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CANADIAN INTERAGENCY FOREST FIRE CENTRE
CENTRE INTERSERVICES DES FEUX DE FORÊTS DU CANADA

Fire Behaviour, Growth, and Decision-Making Workshop Report

November 7-9, 2023
Whitehorse, Yukon

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INTRODUCTION

The 2023 Canadian wildland fire season unfolded as one of the most challenging on record. The season was marked by exceptional fire weather indices and a shattering of hectares burned and international assistance records. Against this backdrop, the Canadian Interagency Forest Fire Centre's (CIFFC) Research and Innovation Integration Committee (RIIC)[1] organized a Fire Behaviour, Growth, and Decision-Making Workshop. This workshop, held from November 7th to 9th, aimed to address the pressing issues faced during the intense 2023 fire season, fostering collaboration and knowledge exchange among diverse stakeholders. Participants included fire management agency staff, First Nations representatives, researchers, model developers, and consultants. The primary objective was to facilitate the sharing of insights on observed fire behaviour, fire growth models, and decision-making processes, ensuring a collective understanding of challenges and paving the way for effective solutions. The aim was to share these challenges to ensure mutual understanding between collaborators moving forward with solutions. This report encapsulates the essence of the workshop, offering valuable insights for the wildfire management community.

[1] The Research and Innovation Integration Committee was formerly the CIFFC Fire Science Committee.

EXECUTIVE SUMMARY: IGNITING COLLABORATION AND KEY INSIGHTS FROM THE WORKSHOP

The Fire Behaviour, Growth, and Decision-Making Workshop focused on collaboration, knowledge exchange, and mobilization. This report captures the workshop's objectives, insights, and outcomes, offering a glimpse into the exchange of ideas and expertise that took place.

Designed with the backdrop of the challenging 2023 Canadian fire season, the workshop aimed to gather and disseminate information regarding observed fire behaviour, fire growth models, and decision-making processes. Embracing an after-action-review framework, it prioritized openness, transparency, and a constructive critique to capture lessons learned during the season and enable a continuous learning environment within the wildfire management community.

At the end of a record-breaking fire season, the workshop provided a timely platform for participants to share their experiences and challenges while the information was fresh. Feedback from several participants indicated that workshop participation also served as a cathartic release. Attention focused on understanding the needs and concerns of fire management agency staff, promoting mutual learning, and avoiding premature solution-oriented discussions.

Participants from various sectors engaged in valuable networking and exchange opportunities, reinforcing existing relationships and laying the groundwork for ongoing engagement and relationship building. One senior-level participant expressed that the workshop offered an excellent opportunity for the right discussions with the right people, both during sessions and informally.

The workshop report, aligned with after-action-review principles, emerges as a comprehensive summary for attendees and the wider fire community, distilling key themes, challenges, and opportunities that surfaced during the discussions. Thematic insights span five areas, 1) use of existing tools and processes, 2) new tools and models for the future, 3) capacity constraints and potential solutions, 4) relationship building and collaboration, and 5) knowledge transfer and communication. The report abstains from prescriptive recommendations, instead, it identifies challenges and opportunities for collaborative action.

Drawing a diverse cohort of 163 participants, predominantly from Canada, with near-universal representation of CIFFC member agencies, the workshop surpassed the organizers' expectations of attendance and engagement. In-person contributions from US attendees, complemented by virtual engagement from Australia and New Zealand, enriched discussions, underscoring a global appetite for collaborative approaches to evolving wildfire management challenges. Strong interest was expressed in future engagements, especially those involving face-to-face interactions, signaling a continued commitment to knowledge sharing and relationship building beyond this single event.

ABOUT THE WORKSHOP: UNITING MINDS AND OVERCOMING CHALLENGES

The three-day workshop, co-hosted by the Yukon Government's Wildland Fire Management Branch and CIFFC RIIC, took place in Whitehorse, Yukon, and online. Word-of-mouth advertising was initiated by RIIC members, with varying energy levels as they faced the demands of an intense fire season. As workshop advertising snowballed, online registration via an MS Teams site was made available, albeit within a tight timeline, potentially limiting accessibility for some interested participants. Nonetheless, despite these logistical challenges, the workshop garnered significant attendance.

As a hybrid format, blending in-person and online participation, the workshop attracted a diverse cohort of 163 attendees. Of these, 42 individuals attended in person in Whitehorse. Participants represent various sectors including fire management agencies across Canada, researchers, private sector consultants, and governmental and non-governmental organizations. Strengthening international ties, participants joined from Australia, New Zealand, and the United States, fostering global collaboration and exchange.

Integral to its purpose, the workshop prioritized knowledge exchange and mobilization, providing a vital platform for participants to reflect on and share their experiences of the demands of a challenging fire season. Facilitated by Heather Simpson, Caleb Tomlinson, Kris Johnson, and Mike Fancie, the workshop's structured agenda (Table 1) featured presentations and panel discussions, ensuring a widespread exploration of pertinent topics.

