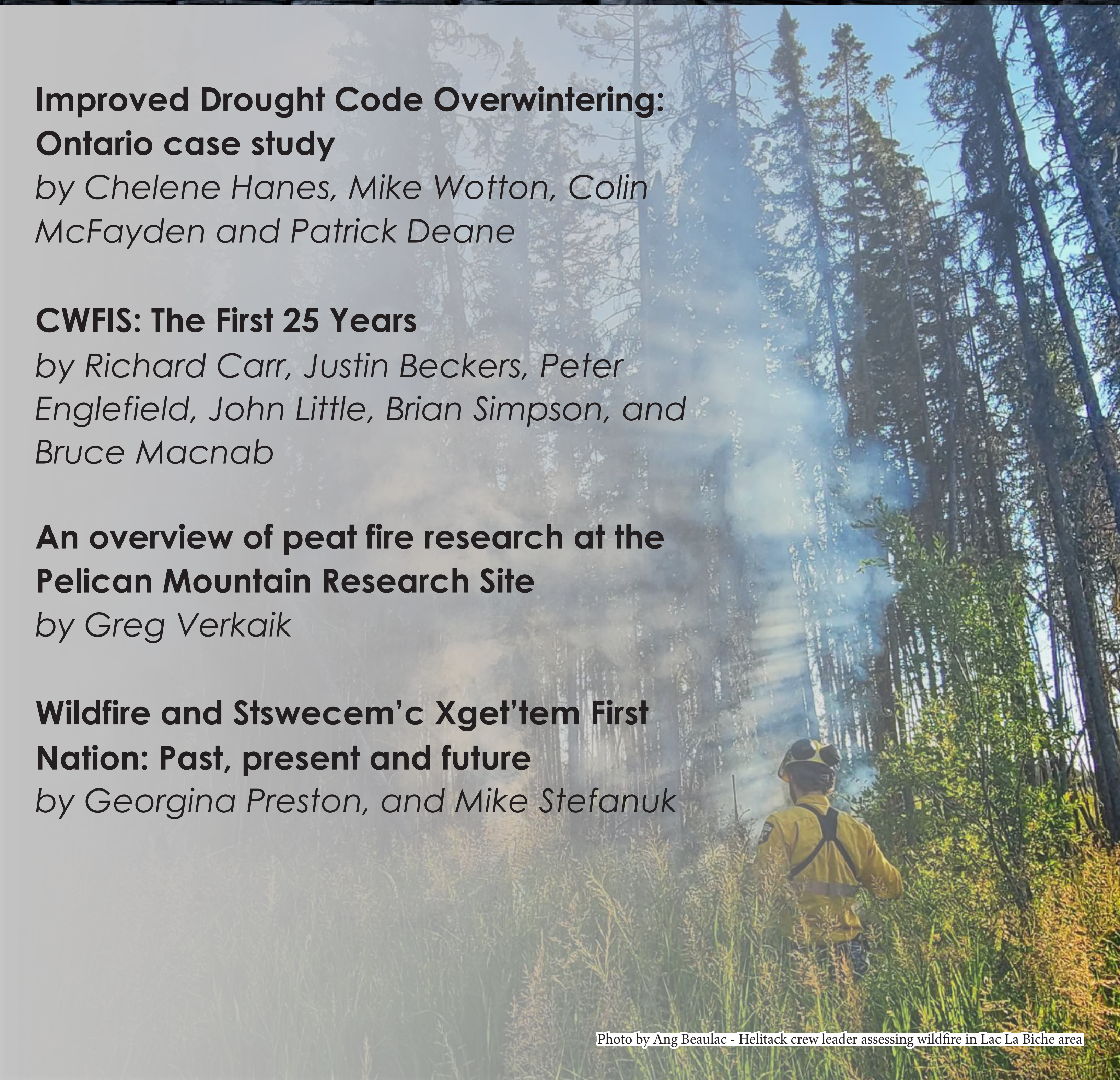
CANADIAN WILDLAND FIRE & SMOKE

NEWSLETTER

FALL2022



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Improved Drought Code Overwintering: Ontario case study

By Chelene Hanes[1], Mike Wotton[1,2], Colin McFayden[1], Patrick Deane[1]
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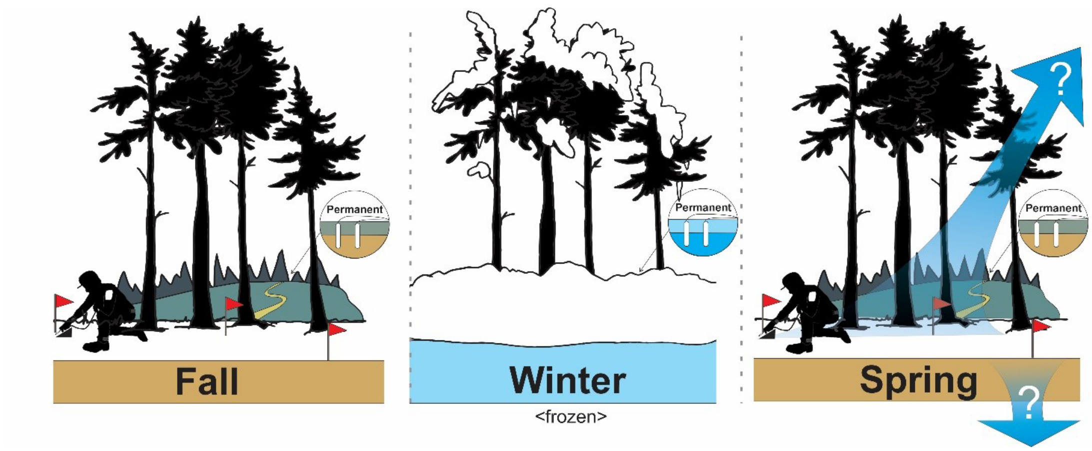

Figure 1 Measuring the soil moisture in the fall and spring to assess the relative change (i.e., did the soil moisture change from fall to spring, and if so, by how much?). Running in parallel were two permanent soil moisture monitoring sites in Dryden and Chapleau, Ontario.

Introduction

The Canadian Forest Fire Danger Rating System is the cornerstone of contemporary fire management in Canada. Although the System is conceptually robust, there are known issues, primarily based on limitations over the last 75 years of its development. One area with many known questions is the Drought Code (DC). Within fire operations management, the DC is primarily used to indicate when potential suppression issues may occur due to burning in deeper, denser fuels that typically take longer to dry but which, once dry, can sustain deep and prolonged burning. The DC is also used to carry-over drought from one fire season to the next when drought conditions are present. Unlike the other moisture codes in the Fire Weather Index (FWI) System, there is much ambiguity around the DC, what it represents, how it should be interpreted and validated, and how and when it should be used to carry the accumulated moisture deficit from one fire season into the next. This latter question is more relevant than ever as we enter into an era where the effects of climate change are becoming apparent, and drought conditions are becoming more commonplace.

A prime example occurred the summer of 2021 in Ontario. The province of Ontario saw extreme DC values well above 30-year maximums. These values influenced the difficulty of fire control and increased lightning ignition receptiveness in one of the most active fire seasons in decades, which included two of the largest fires on record since the 1960s.

High DC values continued into the fall in some regions across the province, and it was anticipated that drought conditions may persist into the spring of 2022. This led to questions about ways to more objectively assess and estimate the spring recharge of the DC from snowmelt and, consequently, any adjustment needed to the season's starting DC value.

