# Post-Natural Disturbance Forest Restoration Guidance

## Landscape Level Wildfire Recovery

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Post-Natural Disturbance Forest Restoration
Guidance - Wildfires

Approved by:

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*Cover photo, left: Southeast of Hanceville, Hanceville-Riske Creek Fire. October 26, 2017.*
*Cover photo, right: North of Bishop Lake, Plateau Fire. September 27, 2017.*

# Executive Summary

Wildfires are a natural part of the ecosystems in the interior of British Columbia. However, evidence suggests that large wildfires may become more frequent as the climate warms, resulting in profound changes in many ecosystems.

Wildfire and wildfire salvage on areas already disturbed by bark beetle mortality can accumulate considerable impacts on the land base. Any salvage response to large wildfires must consider emerging and evolving social, economic, and environmental factors, priorities, and policies, both provincially and locally. As part of a larger strategy for landscape recovery, wildfire salvage should be collaborative and well-coordinated with First Nations and impacted communities.

When planning restoration during salvage harvesting, there are six overarching goals that should be considered in order of priority.

1. Ensure human safety and minimize damage to existing infrastructure.
2. Collaborate with First Nations to include Indigenous values and knowledge.
3. Sustain, restore, or enhance the capacity of impacted ecosystems to expedite the recovery of ecosystem values, such as those related water quality, wildlife habitat, and soil conservation.
4. Consider the collective disturbances on the landscape to mitigate cumulative impacts on environmental and societal values.
5. Recover value from the burnt timber before the wood quality deteriorates.
6. Facilitate the adaptation of forested landscapes to improve resilience to climate change.

Planning should focus on identifying areas that are important to reserve, areas that should be considered for salvage harvesting, and site-specific practices to maintain and restore ecological functions. Specific planning and practices guidance is provided in this document for human safety and critical infrastructure, legal objectives and land base designations, conserving and/or protecting cultural heritage resources, stand and landscape level retention, watershed integrity and function, forest health, soil conservation and riparian management.

# Table of Contents

## 1. About this Document

This document provides guidance to both those designing and reviewing harvesting plans in response to extensive natural disturbances due to wildfire. This guidance has evolved through the wildfires of 2017 to 2021 and is now intended for general application where landscape level wildfire is occurring.

This document is guidance and does not replace or preclude legal requirements or other sources of guidance previously issued by the ministry.

## 2. Introduction

The 2017, 2018 and 2021 wildfires were the most extensive on record in BC, with an estimated 1.2 million, 1.3 million and 863,000 hectares burned respectively (See Appendix 1 for details on the 2017 wildfires). Wildfires are a natural part of the ecosystems in the interior of British Columbia. However, evidence suggests that large wildfires which were previously considered exceptional, may become more common as the climate warms, resulting in profound changes in many ecosystems (Appendix 2).

*__Restoration planning:__ is described as a process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes. It seeks to restore ecological processes that operate at a larger spatial scale, such as those maintaining the population of a species requiring large habitat areas or those responsible for hydrological flows. It builds those conditions and elements over the landscape to provide for habitat, hydrologic function, mid-term timber supply and to support recovery at stand and landscape scales.*

Some ecological landscapes in the BC Interior were extensively disturbed in recent decades by an unprecedented mountain pine beetle (MPB) outbreak, coupled with salvage logging. Other parts of the BC Interior have also experienced significant, though less extensive, disturbance from spruce and Douglas-fir bark beetles. Wildfire and wildfire salvage can accumulate additional disturbance on these already-disturbed landscapes. At the same time, if wildfire salvage is to recover economic value, it must be expedited before wood quality deteriorates. Any salvage response to large wildfires must consider emerging and evolving social, economic, and environmental factors, priorities, and policies, both provincially and locally (Appendix 2).

The use of salvage harvesting after an extensive wildfire should be a proactive part of a larger strategy for landscape recovery. It must be accomplished with an environmentally focused, collaborative, and cautious approach to planning, characterized by a high degree of coordination, cooperation, and efficiency. It is unlikely that all burnt timber can be salvage-logged, considering its economic 'shelf life' may only be two or three years. Planners should identify timber that is important to retain and areas important to reserve, as well as good candidates for harvesting and expedited recovery.

The provincial government will ensure that post wildfire restoration planning involves collaborating with First Nations, engaging impacted communities, addressing multiple values and objectives, and mitigating the cumulative impacts of resource development in affected landscapes.

# 3. Post Wildfire Restoration Guidance

## Overarching Priorities

When planning restoration during salvage harvesting, there are six overarching goals that should be considered in order of priority.

1. Ensure human safety and minimize damage to existing infrastructure.
2. Collaborate with First Nations to include Indigenous values and knowledge.
3. Sustain, restore, or enhance the capacity of impacted ecosystems to expedite the recovery of ecosystem values, such as those related water quality, wildlife habitat, and soil conservation.
4. Consider the collective disturbances on the landscape to mitigate cumulative impacts on environmental and societal values.
5. Recover value from the burnt timber before the wood quality deteriorates.
6. Facilitate the adaptation of forested landscapes to improve resilience to climate change.

In general, restoration during salvage harvesting in areas burned by wildfires should place consideration of human safety and long-term ecosystem function over the short-term economic gain obtained from salvaging timber.

## General Planning Considerations

**Collaboration and coordination** - Forest licensees are expected to collaborate with each other, in partnership with First Nations, provincial and local governments, to develop coordinated, spatialized post wildfire restoration plans. The province will ensure that this planning occurs through the identification of areas that are a priority for post wildfire restoration through harvesting.

**Access management** - In general, access infrastructure built to enable salvage harvesting should include a plan for rehabilitation, taking into consideration reforestation planning logistics, increased hunting pressure and disturbance of wildlife species and future risk of wildfire.

**Mapping Burn Severity** - Planning should incorporate burn severity maps. Planners should interpret burn severity mapping in the context of a whole watershed or Landscape Unit. They should also consider the potential cumulative impacts of pre-existing harvesting, forest health disturbances, and other resource development, in addition to the effects of recent wildfires and potential post wildfire harvesting.