Table 1 - Fire Behaviour, Growth, and Decision-Making Workshop Agenda

November 7th	November 8th	November 9th
Hybrid online/in-person	**Hybrid online/in-person**	**Hybrid online/in-person**
2023 Agency Observations	Fire Growth Models/Tools	Over & Under Prediction
Example Case Studies	The Right Tool for Task	Conveying Things to People
Modelling Limitations	Challenges in Your Role	Knowledge Gaps
In-person only	**In-person only**	**In-person only**
Blue Sky Session	Implementation and Uptake	Focus on Cultural Burning
Automated Models	Topics from the Floor	National Practices
Documentation & Access	KEM Summary	Action Planning
	Hybrid online/in-person	
	AUS/NZ Special Session	

Five primary themes emerged from evaluating the workshop discussion, MS Teams chat, and workshop survey results. Each of these themes is discussed in detail below. Some topics could fit within several themes, but an effort was made to choose the best fit and present topics without duplication. The five themes are:

1. Use of Existing Tools and Processes

2. New Tools and Models for the Future

3. Capacity Constraints and Potential Solutions

4. Relationship Building and Collaboration

5. Knowledge Transfer and Communication

USE OF EXISTING TOOLS AND PROCESSES

Canadian fire management agencies universally rely on the Canadian Fire Behaviour Prediction (FBP) system and its field guide (known ubiquitously as the 'Red Book'). The FBP is a sub-system of the Canadian Forest Fire Danger Rating System (CFFDRS). Notable to the workshop discussion was the varied usage of the FBP system and the inconsistent application of computer-based models that use the FBP system for calculations and custom products.

A recurring theme centered on understanding how agencies and individual Fire Behavior Analysts (FBANs) navigate beyond the FBP system's limitations and fundamental assumptions, particularly concerning non-standard fuel types, challenging weather inputs, shortcomings in fire intelligence, and unclassified resource or suppression effectiveness. Discussions delved into the FBP system's suitability and accuracy in predicting fire behaviour under extreme and irregularly observed conditions, emphasizing the necessity to evaluate and expand the current tools' adaptability to variances like peatland, permafrost, extended daylight hours, and fluctuating foliar moisture content.

The workshop participants emphasized the need to enhance model inputs, explicitly focusing on fuel and weather variables. Discussions and presentations also included model limitations and the blend of the art and the science in fire behaviour prediction. Further discussion recognized a broader need for robust data management processes, highlighting the significant return on investment associated with sound data management practices in fire behaviour prediction.

NEW TOOLS AND MODELS FOR THE FUTURE

The discussion of new tools and models for the future was largely conceptual. While there was general commentary on ongoing work to develop new models, there were no specific updates. Currently practicing fire behaviour modellers emphasized the crucial need for Canadian wildland fire management agencies to adopt new tools and models, specifically regarding expanding computer-based models. The discussion included advocacy for more automated fire behaviour prediction tools, with a caveat acknowledging the necessity for training and ongoing evaluation. Ensuring practitioners' training and familiarity with new tools and ensuring outputs meet reasonable levels of accuracy were considered imperative.

New tools should focus on predicting fire occurrence and danger across various spatial and temporal scales, catering to critical decision-making. Workshop discussion envisioned the creation of models at provincial or national scales, facilitating longer-term predictions, including multi-day, seasonal, and multi-year predictions for informed long-term resource allocation. Medium-scale models are needed to predict season severity or the duration of large individual fires. Participants expressed varied sentiments about the current tools' efficacy in capturing these scales adequately.

In recognizing the need for resilient systems, participants highlighted the importance of developing strategies to address critical situations, such as total communication outages, to ensure operational continuity even in the most challenging scenarios.

CAPACITY CONSTRAINTS AND POTENTIAL SOLUTIONS

In the context of this workshop, capacity constraints are categorized into two areas: 1) trained FBAN capacity within Canada, for which the unprecedented 2023 fire season highlighted capacity challenges, and 2) other forms of fire behaviour prediction and resource specialists, commonly used elsewhere but not broadly employed in Canada (e.g., Long Term Fire Analyst (LTANs), or strategic fire planners).

Multiple potential solutions were proposed to address the capacity and availability of trained FBANs. One approach suggested expanding the FBAN pool beyond agency staff, incorporating retired FBANs, qualified private sector consultants, and researchers— another proposed solution involved developing cross-training tools to streamline the utilization of international interagency FBANs and other specialists. Retired FBANs, consultants, and researchers may be helpful in briefing and onboarding international FBANs when agencies are experiencing challenging fire situations. Additionally, centralized service centres, offering predictive services for various incidents or broad regions, were discussed at different scales, ranging from multi-incident to provincial/ territorial or national service centres.

The second category, other forms of fire behaviour prediction and resource specialists, presented fewer concrete solutions. The context of LTANs in the USA was a primary discussion area. This theme also intersected with the service centre concept, potentially necessitating new roles in Canada. Some participants asserted that Canadian FBANs were already trained for LTAN roles. In contrast, others proposed additional capacity through training and mentorship from national and international partners or hiring a nationally available pool of full-time permanent fire behaviour specialists. Of note, predictive services capacity varies across the country, and the Fire Behaviour Specialist courses, S-589, S-590, and S-591 are in the process of revision, which likely contributes to the contradictions in discussions in this area.