To address this, two things were done. First, Ontario Aviation and Forest Fire Emergency Services (AFFES) staff continued recording FWI System calculations further into the fall than typical until the date of snow accumulation. Second, a moisture monitoring protocol using hand-held soil moisture probes was carried out in the fall of 2021 and again in the spring of 2022 to assess moisture changes overwinter (Figure 1) in select higher DC areas (i.e., using Ontario's Restricted Fire Zones (RFZ)).

DC overwintering procedure background

The overwinter adjustment for DC was originally suggested for application when cumulative overwinter precipitation (P_{ow}) is below a threshold of 200 mm (Turner and Lawson 1978).

$$Q_s = a \cdot Q_f + b(3.94 \cdot P_{ow})$$

The adjustment has four inputs to calculate the starting overwintered spring DC (DCs) (converted from moisture equivalent Q_s):

1. the DC value of the last day of FWI System calculation from the previous fall (DCf) converted to moisture equivalent units (Q_f);
2. the total precipitation (in mm) between that date and the start of FWI System calculations in the spring (P_{ow});
3. the carry-over fraction of the fall moisture deficit a; and,
4. an estimate of the fraction of winter precipitation effective at recharging depleted moisture reserves in spring b.

If agencies run FWI System calculations until the date of snow accumulation, then $a = 1$ and no estimation is needed; this is an easy, low-cost change in procedures which could lead to improved accuracy in spring DC estimation. Research carried out over the last five years in Alberta and Ontario has suggested that the P_{ow} threshold of 200 mm may not be as important as previously thought, particularly in regions with limited overwinter precipitation, i.e., NW Ontario and Western Canada (Hanes et al. 2020).

What is more important to consider is what happened to the snowpack and how much moisture infiltrated the organic layer (b). Using the soil moisture probes and the sampling strategy employed, we can estimate this by measuring the change of moisture in a forest stand from the fall into the spring.

Findings

Despite significant snowpack and P_{ow} across the province (Figure 2), these fall and spring measurements from the field suggested there was little to no recharge in the moisture deficits in the targeted zones. Overall, these paired fall and spring observations indicated that only about 10% of P_{ow} went into the ground during the spring melt in the NW regions measured and <1% in the NE.

Spring DC values were higher (drier) than AFFES station starting values when either measured moisture values were used to estimate DCs, or the overwinter adjustment was applied using the change in moisture to estimate the b coefficient (Figure 2).

Based on local conditions and observations, it is assumed the majority of snowmelt went into runoff this spring. Early investigation into lightning ignitions in May 2022 using the lightning fire occurrence prediction system showed a higher number of ignitions in the NE than expected, potentially due to higher DC values.

The difference in DC values were quite large in some cases (i.e., between: 1) AFFES station estimated using the typical approach; 2) overwintered using b values from Figure 2; and, 3) those measured by

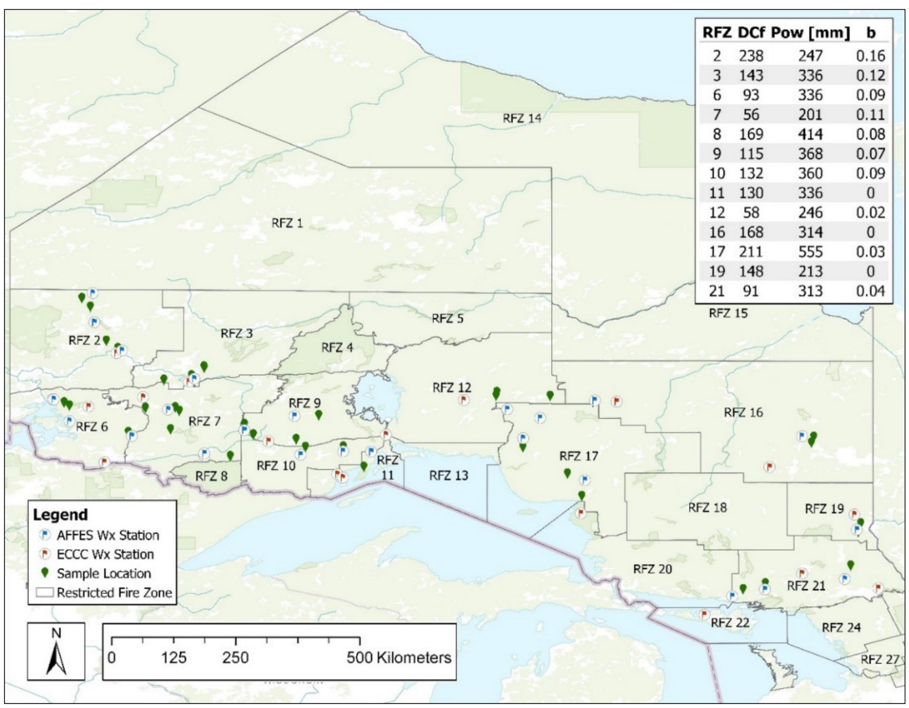

Figure 2 RFZ boundaries, moisture plot locations and associated weather stations.

field moisture probes) (Figure 3). These differences have implications for other codes and indices in the FWI System as well as the assessment of spring fire potential. Keeping in mind that the larger the DC error, the bigger the rainfall event is needed to correct the DC, despite wet conditions experienced across Ontario later in the spring, the difference in values had not reconciled as of early July.

In addition to the handheld moisture protocol, separate continuous automated moisture monitoring has been carried out over the last 3-5 years at locations near Chapleau and Dryden. The data from these longer duration plots, showed that DC values from AFFES weather stations generally have a wet bias (i.e., DC values are often estimated as wetter by AFFES than what is measured in these areas by the "permanent" moisture sensors), particularly in the spring and fall (Hanes 2022). In contrast, similar moisture monitoring sites installed in Alberta, near Edson and Red Earth Creek, typically have a dry bias (i.e., DC values are often estimated as drier by Alberta Wildfire). This may be due to a tendency to overwinter the DC on a regular basis. Calculation of the *b* coefficient with field-based measurements would provide a short-term fix to remove these biases.

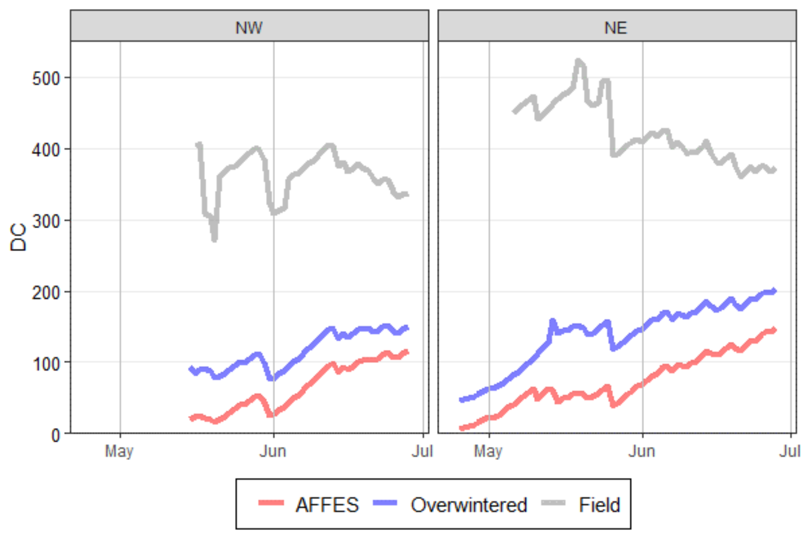

Figure 3 Comparison of DC using different starting values with examples from each region. DC starting values include: 1) the standard AFFES DC (15); 2) Overwintered DC using the DC_f value at snow accumulation and field calculated b value; and, 3) field measured DC_s.