**Planning in a holistic and integrated fashion** - Restoration should focus on entire ecosystems rather than individual attributes, such as fuels. Restoration should centre on creating resilience and functionality in the context of desired conditions. Attempting to return landscapes to a given historical state is unlikely to create either resilience under current or future conditions or socially desirable outcomes. Restoration efforts should prioritize the most degraded landscapes, critically deficient in important characteristics or where there is an increased risk of further catastrophic disturbances.

## Human Safety and Critical Infrastructure

Severe wildfires damage the forest canopy and the plants below, as well as the soil surface, creating hydrophobic soils, which on steeper slopes can result in increased runoff after intense rainfall or rapid snowmelt. Such intense runoff can put homes and other structures downslope of a burned area at risk of localized floods, debris flows and landslides.

- The Ministry of Forests (FOR) will conduct Post Wildfire Natural Hazard Risk Analysis (PWNHRA) to identify and assess the effect of the wildfire on the risk of a natural hazard event that would impact public safety, buildings, and infrastructure. All major fires undergo an initial screening-level PWNHRA. If high risk is identified, a detailed PWNHRA is undertaken by a qualified consultant contracted by FOR and recommendations will be developed.
- While the PWNHRA does not cover risks associated with timber salvage specifically, the initial and the detailed PWFNHRA (where available) should be reviewed by licensees and Ministry staff to ensure adherence to its recommendations.
- Since the values addressed in the PWFNHRA may not cover all relevant values or the entire wildfire area, additional assessments may be required as outlined in the *watershed integrity and function* section in this document.
- It is a priority to salvage burnt trees that may fall, damage or block roadways, powerlines, telephone lines, fence lines, rail lines and buildings. Operator and public safety should be a principal concern during these operations, as well as minimizing damage to water bodies and riparian areas.
- Another priority is salvage harvesting around communities and within the Wildland Urban Interface (WUI), where it can be demonstrated that it contributes to objectives identified in an existing Community Wildfire Protection (CWPP) or the newer Community Wildfire Resiliency Plans (CWRP).

## Addressing Legal Objectives and Land Base Designations.

Wildfire can significantly impact the values for which legal objectives or specific designations were established. Post-wildfire salvaging must consider and incorporate protection and restoration of habitat, biodiversity and other values previously provided for in “landscape-scale” legal designations.

- No salvage harvesting should be considered in ‘protected areas,’ including Ecological Reserves, parks (federal, provincial, regional, and local) and ‘conservation lands,’ unless there is a government-approved management plan that specifically states how salvage harvesting will improve the value of the protected area.
- Salvage activities can proceed only where government has approved a Forest Stewardship Plan that demonstrates how the value(s) associated with “landscape-scale” legal designations will be retained, recovered, or improved by post wildfire harvesting in a manner consistent with legal objectives.[1] These designations include:
    - Archaeological sites established under the *Heritage Conservation Act*;
    - Old Growth Management Areas (OGMA);
    - Ungulate Winter Ranges (UWR);
    - Wildlife Habitat Areas (WHA); and
    - Fisheries Sensitive Watersheds (FSW).
- Visual Quality Objectives (VQOs) can be significantly impacted by landscape level wildfire. Post wildfire salvage harvesting in areas with VQOs can have a positive impact on the recovery of the viewscape. For areas determined to be suitable for restoration, anticipated impacts to the VQOs resulting from salvage harvesting will be incorporated into the plan and design.

[1] For example - Deer Winter Range Strategy Committee. Regional Mule Deer Winter Range Strategy. Williams Lake, BC; 2014.

- Anticipated impacts to OGMAs and the associated biodiversity values should be incorporated into restoration and harvesting plans and designs for post wildfire salvage harvesting in areas determined to be suitable for restoration.[2]
- Where wildfire has severely impacted the value for which an area was originally designated, and it cannot be recovered, the province will determine whether a suitable replacement area can be identified and designated, providing for equivalent or better forest values than what was provided for in the burnt area.[3]

## Indigenous values and cultural heritage resources

The province's commitment to reconciliation through the *Declaration of the Right of Indigenous Peoples Act* (Declaration Act) indicates that moving forward in consultation and cooperation with First Nations (and Indigenous Governing Bodies) relating to the planning of wildfire restoration activities is imperative. The province must do this planning in collaboration with First Nations, and strongly encourage forest licensees to work with First Nations to manage for all values important to First Nations, including cultural heritage resources.

Forest Licensees are also required to adhere to the Results and Strategies in their approved FSPs which manage for the objective set by government in FRPA for cultural heritage resources.

## Stand and landscape level retention

Given the extent of current wildfires, portions of impacted forests will need to be retained to provide long-term habitats and habitat elements. As well, a distribution of stand-level structural elements and biological legacies, including mature trees, large veteran trees, large snags, and large coarse woody debris, contribute to unique and complex habitats and assist in a more rapid ecological recovery.

Priorities include:

- Spatially explicit landscape level retention patches to maintain landscape-scale heterogeneity, interior forest habitat, landscape-level habitat connectivity, and other ecological attributes that support conservation values.
- Landscape retention within the broader boundary of the wildfire, should focus on:
    - marginally impacted or non-impacted stands (at least over the short to mid-term) and,
    - forested areas identified for harvesting deferral for a significant period of time.
- Stand level retention objectives should consider and, where possible, provide for the inclusion of some of the following elements across the landscape impacted by wildfire:[4]
    - Patches with known and/or identified cultural and archaeological sites.
    - Stands and patches of live trees.

[2] For example https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/biodiv-hab-mngt/bc_non-spatial_old_growth_fpc_30jun2004.pdf

[3] Specific guidance about planning for restoration and salvage harvesting in OGMAs may be obtained from Resource Management Objectives Branch, FLNR

[4] More specific and detailed guidance for designing in-block and among block restoration is available from ResourcePractices Branch, FLNR.

- A mosaic of intact unburnt and burnt patches.
- Special habitats and habitat features, particularly if they are unburned.
- A range of burnt timber patches in terms of patch size, burn severity and snag density.
- Biological legacies such as large veteran trees, large snags and large coarse woody debris.
- Landscape-level connectivity with residual trees and wildlife tree patches.