RELATIONSHIP BUILDING AND COLLABORATION

While no individual sessions were explicitly dedicated to relationship building, it was an inherent aim of the workshop and numerous discussions naturally gave rise to the theme. Participants were prompted to articulate their workshop goals during the initial in-person session. Many expressed a primary objective of forging connections with operational practitioners from different geographical areas or engaging with members of the fire behaviour community beyond their specific subject matter area.

The importance of peer support, especially during challenging seasons like 2023, emerged as a recurring theme. Participants valued sharing and connecting over common difficult experiences, enhancing a sense of community.

Collaboration surfaced as both an opportunity and a challenge concerning the benefits of sharing information across agency boundaries. While there are acknowledged benefits, there was also a recognition that more consistent data management practices and policies allowing data sharing may be required.

The proposition of a standard national fire growth projection tool was discussed, as local or regional tools are more common when moving beyond the Red Book. Potential advantages include enhanced user training, greater interoperability, and efficiencies in tool development. Workshop attendees also discussed the prospect of strengthening tool-building processes between Canadian and USA agencies.

Participants reflected on increasing opportunities for students and researchers to engage with fire management agencies and CIFFC, recognizing the positive contributions of two in-person attending post-graduate students. Discussion also focused on the need for more mechanisms to facilitate effective collaboration between fire management agencies and researchers to address the rising volume of requests experienced by some agencies.

KNOWLEDGE TRANSFER AND COMMUNICATION

The theme of knowledge transfer and communication encompasses a broad spectrum of discussions, ranging from training operational staff to effectively communicating fire behaviour and growth predictions to the public. Discussions centred on understanding the intended purpose and limitations when utilizing tools and models. Participants consistently highlighted the need for communication and the transfer of information back to tool-makers and researchers. This encompassed the need to share basic fire behaviour observations, wildfire case studies, and suggestions for establishing processes and databases to provide and store feedback and fire behaviour observations.

Related to the capacity constraints theme, a larger pool of individuals need specialist fire behaviour training than could be expected to serve as dedicated FBANs, as many within the specialist training pool have other obligations. There was interest in exploring how the outputs of tools and models could inform non-technical communication to partners, stakeholders, and the public, as well as internal communication with senior government officials and decision-makers. Participants praised the work of authentic information officers and other information providers. They emphasized the importance of frank and open communication, especially when wildland fires exceed suppression capacity.

THEMATIC SUMMARY AND CHALLENGE AREAS

The workshop discussions yielded insights across five primary themes. Firstly, participants emphasized the reliance on the Canadian Fire Behaviour Prediction (FBP) system while acknowledging its limitations, especially concerning non-standard fuel types and challenging weather inputs. Secondly, there was a call for the development and adoption of new tools and models, focusing on expanding computer-based models to predict fire occurrence and danger across various spatial and temporal scales. Thirdly, capacity constraints regarding trained Fire Behavior Analysts (FBANs) and other specialists were addressed, with proposed solutions including expanding the FBAN pool and developing cross-training tools. Fourthly, relationship building and collaboration emerged as essential for fostering peer support and sharing information across agency boundaries. Finally, discussions centered on knowledge transfer and communication, highlighting the need for effective communication of fire behavior predictions to various stakeholders and the public, along with mechanisms for providing feedback to tool-makers and researchers. Based on these themes, several opportunities or challenge areas emerge:

1. How can we improve on the adaptability of existing fire behavior prediction tools to account for diverse conditions and fuel types, including extreme fire weather indices, peatland, permafrost, and fluctuating foliar moisture content?

2. How can we enhance automated fire behavior prediction tools while ensuring comprehensive training and ongoing evaluation to maintain accuracy and reliability?

3. How can we enhance or establish provincial or national-scale models for longer-term predictions to facilitate informed resource allocation and planning?

4. How can we expand the pool of trained FBANs and other specialist positions? Can we incorporate retired FBANs, qualified private sector consultants, and researchers, while also exploring cross-training opportunities?

5. How can we strengthen data management processes to support robust fire behavior prediction and resource allocation?

APPENDIX A: TABLE OF CONTENTS

Session 1: This Season's Fire Behaviour

This session consisted of five-minute summaries by individuals from fire management agencies across Canada. Presenters were asked to focus on what was unprecedented about their agency's fire season experience of the fire season. Unprecedented items included:

- Extremely large individual fires.
- Large fires occurring out of the typical season.
- The record-setting cumulative area burned.
- Large single-day growth events.
- Extreme fire weather indices.
- Demands on predictive services far exceeding historical norms (e.g., spot weather forecasts, fire growth projections).
- Use of new fire behaviour prediction models.
- Number of evacuations far exceeding historical norms.
- Political-level decision-making incorporating information from fire behaviour forecasts.
- Unavailability of imported resources.
- Importing from different international agencies.