Next Steps

This simple analysis demonstrated the importance of overwintering and the potential to use moisture probes to provide added intelligence about the fire environment. This additional monitoring with moisture sensors to estimate overwinter recharge of forest floor moisture can be done by:

1. Sampling the benchmark locations in the fall and spring, using handheld moisture probes to determine the change in moisture (i.e., to estimate *b*)
    a. For example, this could be done at the local headquarters level or as part of training for advanced understanding of the FWI System.
2. Installing moisture monitoring sites collocated with weather stations in areas of concern to continuously monitor the DC directly.
    a. Year-round monitoring would also be beneficial, as would the use of snow sensors.
3. Both

We are keen to engage with other agencies and operational personnel to conduct similar paired fall/spring moisture sampling in appropriate stands in other regions. In addition to providing a better understanding of where moisture conditions are in the spring, these data would also be beneficial to the Canadian Forest Service to improve the overwinter adjustment and our understanding of drought dynamics and fire.

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An overview of peat fire research at the Pelican Mountain Research Site

By Greg Verkaik[1]

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The Pelican Mountain Research Site is an experimental testing ground for FireSmart™ fuel treatments and wildfire suppression operated by Alberta Agriculture and Forestry in northern Alberta. Comprised of ~100 ha of forested black spruce peatlands, the site provides a consistent location for long-term monitoring projects, experimental fires, and the testing of conventional and novel fuel treatments. Multiple partners have come together to collaborate and perform research at Pelican Mountain, including Alberta Wildfire, Natural Resources Canada's Canadian Forest Service (CFS), FPInnovations, and researchers from multiple Canadian universities, including McMaster University, the University of Alberta, the University of British Columbia, and the University of Toronto. The site and a large number of collaborators provide a wealth of opportunities for learning about the various aspects of wildfire in black spruce peatlands helping inform wildfire management and fuel moisture dynamics.

Image 1. Aerial view of an experimental fire from 2019 at Pelican Mountain Research Site. Image courtesy of Alberta Agriculture & Forestry.

As a PhD student in McMaster's Ecohydrology Lab, Pelican Mountain provides me with the opportunity to study peat moisture dynamics and the vulnerability to smouldering combustion under natural conditions and weather variability. As the climate changes and drought conditions become more frequent and severe, peat smouldering becomes a greater risk to communities and fire managers.

Smouldering peat fires are challenging to extinguish as they burn below-ground. These fires also demand many resources to suppress once they take hold and emit large amounts of smoke and carbon into the atmosphere. Fuel modification treatments, such as thinning, reduce above-ground fuel loads and decrease crown fire behaviour; however, the impact these treatments have on the underlying peat is uncertain.

During an experimental crown fire conducted at Pelican Mountain in 2019 (Image 1), we found that near-surface moisture contents were lower within the hand-thinned treated area compared to the control[1]. This is potentially due to increased canopy openness, allowing further drying within the treatment area. However, there was no significant difference in the peat combustion depth between the treatment and control[1], likely due to differences in above-ground fuel loading. These findings suggest a better understanding of the changes that occur at (and below) the ground surface is needed. Introducing novel, peatland-specific fuel treatments may be necessary to reduce the risk of persistent smouldering within forested peatlands in Alberta.

To examine the efficacy of peatland-specific fuel treatments, three different fuels treatments have been implemented at Pelican

Mountain (Image 3). The three treatments are testing long-term changes to peat moisture dynamics caused by increased canopy openness as well as ground cover and shrub-layer vegetation changes. We have implemented near surface moisture and tension monitoring equipment (Image 4), which, alongside local meteorological and water table data, will help us better understand how these treatments affect peat moisture and smouldering vulnerability through time.

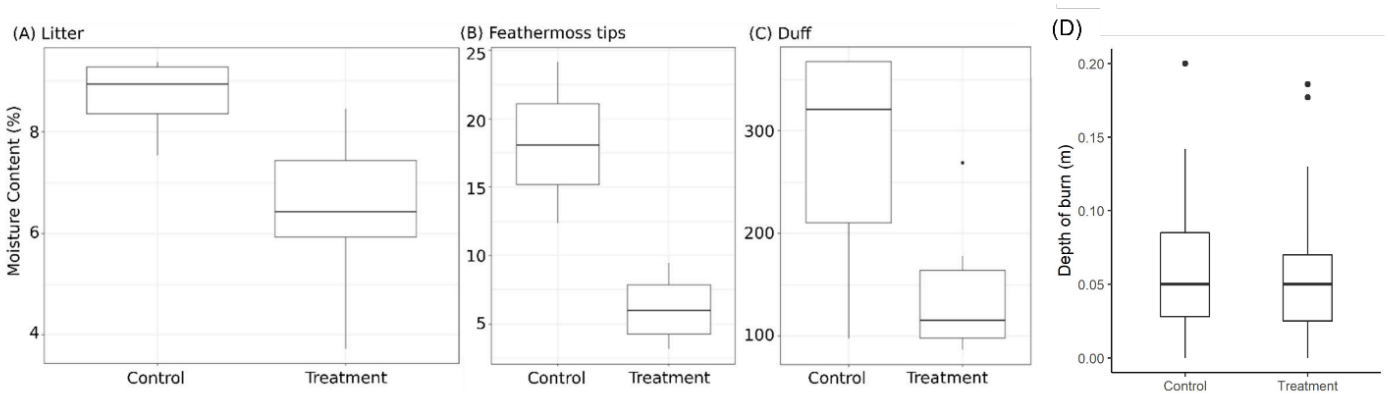

Figure 1. Fuel moisture contents (a-c) and depth of burn (d) from control and treated plots. Modified from Thompson, et al. (2020).

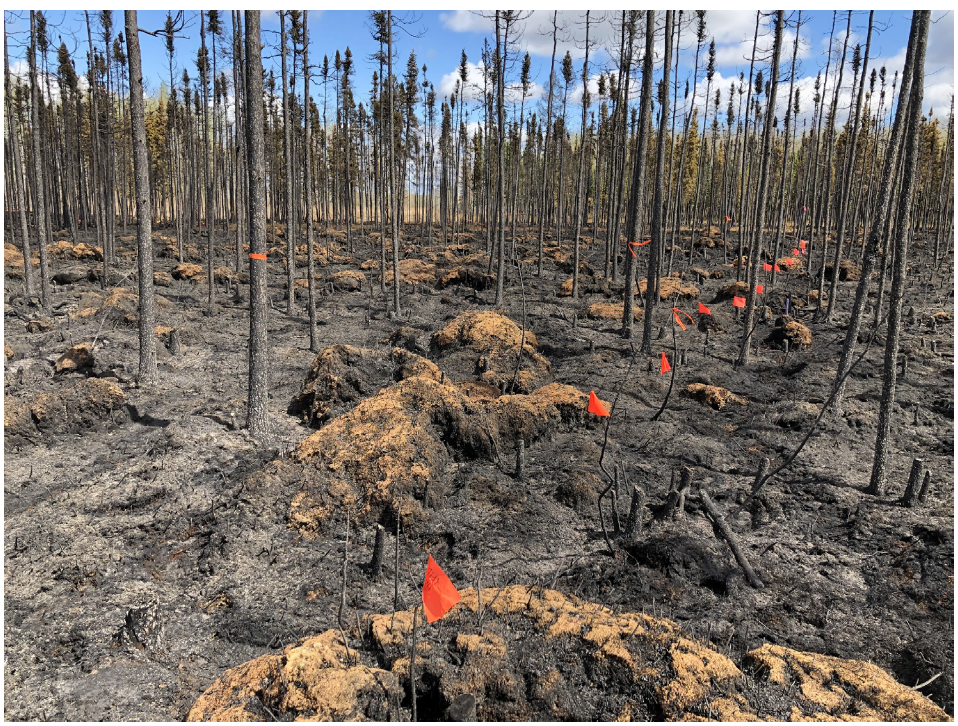

Image 2. Peat depth of burn plots following the experimental crown fire in 2019 at Pelican Mountain Research Site.

