Fire-Resilient Landscapes

Discussion Paper

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Much of this Discussion Paper was prepared while on Temporary Assignment
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Preface

Quotes From the BC Wildland Fire Management Strategy

(BC Ministry of Forests, Wildfire Management Branch 2010)

Most of B.C.'s forest and rangeland ecosystems have evolved with the influence of fire. Historically, an average of about 500,000 hectares would burn each year. Since the introduction of modern fire-suppression techniques, that area has declined to one-tenth the historical average.

Under natural conditions, periodic forest and range fires served to: reduce the build-up of flammable fuels; create a mosaic of young-to-old forest and range conditions and habitats; replace older forest stands susceptible to insects and disease; and limit the occurrence of large fires by creating natural fuel-breaks. When the natural fire cycle is interrupted, however, there is a reduction in the health and vigour of the forest and, as forests age, fuels build to unnatural levels increasing the risk of catastrophic wildfires that are difficult to control and that may seriously impact communities and resource values.

The only feasible response to this situation is to become much more innovative and proactive about management of wildland fire, while also maintaining a high level of suppression capability.

Strategy goals include:

Goal 2: Plan and implement careful use of controlled burning in appropriate ecosystems and under suitable conditions in order to reduce hazards and risks and achieve healthy forests and grasslands.

Goal 3: Monitor wildfires occurring in areas where there is minimal risk to identified values and intervene when appropriate to reduce hazards and risks and ensure optimum use of fire suppression budgets and personnel.

Goal 4: Ensure that plans adequately consider the management of wildland fire at all appropriate scales in order to reduce hazards and risks, achieve healthy forests and grasslands and ensure resource-efficient fire suppression.

This Discussion Paper bears a strong relationship to the goals and strategies of the BC Wildland Fire Management Strategy.

Acknowledgements

While I was on a Temporary Assignment with the Wildfire Management Branch, Lyle Gawalko came into work one morning and shared some insights with me. Over the weekend he'd been thinking about fire resilience, so he posed some questions.

- If you were in a plane flying low over a landscape, how could you tell if it was fire-resilient?
- If you were to describe a fire-resilient landscape to a colleague, how would you portray or depict it?
- If you wanted to create a fire-resilient landscape over, say, the next two or three decades, how would you go about doing that?

Lyle asked me to pull together the science and management literature that forms the basis of this discussion paper. Thanks Lyle for your good ideas and stimulating thoughts.

MoE executive and managers realize the importance of having their staff collaborate with fire managers in other ministries; thus, I thank Kristy Ciruna for her support. Because fire is such a key ecosystem process across much of BC, it's important to retain the essential roles that fire plays across the landscape. Some of the roles include maintaining ecological communities, species and their habitats, predator-prey relations, and nutrient cycling.

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Introduction

BC has a wide variety of climate, soil, and terrain conditions. As well, forests are evident from the 49^{th} to the 60^{th} parallel and species have evolved to locate in settings suitable to their habitat needs. Diverse forest types can be seen from wet low- and high-elevation coastal settings, low- mid- and high-elevation forests in the BC interior. In all these ecosystems, live and dead biomass accumulates with the absence of fire.

In the interior of BC, wildland fire has played pivotal roles in creating (and re-creating) forest stand and landscape structures and composition. The ecosystems, habitats, and species found in BC reflect the diverse conditions that are, in part, created by fire.

However, several factors have affected fire-prone ecosystems; these factors include:

- fire suppression and exclusion,
- grazing,
- timber harvesting,
- human-caused ignitions, and
- inadequate land planning.

The interactions among these factors can alter:

- fuel loads and hazards (surface, ladder, and crown fuels)
- fire regimes (fire occurrences, intensity, behaviour, size, frequency, and type),
- carbon and nutrient cycles,
- hydrology and erosion, and
- plant and animal community composition and habitats.

Climate change is contributing to longer fire seasons and it’s anticipated that we’ll have more large fires and that fires will tend to burn for increased duration (Westerling 2006).

Indeed, as stated in the provincial Wildland Fire Management Strategy, we need to “become much more innovative and proactive about management of wildland fire”.

1.1 Definitions

At this time, there exists no perfect definition for the term Fire-Resilient Landscape (FRL). However, there are definitions relating to some of the words contained in this term.

Fire resilient: able to recover over time without changing state.

Fire resistant: relatively difficult to ignite

Resilient landscapes: landscapes that have the capacity to rapidly 'bounce back', in terms of their ecological structure and function, after various kinds of disturbance.

