CANADIAN WILDLAND FIRE & SMOKE

# NEWSLETTER

FALL2020

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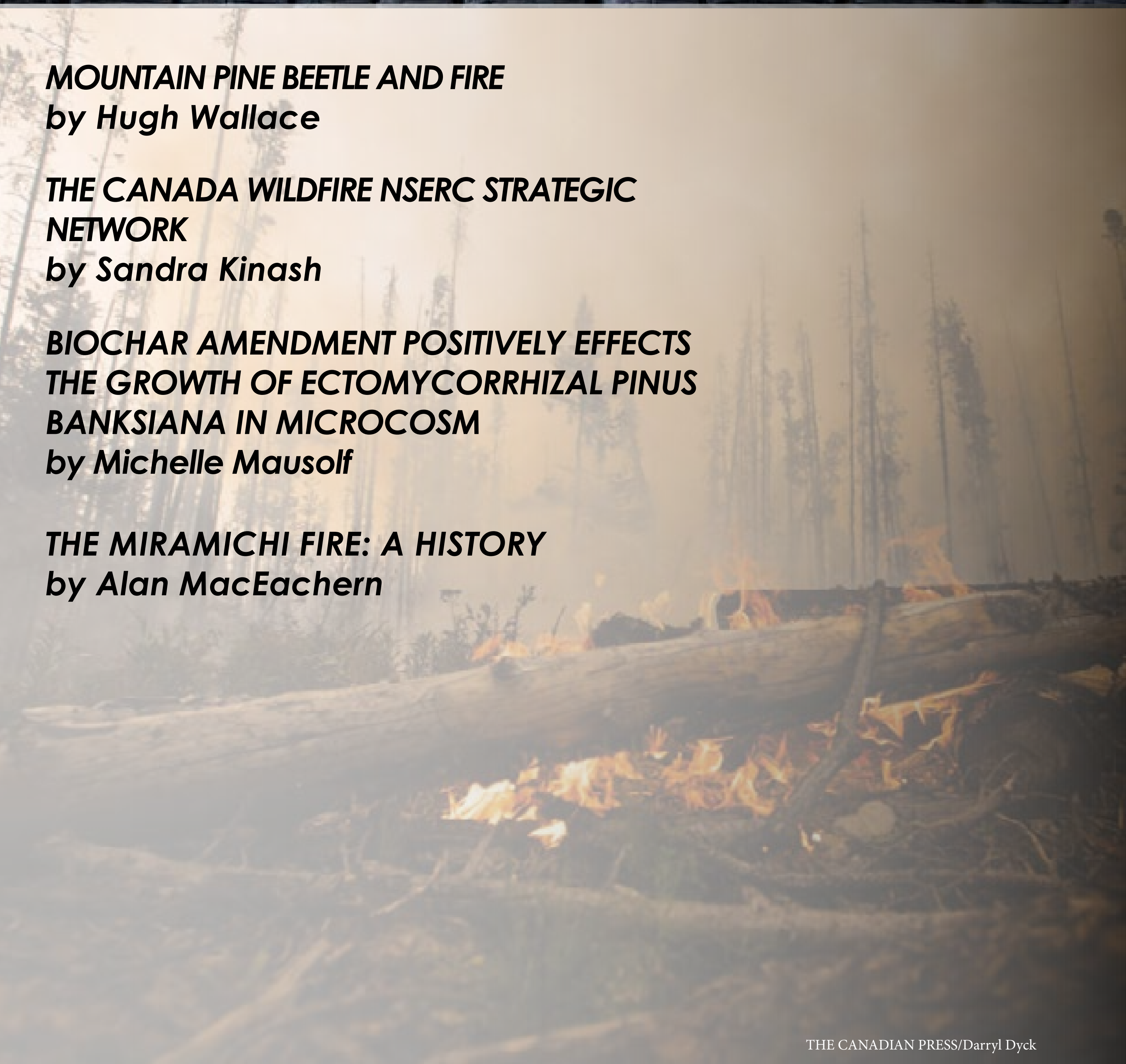


THE CANADIAN PRESS/Darryl Dyck

# Mountain Pine Beetle and Fire

By Hugh Wallace, MSc University of Alberta, currently working with Scion Rural Fire Research in New Zealand, contact info

In recent years British Columbia and Alberta experienced massive mountain pine beetle outbreaks that killed a significant portion of their lodgepole pine forests. These outbreaks were influenced by historical forest management which led to continuous old age stands vulnerable to infestation. In turn these beetle killed forests affect future fire management by altering fuel load, structure, and susceptibility to fire. With regenerating lodgepole pine forests in the west and vulnerable jack pine forests extending across Canada to the east coast, new strategies that balance both fire and beetle management must be considered. One strategy under consideration is progressive strip cut harvesting. This study examined its effects on two factors affecting fire behaviour - fuel load and soil moisture content.

Progressive strip cut harvesting is a novel harvesting treatment that leaves a significant portion of trees uncut at each harvest and results in a mixed age, mixed density stand rather than total conversion to new stand type. The initial pass of the progressive strip cut harvesting treatment alternates narrow parallel harvested strips with wide unharvested strips. Subsequent harvest strips are cut adjacent to the previously harvested strips over set time periods, with the final harvest strip being cut as the first cut strip reaches its rotation interval and is ready for re-harvesting. Since the research site had previously experienced mountain pine beetle attack remaining trees were selectively thinned, targeting visibly infested or vulnerable trees to remove sources for further infestation. These harvesting methods allow consistent fuel maintenance without significantly changing the forest type and create a less homogenous stand with varied fuel load, structure, and age classes that are believed to better resists both fire and beetle infestation. This study examined how the first harvest cut affected the stand, evaluating the cleared harvest areas (clear treatment) and the thinned retention strips (thin treatment) in comparison to an unmodified control treatment.

**Overview of Methodology**

To assess the impact of harvesting on fire susceptibility and behaviour, fuel load and soil moisture content was measured at the harvest sites in the Saddle Hills County of Alberta throughout the 2015 and 2016 fire seasons. Stands were treated with alternating parallel clear cut five-meter-wide machine corridors and fifteen-meter-wide thinned retention strips as described above, with research sites established in each treatment type, as well as control stands (Figure 1, Figure 2).

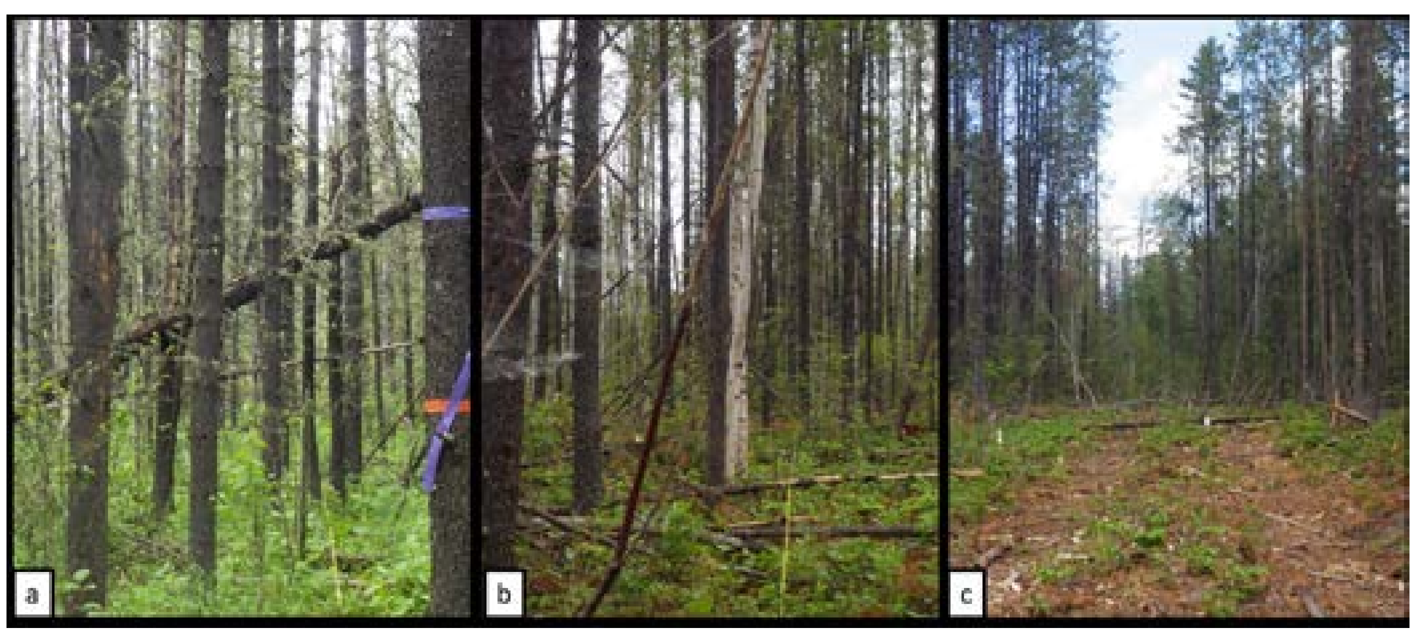



Figure 1. Control (a), Thin (b), and Clear (c) treatments demonstrating effect of harvesting on fuel load and spacing.



