Canadian Forest Service (CFS) Boreal Research and Monitoring Projects (selected examples)

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Natural Resources Canada
Canadian Forest Service (CFS)

Provides science and policy expertise and advice on national forest sector issues, working in close collaboration with the provinces and territories.

Growth and Innovation: Rooted in Sustainable Forests

Priorities:
- Support forest sector competitiveness
- Optimize forest value
- Advance environmental leadership
CFS-ABoVE – A long standing relationship

- **2008-2012 – Pre-ABoVE**
  - Contribution of CFS researchers to VurSAL White Paper
  - Dialogue and exploration of potential collaboration (CarboNA…)

- **2012-2015 – ABoVE planning phase (Science Plan)**
  - Membership of ABoVE Science Definition Team (Dr. J. Metsaranta, NoFC)
  - Coordination of contributions from CFS, NRCan sectors and other federal agencies (Dr. C. Ste-Marie, Ottawa)
  - Organization and hosting of a meeting for the ABoVE science definition and management with 7 federal departments (Ottawa, Dec 2013)
  - Continued dialogue and coordination with ABoVE management
    - Review of ABoVE proposals (Dr. D. Thompson, NoFC)
The National Forest Inventory (NFI)

- A national sampling framework
- National definitions, standards and protocols
- Data management systems, collaboration tools, and information dissemination portal (nfi.nfis.org)
- Field sampling survey (1,115 ground plots)
- Remote sensing survey (aerial photography, satellite data and lidar; 13,158 plots)
NFI Remote sensing and ground plots

1,115 ground plots

Very high spatial resolution satellite survey covering 0.25% of light green zone

Photo-plot survey covering 1% of dark green zone

Contact: Graham Stinson (PFC, Victoria)

Web site at: https://nfi.nfis.org/
NFI tree ring study (Girardin et al.)

Sampling of 749 plots (2002-2010)

- >4300 increment cores collected from 58 tree species

A valuable investment for tracking climate-related changes (past & future)

- Black spruce (31%)
- White spruce (8%)
- Trembling aspen (8%)
- Jack pine (6%)
- Balsam fir (6%)
Mapping and monitoring Canada’s forest properties using NFI data (A. Beaudoin et al.)

- **Geospatial data:**
  - 250 m MODIS time-series, 2001-2011 (CCRS)
  - LC, topo & climate features

- **MODIS-based methods:**
  - Improved temporal $k$NN predictions of NFI attributes (2001-2011)
  - Decadal differentiation of $k$NN predictions integrated with yearly disturbance maps (fires, harvest) *(Guindon et al., 2014, CJFR)*: NFI attributes change with loss/recovery

- **Train/val:**
  - NFI photo-plots network/ k-fold cross-val

https://nfi.nfis.org/en/maps
Mapping biomass (AGB) of northern boreal forests at 25 m based on multi-source EO

**Geospatial data:** SAR/optical data at $\approx 25$ m res
- L-band dual-pol JAXA PALSAR global mosaics (2007-2010, 2015 +);
- C-band Radarsat-2 (2013 +)
- Tree cover, topo, climate features
- Next: Landsat composites; Rsat-2 mosaics

**Train/val:**
- Train: biomass surrogate sampling plots modeled from ICESAT-GLAS (*Margolis et al., 2015, CJFR*)
- Val: k-fold cross-val; independent inventory plots

**Methods:**
- New PALSAR temporal compositing method
- $k$NN predictions within forest strata

$R^2=0.45$
$\text{RMSE } = 29.7$ t/ha

Beaudoin et al. (in prep)
Integrating Remote Sensing & Field Data for Forest Inventory in the Northern Boreal (Hall et al.)

1. **Field Data Collection**
   - Plot/tree level
   - Tree ht, DBH
   - Stand attributes:
     - e.g.: Stand height, volume, crown closure, AGB

2. **EOSD Land Cover**
   - Landsat imagery (c2007)
   - Modelling stratification:
     - Conifer, Mixed
     - Deciduous
     - Non-forest

3. **LiDAR and Field Data Modeling**
   - **Airborne LiDAR**: Stand Attributes: $f$[LiDAR metrics]
   - **ICESat LiDAR**: Stand/Lorey HT: $f$[ICESat metric]
   - Stand attributes = $f$[ICESat HT]
   - Overlay ICESat Airborne HT

4. **Forest Vegetation Inventory Mapping**
   - Multi-Source Veg. Inventory (MVI)
   - GIS Processing (raster to vector)
   - GNWT Forest Inventory (FVI)
   - Satellite Veg Inventory (SVI)

   - k-NN: Stand Attributes Mapped by Scaling to Landsat
Carbon Budget Modelling and Reporting (Kurz et al.)

Canada’s National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)

“An operational to national-scale model of forest ecosystem C dynamics developed to assess the past, present and future role of the Canadian forests in the global C cycle.”

