficit and wind
- DMC is not dependent on wind speed…
- Changes in DMC is related to potential evapotranspiration

Duff Moisture modelling



Drought Monitoring

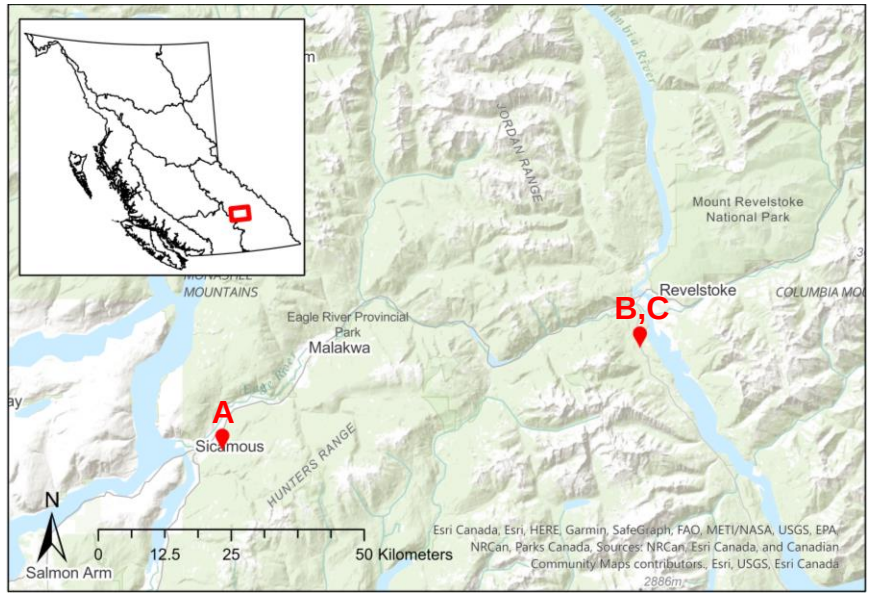
Objectives

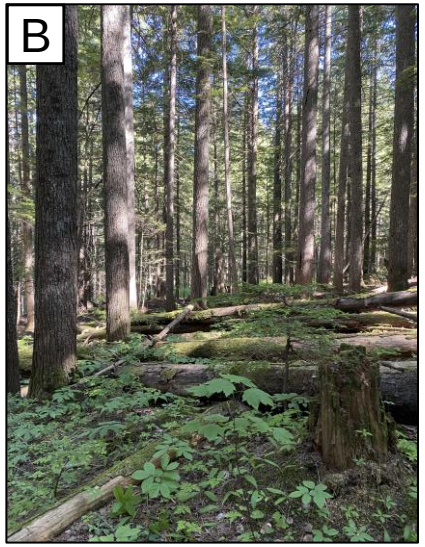
Obtain time series data of soil moisture and temperature to:

1) Field validate land surface models used for soil moisture estimation (i.e. ECCC's Canadian Land Data Assimilation System (CaLDAS))
2) Improve protocol around drought code overwintering (DC startup values)
3) Improve estimation of fire season start date

B.C. Soil Moisture Monitoring Sites

1) Sicamous Control (A)
2) Revelstoke Control (B)
3) Revelstoke Treatment (C)