Session 2: Case Studies of Decision-Making

Professionals in predictive services undergo training to forecast fire behaviour, considering various environmental conditions and utilizing diverse tools and models. Despite the seemingly straightforward nature of these predictions, the process is intricate, involving the integration of data from diverse sources, informed judgments, and interpretations based on expertise. This session presented illustrative case studies, exploring the intricacies of making predictions, the tools and information sources employed, the underlying processes, and the subsequent decisions. We address scenarios where rapid predictions must be made in complex environments and when predictions deviate from established norms like the Red Book. This session comprised two presentations: Session 2a focused on SOPFEU's utilization of a centralized FBAN service centre, while Session 2b explored observing fire behaviour and conducting aerial ignition in the Arctic.

Session 2a: Discussions in this session revolved around Quebec's unprecedented demand for fire growth projections, the ensuing challenges and innovative solutions. The volume demand during the summer of 2023 was unprecedented. Even prioritized fires had to undergo further prioritization. There was sometimes limited information, and assumptions were needed for critical model inputs, which posed challenges. FBANs assigned to the Provincial Fire Centre devised novel approaches, such as using Prometheus to model only active fire portions or areas with values at risk. A total of 130 projections were completed over two months. The number of projections was a substantial increase on the typical workload. Despite the challenges, the agency saw success this season as no permanent homes were lost.

Session 2b: The presenter shared general observations, challenges, and successes related to aerial ignition above the Arctic Circle in the Northwest Territories. Unique challenges arose due to the inapplicability of standard CFFDRS rules, attributed to factors like 24-hour daylight and non-standard fuel types, possibly influenced by permafrost conditions. Successes included correlating burning with temperature and topography. Two specific incidents were detailed: in one case, a cabin was protected using aerial ignition, allowing the fire to back towards a waterway acting as a natural control line. In the second case, the ignition team identified control points based on observing where the fire was halting along "moisture lines." Success was attributed to strategic ignition choices, predicting solar radiation and smoke conditions, and identifying and utilizing control points based on observed fire spread patterns.

Session 3: Model Limitations

This session discussed the inherent limitations of models, emphasizing George Box's adage that "all models are wrong, some are useful." Models provide an answer, but they are not something to follow blindly. Key points included:

- The question, "how wrong does a model have to be to not be useful?"

- Good predictions incorporate the model, the modeller, and the analysts.

- Several different types of things can go wrong: it could be the wrong model, the model might be inherently inaccurate, or there could be poor input data.

- Model users should not push a model beyond its capability. Risks can be assessed based on a range or set of likely possible outcomes, not a single deterministic predicted outcome.

Session 4: Blue Sky Session

This in-person session was an open floor format. A discussion was initiated with participants responding to the question, "What do you want to get out of this workshop?". Participants were asked for their insights and suggestions for this space and possible discussion areas that were missed in the workshop outline. Responses have been categorized around the identified workshop themes.

Addressing Capacity Constraints:

- Address the number of FBANs available nationally.

- Consider the possibility of retired FBANs mentoring those unfamiliar with the CFFDRS.

- Streamline interagency process, including the integration of international FBANs.

- Consider the possibility of private sector and non-fire management agency government staff.

Collaboration, Networking and Relationship Building:

- Desire to network with other agencies to break the sense of isolation.

- Discuss collaboration and information sharing beyond agency boundaries.

- Explore opportunities for consolidating the tool-building process for collaboration between Canadian and American agencies.

- Discuss opportunities for researchers to gain field experience on wildfires.

- Address the challenge of agencies being receptive to researchers amidst a high volume of research requests.

Decision Making:

- How do models inform decision-making made in the field, including evacuation alerts/orders, resource requirements, and prioritization of multiple wildland fires?

- Discuss how to model small, emerging incidents and prioritize fires for suppression.

- Use tools to predict broad resource needs in Canada.

Use of Existing Predictive Tools and Processes:

- Evaluate the suitability of various predictive tools and processes.

- Understand how different agencies address and model with non-standard inputs.

- Explore practical uses of technology despite organizational limitations.

- Development of new tools and understanding new technology.

- Explore the creation of new fire behaviour products to meet evolving needs.

- Explore how technology can aid in predicting fire behaviour.

Knowledge Transfer and Communication:

- Discuss how to make products interesting and novel for crews on project fires.

- Understand how modelling informs non-technical briefings for the public, government, and stakeholders.

Safety:

- Learn from safety thresholds and fatalities experienced in the past summer.

Session 5: Automated Modelling

This session discussed the use of automated modelling across Canada. An overview of FireCast, one such automated growth model, its current challenges and recommendations were discussed. A breakout discussion on the use of automated models followed.

The following statistics were presented on the FireCast automated model: in 2023, almost 14,000 fires were tracked, with 2.5 million simulations completed, which generated 19 million scenarios, resulting in 11 TB of data production. Researchers at the University of Alberta studied six randomly selected fires, and the accuracy of model forecasting over the longer term (multi-day) was 60%.

Challenges:

- Agencies provide data in different formats with very different security permissions.

- Everyone wants slightly different outputs.

- The volume of fires and demand for service slowed service speed.

