CLIMATE CHANGE AND FIRE MANAGEMENT RESEARCH STRATEGY

February 2009

Victoria, British Columbia

A synthesis of the research forum in Victoria, BC, February 17-19, 2009 that identified research and communication needs related to the impacts of climate change on forest and wildland fire management.

BC Ministry of Forests and Range Wildfire Management Branch. 2009. Climate Change and Fire Management Research Strategy. Report and session notes posted at http://bcwildfire.ca/Weather/Climate/index.htm. For further information, email Forests.ProtectionBranchOffice@gov.bc.ca.

Climate Change and Fire Management Research Strategy

February 17-19, 2009, Victoria, BC

EXECUTIVE SUMMARY

Fire is a natural and essential ecological process in most of Canada's forests. Balancing the potential benefits and risks of wildland fire is a complex task, one that will become more challenging as a result of climate change and increased development.

In February 2009, the Future Forest Ecosystems Scientific Council of British Columbia, Parks Canada and the BC Ministry of Forests and Range Wildfire Management Branch sponsored a three-day Climate Change and Fire Management Research Strategy Forum in Victoria, BC, to identify knowledge gaps related to wildfire management and climate change, and to recommend priorities for research.

The forum, developed by an interdisciplinary planning committee, allowed researchers and fire operations managers to work together to recommend research priorities that can help strengthen land and fire management in light of climate change. Participants were asked to focus on research priorities or projects with results that could be put into immediate use, which meant activities had to be operational rather than theoretical.

The 70 people involved represented many disciplines – some with international expertise – and they worked in teams to propose research priorities, which the planning committee later incorporated into three broad themes:

- Adapting Wildland Fire Management
- Balancing Management Options
- Putting Science into Practice for Community Resilience

At the forum, participants looked at each issue being addressed, the kind of research required, the expected outcome and the general timeframe. Time was spent identifying which projects would most likely achieve widespread results.

Forum participants were asked to list potential organizations that might have a role to play in executing the research – providing support or resources, or participating – and those most likely to benefit from the research initiative or make changes as a result. In addition, they identified any additional gaps or research for consideration.

ACKNOWLEDGEMENTS

The forum organizing committee wishes to acknowledge the support of the Future Forest Ecosystems Scientific Council of British Columbia, Parks Canada and the BC Ministry of Forests and Range Wildfire Management Branch for sponsoring the Climate Change and Fire Management Research Strategy Forum. Thanks also to the agencies listed below, which sponsored delegates, and to the 70 participants for contributing so much to the forum.

Alberta Department of Sustainable Resource Development

BC Ministry of Community Development

BC Ministry of Energy, Mines and Petroleum Resources

BC Ministry of Environment

BC Ministry of Health

BC Ministry of Forests and Range

BC Ministry of Healthy Living

Canadian Forest Service

Canadian Interagency Forest Fire Centre

Environment Canada

FPInnovations-FERIC

Interior Health Authority, Health Protection Program (BC)

Northwest Territories Environment and Natural Resources

Pacific Climate Impacts Consortium

Parks Canada

Royal BC Museum

Saskatchewan Ministry of Environment

Simon Fraser University

Union of BC Municipalities

University of British Columbia

University of Washington

Yukon Ministry of Environment

Ministère des Ressources naturelles et de la Faune du Québec

Forest Technologies Systems enhanced the networking opportunities by sponsoring events at the Royal British Columbia Museum.

CONTENTS

This document includes summaries of the research opportunities proposed by forum participants. There are three broad themes identified by letters A, B and C, followed by eight sub-themes identified by Roman numerals, and 16 research summaries identified by numbers. Appendix 1 includes a number of other potential research topics identified at the forum.

Climate Change and Fire Management Research Summaries

INTRODUCTION

Climate change is likely to have a major impact on wildland fire across Canada. While the trend is clear and well accepted, there is uncertainty about the rate and duration of change, in part because these factors depend on future emissions scenarios.

On average, wildland fire threatens about 20 communities and 70,000 people annually in Canada, and fire management costs Canada about $700 million a year. Both the area burned and costs will rise as a result of climate change. In British Columbia, fire records show that the wildfire season has been increasing in length by one to two days a year since at least 1980.

Wildland fire managers need analyses of climate change impacts that are as accurate and forward-looking as possible so they have the lead time they need to prepare. In 2005, the Canadian Council of Forest Ministers (CCFM) approved the Canadian Wildland Fire Strategy, which presents an assessment of current/future problems, including climate change, public safety, economic efficiency and sustainable resource management. It offers a way forward, but one that requires a major commitment. The strategic objectives of the Canadian strategy are enhanced public education/awareness, expanded/innovative science and technology, a Canadian FireSmart Initiative, and enhanced wildland fire preparedness and response capability.

In order to accelerate implementation of the wildland fire strategy, the CCFM established a Wildland Fire Management Working Group, which is working closely with the Canadian Interagency Forest Fire Centre (CIFFC), and has identified two broad themes: climate change impacts and adaptation, and industry transformation. CCFM is looking to develop and implement a national fire research plan, with input and advice on where work is needed.

British Columbia is playing a lead role in the Canadian Wildland Fire Strategy, and has also developed its own complementary strategy. BC's Wildland Fire Management Strategy looks at how the province will effectively restore the natural role of fire in ecosystem processes and improve its ability to continue providing a world-class level of response when unwanted fires occur. This will result in healthier forest

and range ecosystems; communities that are at less risk from fire and smoke; and a more cost-effective fire suppression program.

British Columbia is already experiencing the impact of climate change through the mountain pine beetle infestation, which has the potential to have widespread impacts across Canada's boreal region. The epidemic has led to widespread social, environmental and economic impacts, for communities in the interior and across the province.