We are also tracking vegetation changes through time. Peatlands are typically dominated by Sphagnum and/or feather moss. Sphagnum is generally more productive and capable of holding more moisture when compared to feather moss, making Sphagnum more resistant to burning. Unfortunately, feather mosses outcompete Sphagnum when there is a high canopy fuel load. By opening the canopy during fuel treatments, we expect to increase the coverage of Sphagnum in the long term, thereby increasing the overall near surface moisture content and reducing the risk of smouldering combustion. In addition to ground surface vegetation, changes to shrub layer vegetation are also being observed. Specifically, in fully cleared treatments (clear-felled and mulched), we have seen an expansion of shrubs and grasses. These species may reduce the effectiveness of opening the canopy to encourage Sphagnum and instead cause increased drying in these treatments, resulting in an undesirable increase in smouldering vulnerability. By continuing to track these vegetation changes through time, we will be able to suggest changes to fuel treatment strategies within peatlands to increase their effectiveness and decrease any unexpected negative effects of these treatments.

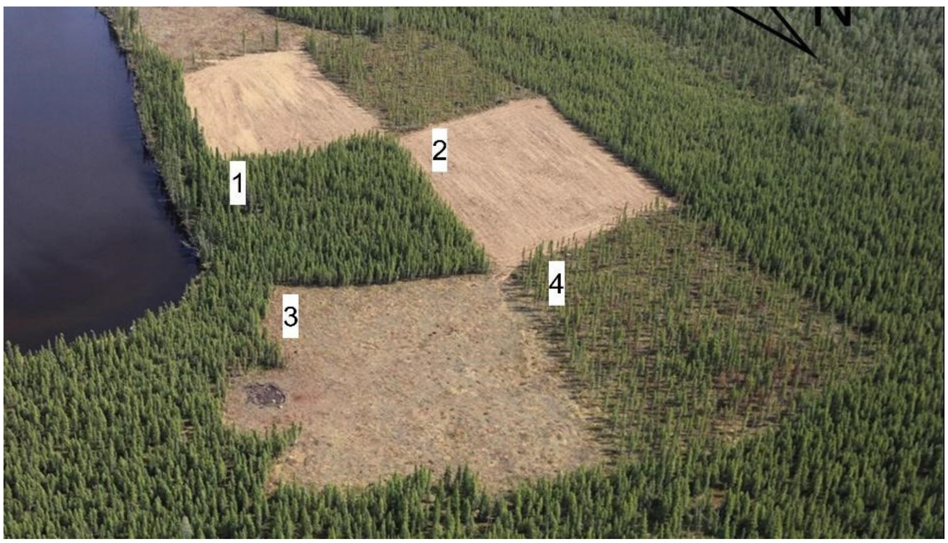

Image 3. Aerial view of Unit 6 with different treatment types: (1) control, (2) mulched, (3) clear-felled, and (4) hand-thinned. Photo courtesy of Alberta Agriculture & Forestry.

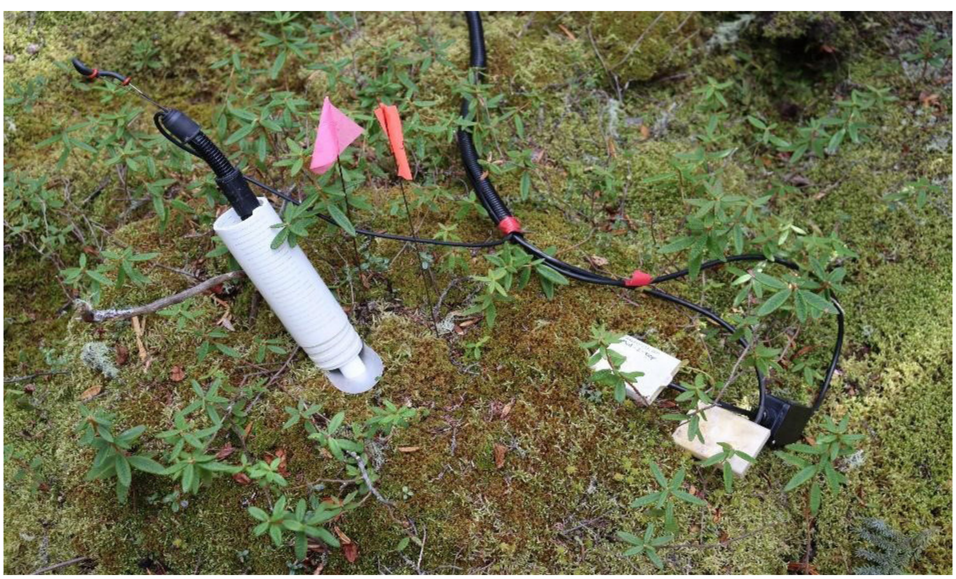

Image 4. Plot setup at Pelican Mountain with tensiometer and moisture probes for measuring peat moisture dynamics.

Novel fuel treatments, both above- and below–ground, are being tested at Pelican Mountain. One such below-ground treatment was inspired by our observations of a reduction in peat burn severity found within seismic lines intersecting peatlands[2]. To mimic seismic lines, we deliberately compressed the peat in order to increase near-surface moisture retention. This treatment was undertaken in the summer of 2018 by a crew of researchers from McMaster, Alberta Junior Forest Rangers, and the Alberta Wildfire Fuels Inventory Crew. By compacting sections of the different treatments at Pelican Mountain, we found that the compression efforts led to an increase in the near surface bulk density and moisture contents and reduced the overall risk of smouldering combustion[3].

Pelican Mountain has provided an incredible opportunity to study fire in an important ecosystem within the boreal landscape. Although the work outlined here is focused on one aspect of the work at Pelican Mountain, a lot of other important research is taking place there, including smoke plume studies, fire retardant testing, fire behaviour model parameterization, novel fire monitoring techniques, and much more. Such interdisciplinary and collaborative efforts allow for important knowledge acquisition and communication that will positively impact fire research and management for years to come.