Resilience: "the capacity of a system to absorb and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks." (Montana Forest Restoration Working Group 2007)

Resilience: "the speed with which a community returns to its former stage after it has been disturbed" (Begon et al. 1996)

Resilience (or counteractive capacity): "a systems' capacity to maintain structure and function in the face of stress" (Harris and Hobbs 2001)

Resilient forest ecosystems, in response to a disturbance, follow a successional pathway that returns the ecosystem to its pre-disturbance state, at least structurally and functionally. This is particularly the case for forests dominated by small-scaled disturbances. A disturbance may be sufficiently severe to reorganize an ecosystem into a state, which in the short term (i.e., decades), may have a different resistance, but in the long term (i.e., centuries) may be equally as resilient as the original state. (Thompson et al. 2009)

1.2 Purpose of this Discussion Paper

- To build awareness about the concept of a Fire-Resilient Landscape
- Consider how one might attempt to develop and achieve Fire-Resilient Landscapes
- To promote consideration and discussion about Fire-Resilient Landscapes

This document also provides information about the objectives of achieving FRLs; basic principles; and land, fuel, and fire management approaches for developing FRLs.

2 Objectives of achieving Fire-Resilient Landscapes

With respect to fire in BC forest and rangelands, a "Desired Future Condition" would include managing fire and fuels in order to achieve numerous objectives.

These objectives might include:

- public, fire-fighter, and community safety;
- avoided costs of fire suppression and post-fire rehabilitation and regeneration; and
- protecting, maintaining, or improving resource benefits such as:
  - timber,
  - water and air quality,
  - native vegetation,
  - habitat and wildlife,
  - long-term site productivity,
  - aesthetics,
  - recreation and tourism, and
  - forest health.

In short, a FRL could be a Desired Future Condition. In order to develop FRLs over time, there are some basic principles and management concerns for consideration (see Section 2).

3 Principles for Fire-Resilient Landscapes

To take an overall approach to the concept of managing fire across landscapes, it can be helpful to consider some basic principles. The following principles are organized into groups: ecological, socio-economic, and management approaches. Of course, the principles within these groups are interconnected.

3.1 Ecological Principles

Fire is an important ecological process in many BC ecosystems.
Sustain, restore, and maintain natural disturbance regimes in order to renew stands and create biocomplexity, compositional diversity, and resilience.

Consider the whole landscape.
Think comprehensively (e.g., beyond the Wildland-Urban Interface and Timber Harvesting Land Base) to include all land within watersheds, from valley bottom to mountain top (wetland/riparian areas, grasslands, forests, and alpine).

Aim for heterogeneous landscapes.
Over time, many of our landscapes have become more homogeneous, which in part has led to increased large fires and burnt area. Seek to create landscapes composed of a mosaic of patch sizes, species composition, seral stage composition, and structure.

Reduce the threat of unnatural crown fire.
Across landscapes and within stands, move stands toward a more natural species composition, density, and structure. Conditions would vary between vegetation types, fire regimes, and local conditions and objectives.

Not all ecosystems are equally resilient to natural or human-caused disturbance.
Effects of fuel reduction treatments will vary, depending on the natural disturbance regime, species present, and moisture, temperature and other responses to the change.

Consider prevalent weather patterns.

Winds and temperature can affect fuel moisture and the rate of spread and its direction, as well as fire shape, and size of fires.

Consider climate change.
Think about how emerging climate change will affect landscape conditions. Will drier conditions evolve? Will future vegetation (composition and structure) differ and will it tend to be more or less flammable? Will climate change bring on increased vegetation mortality due to insects, pathogens, and drought? With climate change, will there tend to be more fire?

3.2 Socio-economic Principles

Engage the public and enhance peoples' understanding and support for reintroducing fire.
There are social considerations that can limit successful reintroduction of fire, including people's aversion to smoke and other emissions and fear.

Integrate fire mgmt with social and economic well-being.
Fuel reduction treatments can provide employment possibilities to help maintain viable communities (both rural and supporting urban areas). Other human-related benefits include: retaining human infrastructure, protecting air and water quality, cost saving from substituting biomass for fossil fuel.

3.3 Fire Management Principles

Initiate, develop, and maintain interagency cooperation and collaboration.
Land use affects management choices and actions and management actions affect land use. Fire managers need to integrate their work with other resource disciplines (e.g., biology, ecology, hydrology, silviculture, and others), other agencies and levels of government, and private landowners (as appropriate). Integrating the goals and objectives of fire management and land management; this can potentially result in restored ecosystems as well as reduced fuel loads.