After the devastating 2003 wildfire season in British Columbia, it was estimated that about 685,000 hectares of high-priority areas of forest adjacent to homes potentially require fuel treatment to reduce the threat of wildfire on communities – and much of this is in areas affected by the mountain pine beetle. This raises questions regarding the social acceptability of treatments and public perceptions about wildfire risk, the effectiveness and costs of treatments over time, the ecological impacts of treatments, and how land use practices affect wildfire risks. These events have received much public attention, strengthening the social licence and imperative for action.

Climate change, pests, disease, alien species, shifting demographics, development within the wildland-urban interface and public policy on land use and land management practices all have a major impact on wildland fire and how it is managed. The complexity has increased rapidly since the 1980s as a result of many social, economic, political, and ecological factors – from conflicting demands on the resource base to a growing population in the wildland-urban interface. There is also an explosion of information that tends to feature the sensational, negative side of wildland fires, with little recognition of the ecological benefits.

THE CLIMATE CHANGE AND FIRE MANAGEMENT RESEARCH STRATEGY FORUM

In February 2009, the Future Forest Ecosystems Scientific Council of British Columbia, Parks Canada and the BC Ministry of Forests and Range Wildfire Management Branch sponsored a three-day Climate Change and Fire Management Research Strategy Forum in Victoria, BC.

Participants worked in teams to identify knowledge gaps and propose research priorities to help strengthen land and fire management in light of climate change, focusing on activities that could be used immediately.

The interdisciplinary planning committee, which organized the event, categorized the resulting research summaries into three broad themes:

- Adapting Wildland Fire Management
- Balancing Management Options
- Putting Science into Practice for Community Resilience

Each research summary examines the issue being addressed, the kind of research required, the expected outcome and the general timeframe. Participants listed potential organizations that might have a role to play in executing the research – providing support or resources, or participating – and those most likely to benefit. They also identified any additional gaps or research for consideration.

This document offers strategic direction for research and adaptation work related to potential changes in fire regimes, with priorities identified for research areas and projects so available resources can be used most effectively.

A. Adapting Wildland Fire Management

Fire behaviour is linked directly to all of the other research topics in this report, and weather is one of the primary factors influencing wildland fire. Temperature, atmospheric moisture, drought conditions and winds affect ignition potential, fire spread and intensity, and increase suppression difficulty and fire effects. Improved fire weather forecasting, tailored to the needs of fire managers, will aid in the response to the anticipated increase in fire activity on the landscape as a result of climate change.

Research into the relationship between weather and forest flammability resulted in a national system of fire danger rating that has evolved over the years. The Canadian Forest Fire Danger Rating System is the primary fire management decision aid used by fire management agencies across Canada and in other parts of the world.

Potential research partners for this work include Canadian forest, fire and environmental agencies, Canadian Forest Service, Canadian Interagency Forest Fire Centre, economists, emergency response organizations, Environment Canada, federal/provincial/ territorial governments, forest industry, First Nations, FPInnovations-FERIC, insurance companies, international users of the Canadian Forest Fire Danger Rating System, local governments, military, Natural Sciences and Engineering Research Council, non-governmental agencies involved with land management (e.g. The Nature Conservancy), Pacific Climate Impacts Consortium, Partners in Protection, policy makers, public health agencies, public safety and emergency preparedness agencies, resource managers, science community, social science/marketing researchers, Social Services and Humanities Research Council, universities, utilities.

The outcome of the research identified would be of value to any agency, organization, company or individual impacted by weather or wildland fire – including fire management agencies (wildland and structural, Canadian and international), economists, emergency response organizations, First Nations, forest industry, health and medical communities, homeowners, insurance industry, land managers, local governments, non-governmental agencies, policy makers, provincial/territorial governments, the research community, resource managers, planners and users, science community, and utilities.

I. Improving Fire Weather and Fire Behaviour Forecasting

> **"We're exceeding thresholds all the time. We'd better start acting soon."**
> **Mike Flannigan, Research Scientist, Canadian Forest Service**

Fire behaviour is the foundation for decisions, strategies, and activities selected by fire managers, land managers and local government – from fuel treatment and ecosystem maintenance or restoration to identifying necessary suppression resources. Understanding how climate change may affect fire behaviour and fire regime, and ensuring related systems are validated regularly is essential to set the right priorities. The need to improve this and other current systems used in Canada will become more urgent if conditions are altered by climate change.

1. OPTIMIZING THE MONITORING AND FORECASTING OF FIRE WEATHER PARAMETERS

Weather forecasting is a complex science with a great deal of variability and some inherent uncertainty; however it maintains a direct link to wildland fire occurrence, behaviour and response. Accurate forecasting depends on monitoring of actual conditions and sophisticated mathematical forecast model outputs, interpretation and analysis.

There is need for a process of continuous improvement for short-, medium- and long-range fire weather forecasting. Weather forecast models could be improved by incorporating tested and reliable information from additional sources. Model users would benefit from finer spatial resolution and improved modelling of topographical effects, relative humidity, smoke dispersal or transport, and precipitation patterns and amounts.

British Columbia has been shown to have a meteorological monitoring site density significantly below that recommended by the World Meteorological Organization. An increase in network density or integration among agencies and better sharing of data could be of value to many agencies along with the meteorological model community. There is a need for research into optimizing multiple networks, all of which have different instrumentations and site conditions. Methods to improve observations of winter precipitation, solar radiation and conditions over the Pacific Ocean would benefit all of Western Canada. Further research into the effects of topography on the key weather parameters, such as temperature, relative humidity, winds and precipitation, would result in advantages for all fire agencies.

There are also opportunities to develop better methods to interpolate the amount of rainfall in areas between weather stations, to better utilize and ground truth radar information, to develop models to optimize the location of weather stations, and to increase the measurements of solar radiation.

2. FORECASTING THE IMPACTS OF A CHANGING CLIMATE ON FIRE WEATHER

There is a need to monitor, track changes and identify trends in local and regional weather to characterize the climate and how it is changing so fire agencies can better understand how to respond and plan strategies, tactics and resources based on the changing fire environment and the values that need to be protected.