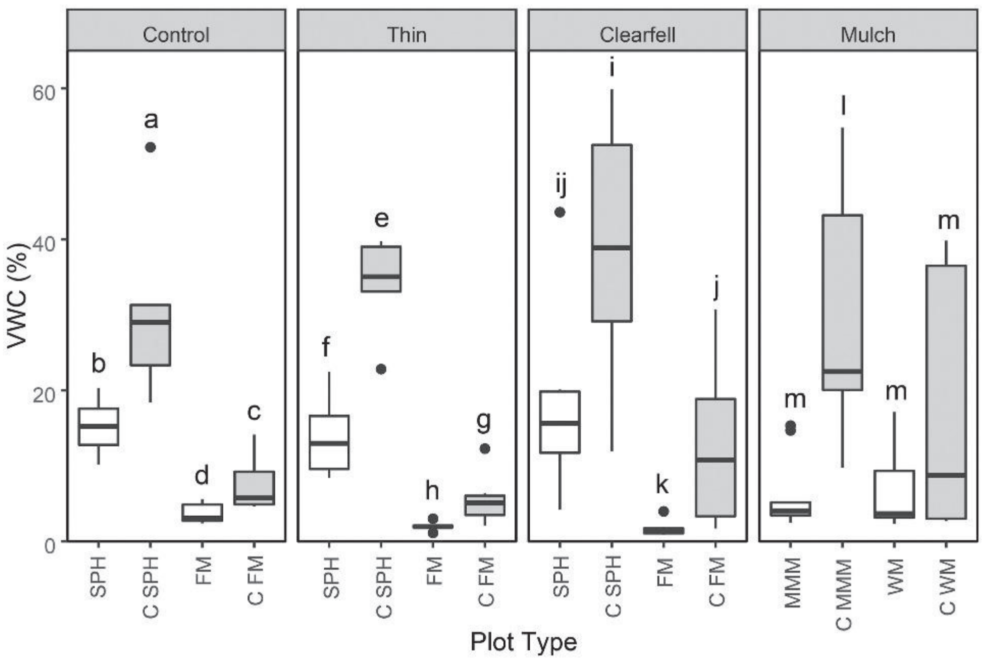

Figure 2. Uncompressed and compressed volumetric water content (VWC %) in different treatments and plot types. C's and grey boxes indicate compressed treatments.

References

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CWFIS: The First 25 Years

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Background

The Canadian Forest Service (CFS) began the development of the Canadian Wildland Fire Information System (CWFIS, see https://cwfis.cfs.nrcan.gc.ca) at a time when spatial internet-based information systems were starting to evolve. The CWFIS, which now includes current observed fire danger, fire occurrence information, forecasted conditions, historical data, and other data and services, began in 1994 with only current and fire danger rating maps. The development of the CWFIS depended on the prior development of the Canadian Forest Fire Danger Rating System (CCFDRS; Stocks et al. 1989), early efforts to develop information sharing, and advances in computer and communications technology.

Development of digital fire information systems began in the 1960s with the advent of electronic calculators and computers, which ushered in a new era of information availability and processing power. When the Fire Weather Index (FWI) System was published in 1970 (CFS 1970), automated calculation of FWI components was already being done (Kourtz 1967). However, limitations in data exchange and computer capabilities limited this to regional efforts. Fire management agencies may have been unable to support the required computer equipment, especially with early systems using punch or magnetic cards. A demonstration system run from Ottawa covering some of the Atlantic provinces required manual typing of output into a teletype for transmission due to a paper incompatibility. Most provincial fire agencies did not have centralized information systems at the time, so a national system was a long way off. However, Kourtz (1967) visualized a more efficient system involving transmission of data between the regional office in Fredericton and the centralized processing facility in Ottawa.

Kourtz (1984) described the first truly operational centralized system set up in western Quebec. Testing was done in Societé de Conservation de I'Outaouais with a computer server in Maniwaki, Quebec. This system featured weather inputs, resource tracking and allocation, CFFDRS output, payroll, and fire prediction, and used databases to manage the data. A similar system successfully tested in Timmins in 1982-83 resulted in plans to expand the system throughout Ontario (Kourtz 1984).

In the late 1980s, Lee and Anderson (1990, 1991) developed the Intelligent Fire Management Information System (IFMIS). The system used databases, Geographic Information System (GIS) spatial analysis, and linear programming to calculate and map CFFDRS outputs, assess coverage by initial attack resources, and model optimal positioning of resources. This system catered to a regional focus, and several agencies adopted the system, some with multiple installations, as fire data management was still decentralized.

Early stages of CWFIS development (1995-2006)

By the 1990s, the increased power and reduced cost of computer hardware allowed for the development of a national-scale fire information system. The Canadian Forest Service began CWFIS development in the mid-1990s at the Northern Forestry Centre in Edmonton, Alberta (Lee 1995). Operations began in 1994, and CFS introduced the system to the public in 1995.

The CWFIS initially consisted of national maps of CFFDRS outputs using weather observations recorded at about 250 widely scattered Atmospheric Environment Service (AES) locations. Summer students developed and ran computer programs to decode weather observations, calculate CFFDRS indexes, insert data into databases, and generate output maps. A simple HTML website provided map display of maps and other content.

An international data stream provided by the World Meteorological Organization (WMO) and the Atmospheric Environment Service (AES) of Environment Canada, now known as the Meteorological Service of Canada (MSC), provided a weather data stream. However, at that time, weather data was not readily available on the internet. Instead, it was obtained via a Canadian communications satellite, the Anik E2, and a dish on the roof of the Northern Forestry Centre. Fuel types for Fire Behavior Prediction (FBP; Forestry Canada 1992) were derived from a national land cover map (Palko 1995) produced by Agriculture Canada and based on AVHRR imagery acquired during the summers of 1988-91.

Unix Sparc 10 workstations provided processing capability. The weather data decoders were written in the Perl programming language, and ESRI's ArcInfo software provided GIS functionality. Weather and FWI components were interpolated between weather station locations to produce gridded data, after which FBP components were calculated for each grid cell. The resolution of the output grids was 10 km.

In early 1996, the CWFIS weather data decoders stopped working, which brought the whole system to a halt. After some investigation, CFS employees found that the AES had adopted a new international standard for surface hourly weather reporting. This required the immediate addition of a new weather bulletin locator and decoder to the weather observation processing suite, and these changes were ready by May 1, 1996. In the early years of the CWFIS, several ad-hoc sources allowed a rough assembly of weather station data, some of which proved to be error-prone, giving incorrect and bizarre results in parts of the country. It became apparent that CFS needed a better connection with AES and WMO, and that data from a larger number of weather stations should be obtained to improve product accuracy. After consultation with WMO and AES, locations of official decoding publications and operational and historical station catalogues provided a greater selection of station data and allowed for mostly automated updates.