Use the best available science, concepts, and tools: biological, physical, social, economic, and management.

Consider the full range of wildland fire analysis, planning, and management.
This includes appropriate planning and use of: fuel management techniques; fire use (e.g., Modified Fire Response and controlled burns); as well as fire suppression.

Protect watershed and soil integrity by using low-impact fire management techniques.
When creating fuelbreaks, reducing fuel loads, or suppressing wildfires, use the least disruptive treatments to reduce the threat of unnatural crown fire. In areas close to settlements, more aggressive fuel reduction and/or suppression techniques may be required.

Consider the cumulative effects of fire and fuel management.
Think about erosion, mass wasting, soil productivity, riparian and hydrologic function, water yields and quality, and forest and grassland succession.

Managers need information about both the benefits of wildland fire and the risks of fire.
Weigh the alternatives by taking a Structured Decision-Making approach or conduct a Multiple Attribute Trade-off Analysis. For example, look at a few options: No action (no fuel reductions); a moderate budget for fuel treatments, and a larger budget for fuel treatments. This kind of approach can help managers assess and understand the benefits, costs, and risks relating to the biophysical environment as well as the ecological, social, and economic values.

Repeat fuel treatments over time.
The benefits of fuel treatments have time limits; for example, fuels re-accumulate and crowns fill canopy gaps as time goes by. Make a commitment to a program of treatments and re-treatments over time.

Learn over time.
So that fire mgmt can be improved over time, provide appropriate levels of monitoring. For example, consider site to landscape scales, and gather pre-treatment (baseline) information and post-treatment data for implementation and effectiveness monitoring

4 Fire and Fuel Management Approaches

Management of landscapes consists of gathering, assembling and assessing data to inform landscape management options and decisions among the options, implementing chosen actions, and monitoring results. Much of the work needs to occur before (not during) fire seasons. During fire seasons, it is necessary for fire managers to make quick but reasoned decisions.

The management approaches listed below are suggestions only. Regional and landscape conditions (ecological, social, economic) need to be taken into consideration.

4.1 Gather information about a landscape

Values at risk

- Some objectives will be prevalent and carry considerable weight, such as human safety in the WUI. These will likely be concentrated in some ecosystem types (valley bottoms where towns/cities are located)
- Other objectives may also carry some weight (e.g., broader safety/security of human infrastructure, species and plant communities at risk, timber volumes, investments in tree plantations, and others).
- Other values (will likely need to seek out information from other organizations)
- Transportation system (maps of roads)

Data and information about the landscape

- biological and physical elements
- the setting (adjacent landscapes)
- prevalent weather patterns

Other

- fire history studies
- maps of fuels
- GIS layers
- Wildland-Urban Interface
- risk assessment information
- co-operative agreements among stakeholders

- unit costs per hectare for fire suppression, Modified Fire Response, and fuel reduction treatments (mechanical, controlled burns, or a combination)

4.2 Consider applying landscape assessment concepts and tools

Concepts:

Use concepts and tools to assist with assessment of landscape conditions, prevalent weather patterns, values, hazards, possible outcomes, and risk. In some instances, it may necessary to invest in staff training to take advantage of available tools, models, and information that is available for fire and fuel analysis and decision making.

Use scale appropriately.
Vast backcountry landscapes and Wildland-Urban Interface (and adjacent) areas will require analysis and management activities at different scales. While we want to increase fire resilience across landscapes, assessments of existing landscape components (such as wetlands, talus, and avalanche tracks) and potential sites for fuel reductions will actually be at stand scale.

Understand the appropriate use of Historic Range of Variability (HRV).
Basically, learn from history. Used properly, this important conceptual tool can help identify departures from historic conditions. It's important to understand that HRV is a guide, not a target. Analysis using HRV can help 'red flag' ecosystem components (e.g., accumulating fuels) that may trending in a direction that will require more resources. While using the HRV, ensure consideration of climate change.

Compare current and historic ecosystems and cover types across fire-prone landscapes.
Analyse structure, species composition, succession, seral stage patches and their distribution, fuel loads, and crown fire potential.

Integrate fire and fuel management with management of forest insects and pathogens.
With successful fire suppression and fire exclusion, in numerous cases, we are increasing the vulnerability of stands and landscapes to insects and pathogens.

During analysis of treatment alternatives, be aware of possible unintended consequences.

As an example, some fuel reduction treatments around human communities may increase understory forage for undesired species such as deer or bear. Also consider the impacts of fuel reduction treatments on timber supply and other values. Consider then needs of fire-sensitive versus fire-requiring species and ecological communities.