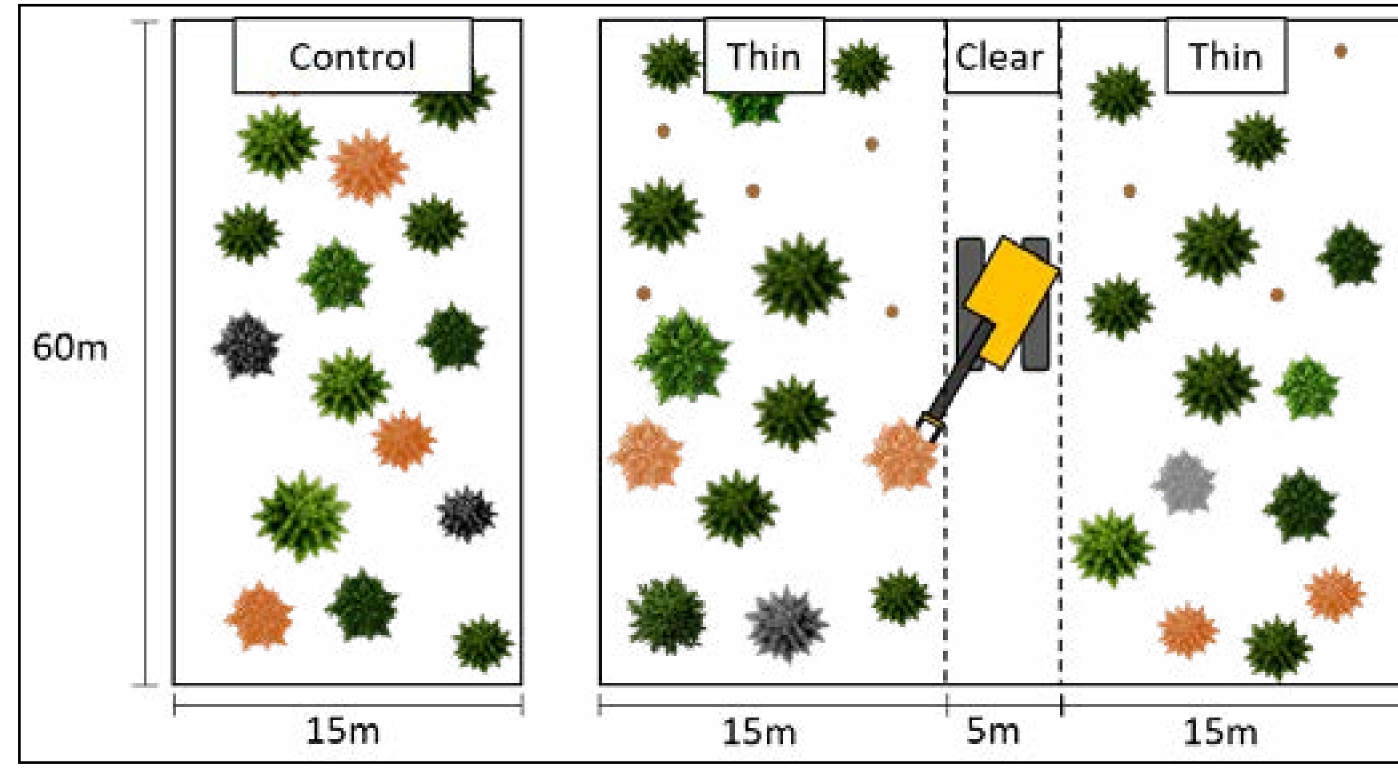


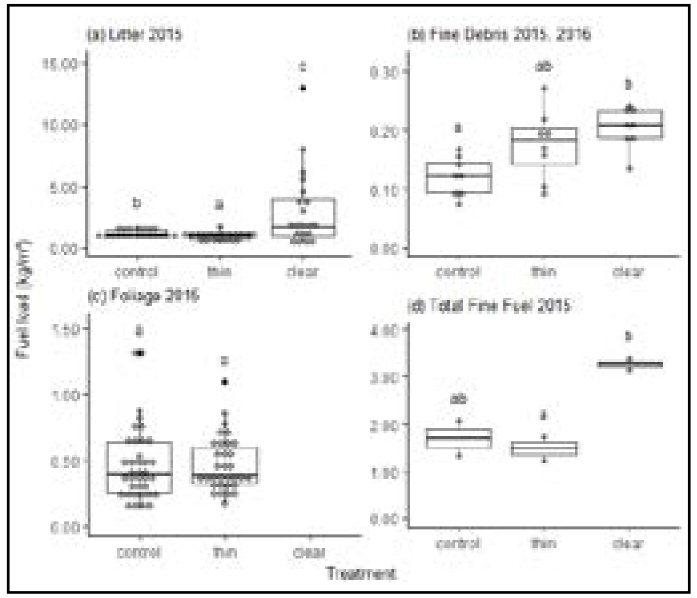

Figure 2. Control, Thin, and Clear fuel treatments. Control sites were unaltered, leaving grey and red stage standing trees, while thin treatments removed attacked, dead, or vulnerable trees. Clear treatments were harvested entirely.

Fuel load sampling followed the Alberta Wildlands Fuels Inventory Program methodology and was supported by Alberta Wildfire Fuel Inventory crews (Government of Alberta, 2016). Resulting fuel load data included litter, duff, all size classes of woody debris, and standing tree fuel load.

Soil moisture sampling was performed on 21 days throughout the 2016 research period for litter and duff, following a modified version of Lawson and Dalrymple's (1996) ground truthing system. Samples were taken between 1 and 5 pm using tubular soil coring tools from randomized sample points, separated into litter and duff layers corresponding closely to the fine fuel moisture code (FFMC) and duff moisture code (DMC) layers, sealed, and weighed. Once returned to Edmonton the samples were transferred to tins and dried 24 hours at 100°C. After the drying cycle was complete samples were removed in small batches and weighed to obtain dry weight.

**Results**

Litter, fine woody debris, and foliage fuel load were assessed independently before being amalgamated for a total fine fuel load for each treatment. Fine fuel load of all types was highest in the cleared treatment (Litter fuel load, Figure 3a: p=0.003, clear 3.059 ± 0.180 kg m$^{-2}$, control 1.180 ± 0.368 kg m$^{-2}$, thin 0.887 ± 0.351 kg m$^{-2}$; Fine woody debris class 1 and 2, Figure 3b: p=0.003, clear 0.204 ± 0.036 kg m$^{-2}$, control 0.120 ± 0.033 kg m$^{-2}$, thinned 0.175 ± 0.060 kg m$^{-2}$) except for foliage fuel load owing to complete standing tree removal (Figure 3c: control 0.406 ± 0.192 kg m$^{-2}$, thin 0.461 ± 0.075 kg m$^{-2}$), which followed our hypothesis that harvesting treatment would unavoidably lead to increased fine fuel loading in each fine fuel group. Interestingly, harvesting did not significantly increase fine debris fuel loading in the thinned treatment despite mechanical thinning taking place. Total fine fuel load was significantly affected by treatment (Figure 3d, p=0.032, clear 3.268 ± 0.169 kg m$^{-2}$, control 1.698 ± 0.517 kg m$^{-2}$, thin 1.488 ± 0.365 kg m$^{-2}$) with the thin and clear treatments being significantly different. Interestingly, neither harvest treatment was significantly different from the control which ran counter to our hypothesis that fine fuel loading would increase with level of harvesting disturbance.