- Stands having low to moderate levels of mortality or imminent mortality[5], should be considered as opportunities for partial cutting, with emphasis on removing dead or dying stems, where such an approach can successfully be integrated into an effective silvicultural system.
  - For more severely damaged stands (70 percent or more mortality), where the only practical silvicultural system is 'clear cut with reserves', opportunities for stand level retention should be utilized in areas with concentrations of living trees, unlikely to incur mortality over the short term.

Considerations when planning retention:

- Patch size objectives for reserves and amalgamated harvested openings that:
  - are known and being implemented by licensees harvesting in the management unit,
  - support maintenance of desired landscape conditions over the long-term, and
  - include objectives for minimizing the extent and adjacency of large or amalgamated openings.
- Spatial wildfire management planning for fuel breaks in areas that are desirable to manage as non-forested or as low-density forest over the long term (e.g., areas that are highly likely to convert to grassland or open forest, areas around communities).

## Watershed Integrity and Function

Qualified professionals may be required to make interpretations and provide guidance when salvage harvesting in watersheds where water quality is a concern.

- Watershed assessments, using a tiered approach, should be conducted or suitably updated as per the current, most up-to-date joint practices guidelines prepared by the Association of BC Forest Professionals and the BC Association of Professional Engineers and Geoscientists (Appendix 3). The focus for watershed assessments by qualified professionals using these guidelines is to understand and manage key risks within watersheds using explicit tolerances of risk, with rationales[6]
- Salvage harvesting in community or domestic watersheds used for water consumption, will be guided by, and consistent with up-to-date watershed assessments and associated recommendations that incorporate the impacts of the wildfire.
- The *Current Condition and 10-Year Historic Trend Analysis of Hydrologic Hazards* reports conducted under the provincial cumulative effects framework should be used when setting priorities for watershed assessments in restoration plans. Further, these reports should be consulted by qualified professionals as a starting point for local watershed assessments. These regional reports are a

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[5] Trees with >70-80% of the tree crown scorched have a high likelihood (>70% probability) of dying due to wildfire regardless of factors such as tree species or size. The likelihood of tree mortality in trees with <70-80% crown scorch appears to vary considerably depending on tree characteristics (tree size, bark thickness), fire damage (bole scorch and cambium damage ) and secondary factors such as drought or attack from bark beetles(genus Dendroctonous). The majority of bark beetle related mortality will occur within 2-3 years following a wildfire

[6] Risk Tolerance - References against which the significance of a risk is evaluated. Generally, these are associated with defined qualitative or quantitative risk levels (ABCFP and APEG. 2020. *Watershed assessment and management of hydrologic and geomorphic risk in the forest industry*. Joint Practice Guidelines).

general GIS-based overview and may be five years or more out-of-date. Regional spatial data may be acquired from Ministry of Forests regional staff.

## Riparian management

- Salvage harvesting will not occur in any Riparian Reserve Zone, based on FPPR stream classes, to maximize the large woody debris (LWD) supply and minimize disturbance-related sediment mobilization into streams.[7]
- Where operationally feasible, consideration should be applied to avoiding salvage harvesting in the Riparian Management Areas (RMA) of streams, wetlands and lakes. Consideration should be applied to anchoring retention areas within RMAs, especially where timber is undamaged or lightly scorched. Even heavily burned stems can contribute LWD and minimize disturbance-related sediment mobilization into streams if left standing.
- Avoid mobilization of sediment into streams and disturbance of stream banks and beds where machines must enter RMAs, with appropriate harvest timing and other best management practices to minimize soil disturbance.
- Maintain a 10 m machine-free zone around non-sensitive small wetlands, lakes, and non-fish streams, where the removal of riparian timber is not anticipated to impact sensitive downstream reaches.

## Managing forest health

Forests in the interior of BC may experience increases in bark beetle activity after large wildfires, and of particular concern is Douglas-fir beetle (*Dendroctonus pseudotsugae*; DFB). Objectives for management of DFB) are to limit the spread of the beetle and to reduce future losses. Accordingly, single tree "fall and burn" techniques to suppress DFB are NOT operationally practical and limit the effectiveness of suppression treatments across landscapes (compared to the efficacy of these treatments for MBP suppression).

- A Douglas-fir Beetle Management Unit (DFBMU) may be delineated in the context of a landscape-level assessment of DFB hazard and risk.[8] DFBMUs require:
  - a clear statement of the rationale and objectives,
  - an evaluation of risk if DFB treatments are not undertaken,
  - a statement of the expected outcomes of treatments and
  - treatment efficacy monitoring.
  - DFBMU planning should involve all relevant stakeholders and consider all relevant factors including: the landscape-level hazard and risk of DFB outbreak; the season of the fire; the severity of the fire; the size of the trees affected and whether special management areas (e.g., OGMA, UWR) or inoperable terrain are present.
- At low levels of infestation, DFBMUs can be used to attempt to protect specific values at the stand level (e.g., OGMA), by reducing the broader risk of DFB infestations.
- DFB harvesting in OGMAs should be limited to:
  - areas where there are relevant, strategic management goals and objectives set for OGMAs prior to DFB infestation, or

[7] i.e., the preference is to not invoke Section 51 (1)(g) of the FPPR.

[8] Specific guidance about planning for direct control of DFB outbreaks can be obtained from Forest Science, Planning and Practices Branch and/or South Area Regional Operations Division, FLNR.

[9] See: [Integrated Pest Management - Province of British Columbia (gov.bc.ca)]

  - the (rare) occurrence of exceptional, extenuating circumstances.

- The Integrated Pest Management[9] approach to decision-making should be considered when planning forest management activities.

- Integrating DFB management with restoration guidance may result in conflicting objectives, particularly where 'aggressive intervention' strategies for DFB management are used. To help reconcile conflicting objectives, practitioners should plan DFB management strategies while considering the role of post wildfire restoration in ecosystem resilience and recovery:

  - Focus DFB management in existing, developed areas to minimize new road construction.
  - Use partial cutting systems wherever possible and monitor for potential windthrow.
  - Where clear cut silvicultural systems are used for DFB sanitation, design cut blocks to focus harvest where at least 70 percent of the timber volume has been killed by wildfire.