One fuel treatment (or set of treatments) does not fit all situations.
Some forest fires are climate-driven (e.g., some relatively high-elevation forests), others are fuels-driven (e.g., low-elevation dry forests), and some are a combination of climate and fuels-driven (e.g., mid-elevation forests).

Tools:

Use Geographic Information Systems; accessible maps, data, and synthesized information (such as Fire Regime Condition Classes and Natural Disturbance Types); and available models.

Use Fire Regime Condition Classes where they are mapped and available.
Fire Regime Condition Classes depict the degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components. Below, the three classes categorize vegetation composition and structure conditions currently existing in the Fire Regime Groups and these serve as simplified wildfire rankings. The risk of loss of key ecosystem components from wildfires increases from Condition Class 1 (lowest risk) to Condition Class 3 (highest risk).

- Class 1 – Low risk (relatively characteristic conditions, similar to the historical regime)
- Class 2 – Moderate risk
- Class 3 – high risk (relatively uncharacteristic conditions, not similar to the historical regime)

Consider the BC Natural Disturbance Types (NDT).

- NDT 1: ecosystems with rare stand-initiating events.
- NDT 2: ecosystems with infrequent stand-initiating events.
- NDT 3: ecosystems with frequent stand-initiating events.
- NDT 4: ecosystems with frequent stand-maintaining fires.
- NDT 5: alpine tundra and subalpine parkland

Stands in ecosystems with frequent stand-maintaining events (NDT 4) are usually the highest priority for fuel hazard reduction treatments. Of intermediate priority are forests with frequent stand-initiating events (NDT 3). Areas with infrequent or rare stand-initiating events (NDT 2 or 1) comprise the lowest priority; this is because the fuel build-up effects of

50-60 years of fire exclusion are minimal in these moister/wetter crown-fire ecosystems.

The BC NDT system is considerably different than the US Fire Regime Groups which are based on frequency and severity (specific to fire, not other disturbances). The US Fire Regime Groups are:

- I - frequent (0-35 years), low severity
- II - frequent (0-35 years), stand replacement severity
- III - 35-100+ years, mixed severity
- IV - 35-100+ years, stand replacement severity
- V - 200+ years, stand replacement severity

Consider features that are important to fire spread rate and crowning, the relative flammability.

- fuel condition (moisture content, fuelbed structure, etc)
- wind speed
- topography

Consider fuel strata

- surface fuels
- ladder fuels
- height to live crown
- crown volume/density

Consider the principles of fire-tolerant or "firesafe" forests.

Summarized in Table 1 below are the fire-tolerant principles: reduce surface fuels; increase height to live crown; decrease crown density; and retain large-diameter trees of fire-resistant species.

Table 1. Principles of fire-tolerant or "firesafe" forests (adapted from Agee 2002; Hessburg and Agee 2003; Agee and Skinner 2005)

Principle	Effect	Advantage	Concerns
Reduce surface fuels	Reduces potential flame length	Fire control is easier; less torching of individual trees	Surface disturbance: less with fire; more with other mechanical treatments
Increase height to live crown	Requires longer flame length to begin torching	Less torching of individual trees	Opens understory; may allow surface wind to increase
Decrease crown density	Makes tree-to-tree crown fire spread less probable	Reduces crown fire potential	Surface wind may increase; surface fuels may be drier
Retain large-diameter trees of fire-resistant species	Reduces potential tree mortality	Improves vegetation tolerance of low- and mixed-severity fires; generally restores historic structure	May become too broadly applied, resulting in simplified landscape patterns of composition and structure; less economical; may keep trees at risk of insect attack

Consider how to optimize fuel treatment locations.
Finney (2003, 2006, 2007) has taken a modelling approach to anticipating fire growth and travel routes, and thus can help optimally identify locations for fuel reduction treatments. This approach takes into account surface and canopy fuels as well as prevailing burn-season weather conditions, such as wind speed and direction, humidity, and temperatures. This approach holds opportunities to reduce fire suppression costs and large fire sizes, and alter fire behaviour and movement.