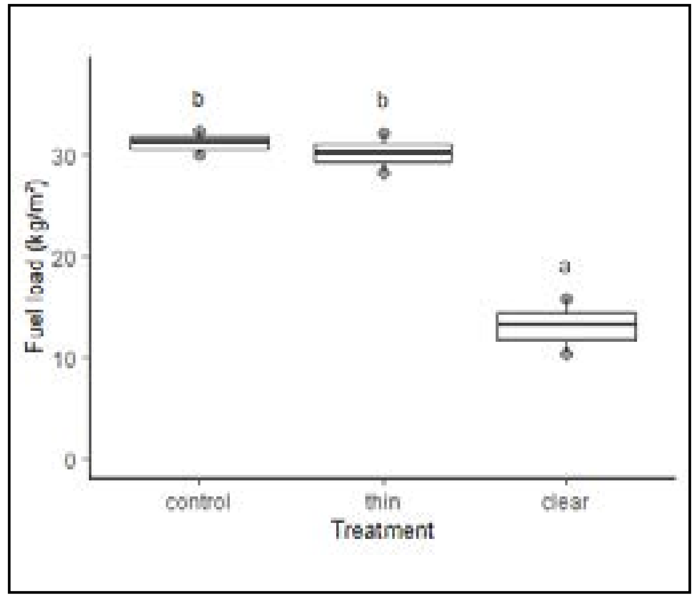




Figure 3. (LEFT) Fine fuel load representing fuels available during flame front passage: organic surface layer fuel load 2015 (a), fine woody debris size classes 1 and 2 (0-1.0 cm diameter) 2015 and 2016 (b), standing tree foliage 2015 (c), and total site fine fuel load 2015 (d) composed of combined site litter, fine woody debris size classes 1 and 2, and foliage from the 2015 sampling period. Fine woody debris was sampled for 2015 and 2016, with no significant effect of year on fuel load, and only data from 2015 was used to create total fine fuel load for 2015. Grey dots represent individual samples. Note that y-axis scales vary between graphs. Figure 4.(RIGHT) Total site fuel load 2015. Total site fuel load includes organic soils, dead and down woody debris size classes 1-6, and standing tree fuels. Grey dots represent individual samples.

Total site fuel load was significantly affected by treatment (p=0.013, Figure 4).The clear treatment had significantly lower fuel load (13.073 ± 3.826 kg $m^{-2}$) than both control (31.097 ± 1.611 kg $m^{-2}$) and thin (30.126 ± 2.672 kg $m^{-2}$) treatments with the latter two not significantly different from each other. Total site fuel load is composed of all measured fuel load sub-categories including litter and duff organic soil layers, woody debris size classes 1-6 (0 to 7.0+ cm), and all standing tree fuel loads composed of stem, bark, branches, and foliage. Dead and down woody debris size classes 1-6, duff fuel load, and standing tree fuel load were not discussed separately as they were not significantly different from each other (clear treatment was not included in standing tree fuel load comparisons as all standing trees were removed by harvesting).

Fine fuel moisture was found to be significantly affected by treatment ($p < 0.001$, Figure 5) , however did not follow our hypothesis that moisture content would decrease as disturbance increased.

While it was expected that the control treatment (182 ± 34%) would have the highest moisture content and that there would be significant differences in moisture contents between each treatment, it was believed that moisture would decrease with increasing degree of disturbance and exposure to weather events. Instead it was found that the thin treatment (111 ± 21%) had the lowest moisture content while the clear treatment (149 ± 28%) held the middle ground, with each treatment being significantly different from the others.

Coarse fuel and duff moisture content results were even more unexpected than fine fuel moisture in that while moisture content was significantly affected by treatment ($p < 0.001$, Figure 6a), the clear treatment (243 ± 35%) was significantly wetter than all other treatments, while the control treatment (213 ± 52%) was significantly wetter again than the thin treatment (189 ± 39%). The DMC conversion (Figure 6a) yielded similar results, though the non-linear conversion to DMC removed the significant different between the control and thin treatments.





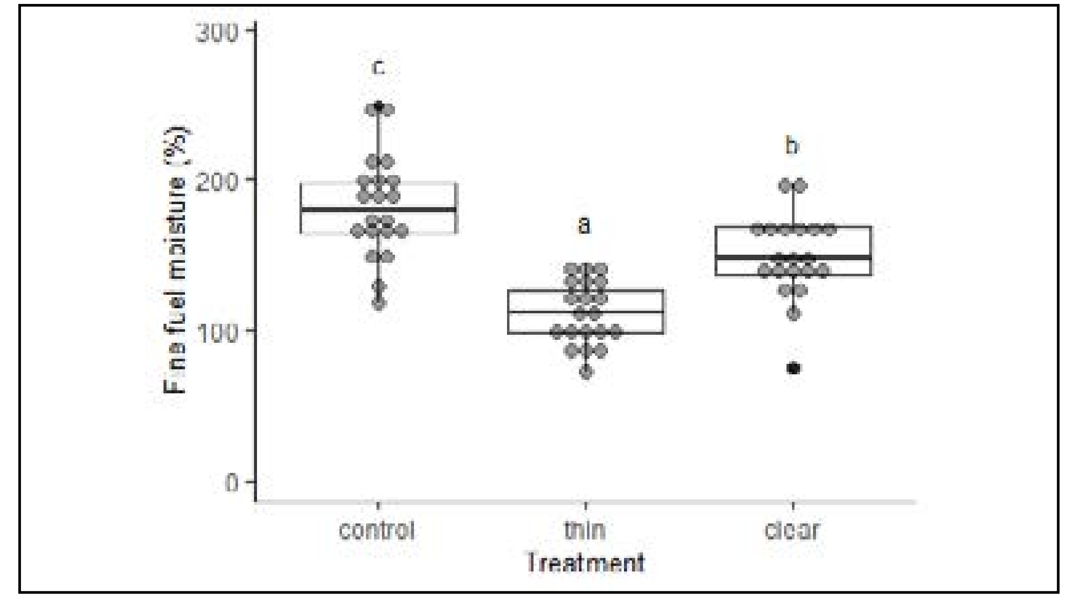



Figure 5. The effect of treatment on fine fuel moisture in 2016. Grey dots represent individual samples.