Recommendations:

- Support more ensemble modelling work to keep up with high fire loads.

- Develop more techniques, models, or approaches for non-standard fuel types.

- Help tune existing fuel-type models.

- Training is essential.

- Feedback for model makers/programmers is essential.

- Create new user inputs (e.g., curing and fuel load layers, more accurate moisture codes, agency weather feeds).

- Determine what to do with the vast amount of data generated.

Breakout Discussion Notes

- Training is required. Automated models will only be useful if people know how to use them and come to appreciate their limitations.

- There needs to be an ongoing assessment of the accuracy and understanding of error sources.

- Agencies must determine how they will use unfiltered model outputs and be aware that non-agency organizations publish unfiltered models.

- Data management and security will require careful considerations.

- Different model uses must be considered, including short-term prioritization of multiple new fires and long-term growth prediction on large fires with limited active areas.

Session 6: Documentation and Access

This open-floor discussion focused on data sharing and the degree to which data should be available to the public. Australia's open, unfiltered, and real-time data sharing was exemplified as a starting point for the discussion. The unique mandates and policy contexts across Canada were also discussed. Other discussion items included:

- IT perspective of open data and public access.

- The need for accurate data for operational decision-making.

- The public and non-technical internal audience needs contextually relevant data.

- The research community's interest in accessing data.

- The varying availability and quality of data from fire management agencies across Canada. Some disagreement occurred on the quality and accessibility of data.

Session 7: Tools Overview

This session presented a high-level scan of tools available in Canada. The following tools were presented and briefly described from an operations perspective:

1. Field Guide to the Canadian Forest Fire Behavior Prediction System, commonly known as the 'Red Book'. This is the most commonly used tool in Canada.

2. RedAPP and FBPGo. Computer and mobile versions of Red Book, respectively.

3. Prometheus. A spatial fire growth model using CFFRDS inputs, which creates deterministic perimeter projections.

4. Pandora. A batch-run overlay for Prometheus. Noted as useful, but more complicated to use.

5. W.I.S.E/PSaaS. An automated wildfire modelling engine. Powers GNWT's modelling platform and FireCast.

6. BurnP3/BurnP3+. A burn probability that uses W.I.S.E. and Cell2Fire.

7. FireSTARR. An automated low data-burden, probabilistic fire growth model. Also has an experimental deterministic option.

8. Cell2Fire. A cell-based fire spread simulator implemented in BurnP3+.

9. BigFoot. An automated deterministic fire growth model powered by Super Duper engine. Coarse 1-kilometre modelling tool – only runs if a fire is 200+ ha.

10. PFAS. Probabilistic climatological fire projection model with an outlook of up to 30 days assuming no suppression.

11. SFMS. Spatial CFFDRS implementation, used to generate the public FWI map.

12. FireHawk. This web-based fire intelligence platform uses W.I.S.E. It can be run as an automated or supervised growth model. It incorporates distance to values, potential impacts, and suppression effectiveness.

13. Torchlight. A high-resolution tactical wildfire detection system/mapping tool. Can be used to inform and improve growth projections. Available by emergency request from the Canadian Forest Service.

14. FireGuard. A USFS/National Guard near real-time monitoring and detection system that was deployed in Canada for the first time in 2023.

15. Other tools

    a. NASA FIRMS

    b. FireWorks/BlueSky smoke prediction maps

    c. Private vendors Technosylva and FireCast

    d. Crown Fire Initiation and Spread (CFIS) system

The discussion noted that other than the Red Book, most of these tools have been inconsistently used by agencies across Canada. Tool use is regional or dependent on the capability of the individual user.

Session 8: The Right Tool for the Task

This session was a panel discussion with three expert fire behaviour prediction tool users, including an introductory presentation from the panel host. The presentation 1) identified considerations for selecting the appropriate tool based on the incident scale and timeframe, 2) recognized the limitations of organizations, especially small organizations, to use the available tools effectively and 3) explored opportunities to develop or improve tools for longer-term forecasting, forecasting in extreme conditions, tracking foliar moisture content, and understanding changes in the burned landscape. The panel discussion included the following points:

- "The right tool" is often the only tool available for the circumstance.

- Different tools solve different problems and can inform different types of decisions, so we need a good toolbox.

- "The right tool" is dynamic because the problems are changing.

- We have tools for dealing with large fires but don't have concepts for dealing with 500,000 ha+ 'monster fires.' These 'mega' or 'monster fires' overwhelm existing tools.

- With new tools, forecasters need a test environment to demonstrate value instead of trying to figure it out in the middle of a fire season.

- Collecting and storing data correctly should provide a sound return on investment, and it is important that agencies make this investment.

Session 9: Challenges in Your Role as a Fire Behaviour Analyst

This was a panel discussion with four FBANs that focused on the human side of predictive services, with panellists sharing their experiences of working operationally as FBANs during the 2023 fire season. Key discussion points included the following:

- The increasing complexity of the FBAN role. Expectations that an FBAN can provide long-term analysis, spatial modelling, can serve multiple incidents at once, and can serve as a field FBAN while also performing other incident or agency duties were all cited as factors in the increasing complexity of the role. The potential for developing a long-term analyst position, developing and utilizing automated tools, and developing predictive services centres were discussed as potential solutions.