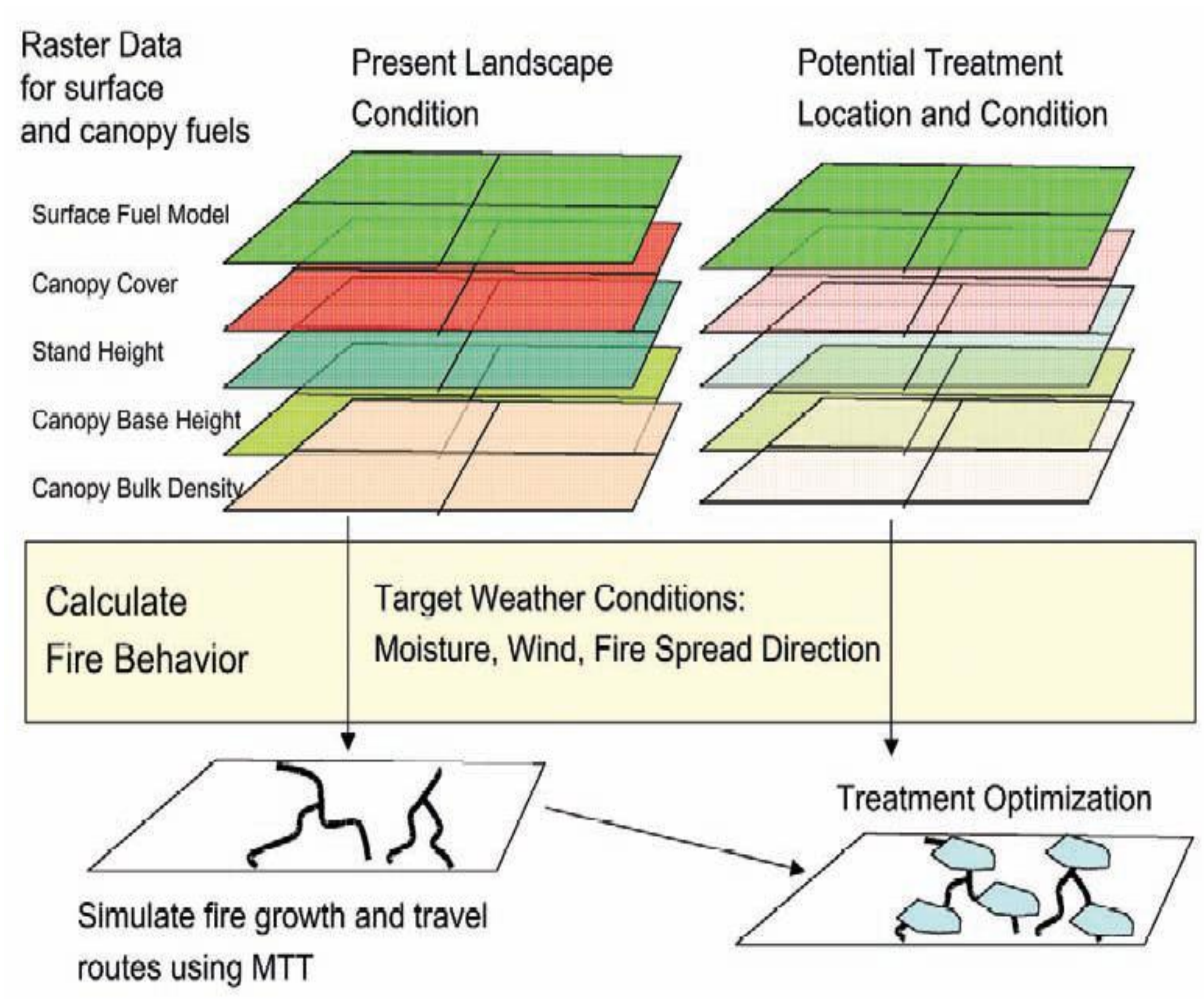

Figure 1. Two landscape fuel conditions are required for the optimization algorithm. One landscape represents the pre-treatment or current fuel conditions; the second landscape represents the potential modifications of fuel strata in all the places that treatments can feasibly be located. Then, each landscape is modeled for fire behaviour under the "target" weather conditions (that is, weather conditions that the treatments are designed for). **MTT** = Minimum Travel-Time. (Finney 2006)

Develop and analyze some landscape-level options and approaches for to fire and fuel management.
Across a landscape, identify natural fuelbreaks (areas of relatively low flammability); also consider terrain and aspect, water bodies, fuel types, historic fire regimes, and prevalent weather patterns (e.g., wind). Identify potential ignition source areas and consider where these are relative to natural and human-made fuelbreaks. The aims of fuel reduction planning and treatments are to reduce hazards, alter fire behaviour, reduce fire severity, and improve fire suppression safety and effectiveness.