Expanding ongoing research into climate change and the impact on local and regional weather in British Columbia could lead to plausible scenarios of future fire weather and fire danger that incorporate variability in global and regional climate models. Although this work would involve continuous improvement, preliminary results could become available in two years.

There are also opportunities to consider extreme event modelling, to investigate the timing and frequency of lightning and precipitation, and to maximize spatial resolution.

3. DEVELOPING DECISION-MAKING TOOLS

In addition to improving weather data and forecasting, enhancing formats and tools so information is more accessible to wildland fire managers would improve the use of the data, increase efficiency and strengthen decision-making processes while being of value to a wide range of organizations. This project would translate and link existing and improved weather data and forecast model outputs into products that can be used for fire management. Initial drafts could be completed in two years.

Tools that could enhance the information transfer process include: relevant summaries; visualization of key parameters; 3-D winds indexes/spatial mapping; data layer display; animated time series; probabilistic/ensemble forecasts used to provide a range of possible outcomes and identify the most likely; and communication of uncertainty of all products.

Confidence in the data and its value depends on meaningful, and preferably standardized, data quality control and assurance processes. There would also be value in looking at ways to tap into the knowledge of specialists, e.g. fire behaviour and resource values.

"From knowns around climate change, we need to develop practical must-dos that can be implemented quickly within current realities (such as budgets, research gaps, succession issues)."

Forum participant comment

4. IMPROVING FIRE BEHAVIOUR PREDICTION SYSTEMS

It is important to be able to predict fire behaviour through a comprehensive and flexible system that can adapt to a changing climate and its impact on the fire environment. For this, fire managers need an improved fire behaviour prediction system that would allow more flexibility in inputs.

This project could facilitate fire behaviour predictions in most fuel complexes, including those located in complex terrain (leading to fuel moisture issues), or in fuel complexes resulting from or modified by disturbances such as insect outbreaks, fuel management and climate change. An improved fire behaviour prediction system is expected to include variable fuel parameters (such as stand density) versus the fixed fuel types that are currently used.

This improved and flexible fire behaviour prediction system would assist with operational, management, and research work under climate change, and could contribute to improved safety for responders and the public. While this project could take 10 to 15 years to complete due to its scope and complexity, a modular approach providing gradual improvements is possible.

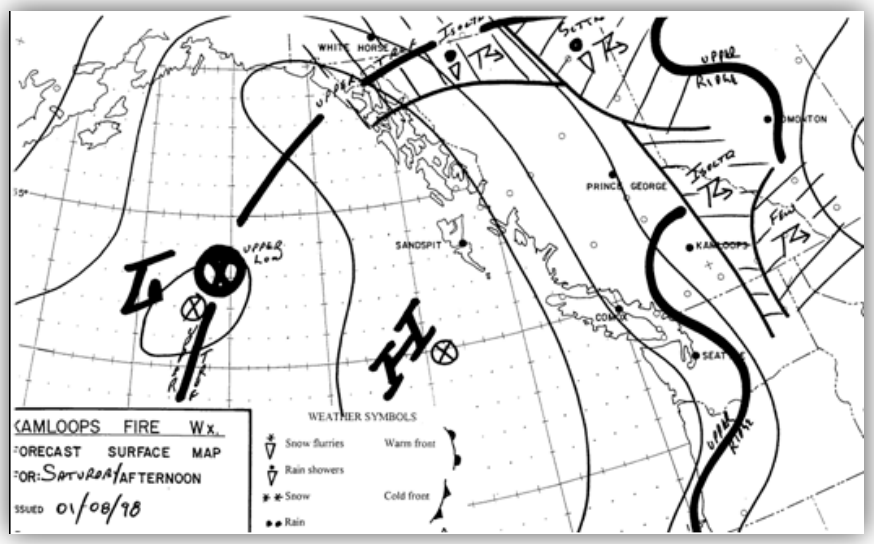
5. ASSESSING HOW THE FIRE THREAT COULD CHANGE

Currently, fire managers have tools and processes to evaluate wildfire threat, and use them to set priorities for activities such as fire response, fuels and land management, and ecosystem restoration. With climate change, several elements included in the current assessment approach may be modified. This needs to be considered for future threat assessment work and for long-term planning purposes.

There is a need to improve, validate and possibly adapt tools and techniques to assess fire threat at various temporal and spatial scales while considering elements such as fire behaviour potential, fire risk, values at risk, and suppression capability, and how these fluctuate/change under climate change at various temporal and spatial scales.

> **"We need to develop and validate models for fire arrival and spread under various climate change scenarios."**
>
> Forum participant comment

This project could take up to five years, and would lead to an improved fire threat assessment process; one that fire management agencies, local governments and land managers could use to identify risks and set priorities. The initiative would be most effective if it involved a collaborative effort with fire management agencies.



6. IMPROVING FIRE OCCURRENCE PREDICTION SYSTEMS

Currently, fire managers across Canada have access to a variety of systems to help them predict fire occurrence. Changes (e.g., number, location, frequency) in the ignition regime have been observed already, and there is a need to improve these systems and adapt them to a changing environment.

If global temperatures rise one or two degrees over the next 50 years, this would have an impact on fire behaviour – as well as affecting other factors such as human ignition, synoptic patterns, the proportion of dry versus wet lightning, and fuel moisture. This project would lead to an adaptable fire occurrence prediction system that could determine how many fires are likely to occur spatially and temporally on the landscape as a function of variables such as observed and forecasted weather, Fire Weather Index System components, synoptic patterns, and other relevant covariates. Separate models may be needed for lightning and human ignitions.

It could take three to five years to develop the first version of an improved fire occurrence prediction system, which should be a collaborative project involving research and fire management agencies.