- The prevalence of burnout this season was discussed, as well as the importance of recognizing that everyone is trying their best and that the season was overwhelming for many.

- The importance of developing relationships and having a network of co-collaborators to succeed as an FBAN and in fire management in general was discussed. The workshop was celebrated as an excellent opportunity to develop networks.

- The need for training was raised, and the disparity between how many people are trained and how many people end up available to perform FBAN roles (i.e. not all trained people are available for operational FBAN work).

Several additional online and in-person attendees acknowledged the importance of recognizing the human elements of FBAN work and expressed appreciation for the session. In post-workshop feedback, a senior FBAN from one agency noted that a remote approach to the FBAN role was not ideal in their agency as it required a highly experienced FBAN and there would be value in gathering perspectives from Incident Commanders and Operations Section Chiefs to define their expectations of the FBAN position.

Session 10: Challenges with Implementation and Uptake

This session included a presentation on the level of uptake and implementation of various fire modelling tools across Canada. A case study and narrative of the design path of the FireSTARR model and implementation and uptake in Ontario and Nationally. Breakout group discussions on the implementation and uptake of new tools followed.

The breakout discussion had many potential trajectories, with the presenter providing a series of optional prompts for each table. The groups independently selected discussion prompts that focused on the importance of trust and relationships in the perceived validity of models. Specific summary points brought forward by the groups

included:

- Trust is required of the people who provide data for models. We trust people who we know.

- Validation is the trust that a product has been peer-reviewed and has been available for a long time.

- A positive feedback loop helps develop trust in relationships and, subsequently, in models. This requires a perception that suggestions have been taken to heart by the model builders.

- Trust is a time-bound asset.

- Working from outside of wildfire agencies is difficult because it is difficult to gain trust. It's also difficult to work inside agencies without strong relationships. Validation requires the fire behaviour to match what the model predicted.

A publication on model uptake and implementation is planned, which may include the outcomes of this workshop session.

Session 11: What is an LTAN?

This was an ad hoc presentation from several Long-Term Analysts (LTANs) in attendance, who shared a brief description of the LTAN role and contrasted it with the FBAN role as utilized in the United States. They described LTANs as providing:

- Climatology-focused fire prediction, answering questions such as when a fire or fire season is going to end. This contrasts with day-to-day safety- and tactics-oriented analysis provided by field/incident FBANs.

- Normally, incident meteorologists are paired with LTANs.

- An investment in LTANs provides a return because people are safer, and longer-term environmental consequences are better understood and therefore managed.

Capacity was also discussed: in the United States, there are 37 LTANs and 107 FBANs, 26 are certified as both. There are also 97 Strategic Operational Planners (SOPL), who bridge the relationship with Operations, 13 LTAN/SOPLs, 33 FBAN/SOPLs.

Session 12: Australian and New Zealander 2023 Deployment Experience in Canada

This session was a panel discussion with panellists from Alberta, British Columbia, Australia, and New Zealand. The roles of panellists included Strategic Planners, Incident Commanders, and FBANs. Special thanks are due to the panellists who called in from deployments in the southern hemisphere. Several themes emerged from the panel discussion:

People and relationships:

- Firefighting is often about people and relationships, and it was essential to develop strong working relationships quickly to succeed.

- The value of flexibility, adaptability, and maintaining good relationships in the face of evolving fire seasons was highlighted. This included relationships between host and imported fire management staff but extended to other partners and stakeholders, including First Nations and industry.

Opportunities to learn from each other:

- Home agencies and incoming resources displayed open-mindedness and a willingness to learn from one another.

- Mentoring opportunities were present and capitalized on, with international mentorship happening with Canadian and international resources in mentor and mentee roles.

Technical Aspects of Interoperability

- Some terminology challenges occurred with the way risk and consequence are described, which were overcome with discussion during the deployments.

- Systems and data access were important to have and generally accessible, but any advance access would further improve onboarding staff.

- Working in different fuel types and with fewer weather stations was challenging.

- FBANs are used differently in different agencies. The role of an FBAN in Australia is not the same as for a Canadian FBAN. Increased knowledge exchange would benefit both countries and their respective FBAN programs.

Session 13: Over and Under-Prediction

This session included a brief presentation and called for instances of over and under-prediction from the audience, including online and in-person attendees. Six audience members provided examples of over or under-prediction. The session lead had the participants systematically describe the type of prediction, factors leading to the error, and the impact of the error, as well as several other elements. The bias towards remembering underprediction, with its potential for disastrous consequences compared to overprediction, was discussed.

Session 14: Conveying Things to People

This was a panel discussion, with panellists discussing communication considerations for various topics, including meteorology, operations, internal briefings, and public information. Some key points follow:

- Consistent, standardized formats are useful. Valid data is essential.

- Without good communication, false information can take over public websites. There are people purposefully providing incorrect information to the public. This is something agencies need to consider when communicating.