Forest inventory and growth & yield data
Natural disturbance monitoring data
Forest management activity data
Land-use change data
Ecological modelling parameters
Canadian Upland Forest Soil Carbon Database (n = 3480) (Shaw et al.)
Mapping Fires: National Burned Area Composite
(R. Hall et al.)
Burn severity mapping (Whitman et al.)
Mapping forested peatlands using forest inventory data

Currently combining this forest inventory-derived approach with LANDSAT-derived EOSD mapping of treeless peatlands

Forested peatland map will be available through NFI and CWFIS datamarts soon, ABoVE science cloud possible too

Information from Dan Thompson

Using fuels structure to predict organic soils

Forest structure, not just leading species is related to peatland (peat >40cm) occurrence in the boreal

CIPHA study
Climate Impacts on Productivity & Health of Aspen

**Aim:** Provide knowledge of how severe drought & its interactions with forest insects & diseases affect aspen stand dynamics across multiple scales

- Methods include tree-ring analysis, annual plot-based measurements & remote sensing
- Initiated in 2000 by Canadian Forest Service & Environment Canada
- Proposed re-measurement in 2016 through partnership with 2 provinces (Alberta & Sask.)

**Key publications**

Hogg et al. 2002, 2005, 2008 (CJFR); Michaelian et al. 2011 (GCB); Hogg & Michaelian 2015 (GCB)

Massive aspen mortality following the 2002 drought
Northern and high-elevation Forest Health monitoring projects

NWT & Parks Canada
Forest Health Monitoring

**What we do:** Annual surveys (aerial and some ground) to assess current forest health conditions, observe trends over time, and discover emerging issues.

**What we see:** Climate-related Forest Health observations have been increasing in scope, especially over the last decade. Direct and indirect damage due to drought and the ongoing warming trend.

**How can we help:** We have pest survey data dating back to 1954. Observations can direct attention to areas of concern or help confirm remotely-sensed issues.

The CFS/PCA MoU represents 82% of National Parks in the Boreal Forest.
Climate change projections  
(D. Price & D. McKenney)

- Downscaling of IPCC AR5
  - ANUSPLIN
  - BIOSIM
- 3 time periods
  - short-term (2010-2040)
  - medium-term (2040-2070)
  - long-term (2070-2100)
- 3 GHG emissions scenarios:
  - RCP 2.5 (low scenario),
  - RCP 4.5 (medium scenario)
  - RCP 8.5 (high scenario)
- Six variables: Tmin/max, Precip., Solar Rad., Wind, Vapour
- 10 km gridded data
- Canadian CGM
Vulnerability of Tree Species to Climate Change (Aubin et al.)

INTEGRATED INFORMATION PRODUCTS
I. Aubin & collab.

Sensitivity to drought of at-risk wood volume 2071-2100

Potential Uses
- Multifaceted vulnerability assessment
- Integrating ecological knowledge with biophysical projections
- Creating value-added products from existing datasets
Forecasts: changes in ecosystem structure/function (Campbell, Price, Hogg, et al.)

Reference 1961-1990

2080s CanESM2, RCP 8.5

Reforestation: drought tolerant trees
A Guidebook for Adapting Sustainable Forest Management to Climate Change (Edwards et al.)

The “How-To Adapt” Manual

Follows a Vulnerability Assessment Approach

www.cccfm.org
– climate change link –
CFS Forest Change Initiative

Building on existing capacity, knowledge and expertise…

1. **A Tracking System** that reports on indicators of climate change impacts to identify forest sector vulnerabilities

2. **An Adaptation Toolkit** of actionable science for sustainable forest management under a changing climate

3. **Integrated Assessment** of climate change implications for the forest sector to guide policies and investment
# Forest Change Tracking System - Indicators

<table>
<thead>
<tr>
<th>System</th>
<th>Dimension</th>
<th>Indicator</th>
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<tbody>
<tr>
<td>Forest</td>
<td>Tree species distribution</td>
<td>• Distribution of Tree Species</td>
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<tr>
<td></td>
<td>Fire regime</td>
<td>• Annual Area Burned • Number of Large Fires</td>
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<td></td>
<td>Tree mortality</td>
<td>• Percent annual loss of living tree biomass</td>
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<tr>
<td></td>
<td>Pest Incidence</td>
<td>• Pest Species Distribution</td>
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<tr>
<td></td>
<td>Forest Growth</td>
<td>• Radial Growth Trends</td>
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<tr>
<td></td>
<td>Phenology</td>
<td>• Timing of Budburst</td>
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<tr>
<td>Human</td>
<td>Cost of Fire Protection</td>
<td>• Wildfire suppression Resource Expenditures</td>
</tr>
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<td></td>
<td>Wildfire evacuations</td>
<td>• Number of evacuations &amp; evacuees • Evacuations location • Number of home losses</td>
</tr>
<tr>
<td></td>
<td>Wildland Urban Interface</td>
<td>• Population at risk of forest fire</td>
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<td>Transportation</td>
<td>• Freeze-thaw of winter roads</td>
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CFS Needs

- **More data for our northern forests**
  - Forest Inventory
  - Species distributions
  - Weather data
  - Soil properties

- **Assistance with tracking change**
  - Regeneration
  - Phenology (forest pests, bud break)
  - Tree mortality
  - Vegetation change

- **Increased understanding of disturbances**
  - Interactions between disturbances
  - Changes in disturbance regimes

- **Socio-economic research for northern forest-based communities**
Opportunity

- There is a clear opportunity to improve efficiency via complementarity of efforts and improved coordination between data collection and engagement activities.