II. Understanding the Changing Needs of Wildfire Response

> **"Whether we like it or not, we're going to have fire – and maybe a lot more of it. Fire managers would prefer to be in the driver's seat."**
> **Brian Simpson, Director, BC Ministry of Forests and Range, Wildfire Management Branch**

Most wildfires in Canada are contained at less than 200 hectares. However, on average, about three per cent exceed that size, and these account for 95 to 98 per cent of the total area burned. Climate change research indicates that the incidence and severity of wildfires will greatly increase over the next century.

The increase in the number of fires and values that need to be protected is a challenge to fire management agencies. They are close to suppression capacity already, and it is eroding as aircraft, facilities, and equipment age, fire management costs rise, fire management agencies face budget constraints, and trained, experienced staff retire.

Current fire suppression resources and practices may not be as successful, and performance objectives may not be attainable under a warmer and drier climate. There is a need to better model and understand fire management resource use and effectiveness in order to find more efficient approaches.

7. QUANTIFYING THE IMPACT OF CLIMATE CHANGE ON FIRE SUPPRESSION

Many factors, including the length of the fire season and the number, size and severity of fires, and the values at risk, determine the immediate and long-term wildfire suppression resources required. Currently, fire management agencies use historical data to plan resources in advance of each fire season and to anticipate what will be needed in the future – and this information may become less reliable with a changing climate

There is a great need to quantify the potential impact of climate change on fire suppression to help with this planning, and to identify future requirements early enough to provide the time needed to develop and bring on new resources.

It is important to start looking at fire suppression through a climate change lens – linking projections of climate change impacts on fire characteristics to models of fire management resource use. This work would enable fire management agencies across Canada to plan their workload and resources with greater accuracy for both immediate and future needs. The initial work could take two to three years, and it would need to be updated, validated and revised as more data becomes available.

There is also a need for science-based projections of national and provincial/territorial resource requirements that consider climate change and support future planning. A related cost/benefit model would help fire management agencies consider various options and plan for a future where the demand for suppression resources could increase. They must start re-examining their approach and capacity in relation to current and future fire environment and management objectives.

A national study of workload and cost/benefit analysis is likely to take about two to five years. The cost/benefit analysis should consider activities such as fuel management and fire prevention that may reduce overall fire management costs. This work could look at management objectives and protection priorities, including infrastructure and community water supplies, as well as new considerations such as carbon sequestration projects.

This project would provide an opportunity to look at demographics, liability, inter-agency and interdisciplinary options and issues, extreme events, innovative prevention and preparedness work, as well as cost-effectiveness of fire fighting operations while ensuring the safety of responders and the public. The session notes, posted at http://bcwildfire.ca/Weather/Climate/index.htm, include additional research opportunities related to this topic.

III. Managing Forest and Rangeland Fuels to Mitigate Impacts

> **"Research into ecosystem restoration may lead us to the development of key performance indicators for fuels management."**
> Forum participant comment

The historical and current management objectives and suppression efforts in some regions of Canada have led to a shift to older, denser forests. This change in fuel structure and composition could lead to fire intensities outside the natural range of variation for these vegetation types. Changing vegetation conditions could also encourage insect infestations, which in turn could lead through a feedback mechanism to potentially larger and more intense fires fuelled by great quantities of dead woody material.

It is essential that land managers understand the impact this will have on their management of forest and rangelands. While fire management agencies will continue to offer expertise, there is a need for broader integrated land management involving many individuals and organizations.

8. ASSESSING THE EFFECTIVENESS OF FUEL TREATMENTS

The attempted exclusion of fire in some regions of Canada has led to a shift to older or denser forests, and this change in fuel structure and quantity could lead to high-intensity fires. Changing forest conditions may also lead to more severe insect outbreaks, which in turn, may alter fuel conditions. There is a need to involve land managers, and broaden responsibility for managing forest and range fuels.

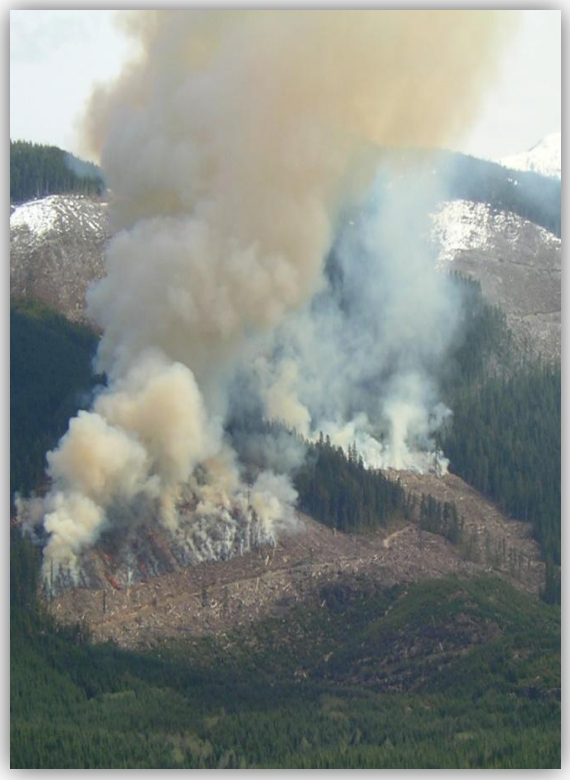
As interest in forest and rangeland fuel treatments increases, there is a need to better understand how effective these treatments are over time – at the stand and the landscape level, and under both current and climate change scenarios.

Tools and models that can evaluate fuel treatments at the stand and landscape level would help to focus resources on the right priorities and most effective approaches. Fire behaviour models currently do not deliver the empirical evidence needed to show whether treatments are actually reducing the threat. Rather than basing decisions on professional knowledge, they could be based on scientific evidence.

This research could start immediately, and take five to 10 years, using tools and models that show how different fuel treatments can alter fire threat over time. Researchers could simulate different treatments and model fire behaviour under different weather conditions, and introduce climate change scenarios. This could be combined with field experience and studies of wildfires that have occurred to help build greater understanding.