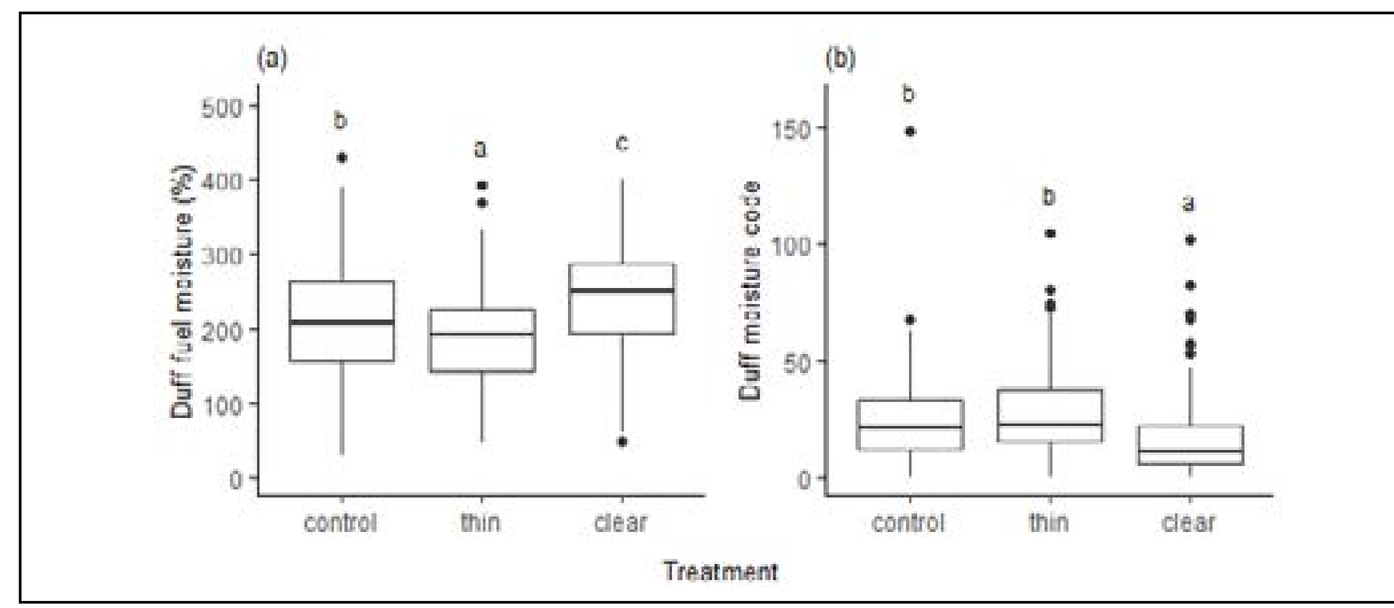



Figure 6. Duff fuel moisture (a) and duff moisture code (b) 2016, blocked by day. Individual samples not shown due to their large number.

**Discussion**

At the outset of this research it was hypothesized that as level of harvest increased fine fuel load would increase and fuel moisture content would decrease. Instead, it was found that harvesting could successfully be performed with minimal effect on fine fuel load, and that harvesting leads to changes in fuel moisture that cannot be accounted for using Fire Weather Index System weather inputs alone.

Total fine fuel load was affected by treatment, but only between the thin and clear treatments. This is most likely a feature of the harvesting method that deliberately aimed to remove targeted trees from the thin treatments with minimal disturbance. As handling will unavoidably result in at least some fuel loading and the clear treatments were not only harvested but also used as equipment corridors to remove cut trees from the adjacent thin treatments, it is a logical conclusion that fine fuel loading would be highest in the clear treatments. It had been supposed that the thin treatments would also experience an increase of fine fuel loading due to harvesting, however it appears that the directive for operators to minimize disturbance was more successful than anticipated. This is further supported by the fact that fine fuel loading in the clear treatments were lower than those fuel loads found in other studies of fuel load in similar harvested sites.

Total fuel loading was significantly reduced in the clear treatment, which was due to the removal of standing trees from the clear treatment. While large diameter standing fuels do not significantly contribute to flame front passage, they remain a significant portion of total fuel load and may affect potential fire behaviour and support considerable smouldering combustion if they reach the fuel bed, as often occurs over the years following pine beetle infestation. Within total fuel load it was also observed that harvesting treatments did not result in significant changes to dead and down fuels. This suggests that the harvesting techniques employed in the research, namely focussing on minimizing disturbance and slash loading was effective. As harvesting may lead to dead and down debris loading up to 2 m deep, the lack of significant difference between the control and machine harvested treatments is a notable result (Van Wagner et al., 1992).

Perhaps one of the most significant findings of this work was that fine and coarse fuel moisture content did not decrease in direct relation to level of disturbance as was initially supposed. In this case, the thin treatment was consistently the driest for both the fine and coarse fuel moisture measurements, while the control had the wettest fine fuels and the clear treatment had the wettest coarse fuels. This is surprising because the presence of trees in the thin treatment was expected to moderate soil moisture levels by providing shade and reducing wind, leading to reduced evaporation. Instead, it appears that a more complex process played a part in wetting and drying. One possible driver of increased fuel moisture in the cleared treatments is overnight radiative cooling leading to increased relative humidity offsetting drying in all but the finest (<0.635 cm) fuels (van der Kamp, 2017). Additionally, lower soil moisture levels in the thin treatment could be explained by increased transpiration due to vapour pressure deficit, drawing up to 3 times normal in-stand moisture from the duff and potentially even drying surface layers from below (Bladon et al., 2006; Pook and Gill, 1993; Whitehead et al., 2008; Wotton and Beverly, 2007). Under normal circumstances thinning which would cause increased transpiration would remove enough trees to offset the increased moisture uptake, however since the majority of tree removal occurred adjacent to the thinned sites it is suspected that thin treatments experienced increased moisture uptake without the usual overall reduction in trees drawing moisture.

**Conclusion**

This study found that progressive strip cut harvesting did not significantly increase fine fuel loading or total fuel load, suggesting the treatment should not lead to increased fire behaviour based on additional fuel loading as most harvested fuel types would. It also demonstrates that careful mechanical harvesting can be used to effectively modify fuels without increasing total ground fuel load, a finding that could increase efficiency and treated area for fuels management.

Surface soil layers and fine fuel moisture content was significantly lower in the treated stands compared with the unharvested control stand, which suggests that the treated stands would have a higher proportion of fine and fuels available for combustion. Coarse fuels by contrast varied more widely, with the clear treatment being significantly wetter than the control and the thin treatment being significantly drier. This divergent trend leads to some distinct challenges in predicting fire behaviour as it moves between the treatments.

While treatments clearly affect both fuel load and fuel moisture, the factors driving fuel moisture changes merit further research. Additionally, research is required to examine the interaction between progressive strip cut harvesting altered fuel loading, structure, and moisture content in relation to likelihood of ignition, intensity, and rate of spread.

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Full thesis available here

# Welcome Sandra to the Canada Wildfire Team!

We welcome Sandra Kinash as the new knowledge translation and mobilization specialist for Canada Wildfire. Sandra joined Canada Wildfire on July 16, 2020 and brings a wealth of experience in strategic communications with the University of Alberta. She most recently worked at the UofA Research Services Office where she helped researchers by launching a more usable website and establishing a funding opportunities database. Previously, she worked in pediatrics, surgery, and Community-University Partnership. She enjoys working with working with scientists, learning about their research, and effectively communicating their findings.

Sandra will help promote and aid knowledge exchange at Canada Wildfire. She is looking forward to working with agencies and researchers to help facilitate knowledge translation. Since joining, she is impressed and fascinated with all the impactful wildland fire science research happening and the level of collaboration.

Sandra is proud to call Edmonton home and enjoys exploring the river valley and dog parks with her pug, Fifi. She enjoys nature, music, camping, and traveling. This past summer, she and her family explored Kananaskis Country, checking out Wedge Pond and Barrier Lake for the first time.

# The Canada Wildfire NSERC Strategic Network: Preparing Canadians for Changing Wildfires

By Sandra Kinash
Knowledge Translation & Mobilization Specialist, Canada Wildfire, skinash@ualberta.ca

Pelican Mountain Experimental burn of a black spruce peatland showing the resistance of Sphagnum moss (orange colour) to ignition. Photo: Sophie Wilkinson.

Wildfire seasons are beginning earlier and lasting longer. Fires have become larger, more frequent, and more intense over recent decades resulting in impacts to wildlife, forest resources, and Canadian communities while also releasing more carbon into the atmosphere and contributing to climate change.

Climate change is increasing temperatures and Canadians will continue to face mounting pressures from wildland fire, like air quality reduction, more frequent evacuations, and economic loss including the destruction of houses and infrastructure. Adding to the challenges, investment in wildland fire science research was declined prior to 2019 with few education options, resulting in fewer trained fire experts. Administered through Canada Wildfire, the Natural Science and Engineering Research Council of Canada (NSERC) Canada Wildfire Strategic Network (the Network) is a promising step toward strengthening wildland fire research and a new generation of fire experts.

**What solutions can help Canadians better prepare for changing wildfires?**

The Network aims to discover new solutions to better equip Canada to respond to future wildfires. This Network of post-secondary researchers across Canada will respond to fire in a changing world by assessing risk and danger and honing solutions to better predict when and where fires might occur and how they might behave. It will also focus on ecosystem impacts, looking at how they interact with and are impacted by fires. Through focused research, the Network will improve the prevention, detection, and reduction of damaging wildfires while reducing evacuations and enhancing recovery from wildfires.