## Soil conservation

Mechanical soil disturbance can increase erosion, compaction, and potential encroachment by invasive plants. The general goal is to minimize this disturbance during salvaging activities. More specifically:

- Address soil sensitivity and terrain stability concerns in burnt areas, by adhering to all related practice requirements or results and strategies in Forest Stewardship Plans (FSPs).[9]

- Conduct site-level assessments of soil sensitivity prior to salvage harvesting and utilize harvesting practices that limit mechanical disturbance in burnt areas, particularly in severely burnt areas (e.g., low impact equipment and/or winter harvesting on snow).[10,11]

- For more detailed practice guidance - see those provided for soil conservation during salvage harvesting in areas affected by mountain pine beetle.[12]

## Linkages and Funding Opportunities

Stand-level treatments intended to minimize impacts of wildfires on timber supply may be funded by government initiatives that have other goals and requirements. Those initiatives include the following:

- The Forest Investment Program (previously the Forests for Tomorrow[13] and Forest Carbon Initiative) may fund the rehabilitation of previously free-growing plantations and mature forest damaged by wildfire.

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[9] See - Forest Planning and Practices Regulation [FPPR] section 35) and site-specific terrain stability (FPPR Sections 37 and 38.

[10] Hope G, Jordan P, Winkler R, et al. Post-wildfire natural hazards risk analysis in British Columbia. Victoria BC: MFLNRO; 2015. https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/lmh69.pdf

[11] B.C. Ministry of Forests. Hazard assessment keys for evaluating site sensitivity to soil degrading processes guidebook. Victoria BC: Forest Practices Branch, BC Ministry of Forests; 1999. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/silviculture/silviculture-surveys/hazardassesskeys-web.pdf

[12] Berch S, Dube S, Hope G. Best management practices for soil conservation in mountain pine beetle salvage operations. Victoria BC: Ministry of Forests and Range Forest Science Program; 2009. http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=14707

[13] https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow see specifically https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/5postwildfireassessmentoverviewjan23.pdf

- FRPA Section 108 funding[14] may be used to fund rehabilitation of damaged plantations that had yet to achieve free-growing status at the time of the wildfires.
- The Forest Enhancement Society of BC[15] may fund a variety of activities related to preventing and mitigating the impact of wildfires, including treating forests to improve the management of greenhouse gases under the auspices of the Forest Carbon Initiative.[16]

## Additional guidance references

Government has published several other guidance documents that may be of use when designing restoration plans.

- Cariboo-Chilcotin Land Use Plan: Regional Biodiversity Conservation Strategy; Update note #14, the function and management of old growth management areas in the Cariboo-Chilcotin.[17]
- Cariboo-Chilcotin Land Use Plan: Regional Mule Deer Winter Range Strategy; Information Note #1, Guidance for fire-damaged stands[16]
- Guidelines for Fire Salvage Kamloops TSA (November 6, 2003)[18]
- Recommendations for Individual Tree and Stand-Level Retention Following Large–Scale Wildfires - prepared by: Doug Lewis, RPF BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development Draft Version 1.1 – August 01, 2018.
- Steps to Implementing Forest Landscapes Restoration Following Large-Scale Natural Disturbances in South-Central British Columbia – prepared by D. Lewis - Version 1.1– 09/04/2018
- Guidance on riparian management specific to post-fire salvage logging - Prepared by Lisa Nordin, M.Sc., R.P.Bio., Aquatic Resource Stewardship Officer. 2017-10-27.

There is also potentially relevant guidance about salvage harvesting in response to insect outbreaks.

- Omineca Region guidance stand and landscape-level retention for harvesting in response to spruce beetle outbreaks (September 2017)[19]
- Guidance on Landscape- and Stand-level Structural Retention in Large-Scale Mountain Pine Beetle Salvage Operations (December 2005)[20]
- Best Management Practices for Soil Conservation in Mountain Pine Beetle Salvage Operations.[21]

Where both wildfires and insect outbreaks have affected the landscape, planning should consider the interacting effects of both disturbances and should be based on all relevant guidance.

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[14] https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/forest-and-range-practices-act-frpa-section-108

[15] http://www.fesbc.ca/index.html

[16] https://climate.gov.bc.ca/feature/restoring-forests/

[17] https://www.for.gov.bc.ca/tasb/slrp/lrmp/williamslake/cariboo_chilcotin/plan/biodiv/2014_June_Final_Information_Note1.pdf

[18] https://www.for.gov.bc.ca/hfd/library/fia/2004/FIA-04-05-0086a.pdf

[19] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/bark-beetles/restorationguidance_spruce_beetle_20sept2017.pdf

[20] https://www.for.gov.bc.ca/hfd/library/documents/bib95960.pdf

[21] https://www.for.gov.bc.ca/hfd/pubs/docs/En/En91.pdf

# APPENDIX 1 – Severity and Impacts of a large wildfire complex: The 2017 Cariboo wildfires.

## Area burned

In 2017, wildfires affected over 1.2 million hectares in British Columbia, the largest impact on record, and over eight times larger than the average annual area burned (142,000 hectares). The area affected is seventeen times larger than the long-term median, because there were relatively few, very large wildfire years; 40% of the total area affected by wildfire in the last century was the result of the 10 largest wildfire years (Figure 1).