- Within the fire management community, we are used to working with uncertainty, but there's a balance between conveying accurate information and reaching the audience.

- When communicating with the public or briefing senior management and decision-makers, prioritize the presence or absence of risk – some concerns might not represent real risks.

- Simple, actionable communications make people the most likely to act desirably.

- It is challenging to form close relationships while on short deployments and then have to leave those areas and suddenly lose those connections.

Session 15: What We've Learned and Knowledge Gaps

This session recapped some of the key themes and learnings of the workshop, including:

- The importance of relationships.

- Developing and implementing modelling tools that people trust.

- Opportunities to adopt other types of roles or service models in addition to FBANs serving on incidents, including LTANs and FBANs on incidents, at service centres or hubs serving a broader area.

An open floor discussion of knowledge gaps included discussion of:

- Looking to *The Blueprint for Wildland Fire Science in Canada*[2] as a reference that can help create the workshop report.

- Lack of clarity about how all the pieces we discussed at the workshop fit together.

- A gap between model development and training.

- Capacity of people: "It's all fine to have models, but you need people to use them."

- People spend less time on fire crews, limiting access to field-experienced trainees.

Some potential solutions were discussed as well:

- Improve capacity by accompanying FBAN deployments with trainees and field observers. Utilize mentors, retirees, the CFS, contractors, and predictive services teams.

- The people working on the next generation FBP system are investigating the potential to integrate new phenomena like the impacts of drought on foliar moisture content, smoke, and cloud content, and so on.

- Sometimes, IMTs emphasize FBANs' responsibilities too much. It's an operational job, not a strategic intelligence job, and a team-based predictive services approach will support successful long-term forecasting.

- In 50 years, we will not solve chaotic problems like very fine fire spread projections – and maybe that isn't necessary. "If you predict 3 meters/minute, but you observe 0.3 meters/minute, that's a crazy overprediction, but it doesn't practically matter that much."

[2] Sankey S (2018) Blueprint for Wildland Fire Science in Canada (2019-2029). Canadian Forest Service, Northern Forestry Centre, (Edmonton, Alberta)

- Teams can help operational staff understand the cause of a question so that the answers can support decision-making. Even with a large margin of error, data can still answer questions.

Data collection

- Quebec has a cooperative, inter-agency weather network; even though the data isn't universally useful, it helps provide more information. Mobile weather station data uploads to the agency web portal, so as long as its location is up-to-date data from different places can be accessed.

- During a busy fire season, there's a role for private-sector and student hiring to collect data on agencies' behalf.

- It's important for people to know the details of how weather inputs are being processed (i.e. wind speed as a max measurement speed, or 10-minute average, or something else).

Session 16: Cultural Burning Practices

This session included a presentation and two videos on cultural burning. The presentation discussed the global history of fire use by Indigenous peoples and the importance of fire for land management and cultural practices. The concept of the Land Stewardship Cycle was introduced, showing the relationship between fire and other traditional activities. The speaker and the videos discussed the decline of cultural burning due to colonization and the current resurgent interest in and practice of cultural burning in recognition of its benefits.

Session 17: National Practices

This session discussed national practices related to fire behaviour modelling, analysis, and communication. It was an open-floor conversation. It included some discussion of the difference between practices and standards and the challenges of creating national standards. Some participants thought that CIFFC should be empowered to create national standards for things such as spot weather forecast templates, while other participants thought that standard-setting should rest with fire management agencies. There was an ensuing discussion about the role of CIFFC and the decision-making processes within CIFFC. Agency participants were encouraged to ensure vertical alignment in their fire management agencies.

Session 18: Action Planning

The final session of the workshop was an open-floor discussion of what should come next. The following topics were raised:

- A central web-based repository of fire behaviour and modelling resources. This could be grey literature, similar to the US Lessons Learned Centre. Notably, there were questions about who would host and maintain such a resource and who would use it. How would this resource compare to other similar resources that are already available? Some similar resources were mentioned.

- Improvements to international interoperability.

- Future in-person gatherings would be beneficial for continuing these conversations and building and strengthening networks.

- International Association of Wildland Fire membership will be free beginning in 2024.

- The Wildland Fire Canada conference is in Fredericton in October 2024. This conference has shifted to be more of an academic discussion, and it is one that people hopefully will find to be more friendly to operational personnel.

- General support was expressed for participative workshops rather than trying to meet at conferences or other presenter-focused meetings.