**The Federal Government Invests in the Network**

Funding for the Network is part of a federal government investment in the Emergency Management Strategy to help Canadians become more resilient to a range of risks including floods, earthquakes, and wildland fire. NSERC will provide $5 million dollars over a five-year research period to support academic research. The NSERC network and funding was formally announced by Minister O'Regan of Natural Resources Canada on June 24, 2020. Over 70% of the funding will train the next generation of fire scientists, supporting 66 post-graduate students including 35 masters and 19 doctoral students, and 12 postdoctoral researchers.

**Research Priorities Come from the *Blueprint***

From 2018 to 2019, groups of Canadian wildfire science experts met to identify the greatest research needs, coordinated by the Canadian Forest Service. This led to the development of a summary document, *The Blueprint for Wildland Fire Science in Canada (2019–2029)*. This document helped guide two further NSERC sponsored meetings to specifically discuss the scope and priorities for the development of an NSERC research proposal.

The *Blueprint* recommended research organized around six connected themes; the Network will focus on the **bolded** ones:

**1. Understanding fire in a changing world**
2. Recognizing Indigenous knowledge
3. Building resilient communities and infrastructure
**4. Managing ecosystems**
**5. Delivering innovative fire management solutions**
6. Reducing the effects of wildland fire on Canadians

**The Network Teams**

To create needed solutions within the three themes, diverse post-secondary research teams, each with their own specialties, are assembling across Canada. The teams will work collaboratively on seven fire research priorities within the three *Blueprint* themes, and each team has a lead with co-applicants that will receive NSERC funding. In turn, each team has collaborators who are contributing their own resources and come from universities, government fire management agencies, Indigenous groups, and other research organizations across the country. Jointly they will supervise the 66 post-graduate students.

Network Team Leads:
- Dr. Mike Flannigan (University of Alberta), Principal Investigator/Science Director
- Dr. Laura Chasmer (University of Lethbridge)
- Dr. Lori Daniels (University of British Columbia)
- Dr. Patrick James (University of Toronto)
- Dr. David Martell (University of Toronto)
- Dr. Mike Waddington (McMaster University)
- Dr. Douglas Woolford (University of Western Ontario)

**Network Research: Three Themes and Seven Priorities**

Teams will focus on seven research priorities addressing questions drawn from the three themes from the *Blueprint*.

***Theme: Understanding Fire in a Changing World***

*Priority 1: Wildfire Risk*

Canada's need for a comprehensive framework for wildfire risk assessment is documented in the *Blueprint*. Fire spread and damages in recent high-profile fire events remain poorly understood and methods and models are needed to estimate risk at all scales. The Network will develop models that fire agencies can use to assess the risk of wildfire, collaborating with Canadian Forest Service and provincial and federal fire management agencies.

To develop these risk models, the Network needs to better understand the risk of a fire, looking into such factors as human-caused fires and the chance peat will ignite. The team will assess what makes an area vulnerable to large fires, looking at prevention efforts, fire management policy and decisions, and weather forecast uncertainty.

*Priority 2: Wildfire Danger*

The *Blueprint* addresses the urgency to better understand how changes in the Canadian landscape are affecting wildfire. Increased burnable vegetation caused by climate change, pest infestations, and past fire-suppression practices and policies has created a challenge for successful fire management.

To answer the most pressing wildfire danger research needs, the Network needs to better understand flammability and how insect outbreaks change fuel and impact wildfires.

Fire managers need the Canadian Forest Fire Danger Rating System (CFFDRS) to better represent organic fuels (peat soils). The Network will contribute to updates to the CFFDRS by studying the factors that cause flammability. They will develop a model to understand how different organic fuels are connected to each other across the landscape.

The Network will investigate how climate change contributes to insect outbreaks and in turn their impact on wildfires and the forest's health and sustainability. Specifically, they will assess fuel changes through defoliation caused by spruce budworm, jack-pine budworm, and mountain pine beetle.

*Priority 3: Measurement Improvements and Novel Data Sources*

Fire-management faces more complex decision-making as the nature and behavior of fire changes. To support flexible operational and response activities, the *Blueprint* explains that new advancements are needed in the collection of accurate, timely, and accessible data. This includes improvements in earth observation technologies, such as LiDAR, that provide key observations for developing models and decision-support tools.

The Network will develop new ways to use airborne and satellite remote sensing to measure fuels using a number of different technologies. LiDAR, which measures the 3D structure of trees, shrubs, and ground characteristics provides information that is similar to on the ground measurements, but across large areas.

The information that LiDAR provides is often less expensive to collect than field measurements. Because many ecosystems are sampled, these datasets will be used to understand the flammability of the environment, while also being used to compare with freely available satellite imagery, collected everywhere almost every day. The Network will use this new information to support updates to the CFFDRS and the Canadian Wildland Fire Information System, adding to the understanding of how fuel is impacted by climate change effects such as increased insect infestation and uprooted trees across Canada.

***Theme: Managing Ecosystems***

*Priority 4: Fire Effects on Ecological Processes*

The *Blueprint* outlines that more must be learned about the immediate, short-term, and long-term effects of fire on the health and resilience of ecosystems and related ecological processes including vegetation, wildlife, hydrology, carbon stocks, and soils. There are gaps in what is known about the complex interactions among wildland fire, landscapes, people, and climate change.

To measure ecosystem health, the team will generate new methods for using remote sensing of trees and other important parts of the ecosystem after a fire. LiDAR and field data collected across large areas of Canada's north will be used to measure how much vegetation was burned, how much was released into the atmosphere as carbon dioxide, and how these ecosystems will regrow and change after a fire.

These results will link to other satellite images and models, which will give the Network a longer time scale perspective of the health of ecosystems across Canada, including Canada's forests, wetlands, and tundra.

*Priority 5: Past, Present, and Future Fire Regimes*

The *Blueprint* acknowledges that improvements are needed to describe fire regimes and how they interact with other disturbances such as climate change, insect outbreaks, and diseases.

The Network will improve fire descriptions, including their frequency, size, severity, cause, and when they occur. They will provide forecasting tools to researchers, and fire and forest managers allowing them to simulate fires and determine what management, fire, and insects will do to timber supply, forest health, and resilience.

The team will describe how fuels, weather, and surface features of the land contribute to a fire's severity. By looking at how plants recover after a fire, they will investigate how wildfires and logging from burned areas impact the strength of a forest.

The Network will measure how proactive strategies such as prescribed fires and reducing fuels, including thinning of forests and reducing hazardous fires, will contribute to resilience from future fires. The team will work with Indigenous experts to learn their methods and results of using prescribed burns. These observations will be linked to models and remotely sensed data so that we can predict fire behaviour across larger areas.





***Theme: Delivering Innovative Fire Management Systems***

*Priority 6: Fire Improvements to Operational Response*

The *Blueprint* recognizes that fire managers need enhanced tools so they can protect communities by responding more safely, quickly, and more efficiently to the rapidly changing nature of wildland fire. The Network researchers will draw on their analytics and artificial intelligence expertise and collaborate with fire management agencies to develop and test improved decision-making tools and train the next generation of scientists along the way.

Through the detailed mapping of fuel types, the tools will help decision-makers, like duty officers, identify where fires can be left to burn safely and monitored without significant suppression intervention. Integrating fire risk assessments into the tool will inform the development of fire management strategies through an innovative and appropriate response. To better manage resources required to extinguish unwanted fire, the research results will provide guidance on the optimal deployment and use of fire suppression resources, including the sharing of such resources between provinces or countries.

*Priority 7: Improvements to Planning*

Fire managers require effective tools that help optimize scarce resources and enable the most efficient deployment of firefighting assets, as identified in the *Blueprint*. To help improve fire management planning, the Network will determine how decision support systems can be used to support the efficient sharing of Canadian fire management resources. A resource sharing tool will be created based on data from three provincial resource sharing models. The tool will be based on a better understanding of agency needs.

In particular, researchers will study the use of air tankers, a costly but effective resource. The research results will help make better use of tankers by helping fire managers decide where and when to best use them and when they can be shared with other provinces.

**Training the Next Generation of Canadian Wildland Fire Scientists**

In 2016, the updated Canadian Wildland Fire Strategy identified a lack of qualified fire management candidates as a major issue that fire management agencies are already facing. To address this pressure, Network researchers will train 66 postgraduate students. Their training will prepare them to work and conduct research with Canadian forest fire management agencies. These new researchers will contribute to innovative wildfire science and management solutions for the next several decades.