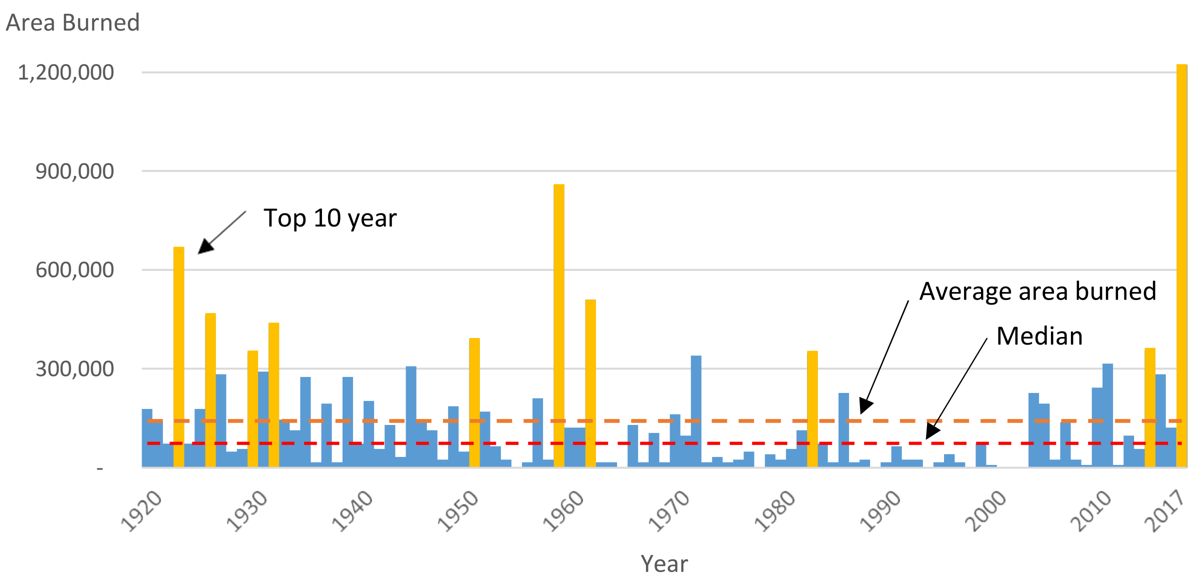


*Figure 1. Annual area affected by wildfire provincially.*

Ninety-six percent of the area affected by wildfires in 2017 was in the southern interior (Cariboo, Kootenay/Boundary and Thompson/Okanagan forest regions), with 80% of the affected are in theCariboo region. Only 40,000 hectares were burned on the coast and in the northern interior (Figure 2).

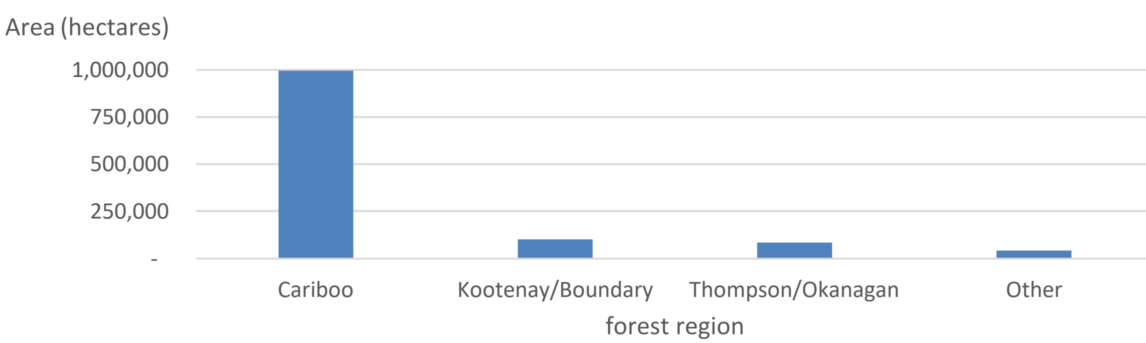


*Figure 2. Regional area affected by the 2017 wildfires (Other includes the South Coast, West Coast, Skeena and Northeast regions).*

It is important to understand that these estimates represent the total area within the mapped perimeter of the wildfires. However, not all of the forest in these areas was completely consumed by wildfire. Estimates of burn severity, based on satellite image interpretation, are complete for 88%[xxv] of the burnt area, and show that the burns were highly variable in intensity (Table 1).

The three largest wildfires in 2017 represent over 75% of the area affected; the **Plateau Fire complex** (521,000 hectares), the **Hanceville-Riske Creek** fire (239,000 hectares), and the **Elephant Hill** fire (192,000 hectares) (Figure 3). The Plateau Fire complex is the largest wildfire on record in BC; double the size of the previous largest wildfire (a 244,000-hectare wildfire that occurred in 1958).

*Table 1. Proportion of area inside the wildfire perimeters by burn severity category*

| Severity Category | Estimated % of volume killed* | Area (hectares) | Percent of Area |
|---|---|---|---|
| Unburned | 3 | 82,031 | 7 |
| Low | 14 | 148,966 | 12 |
| Medium | 27 | 340,726 | 28 |
| High | 85 | 504,740 | 41 |
| Known Severity Total | | 1,076,463 | 88 |
| Unclassified | | 149,399 | 12 |
| Total Area | | 1,225,862 | 100 |

*Estimate of % volume killed in each category is derived from post-fire field measurements of volume loss in monitoring plots within the fire perimeter.

## Effects on forest ecosystems and age classes, effects of burn severity on timber volume

The 2017 wildfires affected one million hectares of forest, nearly 2% of the forested area of the province (55 million hectares). The remaining 200,000 hectares affected by wildfire was non-forested; mostly grasslands. Nearly 80% of the forested area was mature forest (greater than 80 years old) and nearly 25% was old forest (greater than 140 years old) (Figure 4).

Nearly 75% of the area affected was in seven, primarily dry and very dry, Biogeoclimatic Ecosystem Classification (BEC) subzones/variants: IDFdk3, IDFdk4, IDFxm, MSxv, SBPSdc, SBPSxc and SBPSmk.

A total of nearly 60 million $m^3$ of timber volume in the timber harvesting land base (THLB) was within the area affected by wildfire in the four most severely affected TSAs; (Table 2). Based on the estimated percentage of trees killed by wildfire in each severity class (Table 1), approximately 22 million $m^3$ of timber was killed by wildfire in those TSAs and an additional 12 million $m^3$ of timber already killed by MPB was burned during the wildfires. An additional 3.5 million $m^3$ was affected across all severity classes elsewhere in the province.

[xxv] The percentage of burn severity estimate mapping complete as of January 12, 2018.