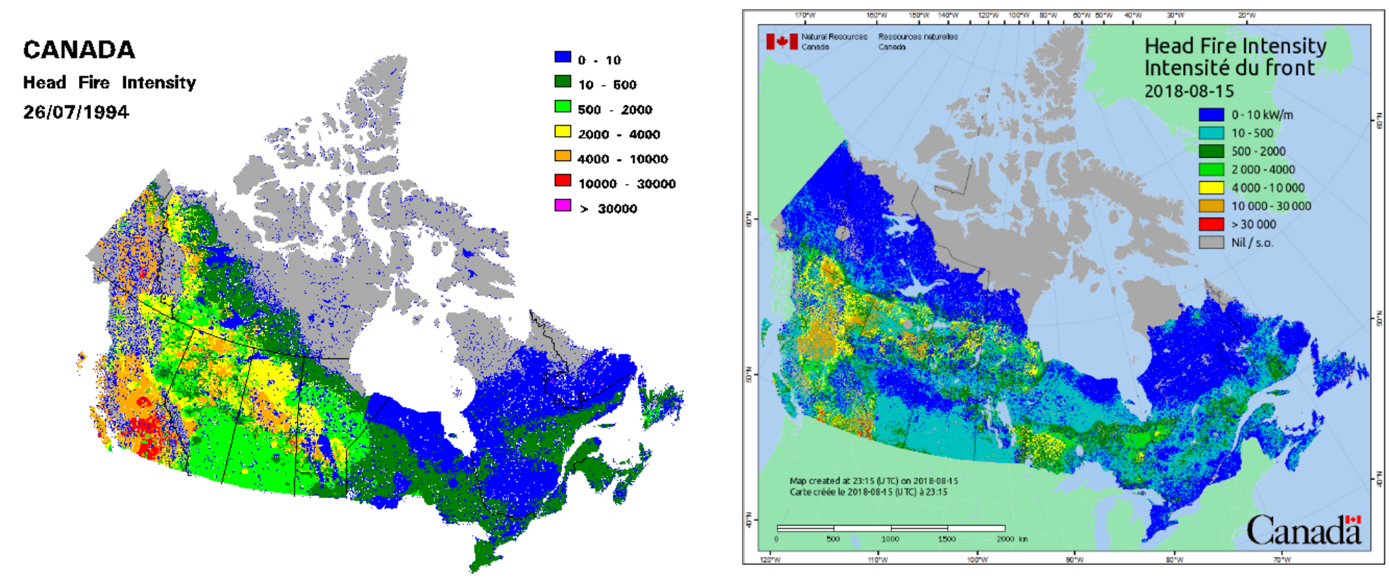

Figure 1. Sample graphic on the left from the development phase in 1994, and a recent graphic from 2018 on the right. Early maps used 250 weather stations; now, more than 2000 are used.

In 1997, CFS developed a new GIS processing module called the Spatial Fire Management System (SFMS; Englefield et al. 2000), based on ESRI's ArcView. The SFMS later became the GIS engine for the CWFIS, replacing ArcInfo with several fire management agencies in Canada (British Columbia, Alberta, Saskatchewan, Ontario, and Wood Buffalo National Park) and abroad (Michigan, Mexico, Indonesia, Malaysia, New Zealand, and Cyprus) adopted this mapping tool.

Meanwhile, the ArcInfo-based system was being used in Florida (Herbster et al. 1998), where it was augmented with smoke dispersion model output from the Lavdas atmospheric stability index (Lavdas 1986). The CFS added these outputs, which included mixing height, transport wind vector, dispersion index, and ventilation index to the CWFIS.

In 1998, the weather and fire danger maps were improved by implementing an elevation adjustment into the interpolation of temperature and relative humidity (RH). This adjustment relies on the assumption that the mixing ratio of water vapour to dry air remains constant over small vertical distances, and that the U.S. standard atmosphere lapse rate provides a reasonable temperature profile. At the same time, the standard interpolation method used in map development was replaced with cell-by-cell calculation using the fuel moisture grids from the day before as well as the weather grids as inputs. This change meant that the elevation-adjusted temperature and RH were incorporated into the gridded FWI calculations.

In the late 1990s, the Canada Centre for Remote Sensing (CCRS) developed an algorithm to identify heat sources (primarily fire) from NOAA AVHRR satellite imagery. The CCRS began providing daily maps of hotspots, smoke, and cloud via the Fire Monitoring, Mapping, and Modeling (FireM3) system (Lee et al. 2002, Englefield et al. 2004). The CFS subsequently integrated FireM3 into the CWFIS, and FireM3 processing moved to the Northern Forestry Centre.

In 2000, the Forest and Fire Meteorology Working Group (FFMWG) formed under the Canadian Interagency Forest Fire Centre (CIFFC). A 2001 meeting in Halifax enabled the inclusion of data from Nova Scotia's fire weather network. Since then, the addition of provincial, territorial, and U.S. National Weather Service data has improved weather data resolution.

FireM3 and CFFDRS outputs contributed to annual carbon emissions estimates, beginning in 2004, with the development of what later became the National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS; Kurz and Apps 2006, de Groot et al. 2007). This system required accurate end-of-season burned area maps. While the FireM3 system featured coarse resolution maps derived from SPOT-VGT imagery (Fraser et al. 2000), this project also took advantage of maps from two additional sources:

1. Maps produced by the provincial and territorial fire management agencies using various methods, including helicopter-based GPS and air photo interpretation. These maps are now collected annually and added to the Canadian National Fire Database (Stocks et al. 2003)
2. Maps derived from higher resolution (30m) Landsat imagery. These maps are also collected annually and form part of the National Burned Area Composite (Hall et al. 2020), which was recently expanded back to 1986 (Skakun et al. 2022).

Both of these datasets are available via the CWFIS website.

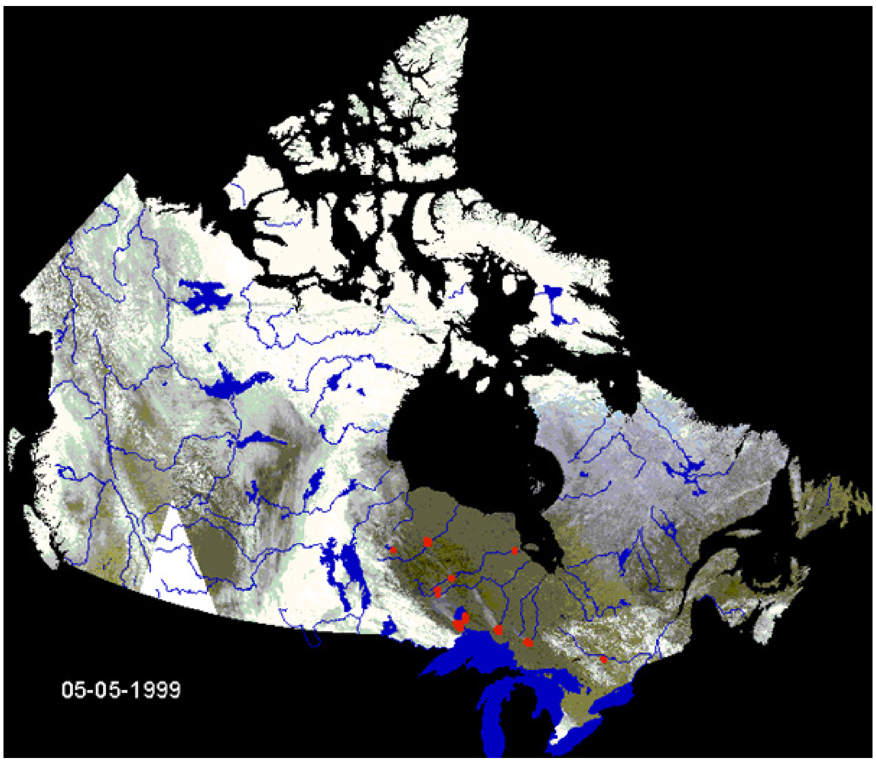

Figure 2. Sample of an early FireM3 map. On May 5, 1999, several fires were burning in Ontario. Some smoke plumes are visible in this AVHRR daily composite image.

More recent developments (2007-2020)

Forecast fire danger maps have been a CWFIS feature since 2006. The first two forecast days are based on SCRIBE matrices, the ECCC model output package with bias correction at forecast locations (used for public forecasts). Days three through sixteen use North American Ensemble Forecast System (NAEFS) output with FWI calculated for each ensemble member and the median (50th percentile) used for map production

CFS also uploaded an interactive map on the CWFIS website in 2006. For the first time, users could zoom into their province, individual fires, or hotspot locations. Originally developed using MapServer and Chameleon, the map now uses GeoServer and Open Layers. The interactive map page is now the most requested CFS page during the fire season. Usage increased rapidly during and after 2016, the year of the Horse River (Fort McMurray) fire – with some unexpected results. The hotspot-based perimeter estimates, for example, were assumed to have accuracy far beyond what the underlying satellite imagery could provide, and were trusted to indicate whether a fire had crossed the nearby road or river.