They will study diverse aspects of wildfire science, including fire danger rating, wildfire risk analysis, and landscape and vegetation ecology. They will acquire knowledge in wildfire management planning, logistics, and environmental issues and an understanding of climate change. They will learn how natural systems like forest ecosystems are influenced by fire and will develop skills in remote sensing and computer simulation.

Students will build their networking, leadership, and presentation skills at conferences, workshops, and meetings, including the Network's annual general meeting (AGM). They will build long-term connections with fire managers, fellow students, and colleagues, leading to new collaborative research opportunities. They will contribute to the Network's knowledge exchange through research publications, conferences, and more. Many will have opportunities to sharpen their mentoring skills by supervising graduate and undergraduate students.

Students will receive:

- Internships at government agencies such as Canadian Forest Service and provincial wildfire agencies as well as industry and other research organizations. Students will attend prescribed burns, interact with fire management agency staff, and receive some fire management certification.
- Participation in one of the Wildland Fire Canada Conferences (in either 2021, 2023, or 2025) alongside wildland fire managers, specialists, researchers, and graduate students.
- Attendance at one Network AGM, timed with the Wildland Fire Canada Conference. AGMs will focus on information sharing, project updates, and emerging research opportunities. Students can attend workshops and informal networking events organized for them.
- Exchanges with other Canadian universities
- Lab visits

Proposed courses for students include:

- Principles of Wildland Fire, a multi-day course delivered by Canada Wildfire and Canadian Forest Service.
- Field Course in Wildland Fire, a specialized field course delivered by Canada Wildfire.

- Analytics Training, using statistical software and learning data modeling methods taught by Douglas Woolford, options for either online or in-person workshop.
- The Incident Command System - coordinated through the Canadian Interagency Forest Fire Centre (CIFFC).
- Advanced Remote Sensing - A training course provided through the University of Lethbridge and others.
- Wildfire Science and Interactions between Wildfire and Other Forest Disturbances - a summer school program taught through the University of Toronto.

**Strengthening Relationships with Fire Agencies and Reporting Research Results**

In partnership with Canada Wildfire, the Network will communicate its new wildland fire knowledge, led by their knowledge translation and mobilization specialist. A strategic knowledge exchange plan will create numerous ways to communicate Network results.

One key way to exchange knowledge is through "The Hub", a central virtual resource. The Hub will provide a place where fire practitioners and managers can connect with Network researchers. This will help practitioners and researchers understand each other and how the new knowledge will effectively be applied in the field. It will enable managers to adopt policy and operating changes and move wildfire management forward.Once created, the strategic exchange knowledge plan will share Network results through numerous tools including websites, social media, meetings, and more.

**The Network's Management**

The Network is led in partnership with Canada Wildfire with leadership from a board of directors and guided by a scientific advisory committee.

**Network Board of Directors**

The Network board is responsible for the management, direction, and financial accountability. They review scientific progress and financial reports and make budget recommendations to NSERC. The Network board includes members of Canada Wildfire's executive committee.

Voting board members include:

- Chair of the Canada Wildfire Executive Committee (or designate) will also serve as chair of this board.
- All other members of the Executive Committee for Canada Wildfire who are as of June 2020:
    - The Canadian Forest Service.
    - The University of Alberta.
    - Alberta Agriculture and Forestry.
- BC Wildfire Service.
- Canada Wildfire science director.
- Forest Products Association of Canada
- Gwitch'in Council International
- University of Alaska

The remainder of the voting board members will come from other wildland fire agencies, Indigenous organizations, emergency response communities, insurance companies, forest industries, and fire organizations. Non-voting board members include the managing director of Canada Wildfire (who serves as secretary), the NSERC representative, and others designated by the board. The board will meet at least twice per year.

**Scientific Advisory Committee**

The Scientific Advisory Committee will assist in evaluating the Network's scientific progress, adjusting goals, priorities, and milestones as needed. As science director, Mike Flannigan will chair the committee. The committee will prepare an annual report for the Network's board of directors.Committee members are the Network's lead researchers, representatives from CIFFC's Fire Science Committee, and other members from academia, industry, government, and non-governmental organizations.

The committee meets quarterly.



THE CANADIAN WILDFIRE STRATEGIC NETWORK

**Managing Director**

The Network has a managing director, Brian Wiens, who oversees the administration of both the Network and Canada Wildfire. Weins manages the Network's finances, including distributed funds and reporting. He works closely with lead researchers to monitor progress, set work plans, manage resources, and spending. Wiens will create administrative and archive policies, ensuring confidential data is securely stored. He supervises Sandra Kinash, the knowledge translation & mobilization specialist, and is involved in the exchange and communication of research results. As well, he coordinates the annual general meeting, board of directors, and science advisory committee meetings.

**Network Outcomes**

Through the Network's efforts, they aim to contribute to:

- Better fire management strategies
- Informed forest management policy and practices
- An educated public
- A strong, integrated research community
- Enhanced research capacity in face of scarce resources
- Sharing and use of their knowledge
- Collaborative approaches to shared national priorities

We hope that the Network will be a foundation and a catalyst for future and expanded fire research efforts in Canada.
For Network updates, go to www.canadawildfire.org/nsercnetwork

# Biochar amendment positively effects the growth of ectomycorrhizal *Pinus banksiana* in microcosm

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Figure 1. Biochar preparation

Ectomycorrhizal (ECM) soil fungi typically form symbioses with woody plants (Smith and Read, 2008). Many tree families (*Pinaceae, Betulaceae, Salicaceae*) form mutualistic symbioses with a diverse array of fungi that obtain and transfer nutrients from mineral and organic sources to their plant hosts in exchange for photosynthetically derived carbohydrates (Smith and Read, 2008). Wildfire is an essential process in forested ecosystems that contributes to reproduction of serotinous tree species, removal of organic litter accumulation, and soil nutrient cycling. Wildfire also leads to the deposition of charcoal into soil in differing amounts depending on landscape and climatic conditions at the time of the fire. Following low intensity fires where part of the organic layer remains unburnt and some trees survive, ECM fungi may have a role in improving plant health and survival in recovering forests (Jonsson et al., 1999). However, mycorrhizal fungi colonize organic and upper mineral soil horizons and are therefore sensitive to deep soil heating that results from burning thick organic material accumulations (Borchers and Perry, 1990). In addition to the lethal direct effects of soil heating, fire indirectly affects the persistence of mycorrhizal fungi by removal of their symbiotic host plants which tends to decrease mycorrhizal survival (Amaranthus and Perry, 1987, Allen, 1991). Work in northeastern Alberta has shown that Jack pine form symbioses with at least 56 species of mycorrhizal fungi (Danielson, 1984, Danielson and Visser, 1989). Several ectomycorrhizal fungal families, including Suillus, are specific to pines and do not form mycorrhizae with other conifers (Bruns et al., 2002). Suillus inoculation has been shown to enhance pine seedling survival under harsh, competitive conditions like those created after fire (Lonergan et al., 2014).

The objective of this study was to investigate how differing quantities of charcoal affect the formation of ectomycorrhizal symbioses and growth of ectomycorrhizal pine. To meet this objective ectomycorrhizal *Suillus tomentosus*–jack pine seedlings were grown in microcosms with three levels of biochar amendment, reflective of a high severity and low severity burn given published values. Pine seedling radicle length and fungal mycelial area were measured to capture the impact of biochar amendment on growth. Ectomycorrhizal symbiosis was confirmed by microscopic visualization of 'Hartig Net' structures in stained root tip cross-sections. By working in microcosms, I isolated the pine-fungal ectomycorrhizal symbiosis from other soil microbes and fungal grazers.