9. UNDERSTANDING THE FIRE HAZARD ASSOCIATED WITH POST-HARVEST FOREST RESIDUE

In light of climate change and changing harvest patterns, it is important to have a science-based understanding of the fire hazard associated with post-harvest forest residue, especially near communities. Currently, post-harvest fire hazard assessments are not consistent, and a science-based approach is needed to better assess the potential fire behaviour and threat to values at risk from fire in harvested areas.



A starting point could be to look at where fires have occurred and the kinds of fuels involved, and compare this with the outcome of current harvest methods and patterns. A related research opportunity would be to look at the fire hazard related to harvest and mechanical treatments that aim to preserve and/or enhance understory vegetation, especially in beetle-affected stands in British Columbia.

This project could take approximately two years to complete, and would result in a current, consistent, and science-based fire hazard assessment for post-harvest forest residues. The work would need to be revisited and validated periodically.

IV. Strengthening the Operational Uptake of New Science

> **"We need to identify and get over existing barriers that limit our ability to move forward around climate change such as social impacts, legal liability, research gaps, knowledge transfer, decision and monitoring tools, and extreme weather events."**
> **Forum participant comment**

This is not a time for business as usual. Wildland fire managers need to use all the tools available so they can make the most informed decisions, and they need to incorporate new research and developments, including climate change information, into best practices. The forum brought together researchers and fire managers, and this kind of interaction must be strengthened so both are able to gain from the knowledge and expertise each can offer.

10. SHARING SPATIAL DATA

Many climate change research projects will require the same datasets. There is a need to develop mechanisms to share spatial data such as climate and fire weather projections, fuels, values at risk etc. for use by both researchers and managers, to prevent duplication of effort, and to increase access to information, which would lead to better decisions. The National Forest Information System (NFIS), developed under the auspices of the Canadian Council of Forest Ministers, is one possible mechanism to provide such information.

There is also a need to provide a definitive dataset to expedite and coordinate scientific research. This project would involve two phases, each involving short-term implementation and long-term maintenance:

- The first would identify data (quantity and type), secure data-sharing agreements, have a peer review of the data, and establish and implement a framework.
- The second phase would involve populating the database with completed, ongoing and proposed research to promote collaboration.

Additional options for consideration include lobbying research grant providers for mandatory inclusion of research data, and gap analysis to identify what knowledge and research is missing. It is important to ensure there is consensus among agencies on data gathering and monitoring products to avoid lengthy negotiations.

B. Balancing Management Options

Wildland fire is part of the natural ecological process in most of Canada's forests. To balance potential risks and benefits, it is important to understand the impact fire can have on everything from carbon emissions and sequestration to impacts on sensitive ecosystems – while appreciating its value in reducing the build up of fuel, replacing older stands susceptible to insects and disease, and much more.

Potential research partners for this work include Forest Investment Account (BC), Future Forest Ecosystems Scientific Council of BC, Canadian fire and forest management agencies, Canadian Forest Service, Environment Canada, First Nations, Forestry Innovation Investment (BC); local governments and universities.

This work would be of value to Canadian fire, forest and environmental management agencies, Canadian Forest Service, community and economic development agencies, First Nations, forest industry, policy makers, land managers, local communities, non-governmental organizations, planners, provincial/territorial governments, species at risk managers and water users.

I. Wildfire, Prescribed Fire and Carbon – Better Understanding Tradeoffs

> **"Fire is a major driver of forests that are a carbon source or sink in Canada."**
> **Gordon Miller, Director General, Northern Forestry Centre, Canadian Forest Service**

Wildfire is a critical element in the carbon budget of Canada's forests. International agreements on carbon require information on how wildland fire affects the carbon balance. In Canada, combustion from wildfires averages about one fifth of the carbon from fossil fuels in the country. Fire plays a role in determining net biome productivity and this in turn affects carbon balance. Climate change may mean melting permafrost, and drought and peat fires may become more common.

Similar to wildfire, prescribed fire releases carbon but under managed conditions. It can help achieve air quality and climate action targets by replacing large intense burns with more frequent, well-timed, light-intensity fire. Given that carbon is becoming an important forest value, the role of fire management to help mitigate climate change is becoming more important. In addition, opportunities exist to reduce the impact of mountain pine beetle on carbon evolution by combining fuel management with clean energy sources (bioenergy).

1. MEASURING THE IMPACT OF FIRE ON CARBON

There is a need to understand the impact of fire and fire management alternatives on carbon emissions and sequestration at various temporal and spatial scales. Fire management activities such as prescribed burning and modified response to wildfire result in carbon release into the atmosphere but little is known yet on the balance between short-term carbon release and long-term carbon sequestration resulting from fire management activities.

A starting point could be to identify and prioritize specific research questions, and to examine and determine where existing modelling tools (e.g. Carbon Budget Model of the Canadian Forest Sector, Forest Vegetation Simulator Fire effects model, Forecast, and others) need to be modified to address these questions. Specific kinds of questions could include how different fuel treatments and/or variations in fire effects resulting from differing fire intensities can impact vegetation response and the resulting carbon sequestration, above- and below-ground, at both local and landscape scales. This kind of work could take three to five years or longer, depending upon treatments under consideration.

Overall, the research could take five to seven years, and result in a process/model to evaluate the impact of different management alternatives on climate change and on the carbon budget of forests. A starting point would be to quantify the short- and long-term net carbon balance of current fire-related activities – such as wildfire, site preparation and silviculture, prescribed burning, and fuel treatments in various conditions.

Other options include considering soil organic carbon associated with grasslands and open forest; capturing stand- and landscape-level variability; and examining how soil carbon dynamics, as influenced by succession (following fire) in plant communities, may be affected.

2. BALANCING OBJECTIVES OF FIRE MANAGEMENT

Trade-offs between different forest and fire management alternatives must be evaluated – considering competing/complementary values such as carbon/budget/sequestration, fire-prone landscapes, healthy ecosystems, biodiversity, economics, social expectations, recreational values, cultural values, and habitat.