APPENDIX B: ATTENDEES

Canadian Fire Management Agency

Yukon

Brian Douglas

Conner Lee

Haley Ritchie

Jennifer Sharp

Keith Fickling

Kris Johnson* (RIIC)

Kyle MacDougall

Linda Brandvold

Mac Prawdzik

Mike Fancie*

Mike Smith*

Randy Mitton

Scott McKenzie

Tyson Cole

Northwest Territories

Franco Nogarin*

Jason Currie*

British Columbia

Andrew Simpson

Ben Boghean

Brett Soderholm

Darren Boss

Eric Kopetski

Glenna Tomlins

Ian Ward

Matthew MacDonald

Mike McCulley* (RIIC)

Neal McLoughlin*

Alberta

Brad McKenzie

Connor Wollis

Dale Thomas

Dave Schroeder* (RIIC)

Elizabeth Chapman

Jarret Whitbread

Jill Moorley

Kelsy Gibos* (RIIC)

Olivia Aftergood

Tanya Letcher*

Ryan Good

Saskatchewan

Chris Dallyn* (RIIC)

Robert Kruus

Sindy Nicholson*

Manitoba

Ezekiel McLeod

Garth Hoeppner* (RIIC)

Hilary Smith

Kim Fiddler

Lauren Senier

Mark Moffatt

Samuel Done

Ontario

Barry Graham

Den Boychuk

Ian Staley

John Johnston

Kendriah Pearse

Matthew Corbett*

Margot Santry

Melanie Wheatley

Québec

Caroline Boyaud (RIIC)

SOPFEU

Alain St-Onge*

Christine Bussieres*

François Carpentier

Normand Lacour*

Olivier Lundqvist (RIIC)

New Brunswick

Danny Goddard* (RIIC)

Nova Scotia

James MacKinnon* (RIIC)

Newfoundland

Laurie Holloway* (RIIC)

Parks Canada

Anne-Claude Pepin

Dustin Guedo

Gregg Walker (RIIC)

Jane Park

Jay Zakaluzny*

Katie Ellsworth

Landon Shepherd

Matthew Johnson

Philippe Allaire

Rachel Dietrich

Ryan Burlingame

Scott Bryer

First Nations

Yukon First Nations Wildfire

Hyder Bos-Jabbar*

Nick Mauro

Other Government

BC Public Service

Brett Edwards

Conor Brady

Morgan Boghean

BC Capital Regional District

Jonathan Reimer

NT Environment and Climate Change

Mike Westwick*

YT City of Whitehorse

Rebecca Rothgeb

Consultancy and NGO

CIFFC

Caleb Tomlinson*

Emmanuel Diaz

Heather Simpson* (RIIC)

Country View Consulting

Walter Born

Ember Research Services

Brad Armitage

Suzanne Lavoie

Forsite Consultants

Gregory Greene

Joanna Wand

John Davies

Kate Bezooyen

Google

Kevin Holst

Heartland Software Solutions

Travis Redpath*

Robert Bryce*

OroraTech

Tyler Smith

Shifting Mosaics/Northern Fire WoRx

Sonja Leverkus

Unaffiliated

Mike Dittaro

Dana Hicks

West Coast Weather Services

Christina Van Eaton

Wild Rose Fire Behaviour

Marty Alexander

Wildlife Conservation Society

Tobi Oke

Research

Canada Wildfire

Brian Wiens*

FPInnovations

Andrew Stack

Razim Refai (RIIC)

Steven Hvenegaard

Natural Resources Canada

Canadian Forest Service

Chelene Hanes (RIIC)

Colin McFayden*

Daniel Perrakis

Jordan Evens

Julienne Morissette

Kim Morrison

Natasha Jurko

Patrick Deane

Sam LaCarte*

Shiyang Zhao

Stefana Dranga

Steve Taylor (RIIC)

Tom Swystun

University of Alberta

Ilbin Lee

Jen Beverly

University of British Columbia

Georgina Preston

Jen Baron

John Braun

Lengyi (Spectrum) Han

T. Don Nguyen

University of Lethbridge

Amanda Bakalarczyk

Laura Chasmer

Yukon University

Jaclyn Semple*

International

Fire and Emergency New Zealand

Darrin Woods

Rachael Thorp

United States

Bureau of Indian Affairs

Thomas St. Clair

Bureau of Land Management

Jennifer Jenkins

Fish and Wildlife Service

Lisa Saperstein

University of Alaska Fairbanks / Alaska Fire Science Consortium

Alison York (RIIC)

Mitchell Burgard*

Minnesota Department of Natural Resources

Travis Verdegan

National Park Service

Casey O'Connor

Christopher Moore

Heidi Strader

Patty Johnson

National Weather Service

Benjamin Bartos

USDA Forest Service

Christopher (Kit) O'Connor

Kip Van de Water

Sam Amato*

Tami Parkinson*

Australia/New Zealand

Special Session Attendance

Australia

Country Fire Authority

Victoria, Australia

Nick McCarthy*

Andy Ackland*

Department of Energy, Environment and Climate Action

Victoria, Australia

Tim Gazzard*

Peter Brick*

David Roberts*

Emergency Management Victoria

Victoria, Australia

Alison Ireland*

Rural Fire Service

New South Wales, Australia

David Clarke*

New Zealand

Department of Conservation New Zealand

E. Karwowski

S. Bowie

Fire and Emergency New Zealand

Alan Doherty

Craig Cottrill*

David Utumapu

Jason Hill

Tim Mitchell*

* A special acknowledgment to the presenters, panellists, facilitators, and organizers, who are noted with a * or (RIIC) designation or both.

ACKNOWLEDGEMENTS