FPInnovations

BRITISH COLUMBIA

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Foliar moisture modelling

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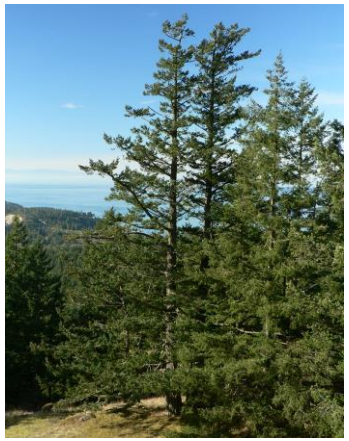
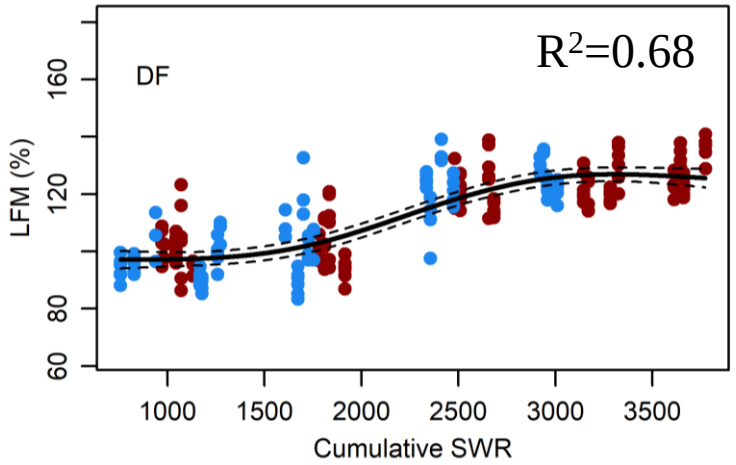
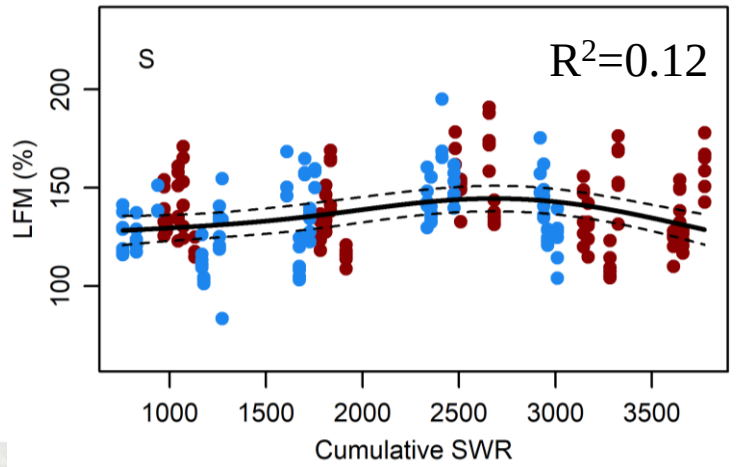


Old foliage





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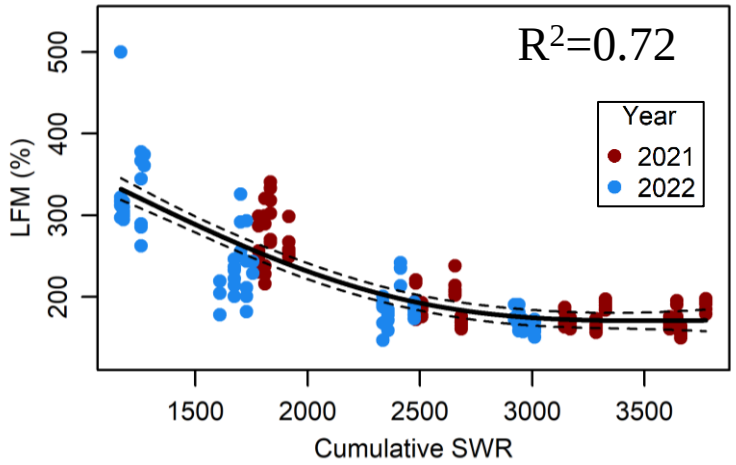

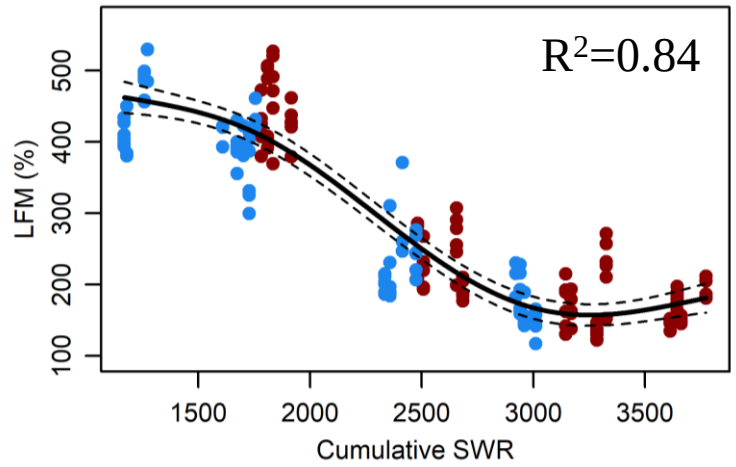

Instrumentation questions

Thank you!