Over the last decade, CWFIS development has moved away from commercial software to reduce licensing fees and avoid keeping up with new versions. In its place, open-source software has provided equivalent functionality, beginning in 2007 with a switch to PostgreSQL for database functionality.

In 2007, the CWFIS began producing long-term seasonal forecasts based on CanCM3 and CanCM4 model output. At first, these were shared with fire management agency personnel only; since 2011, they have been posted on the CWFIS site. A new forecast is issued on the first of each month from March to August.

In 2016, CFS introduced a new SFMS version coded in C, with PostGIS providing GIS functionality. The new SFMS is also used by several provincial fire management agencies and recently adapted for use in Switzerland]. Other changes include:

- The AES/MSC discontinued the satellite weather data system and replaced it with an online datamart.
- The weather collection code was rewritten in C with a module for decoding ECCC's newest surface hourly reporting scheme, the XML-based Surface Weather OBservation (SW-OB) format.
- FireM3 code was rewritten in PHP, with most of the GIS processing done in PostGIS.

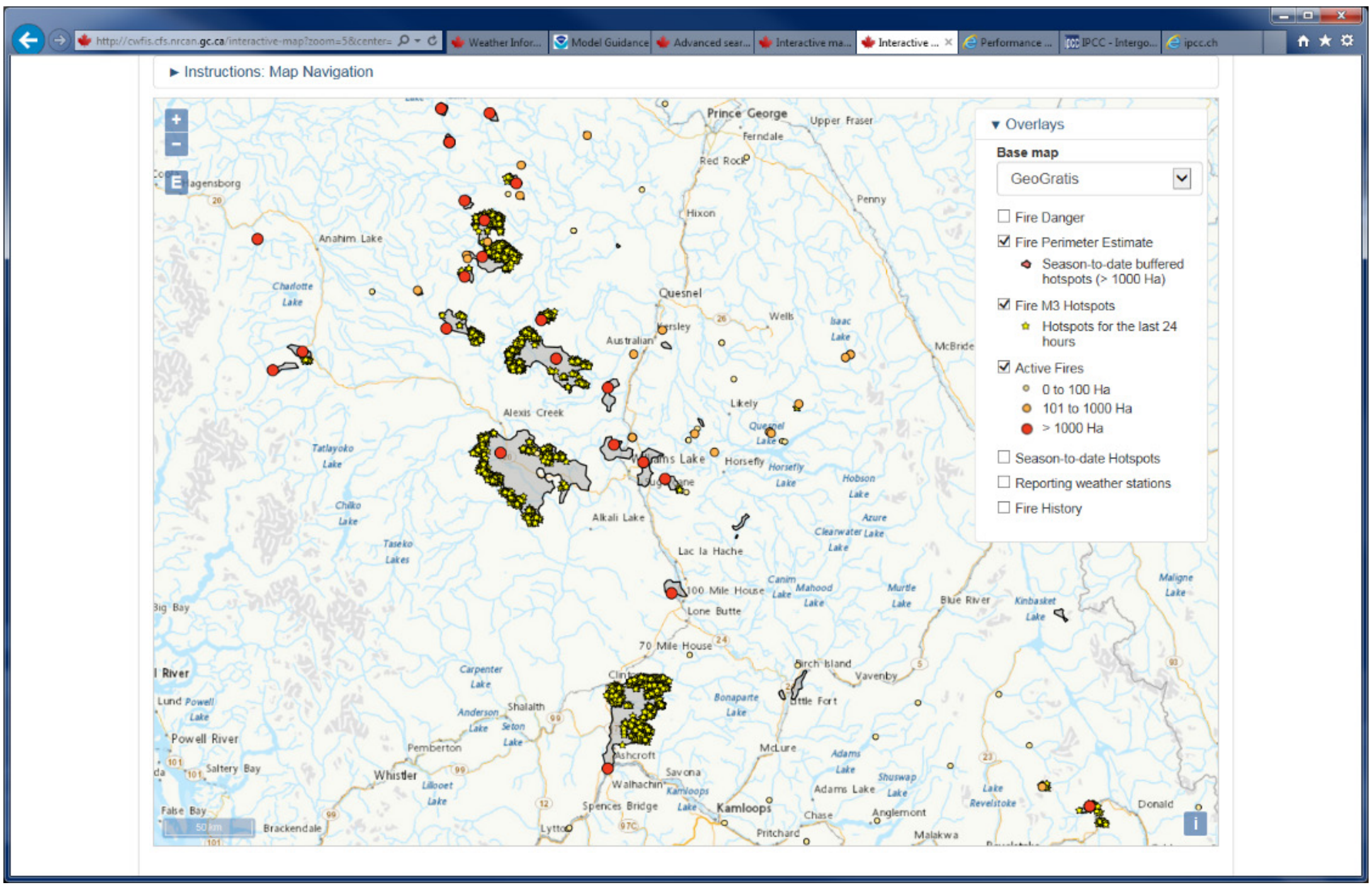

Figure 3. Sample Interactive map zoomed into central British Columbia for July 30, 2017, showing features from federal and provincial sources.

The CWFIS also provides daily hotspot-based fuel consumption and emission estimates for use in smoke forecasting models. The University of British Columbia runs the Bluesky model (see firesmoke.ca), and the FireWork model developed by ECCC contributes to the Air Quality Health Index forecast.

The CWFIS currently provides numerous tools and data services, including

- FWI/FBP maps at 2km resolution
- Current and historical hotspots
- Seasonal forecasts
- Weekly situation reports
- Fire perimeters from buffered hotspots
- Agency-reported fire locations and status
- Fire growth model predictions
- Fire history
- Web map, coverage, and feature services

The CWFIS audience and user community grew to include government officials, emergency responders, fire-managers, researchers, education facilities, media and the public. This increased importance led CFS to create a cloud-based redundant backup system in 2015. In addition to providing a backup, the cloud solution offers flexible access to the more powerful computing resources required by the system as web usage increased.

Looking ahead: meeting new challenges

The need for data exchange between agencies and researchers, large data capability, expanded use of the CWFIS in fire management, and provision of data to national and international officials is driving the ongoing development of the CWFIS. Data sharing using international standards such as those developed by the Open Geospatial Consortium is the industry standard for future data exchange. The Data Integration Project (DIP), a collaboration among the CIFFC IM/IT Committee members, defines minimal standards for fire data exchange among fire agencies in Canada. This facilitates a single, more accurate, and timelier source for national fire data in Canada. The DIP's first success is the integration of fire report data from the provinces and territories into a single dataset, updated continuously during the fire season. Work has begun on standardizing weather station and weather data exchange. The DIP is currently used to derive daily statistics for the CIFFC situation report and to drive several interactive maps in CIFFC and member agencies. Finally, continual improvements to data processing and methodologies have occurred throughout the history of the CWFIS and are planned to continue into the future.

New research or revamped systems, such as the pending revision of the FBP System (Canadian Forest Service Fire Danger Group 2021), the needs of organizations involved in response to fire, or other developments, will also play a role in the future direction. In 2019, Natural Resources Canada (NRCan) received funding to develop a wildland fire project to promote and enable data sharing and integration among all CIFFC's member agencies. The Canadian Wildland Fire Information Framework (CWFIF) will support the development of an operational IM/IT Framework and Platform which will directly support the role of the government of Canada in providing information and guidance to wildland fire prediction, risk assessment, and response preparedness planning, to support strategic planning, tactical fire management decisions, and the entire government response to significant fire events.