There is a need to balance the value of fire on the landscape with objectives to reduce carbon emissions. This research would consider ways to value non-monetary benefits and distribute benefits, costs and risks – for example, whether coarse woody debris should be left in the forest or converted to biofuels. This could be a two-year project, one that is updated as new research studies in carbon management are produced.

The results would help to inform the public, land managers and fire management agencies of the optimum fire management alternatives to support healthy ecosystems and reduce carbon emissions. Research options include looking for ways to improve carbon storage during fire and ecosystem restoration activities, and determining whether British Columbia's deep organic coastal forests and their fire regimes are more valuable and/or vulnerable than the boreal with its peat.

II. Measuring Climate Change and Wildfire Effects

> **"We can't expect to keep fire dependent ecosystems healthy without acknowledging fire as a necessary process."**
> **Judi Beck, Manager, Fire Management, BC Ministry of Forests and Range, Wildfire Management Branch**

While it is recognized that fire is a natural disturbance needed to keep many ecosystems healthy, land and fire management objectives and actions that disturb the fire regime may have unintended ecological impacts. Research is required to identify how to keep ecosystems healthy and resilient in the face of climate change without damaging sensitive ecosystems or causing unintended ecological, social or economic impacts.

3. MEASURING THE IMPACT OF FIRE ON HYDROLOGY AND VEGETATION

Predictions of climate change impacts include larger and more severe future wildfires. There is a need to understand how severe fires impact regional ecosystems. This research would use modelling and case studies to examine how large-scale, high-severity fires affect a selection of regional ecosystems, with a focus on hydrology, dominant plant species and succession.

The research could take two to three years and result in a better understanding of the predicted effects of how large-scale, high-severity fires impact ecosystems from a perspective of vegetation recovery and hydrological changes. This information could be used to guide management objectives and actions such as landscape restoration or water management.

4. MEASURING THE IMPACT OF FIRE ON HIGHLY SENSITIVE ECOSYSTEMS

To guide the use of fire as a climate change adaptation tool and define priorities for wildfire management, there is a need to better understand how fire affects highly sensitive ecosystems. Research is required to assess ecosystem resilience and response to fire so ecosystems that require specialized fire management actions can be identified. This assessment would also provide a spatial analysis of the present and predicted range and distribution of ecosystems as climate change progresses.

This work would result in a planning tool to determine the sensitivity of an ecosystem to fire at a scale relevant to ecosystem community management. It could be used at a landscape level by managers and scientists to reduce fire impacts on highly sensitive ecosystems, and be applied at a provincial scale to set policies for ecological considerations of fire and land management.

This research could also provide models that predict ecosystem changes to fire resilience and resistance to changes in climate for different biogeoclimatic zones, subzones, and variants with respect to fire. Predicted ecological changes depend on accurate climate change models and there would be a need to incorporate potential changes in the fire regimes based upon climate change modelling.

Based upon current biogeoclimatic ecological classification (BEC) mapping and predicted BEC shifts from climate change analysis scenarios, a first version could be developed in less than a year, and this could be defined and revised over time as more information is available.

There are a number of other considerations such as the impact on water regimes, especially in British Columbia where the mountain pine beetle infestation is expected to affect hydrology, and whether this might affect the availability of water for fire suppression. It is possible that Fire Weather Index System components could be used to predict the ecological effects of modified response management of wildfires.

Additional opportunities related to changing disturbance regimes, reference conditions and fire/vegetation response and succession modelling at different scales are included in the full session notes posted at http://bcwildfire.ca/Weather/Climate/index.htm.

C. Putting Science into Practice for Community Resilience

When building public support or social licence for wildland fire management or when encouraging the public, local governments and land managers to take proactive steps to protect their property, it is as important to understand social values, behaviours and expectations, as it is to deal with the physical and biological aspects of wildland fire.

Potential research partners include Canadian fire, forest and community development agencies; Canadian Forest Service; Canadian Interagency Forest Fire Centre; FPInnovations-FERIC; Indian and Northern Affairs Canada; insurance industry; local governments; Natural Sciences and Engineering Research Council, Partners in Protection; provincial fire commissioners; provincial/territorial governments, social science and marketing researchers, Social Services and Humanities Research Council, standard setting organizations.

The research summaries identified would be of value to communications/public affairs officers, emergency planning agencies, fire management agencies (wildland fire and structural), First Nations, Indian and Northern Affairs Canada, insurance industry, local governments, marketing strategists/consultants, media, parks, policy makers, private campground owners, public and universities.

I. Protecting the Wildland/Urban Interface

> **"More fires means more communities [will be] at risk."**
> **Gordon Miller, Director General, Northern Forestry Centre, Canadian Forest Service**

The expansion of communities, recreation, and commercial development into forested areas increases the risk of human-caused fire, and the threat to people, homes, businesses and infrastructure. Added to this risk is the fact that there are a number of organizations involved in activities related to fire in the wildland-urban interface.

Although wildland fire is a real concern in some interface areas, few homeowners and local governments understand the role they can, and should, play in reducing their fire risk. Few communities encourage homeowners to design and build wildfire-resistant homes, and few have programs in place to manage forest fuels. FireSmart is an effective tool developed to help individuals reduce wildfire threat; however, Canada lacks national science-based technical standards so communities can improve their fire resistance.

1. BUILDING A SCIENTIFIC FOUNDATION FOR FIRESMART

FireSmart: Protecting Your Community from Wildfire is a comprehensive manual to help professionals and the general public address fire issues related to the wildland-urban interface. FireSmart uses the knowledge and experience of fire managers and emergency responders to help individuals, businesses and communities reduce fire risk. If it had a firmer scientific foundation, it could be used to support changes in bylaws or insurance riders related to things that can impact fire risk in wildland-urban interface areas such as the choice of building materials and landscaping.