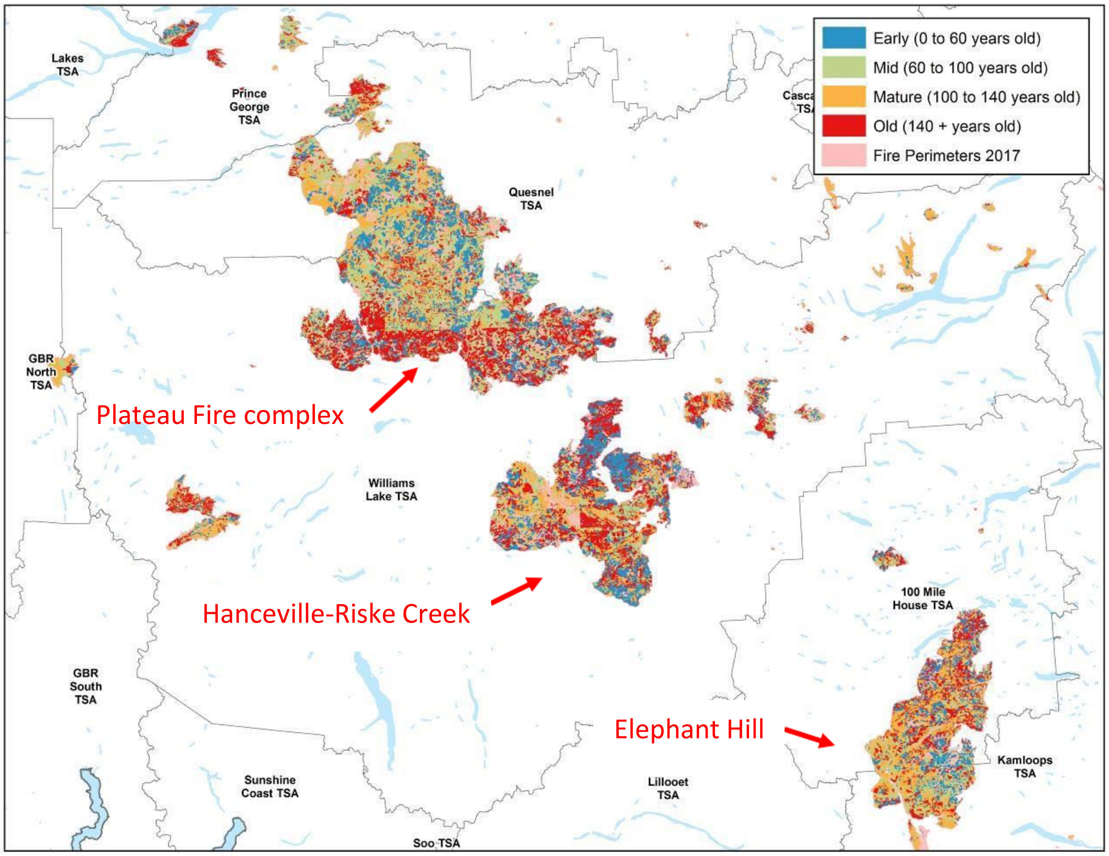


*Figure 3. Age class of forest affected by wildfires; showing the area of greatest damage (the Cariboo Forest Region) andhighlighting the three largest wildfires.*

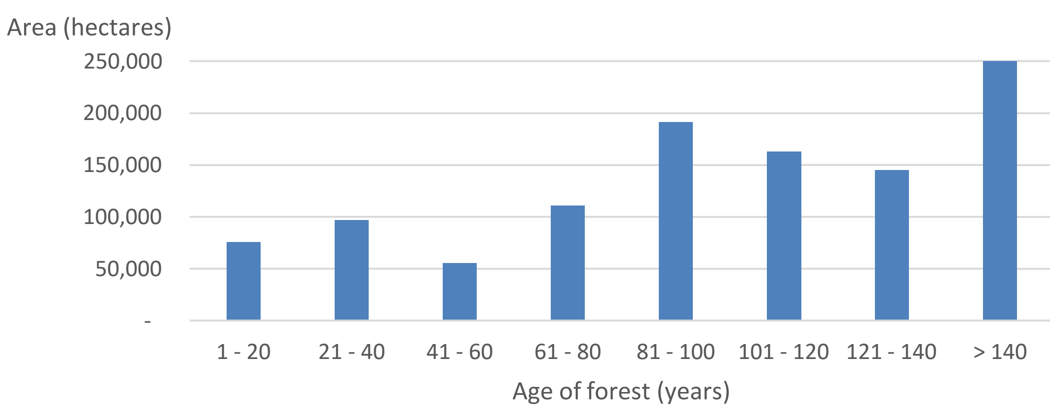


*Figure 4. Provincial summary of age of forest burned.*

*Table 2. Volume (000s of $m^3$) of live and dead (killed by mountain pine beetle) timber in the timber harvesting land base affected by the 2017 wildfires, by Timber Supply Area and burn severity class*

| | | Burn Severity* | | | | |
|---|---|---|---|---|---|---|
| **Timber Supply Area** | **Live/Dead** | **Unburned** | **Low** | **Medium** | **High** | **Total** |
| Quesnel | Live | 18 | 242 | 1,012 | 7,707 | 8,979 |
| | Dead | 9 | 138 | 1,007 | 6,636 | 7,790 |
| | | | | | | 16,769 |
| Williams Lake | Live | 54 | 320 | 1,079 | 6,700 | 8,153 |
| | Dead | 9 | 52 | 441 | 2,693 | 3,195 |
| | | | | | | 11,348 |
| 100 Mile House | Live | 26 | 320 | 585 | 2,835 | 3,766 |
| | Dead | 3 | 49 | 130 | 598 | 839 |
| | | | | | | 4,604 |
| Kamloops | Live | 7 | 88 | 289 | 1,035 | 1,418 |
| | Dead | 0 | 13 | 133 | 342 | 489 |
| | | | | | | 1,907 |
| Total** | Live | 105 | 970 | 2,965 | 18,276 | 22,316 |
| | Dead | 21 | 252 | 1,711 | 10,329 | 12,313 |
| | | | | | | 34,629 |

* See Table 1 for definitions of burn severity classes. Approximately 0.5 million $m^3$ was inside the perimeter of wildfires where burn severity was not estimated.