The suggestions below may help to identify appropriate actions that could be implemented at the landscape scale

Take a 3-zone approach.
- Community Fire Planning Zone (CFPZ) -- immediately adjacent to towns/cities; managed for community protection
- Wildfire Resilient Zone (WRZ)-- beyond the CFPZ for a few kilometres; managed to minimize unplanned fire (through containment or suppression) and to restore resilience to inevitable fires
- Fire Use Emphasis Zone (FUEZ) – preference for Modified Fire Response (fire use) when conditions allow (weather, personnel availability, etc) and only where fire can produce resource benefits.

Within each of these 3 zones, what and where are the “values at risk” and which fire and fuel management tactics are appropriate?

Develop a Forest Discontinuity Network of relatively fire-resilient patches.
This approach uses three major categories to reduce fuel continuity:
- Category 1: Existing fire-resilient areas. Currently have a lower crown-fire potential (completed controlled burns or fuelbreaks, riparian or wetland areas, fire-resilient late-seral forests, natural openings and other relatively fire-resistant areas.
- Category 2: Areas readily made fire resilient. Where relatively little investment may create relatively fire-resilient conditions. May include strands on upper two-thirds slopes within dry and moist stands, and maintenance of previous controlled burn areas and fuelbreaks.
- Category 3: Areas that occupy a strategic geographic position in the landscape relative to Categories 1 and 2. Examples include: WUI zone, corridors within 15m of riparian or wetland areas, and roadside corridors.

These categories are then divided into smaller units by plant association group and location in the landscape, and subsequently prioritized for treatment.

Enhance connectivity among existing areas of relatively low-flammability (natural fire boundaries).
This may lower the chance of ignition and sustained combustion.

- fuel related: fuel types, stand density, crown closure, horizontal and vertical fuel continuity,
- ecosystem related: wetland and riparian areas, open grassland, hardwood/broadleaved species (e.g., aspen, birch, alder)
- abiotic: rock, talus, water bodies, ridges
- other: relatively cleared road or utility right-of-ways

Examine opportunities for creating fuelbreaks.
Link natural fire barriers and relatively low-flammability areas and thus lower the chances of ignition and sustained combustion.

- Develop appropriate fuelbreaks: Primary (wider) and secondary (narrower)
- Strategically overlap fuel treatment units and fuelbreaks, such that fire control efficiency is improved by taking into consideration features important to fire spread rate and crowning
- Maintain fuelbreaks over time.
- Consider reducing fuels in areas adjacent to the fuelbreak itself. This might reduce fire intensity and spotting if a wildfire approaches the fuelbreak and enhance potential opportunities for safer fire suppression operations.

Consider the basic fire mgmt approaches

- Fuel reduction treatments – mechanical, controlled burns, chemical
- Fire use planning and tactics
- Modified Fire Response
- Controlled burns
- Fire suppression planning and tactics
- Direct
- Indirect
- Monitoring

How might these techniques be used in and around fuelbreaks?

5 Challenges

Focus efforts on eliminating or managing constraints and challenges.
Fire mgmt can be considered a 'wicked' pursuit in that there are numerous challenges; these include:

- Air quality regulations
- Limited burn windows (appropriate fuel and weather conditions)
- Complex land ownership patterns (differing objectives, philosophies, liabilities, and mandates)
- Competing objectives (protecting social values [e.g., human safety] weighs heavier than restoring fire to fire-prone ecosystems)
- Lack of information about fire benefits
- Political perspectives (differing aesthetics)
- Potential for escaped fires
- Logistical constraints (trained staff, budgets)

Competing values.
Is there a willingness to sacrifice economic activity to enhance fire resilience across landscapes? Is fire resilience deemed to be a relatively small issue when compared with mountain pine beetle concerns, fibre markets, and transportation options?

Competing budgets.
Budget limitations will be an on-going challenge. For the benefit of decision-makers (and others), portray both the costs and benefits of fire management decisions. Market costs and benefits (revenues) may be relatively easy to measure and portray; on the other hand, it can be a challenge to specify non-market costs and benefits such as wildlife habitat and visual aesthetics.

Sprawling Wildland-Urban Interface.
It will be difficult to have an effect on urban sprawl. Be prepared to work with partners (e.g., local governments) to address this challenge.

There are other factors at play.
Non-native species, climate change, and other human-induced factors (e.g., urban sprawl, above) will influence fuel treatment effectiveness in the future.