A science-based tool created through research could support standards for community fire plans, and motivate the public and local governments to take responsibility for actions to make structures more resilient. Activities could include: modelling fire behaviour potential in relation to fuel treatments dynamics; conducting case studies of structure losses in wildfires; better defining the interface and what structures are most susceptible to fire; and quantifying the risk of wildland-urban interface fires.

It was suggested that this would take three years. Also, while it is important to strengthen the science supporting FireSmart, it is just as important that the program remain practical so it can continue to meet public needs. The research could also consider liability issues.

II. Improving Communications and Public Education

> **"We let 150 wildfires burn each year and we need to be more transparent about that. The public needs to know what we can and can't do."**
> **Judi Beck, Manager, Fire Management, BC Ministry of Forests and Range, Wildfire Management Branch**

Knowledge-based fire management decisions are possible only with public acceptance and/or understanding, and many people have been conditioned over time to view wildland fire as negative and do not appreciate its value in many ecosystems. Also, individuals may not act to make their property more fire resilient if they do not understand the possible outcome or expect that government will provide necessary protection.

2. STUDYING SOCIAL VIEWS OF WILDLAND FIRE

It is important to be able to effectively communicate science knowledge to a range of community groups, including practitioners, policy makers, media, First Nations and the public. This includes talking about everything from fuel treatments to smoke. There is a need to explore value labels such as "positive", "negative", and "significant" when describing future wildland fire risks/impacts within scenarios of climate change. There is also a need to understand how much individuals understand or accept the fact that climate change is likely to impact wildland fire management.

A starting point is to determine public knowledge and perceptions related to wildland fire management and the impact of climate change. Sociological research could be used to survey public views so effective and meaningful public education can be developed. This could include communications and marketing strategies to raise understanding and support for wildland fire activities and to highlight positive aspects for a range of audiences, including the public, policy makers, media and local government. It could also be used to develop a marketing strategy to educate, garner support and ultimately empower the public and communities to play an active role in protecting their property. The research would need to be refreshed regularly, and the resulting communications and marketing would involve an ongoing effort.

D. Putting the Research Strategy into Action

The Climate Change and Fire Management Research Strategy Forum allowed some of Canada's leading experts to identify research and communications needs and approaches related to the impacts of climate change on forest and wildland fire management. Their goal was to create a five- to 10-year strategy with research activities that have practical, operational applications.

The forum planning committee selected and invited participants who were able to offer the highest level of expertise and knowledge – both in research and in fire operations. Through the forum, these individuals shared information and worked together to understand issues, then used this knowledge to identify priority areas for research.

This strategy is a general guidance document that reflects the outcome of the forum. It provides a strategic direction for research and adaptation work related to potential changes in fire regimes, with priorities identified for research areas and projects so available resources can be used most effectively. As a guidance document, its value will come as it is used to support research activities.

The individuals and agencies involved with the forum are well positioned to champion this work. Many of the agencies – including fire, environmental and health agencies, universities and research organizations from across Canada – have agreed to incorporate this work into their research planning where possible, and encourage others to take on specific projects.

This research strategy is posted at http://bcwildfire.ca/Weather/Climate/index.htm along with the full session notes from the forum, and copies of all forum presentations. For further information, email Forests.ProtectionBranchOffice@gov.bc.ca.

"This work will help us foster collaboration and support the integrated, interdisciplinary approach to research that is essential to deliver results across Canada through the Canadian Wildland Fire Strategy."
Gordon Miller, Director General, Northern Forestry Centre, Canadian Forest Service

"British Columbia researchers will use this strategy to look for ways we can increase our understanding of the impacts of climate change on forest and range ecosystems, so we can be sure our management approaches and practices will meet future needs."
Jim Snetsinger, Chief Forester, BC Ministry of Forests and Range

"Climate change will significantly alter how we do our business in managing wildland fire, and we will need lots of lead time to prepare strategies for success. This research strategy will help us identify and promote the correct research to strengthen operational activities and long-term planning."
Dennis Brown, Director, Canadian Interagency Forest Fire Centre

APPENDIX 1: OTHER RESEARCH TOPICS

In addition to research priorities identified in the body of this strategy, participants discussed other gaps and potential opportunities during the three-day forum. All of this information is captured in the session notes posted at http://bcwildfire.ca/Weather/Climate/index.htm, and the planning committee used some of the details to create the following research topics.

MEASURING THE IMPACT OF SMOKE

There is a need to compile research about the social, health, and economic impacts of smoke into an indexed volume to be used by decision makers. This work would be of value to managers involved with any fire decisions, as well as health authorities, ministries, the Union of BC Municipalities, BC Provincial Emergency Program and local governments. Other considerations include looking for ways to index the smoke impact to the allowable annual cut to show how harvesting and subsequent treatment can reduce smoke effects; to help to determine the long-term health impacts of increased smoke exposure over the next 20 years; and to produce a quantitative model of fire emissions and smoke effects for British Columbia.

EFFECT ON FIRE REGIMES AND RELATED DISTURBANCES

It is important to understand how the "natural" role of fire evolves as vegetation types and ecosystems change in response to changing climate envelopes. An assessment of the combined and cumulative impacts of climate change on forest growth, species distribution and age structure that includes impacts on forest health (e.g. pests, drought and water balance) will be needed to determine/predict changes to fire risk and response spatially and temporally. There is a need to study whether a corresponding shift in natural disturbance regimes can be determined from this information, and how wildfire management might need to be adapted to meet these changes.

EFFECT ON BIODIVERSITY

To support ecosystem resiliency and adaptation it will be necessary to determine the effect of climate change on landscape level biodiversity and what types of management can be undertaken to respond to changing wildfire regimes. This will require answers to several questions. Are there reference conditions that could be used? Can paleoecological reconstruction of past fire climate during analogous warm periods (MWP, 4000 years ago) serve as reference ecosystems for future climate conditions? How will wildlife species adapt to rapidly changing habitats as a result of climate change and associated changes to fire response including more fire, more burned area, altered seasonality, altered severity, etc. In addition, it will be important to determine the response and ecological effect of invasive species in fuel management areas such as fuel breaks, prescribed burns and wildfires in consideration of climate change.