** Approximately 3.5 million $m^3$ was affected to varying degrees in other TSAs; notably, Prince George, Invermere and Cranbrook.

## Effects on special management areas

The 2017 wildfires had a significant effect on 'special management areas' in the province, notably Wildlife Habitat Areas (WHAs), Ungulate Winter Ranges (UWRs), Old Growth Management Areas (OGMAs) and parks and other protected areas (e.g. ecological reserves) (Figure 5).

The only legally designated OGMAs that were affected by wildfires were in the Cariboo region, where about 15% of the OGMAs were affected (118,000 of 791,000 hectares). Throughout the rest of the southern interior,[xxvi] about 2% (22,000 of 1,087,000 hectares) of 'non-legal' OGMAs[xxvii] also burned.

Provincially, about 3% of the area in UWR was affected; but 6% of the area in UWR specifically designated for bighorn sheep and 8% of the mule deer UWRs were affected. In the Cariboo region, the most severely affected area, just over 10% of the UWRs were affected.

Provincially, about 1% of the area in WHAs was affected, but 22% of the area in American White Pelican WHAs was affected; the latter located around lakes in the Cariboo region.

[xxvi] Kootenay-Boundary and Thompson-Okanagan regions.

[xxvii] Spatial OGMAs referenced in FSPs but not legally designated by government under a Land Use Objectives Regulation order.

Less than 0.5% of the area in parks and protected areas in the province was affected by wildfires, but some individual parks were severely affected (Table 3).

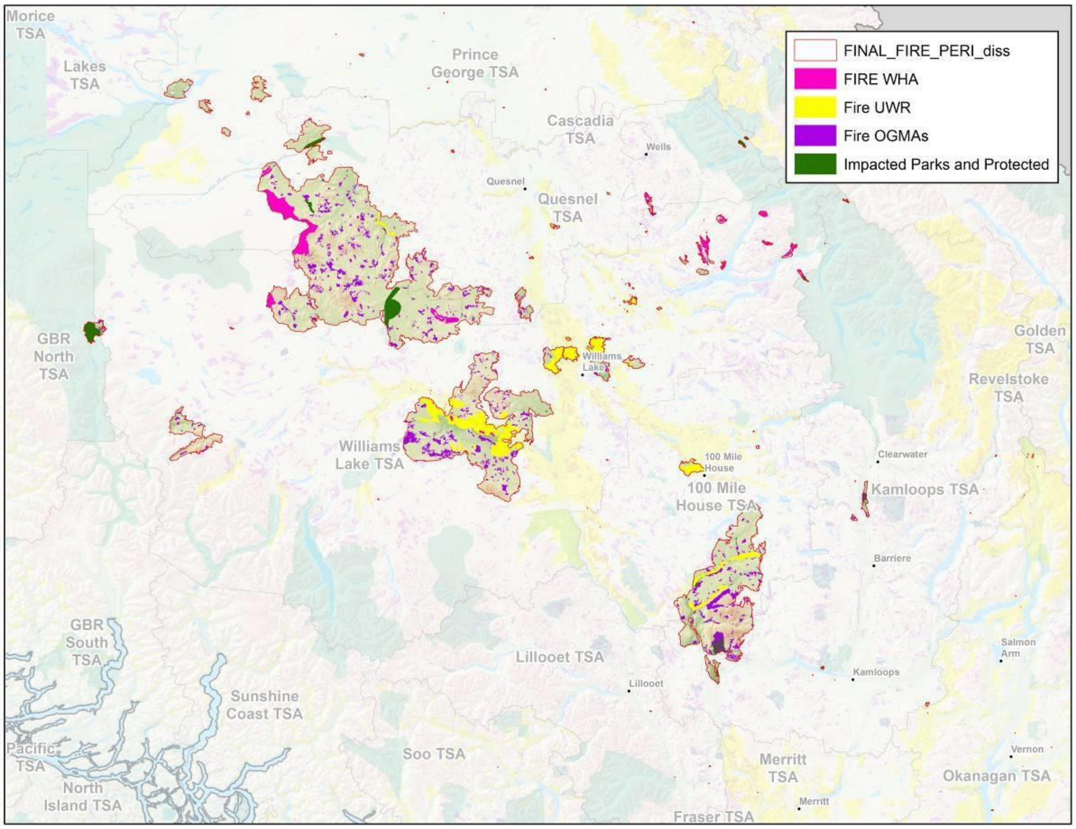


*Figure 5. Extent of wildfires in special management areas in the most severely affected portion of the province.*

*Table 3. Proportion of area impacted in severely affected protected areas (i.e., greater than 30% affected)*

| Protected area name | Area affected | Total area | Percent affected |
|---|---|---|---|
| Narcosli Lake Ecological Reserve | 1,090 | 1,090 | 100% |
| Loon Lake Park | 3 | 3 | 99% |
| Arrowstone Park | 5,561 | 6,156 | 90% |
| Nazko Lake Park | 9,410 | 12,063 | 78% |
| Big Creek Ecological Reserve | 113 | 262 | 43% |
| Akamina-Kishinena Park | 3,505 | 10,635 | 33% |
| Chasm Park | 1,025 | 3,152 | 33% |
| Darke Lake Park | 483 | 1,504 | 32% |
| Elephant Hill Park | 295 | 973 | 30% |

## Forest health considerations

Approximately 40% of the area affected by the 2017 wildfires burned in areas that were already affected by the ongoing MPB outbreak (which began in 1999). While that infestation had largely subsided;[16] mountain pine beetle populations are again increasing, with affected area up by forty percent over 2015 (to 55,000 hectares) in the southern interior.[17]

Spruce Beetle (*Dendroctonus rufipennis*) and Western Balsam Bark Beetle (*Dryocoetes confusus*) infestations are on the rise in BC. However, most notable in the context of the 2017 wildfires, is the significant year-over-year increase in DFB attack throughout the southern interior, with up to an eightfold increase in some areas between 2015 and 2016. Eighty-five percent of the area affected by theDFB is in the Williams Lake and 100 Mile House TSAs, although only 194 hectares of this DFB area is within the wildfire perimeters.[17]

Fire-damaged forest can increase the growth and severity of DFB infestations and it is likely that the current DFB infestation will increase in size, partly as a result of the 2017 wildfires. Landscape-level suppression of DFB is not practical,[18] compared to the efficacy of single-tree treatments for MPB suppression across landscapes at low infestation levels. DFB treatments to suppress infestations across landscapes are ineffective; in part, related to challenges identifying green attacked Douglas-fir, and in part, related to the operational difficulty of undertaking single-tree treatments (fall and burn) on large, mature Douglas-fir trees. Objectives for DFB management are therefore focused on reducing the spread of the beetle to reduce future timber losses.