6 Monitoring to learn

Monitor results, so individuals and the organization can learn.
During planning stages, when a site has been chosen for fuel reduction, conduct a pre-work inventory to gather baseline information (fuel type, stand structure, fuel strata, etc). After the fuel reduction treatments are completed, monitor. Monitoring may take different forms:

- Implementation monitoring – ask: was the fuel reduction implemented as planned?
- When a fire hits the treated area, conduct:
- effectiveness monitoring – ask: was the fuel reduction effective in slowing or stopping a fire and under what conditions?
- validation monitoring – ask: were our assumptions about what would occur correct?

Note: it could be a wildfire or a back-burn conducted during a wildfire situation, or a controlled burn under prescribed conditions.

Track and report fuel reductions and planned and unplanned fire events.
Include the number of hectares treated; fire management costs (for Modified Fire Response or full suppression); and other market and non-market costs and benefits.

- Modified Fire Response
- Controlled burns
- Mechanical fuel reduction treatments
- Combination of planned and unplanned events:
    - Mechanical fuel reductions followed by controlled burns
    - Mechanical or controlled burn fuel reductions followed by suppression of wildfire
    - Mechanical or controlled burn fuel reductions followed by Modified Fire Response

7 Glossary

Condition Class -- Depiction of the degree of departure from historical fire regimes, possibly resulting in alternations of key ecosystem components. These classes categorize and describe vegetation composition and structure conditions that currently exist inside the Fire Regime Groups. Based on the coarse-scale national data, they serve as generalized wildfire rankings. The risk of loss of key ecosystem components from wildfires increases from Condition Class 1 (lowest risk) to Condition Class 3 (highest risk).

Fire Frequency - A general term referring to the recurrence of fire in a given area over time.

Fire Interval - The number of years between two successive fire events for a given area; also referred to as fire-free interval or fire-return interval.

Fire Regime - Description of the patterns of fire occurrences, frequency, size, severity, and sometimes vegetation and fire effects as well, in a given area or ecosystem. A fire regime is a generalization based on fire histories at individual sites. Fire regimes can often be described as cycles because some parts of the histories usually get repeated, and the repetitions can be counted and measured, such as fire return interval.

Fire Regime Current Condition Class - A qualitative measure classified into three classes describing the relative degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, canopy closure, and fuel loadings.

Fire Regime Groups - A classification of fire regimes into a discrete number of categories based on frequency and severity. The national, coarse-scale classification of fire regime groups commonly used includes five groups: I - frequent (0-35 years), low severity; II - frequent (0-35 years), stand replacement severity; III - 35-100+ years, mixed severity; IV - 35-100+ years, stand replacement severity; and V - 200+ years, stand replacement severity.

Fire Resistant Tree - A species with compact, resin-free, thick corky bark and less flammable foliage that has a relatively lower probability of being killed or scarred by a fire than a fire sensitive tree

Fire Sensitive Tree - A tree species with thin bark or highly flammable foliage that has a relatively greater probability of being killed or scarred by a fire.

Fire Severity - Degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time.

8 Sources

Agee, J. 2002. The fallacy of passive management. Conservation Biology in Practice 3(1): 18-25.

Agee, J. et al. 2000. The use of shaded fuelbreaks in landscape fire management. Forest Ecology and Management 127: 55-66. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6X-3YF3VKM-5&_user=852502&_coverDate=03%2F01%2F2000&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1261983194&_rerunOrigin=google&_acct=C000045965&_version=1&_urlVersion=0&_userid=852502&md5=f459bd446a21c5364c735e9a55f83fbf

Agee, J. and C. Skinner. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management 211: 83-96. http://www.fs.fed.us/psw/publications/skinner/psw_2005_skinner(agee)001.pdf

Arno, S. and S. Allison-Bunnell. 2002. Flames in our forest: Disaster or renewal. Island Press.

BC Ministry of Forests and BC Ministry of Environment, Lands and Parks. Biodiversity Guidebook. Forest Practices Code of BC. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm

Begon, M. et al. 1996. Ecology. Blackwell Science.

Cole, D. et al. Naturalness and beyond: Protected areas stewardship in an era of global environmental change. The George Wright Forum 25(1): 36-56. http://www.fs.fed.us/psw/publications/millar/psw_2008_millar(cole)035.pdf

Douglas, T. and P. Burton. 2004. Integrating ecosystem restoration into forest management in BC, Canada. In: Restoration of boreal and temperate forests: 423-444. CRC Press.

Finney, M. 2001. Design of regular landscape fuel treatment patterns for modifying fire growth and behaviour. Forest Science 47(2): 219-228. http://www.ingentaconnect.com/content/saf/fs/2001/00000047/00000002/art00011

Finney, M. 2003. Calculation of fire spread rates across random landscapes. International Journal of Wildland Fire 12: 167-174.