The CWFIF design aims to seamlessly produce, manage, and share information about wildland fires across Canadian jurisdictions, helping to ensure communities and the public have the information and tools available to make sound decisions around risk mitigation and emergency response. Included in the Framework is the implementation of a consistent national system for information management and data exchange. This comprehensive information and data framework will facilitate interoperability between NRCan/CFS systems and Canadian fire management agencies. It will also address knowledge gaps in a coordinated manner, maximizing cooperation and minimizing duplication. The goal is to increase the timeliness, availability and quality of wildland fire data and information for planning, decision support, research, and policy development.

The CWFIF will be described in greater detail in an upcoming publication.

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Wildfire and Stswecem̓c Xget'tem First Nation: Past, present and future

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Image 1. Meeting and appreciating an impressively large interior Douglas-fir tree. SXFN Stewardship and UBC research sharing knowledge and time together (Photo: J. Garsson)

August 2021 was hot in interior British Columbia (BC). Smokey, too. Despite the conditions, members of the Stswecem'c Xget'tem First Nation (SXFN) Stewardship Department agreed to go on a walk in the woods to visit a plot where Georgina Preston and Mike Stefanuk, graduate students in the Tree-Ring Lab at the University of British Columbia, were conducting wildfire research.

After walking and sharing stories among the fire-scarred Douglas-fir trees, the group climbed a grassy hill to take in the view of the Fraser River valley below. The distant hum of helicopter rotors grew as they sat, and eventually, three were making flights overhead in rapid succession to bring buckets of water from the Fraser below to the nearby Flat Lake fire. This little group on the hilltop found themselves caught at an intersection between historic wildfires they had come to study and current, highly aggressive megafires that threaten forests and communities in BC's dry interior.

The Flat Lake Fire eventually burned over 70,000 hectares of SXFN Traditional Territory, much of it at high severity with high levels of tree mortality. And the Flat Lake Fire is not the only fire to threaten SXFN communities in recent memory – large areas of the territory burned in 2018 by the Wild Goose Lake fire, in 2017 by the Hanceville-Riske Creek and Gustafsen Lake fires, and in 2010 in the Dog Creek fire. SXFN, who are part of the broader Secwepemc Peoples, is comprised of two main communities: Canoe Creek and Dog Creek, but citizens have homes throughout the forest as well. SXFN citizens' homes have been recently and repeatedly threatened, not only by these large fires, but also by many fire starts that SXFN and the BC Wildfire Service are able to put out. This threat of fire motivated Preston and Stefanuk to begin their research on wildfire risk and historical wildfire regimes.

Before beginning her master's studies, Preston worked for SXFN's Stewardship Department. "I had the privilege and responsibility of helping the communities meet their ecological-cultural stewardship goals. I learned from SXFN citizens that fire had always been part of their Traditional Territory, but in recent years the risk of community-threatening wildfire was increasing. When trying to create proactive solutions to wildfire risk around the communities, I was struck by the economic and policy barriers to doing so," said Preston.

A set of old-growth management areas and mule deer winter ranges are established around SXFN communities, covering 55% of SXFN's two-kilometre wildland-urban interface, which are designed to promote old-growth forest and wildlife habitat. However, they come with forest management restrictions that complicate SXFN's ability to manage wildfire risk around communities.

"The citizens taught me that the forests and grasslands surrounding their communities had become much denser with young trees throughout their lifetimes and that historically many Secwepemc peoples would have burned their Territories for a myriad of reasons to help create the open, uneven-aged forest condition that famously characterizes interior Douglas-fir forests," said Preston.

Flat Lake and other recent megafires demonstrate that such dense forests can support highly aggressive wildfire, and these forests are immediately on SXFN's doorstep.

Preston is using wildfire fuels measurements and the Crown Fire Initiation and Spread model to predict the likelihood of high-severity crown fire around SXFN communities. She will simulate fuel treatment scenarios like thinning out tree density and pruning low-hanging branches to identify how crown fire risk can be reduced, despite complex provincial land management policy. These results will demonstrate the challenges that exist in navigating colonial systems to implement fuel treatments close to communities. Preston's research results may be used as a tool by SXFN to advocate for greater control over their Traditional Territory, especially when it comes to the safety of their communities. "A fuel treatment isn't good enough; it must be an SXFN-led fuel treatment that considers the Nation's eco-cultural values for today and many generations into the future," said Preston.

"I have been lucky to see much of SXFN Traditional Territory, and there's nowhere I've been that hasn't been affected by wildfire," said Stefanuk, PhD student, "but the wildfires we see in the region today are very different from those of the past."

Stefanuk is building on work by colleagues who used fire-scarred trees and dendrochronology – the study of past environments using tree rings – to reconstruct wildfire regimes in dry forests in SXFN Traditional Territory.

Given other studies in the region and parallels in traditional Secwepemc fire stewardship, Stefanuk predicts that he will find a mixed-severity fire regime with occasional large high-severity fires (like we see today) and frequent low-severity fires – some of which were purposefully set by SXFN people.

"I study trees and fire, but I see this work as very human. How would fires have affected people in the past? How were SXFN people using cultural fire? I hope this work can tell a story in line with SXFN People's history," said Stefanuk.

Image 2. Smoke plume from the Flat Lake fire on August 17, 2021 (Photo: M. Stefanuk)

Image 3. Mike Stefanuk using a chainsaw to collect a tree-ring sample from a fire-scarred Douglas-fir snag (Photo: M. Moses)

Stefanuk also plans to use past wildfires to help predict future wildfire carbon emissions. BC's forests, on balance, are emitting more carbon than they store, and the emissions are largely through wildfire. Using historical fire regimes and current forest and fuel conditions, Stefanuk will quantify stored forest carbon and use the Forest Vegetation Simulator to make predictions about the amount of carbon that would be emitted into the atmosphere if forests near SXFN were to burn.

"Climate change is making wildfires more aggressive, which is causing more carbon emissions, and this cycle will continue without thoughtful forest management," said Stefanuk. He will simulate forest management interventions to identify solutions that could shift fire regimes towards less extreme fire behaviour and emissions.

Image 4. Georgina and Mike collecting tree-ring samples using an increment borer to measure stand age (Photo: J. Garsson)

Preston and Stefanuk both rely on relationships with SXFN citizens in their research. "SXFN Leadership and the representatives from their Stewardship Department helped shape and approve our research questions and methodologies," said Preston, adding that working in partnership has "helped us contextualize our findings and ensure that we are still focused on SXFN priorities."

Stefanuk, in discussing how one might identify a past cultural burn, noted that "Tree-ring evidence can get us close to answers and give us hints about ignitions and fire use, but they aren't enough to know for certain – SXFN Elders and Knowledge Holders hold the cultural knowledge and context of fire."

Their partnership is formalized in a legal agreement, which Preston indicated "includes principles of the United Nations Declaration on Indigenous Peoples (UNDRIP) and the First Nations Principles of Ownership, Control, Access, and Possession. This means that all research activities must have free, prior, and informed consent of SXFN, and that all data collected is owned solely by SXFN."

Stefanuk said that the work of relationships is ongoing. "Getting to know some people from SXFN has helped the work a lot. And I'm still working on this. I plan to get to know people the whole way through and after this project," he said.

Canada Wildfire

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