**Experimental Design Overview**

Microcosms were constructed to test the effect of biochar on growth of ectomycorrhizal symbiotic partners *Pinus banksiana* and *Suillus tomentosus* in a factorial study with three levels of biochar amendment. The effect of biochar application was assessed on fungal mycelial area and pine radicle length. Ectomycorrhizal symbiosis was confirmed via the presence of a 'Hartig Net' on the pine radicle tip by cross-sectional tissue sampling and staining for confocal microscopy. Non-mycorrhizal microcosms containing only *S. tomentosus* or *P. banksiana*, and mycorrhizal microcosms containing both species were constructed at three biochar amendment levels; no biochar, low biochar, and high biochar (Figure 2). Forty of each non-mycorrhizal and mycorrhizal microcosm were constructed at each biochar treatment level (360 total microcosms). The microcosm methodology used in this study was adapted from Jones et al., 2013.

Biochar was prepared from Jack Pine (*P. banksiana*) and Scots Pine (*Pinus sylvestris L.*), branches and needles collected from the North Saskatchewan River valley near Fort Saskatchewan, Alberta. Chopped pine material (100g) was wrapped in foil, placed in a foil dish, and embedded in sand to create an anaerobic environment. The dish was placed in a cold muffle furnace ramped over 30 mins to 500°C, then held for 2 hours.

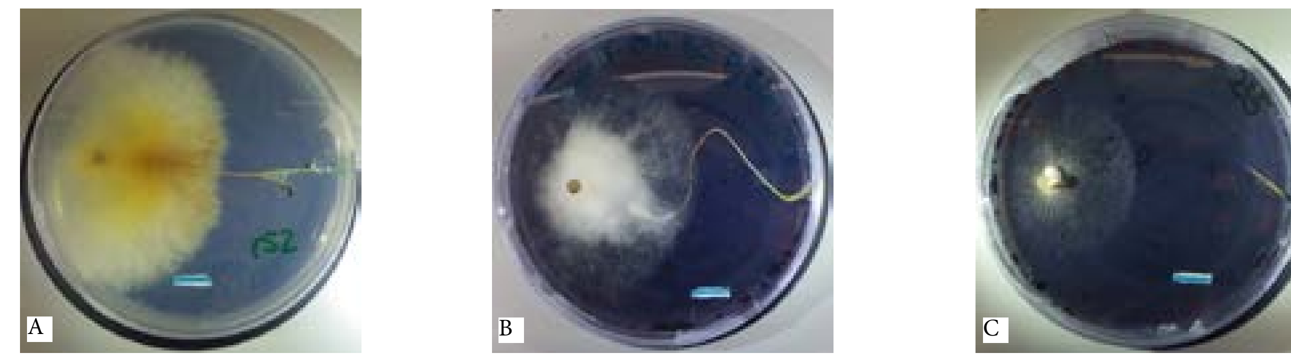


Figure 2. Microcosms containing *Suillus tomentosus* and *Pinus banksiana*. Photographs show three biochar amendment levels; no biochar (A), low biochar (B), and high biochar (C). Microcosms pictured are at day 35.

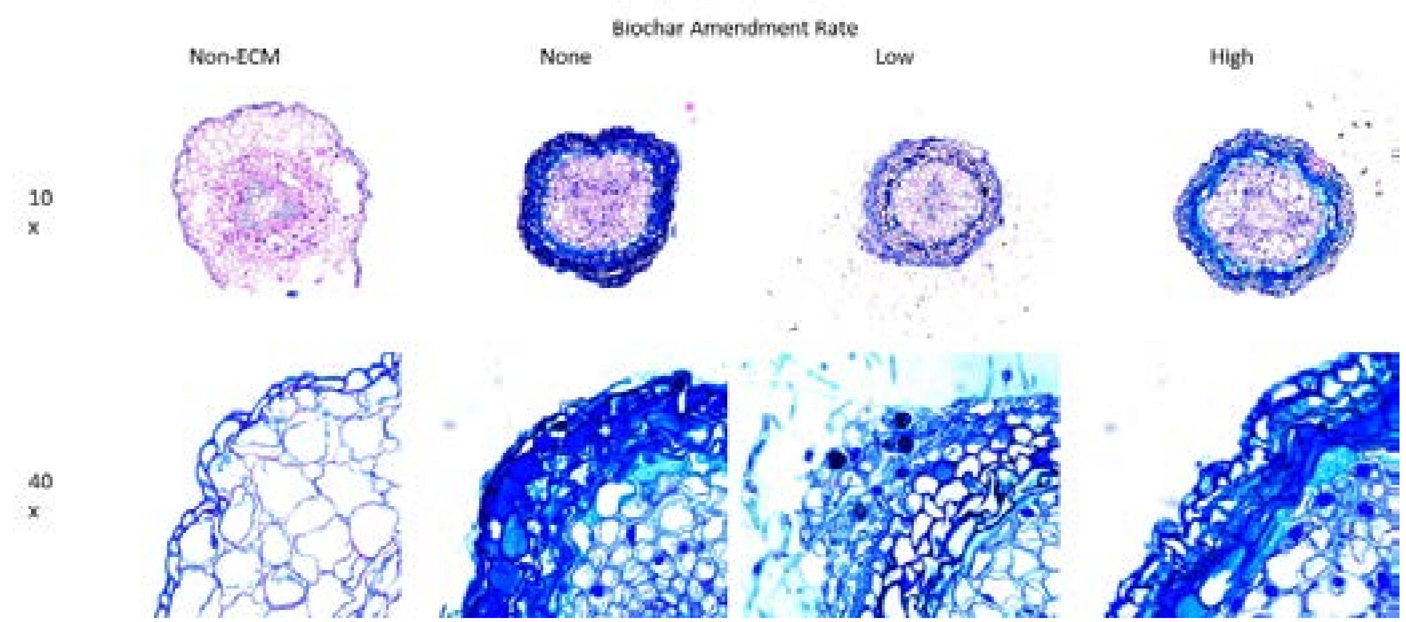


Figure 3. *Pinus banksiana* root tip cross sections. Cross sections of root tips show structures indicative of ectomycorrhizal symbiosis with *S. tomentosus*; a non-ectomycorrhizal (non-ECM) is included for comparison. 8 µm sections were embedded in wax and stained with toluidine blue; both fungal and plant root cells appear blue.

**Results**

Biochar had a significant positive effect on ectomycorrhizal pine radicle length, and radicles amended with biochar reached peak length faster than those without biochar. Ectomycorrhizal radicles in low biochar reached a peak mean length of 6.26 ± 0.14 cm at day 42, while radicles in microcosms without biochar had a mean peak length of 5.02 ± 0.13 cm by day 49 (Figure 4. A, B). Radicles amended with high biochar reached peak mean length, 6.00 ± 0.16 cm, at day 42 consistent with radicles amended with low biochar application, however growth was not increased with the higher level of biochar.

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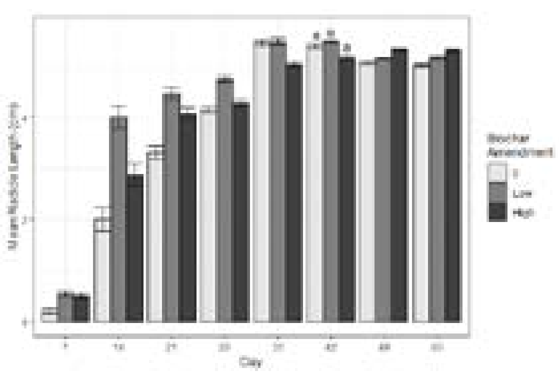
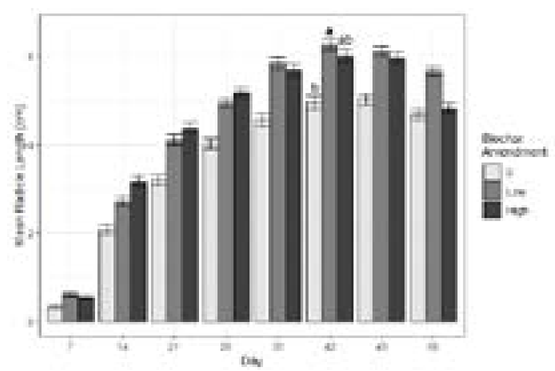
Biochar had a significant negative effect on *S.tomentosus* mycelial area in microcosms without pine (non-ectomycorrhizal *S. tomentosus*). Unlike ectomycorrhizal *S. tomentosus*, both low and high biochar decreased fungal growth compared to non-ECM fungus without biochar. The lowest fungal area was observed with low biochar, which reached a peak mycelial area of 10.2 ± 1.36 $cm^2$ compared to 32.3 ± 1.12 $cm^2$ peak mean area in microcosms without biochar (Figure 5. A, B).