Finney, M. 2006. Computational method for optimizing fuel treatment locations. US Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-41: 107-123.

Finney, M. 2007. A computational method for optimizing fuel treatment locations. International Journal of Wildland Fire 16: 702-711.

Fitzgerald, S. (editor). 2004. Creating fire-resilient landscapes: Improving our understanding and application. Conference proceedings, Oregon State University.

Forestry Canada Fire Danger Group. 1992. Development and structure of the Canadian forest fire behaviour prediction system. Forestry Canada, Information report ST-X-3.

Hann, W. et al. 2010, Version 3.0. Interagency Fire Regime Condition Class Guidebook. US Forest Service et al. http://www.fire.org/niftt/released/FRCC_Guidebook_2010_final.pdf

Harris, J. and R. Hobbs. 2001. Clinical practice for ecosystem health: the role of ecological restoration. Ecosystem Health 7: 195-202.

Hessburg, P. and J. Agee. 2003. An environmental narrative on Inland Northwest US forests, 1800-2000. Forest Ecology and Management 178: 23-59. http://www.fs.fed.us/rm/boise/research/fisheries/fire/FAE%20Papers/hessburg_final_FAE.pdf

Keeley, J. et al. 2009. Ecological foundations for fire mgmt in North American forest and shrubland ecosystems. US Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-779. http://www.fs.fed.us/pnw/pubs/pnw_gtr779.pdf

Landres P. et al. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9(4): 1179-1188.

Miller, C. et al. 1999. Evaluating risks and benefits of wildland fire at landscape scales. In proceedings: Crossing the millennium: Integrating spatial technologies and ecological principles for a new age in fire management: Joint Fire Science Conference and Workshop.

Millar, C. et al. 2007. Climate change and forests of the future: Managing in the face of uncertainty. Ecological Applications 17(8): 2145–2151.

Montana Forest Restoration Working Group. 2007, 3rd edition. Restoring Montana's National Forest lands. Montana Forest Restoration Committee. http://www.montanarestoration.org/van_upload/UP0000000080.pdf

Ohlson, D. et al. 2006. Multi-attribute evaluation of landscape-level fuel management to reduce wildfire risk. Forest Policy and Economics 8(8): 824-837. http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6VT4-4FY294S-2-9&_cdi=6280&_user=852502&_pii=S1389934105000286&_origin=na&_coverDate=11%2F01%2F2006&_sk=999919991&view=c&wchp=dGLbVtz-zSkzS&md5=72e89467b343fec680ebe526d49f89ff&ie=/sdarticle.pdf

Predmore, A. et al. 2008. Ecosystem management in the US Forest Service: A persistent process but dying discourse. Journal of Forestry 106(6): 339-345. http://www.ingentaconnect.com/content/saf/jof/2008/00000106/00000006/art00008

Reinhardt, E. et al. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western US. Fore Ecology and Management 256: 1997-2006.

Rytwinski, A. and K. Crowe. 2010. A simulation-optimization model for selecting the location of fuel-breaks to minimize expected losses from forest fires. Forest Ecology and Management 260: 1-11.

Stockmann, K. et al. 2010. Integrating fuel treatment into ecosystem management: A proposed project planning process. International Journal of Wildland Fire 19: 725-736. http://www.fs.fed.us/rm/pubs_other/rmrs_2010_stockmann_k001.pdf

The Nature Conservancy. 2006. New Mexico forest restoration principles. http://www.fs.fed.us/r3/spf/nm-restor-principles-122006.pdf

The Wilderness Society. 2006. Managing the landscape for fire: A three-zone, landscape-scale fire management strategy. Science and Policy Report. http://wilderness.org/content/managing-landscape-fire

Thompson, I. et al. 2009. Forest resilience, biodiversity, and climate change: A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. UNEP, Secretariat of the Convention on Biological Diversity, Technical Series No. 43. http://www.cbd.int/doc/publications/cbd-ts-43-en.pdf

Westerling, A. et al. 2006. Warming and earlier spring increase western US wildfire activity. Science 313: 940-943. www.sciencemag.org/cgi/rapidpdf/1128834.pdf

Wilmer, B. and T. DeLuca. 2008. Fire and fuels restoration priority system: Using mapping and analysis to help prioritize restoration projects. The Wilderness Society, Ecology and Economics Research Department. http://wilderness.org/files/Fire-Fuels-Restoration-Priority-System.pdf