BUILDING CAPACITY IN COMMUNITIES OF PRACTICE

There is a need to test available wildland fire management tools and protocols against climate change scenarios (e.g. global, global downscaled to regional); different antecedent conditions of forests (e.g. fuels, health, age); and different circumstances (e.g. interface, park, tree farm licence, timber supply area). This project would connect universities and research organizations with wildland fire managers to make sure they are transferring knowledge that will become part of best practices.

ENHANCEMENT OF NON-TIMBER FOREST PRODUCTS

There is a need to research the options within ecosystem restoration and fuel management treatments to enhance the value (quantity and quality) of non-timber forest products such as mushrooms and floral greenery. This work would be of value to federal/provincial/territorial governments, First Nations and forest/land managers.

FACILITATED MIGRATION OF TREES

The BC Ministry of Forests and Range is currently involved in research related to facilitated migration of tree species. There is a need to understand whether facilitated migration could be successfully used to create resilient ecosystems. To support assisted migration of tree species, there is a need for better predictive models for the future forest conditions including precipitation, frost, and temperature. The project would focus on three keystone species that are the least resilient, such as cedar in the Interior Cedar-Hemlock BEC zone, whitebark pine or western larch. Trials would be used to determine the success in transplanting these species to potential future habitats under climate change scenarios. The sites would be selected based on results of predictive modelling for 30 to 50 years in future climate change scenarios.

REDUCING FOSSIL FUEL EMISSIONS

There is a need to quantify the amounts of fossil fuels used in fire response and suppression activities, and find ways to reduce emissions. By identifying ways to reduce fuel consumption through technology and response decisions, it may be possible to reduce emissions and the resulting impact on climate change while maintaining efficiency and effectiveness. One consideration is the need to compare the cost of fossil fuels versus the benefits in terms of carbon reduction.

APPENDIX 2: FORUM SPEAKERS

"Weather and Climate"

Mike Flannigan

Research Scientist

Canadian Forest Service

"Canadian Wildland Fire Strategy"

Gordon E. Miller

Director General, Northern Forestry Centre

Canadian Forestry Service

"British Columbia's Wildland Fire Strategy"

Judi Beck

Manager, Fire Management

BC Ministry of Forests and Range

"Social, Economic, Ecological Impacts of Climate Change

Mountain Pine Beetle – A Case Study"

Ray Schultz

Assistant Deputy Minister

BC Ministry of Community Development

"Ancient Fire-Climate Regimes"

Richard Hebda

Royal BC Museum

APPENDIX 3: FORUM PLANNING COMMITTEE

Judi Beck, BC Ministry of Forests and Range

(now with the Canadian Forest Service)

Tim Ewart, BC Ministry of Forests and Range

Lyle Gawalko, BC Ministry of Environment

(now with the BC Ministry of Forests and Range)

Victor Kafka, Parks Canada

Ed Korpela, BC Ministry of Forests and Range

Nathalie Lavoie, BC Ministry of Forests and Range

(now with Ministère des Ressources naturelles et de la Faune du Québec)

Anne McCarthy, Environment Canada

Steve Taylor, Canadian Forest Service

Facilitator: Shelly Berlin, Berlin, Eaton & Associates

Writer: Marj Welch, Ermine Communications

APPENDIX 4: INFORMATION SOURCES

The Climate Change and Fire Management Research Strategy Forum has posted this strategy, full session notes and presentation at http://bcwildfire.ca/Weather/Climate/index.htm.

BC Climate Action Secretariat

www.climateactionsecretariat.gov.bc.ca/

BC Forestry Climate Change Working Group

www.bcclimatechange.ca/

BC Ministry of Environment

www.gov.bc.ca/env

BC Ministry of Forests and Range www.gov.bc.ca/for/

- Forest Investment Account www.for.gov.bc.ca/hcp/fia/
- Forests for Tomorrow www.for.gov.bc.ca/hfp/fft/
- Future Forest Ecosystem Initiative http://www.for.gov.bc.ca/hts/Future_Forests/

BC Provincial Emergency Program

www.pep.bc.ca

BC Species at Risk Coordination Office

www.env.gov.bc.ca/sarco

Canadian Council of Forest Ministers

www.ccfm.org

Canadian Forest Fire Management Agencies

http://fire.cfs.nrcan.gc.ca/links-liens-eng.php

Canadian Interagency Forest Fire Centre

www.ciffc.ca

Canadian Wildland Fire Information System

http://cwfis.cfs.nrcan.gc.ca/en/index_e.php

Canadian Wildland Fire Strategy

www.ccfm.org/english/coreproducts-forestfires.asp

Future Forest Ecosystems Scientific Council of British Columbia

Call for Expressions of Interest (closed April 14) www.for.gov.bc.ca/hts/Future_Forests/EOI.htm

Gap analysis www.for.gov.bc.ca/HTS/Future_Forests/Projects.pdf

Potential research topics www.for.gov.bc.ca/HTS/Future_Forests/Topics.pdf

FPInnovations-FERIC Division

www.feric.ca

FERIC - Wildland Fire Operations Research Group

http://fire.feric.ca/

National Forestry Database Program

http://nfdp.ccfm.org/

Natural Sciences and Engineering Research Council

http://www.nserc-crsng.gc.ca/

Pacific Climate Impacts Consortium

http://pacificclimate.org/

Pacific Institute for Climate Solutions

http://www.pics.uvic.ca/

Partners in Protection (Alberta)

www.partnersinprotection.ab.ca/

Social Services and Humanities Research Council

http://www.sshrc.ca/

Union of BC Municipalities

www.civicnet.bc.ca

University of British Columbia

Centre for Forest Conservation Genetics http://www.genetics.forestry.ubc.ca/cfcg/

For more information about the Climate Change and Fire Management Research Strategy, email Forests.ProtectionBranchOffice@gov.bc.ca.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