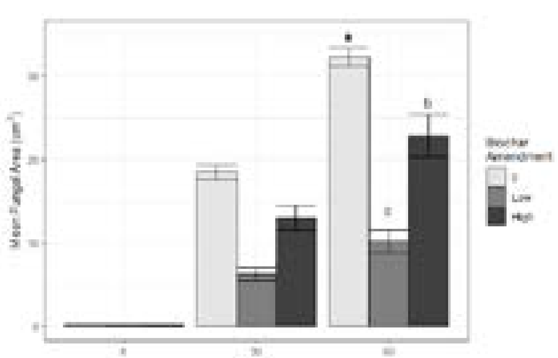


4.A

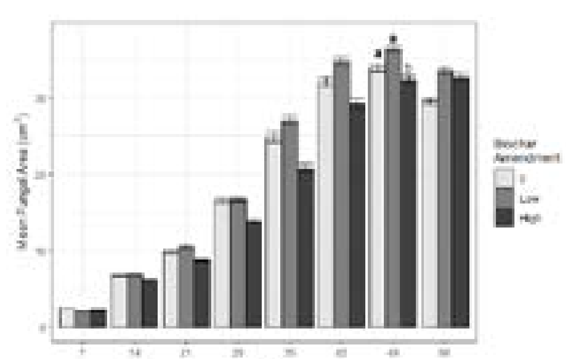


4.B

Figure 4. The effect of biochar amendment on Pinus banksiana radicle length. Biochar had no effect on the growth of non-mycorrhizal pine radicles (Figure 4.A). Low biochar amendment has a significant positive effect on mycorrhizal pine radicle length (Figure 4.B).



5.A



5.B

Figure 5. The effect of biochar amendment on Suillus tomentosus mycelial area. Biochar amendment had a negative effect on non-mycorrhizal S. tomentosus mycelial growth (Figure 5.A). Mycelial area was analyzed by Kruskal-Wallis test of ranks after 60 days in microcosm. Biochar amendment had a positive effect on mycorrihazl S. tomentosus mycelial area at day 49 (Figure 5.B).





**Discussion and Conclusion**

Ectomycorrhizal symbiosis with *P. banksiana* allowed *S. tomentosus* to overcome the negative effect of biochar on mycelial growth. When ECM mycelial growth was considered over the length of the study (60 days), it became clear that S. tomentosus in the absence of biochar and with low biochar amendment gains area until peaking at day 49, while S. tomentosus with high biochar amendment gains area steadily until day 60. By day 60, S. tomentosus in the absence of biochar and with low biochar amendment had lost area, suggesting that microcosm water and nutrients had been exhausted by the growing ectomycorrhizal pine after day 49. I observed that between day 49 and 60, ectomycorrhizal *S. tomentosus* retained more area with low biochar amendment than in the absence of biochar. This observation may be attributed to increased effectiveness of ectomycorrhizal symbiosis with low biochar application, or to increased water holding capacity in microcosm gel with biochar amendment. Especially with low biochar application, the particularly negative effect of biochar on growth in non-ectomycorrhizal *S. tomentosus* is overcome by symbiosis with *P. banksiana*.

It is possible that microcosms with biochar amendment more closely simulate natural conditions compared to growth media alone, and slow ECM growth to a rate more similar to that without a symbiotic host plant. The negative effect of biochar application on non-ECM *S. tomentosus* could be explained by the observation that ECM fungi in general have lower survival without a host (Amaranthus and Perry, 1987, Allen, 1991). However, the stronger negative effect of low biochar amendment compared to high biochar amendment cannot be accounted for through this observation. The negative effect of biochar amendment on non-mycorrhizal fungal growth observed in this microcosm study presents an opportunity for further investigation with *S. tomentosus* and other ECM fungal species to better understand the mechanisms of PyC on growth, as well as the effect of biochar surface area on mycelial growth.

This study of early establishment of ectomycorrhizal symbiosis showed that biochar can enhance early growth of symbiotic partners *P. banksiana* and *S. tomentosus*. Ectomycorrhizal symbiosis was able to overcome the negative effect of low level biochar amendment on fungal growth. The different responses of mycorrhizal and non-mycorrhizal mycelial growth to biochar amendment suggest that ectomycorrhizal symbiosis improves the survival of both symbiotic partners, not limited to the plant host, and reinforces the important role that soil fungi play in forest recovery from wildfire.

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Full thesis available here

# The Miramichi Fire: A History

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R. Thresher, View of Beaubear's Island, Miramichi - The Commercial Establishment of John and Alexander Fraser and Co., c. 1825. Oil painting in Heritage Branch, New Brunswick, GH 996.9.1.

On Oct. 7, 1825, a massive wildland fire swept across Maine and New Brunswick. It would later be estimated that 1300 square miles (3400 square kilometres) burned in Maine, making this what is still the most extensive fire in the state's history. But the greater destruction was in New Brunswick. There, communities along the Miramichi River were wiped out, with an estimated 160 killed and thousands left homeless. Early reports estimated the fire's range in New Brunswick as 6000 square miles (15,500 square kilometres) – a full one-fifth of the colony – and virtually every account over the following generation confirmed that figure.

What became known as the Miramichi Fire generated not only substantial press but also a substantial relief effort across the Western world. Small wonder. It was, at the time, the largest fire ever recorded. It was also the first forest fire to make European settlers consider that the bounty of North America might not be inexhaustible, that people could inadvertently lay it all to waste. The Miramichi Fire is still the largest wildfire to have occurred within the British Empire, and the largest ever recorded along the Eastern Seaboard. When fire scientists or forest historians compile lists of historic wildland fires, the 1825 Miramichi Fire is almost always the first one cited.

And yet the fire, one of Canada's most famous natural disasters in the nineteenth century, all but disappeared in the twentieth and the twenty-first. A 1906 article by New Brunswick historical geographer W.F. Ganong has for all that time been the longest sustained historical analysis of the disaster, at nine pages.



This summer, I published The Miramichi Fire: A History (available through Chapters, Amazon, or the publisher, McGill-Queen's). The book explores the factors that shaped the fire's scale of destruction: everything from the 1815 Tambora eruption – which had led to a cool, wet period prior to 1825, with fewer fires and an accumulation of vegetation – to recent British immigrants' unfamiliarity with forest fires. It explores the fire itself, determining that it was part of a complex that burned that fall throughout all of northeastern North America – including around Montreal where, remarkably, the fires of 1825 would be remembered for decades as "l'incendie de Miramichi." And it explores the fire's aftereffects – not just the loss of life and the economic, social, and demographic changes it brought to New Brunswick, but also the environmental effects it had on forests, waterways, and fish and wildlife, rippling throughout the rest of the nineteenth century.

The Miramichi Fire relies heavily for its existence on the proliferation of online historical databases, which allowed me to uncover a great deal of textual information that had been unavailable to earlier researchers. But it also relies heavily on fire and forestry science literatures, both contemporary and historical. And that is why I want to bring the book to the attention of fire researchers and managers associated with the Canadian Partnership for Wildland Fire Science. I argue that the Miramichi Fire "disappeared" because of late nineteenth and early twentieth century popular and scientific understanding as to fire's effects on forests. The persistence of the damage it caused in some places convinced many people that fire resulted in longterm or even permanent damage everywhere it touched. But the forests of the Miramichi region were healthy, ecologically diverse, and resilient, and so in most cases they grew back fully, although often with a new species composition. On this basis, commentators decided that the early accounts had been greatly exaggerated as to the fire's scale and ferocity. Essentially, they used nature against itself: using its restorative power to discredit its destructive power.

For more information check out a recent CBC article at:
https://www.cbc.ca/news/canada/new-brunswick/nb-author-great-miramichi-fire-remember-1.5751761


From James DeMille, Fire in the Woods (Boston: Lee and Shepard, 1871), 245.

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Canada Wildfire
EDITORS: Mike Flannigan and Renée Beaulac
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