The success of implementing these objectives will depend on careful consideration of other values that may be impacted by DFB management. In particular, aggressive management strategies for DFB assume that there is a commitment by all stakeholders to support multiple, consecutive years of DFB control activities that include both short-term and long-term strategies. It is understood that Mule Deer Winter Range (MDWR), OGMA, watershed or aesthetic considerations can limit the application of aggressive management tactics and/or directed harvesting.

# APPENDIX 2 - Effects of post-wildfire salvage harvesting on ecosystems and societal values

*This appendix is currently in draft format. It will be reviewed and updated as new information becomes available.*

Post-wildfire salvage harvesting is often conducted to recover economic value in the dead and damaged trees that would otherwise be lost. Other specific objectives include: mitigating safety concerns, reducing fuels available for subsequent wildfires; reducing the incidence of forest pests and improvingthe re-establishment of forest cover. While salvage harvesting may be an effective management response to disturbance, the degree to which these objectives can be achieved, and whether attempts to achieve them compromise other values on the landscape, remains a matter of debate. [8,19,20-21]

## Ecological resilience and climate change

The ecological resilience of a system refers to the amount and type of disturbance an ecosystem can absorb while still maintaining its key organizing processes and structural and functional identity.[6,22,23] In BC forests, key organizing processes create a range of tree species and stand ages across landscapes, creating a diversity of habitats and accordingly structuring local plant and animal populations. Resilience does not mean that systems survive disturbance, but rather, that they thrive from it; ecological resilience indicates the range of natural disturbance that maintains a system's adaptive capacity and its tendency to self-organize and persist. [23–25] Ecological resilience (and ecological thresholds, or 'non-linear change dynamics'; see Box 2[26–29]), has emerged as the predominant framework for understandingdisturbance ecology, with literature notably arising from study of the forests of western North America. [30–33]

Thresholds in the range of natural variability (Box 2) can accordingly be used to identify changes that may significantly affect the provisioning of ecosystem services. Disturbance thresholds are relevant for three reasons. First, because ecosystems may respond differently to large, infrequent disturbances than they do to smaller, more frequent disturbance of the same type.[34,35] This implies that disturbance effects on recovery that are relatively benign at finer scales can be problematic for ecosystem functioning if they are widespread over coarser scales. For

***BOX 2. Ecological Thresholds:*** *At the boundaries of system capacity, ecosystems lose resilience where ecological thresholds occur - changes in key ecosystem processes that produce a markedly different condition. Ecological thresholds and the loss of resilience are of particular management concern in wildfire affected areas because breaching thresholds can cause long-lived or effectively irreversible changes on the landscape, such as loss of the ability to self-organize to the previous state. In wildfire landscapes, loss of resilience could result in shifts to grasslands, persistent shrub-dominated states or different (i.e., less desirable) forest composition and structure (e.g., lower value tree species, low density stocking).*

example, the removal or destruction of seed sources, if it exceeds the dispersal capacity of the species, can change local or regional vegetation composition.[28,36] Habitat losses that can be temporarily tolerated at finer scales (i.e., habitat ‘’sinks”) can cause threshold effects on populations (e.g., rapid declines) at landscape levels if sink habitat is widespread.[37]

Secondly, because habitat is structured by the range of natural variability in disturbance regimes at stand and landscape scales, and species have evolved within these regimes, exceeding thresholds in the rate, extent or severity of disturbance can result in threshold effects on individual species, through loss or alteration of habitat, if their minimum requirements for habitat amount, connectivity, or quality are no longer met.[37]

Third, in addition to the implications of large, infrequent disturbances, the multiple nature of disturbance in the wildfire landscapes is of concern to disturbance thresholds in the context of recovery. The unprecedented 2017 wildfires burned in landscapes that were in the early stages of recovery from two previous, large disturbances; first, a mountain pine beetle outbreak of exceptional extent, and second, the ensuing, salvage harvesting operations. Ecosystems are at their lowest resilience immediately following disturbance, meaning that thresholds are most likely to be breached at this time, and that the system is less resilient to subsequent disturbance.[38] The empirical evidence for threshold effects caused by multiple disturbances in quick succession is in part related to climate change and the amplifying effects of the disturbance interactions, and resulting lag times in recovery or the loss of capacity to self- organize, with an increase in random, unpredictable (i.e., stochastic) outcomes. [22,28,39–44]

It is likely that the landscapes of the 2017 wildfires represent extremes, if not breaches, in these measures of disturbance – extent, severity, periodicity, and disturbance interactions. The relatively rapidperiodicity of large, interacting disturbances (MPB, salvage, wildfire) in the landscapes of the 2017 wildfires have resulted in the presence of multiple, key factors that in other landscapes, and in the face of climate change, have led to the loss of ecological resilience. A substantial portion of the area disturbed by wildfire is predicted to change BEC variant or subzone by 2050. There is concern that the effects of these multiple, interacting landscape-scale disturbances, in conjunction with the effects of a century of natural resource development[10] and current and projected changes in climate, may compromise recovery, the ecological resilience of these ecosystems and/or their resident species.[6,7,14]

## Effects on soil

Soils deserve particular attention because soils and soil productivity are irreplaceable within human time frames, and are crucial to forest recovery, stream conditions, and hydrologic processes. Post-wildfire salvage harvesting, unless very carefully managed, has negative effects on forest soil; over and above the effects of crown fires alone (destruction of surface organic matter causing soil erosion and loss of soil nitrogen).[8]

Wildfire-affected soils are especially vulnerable to additional disturbance (e.g., compaction or increased erosion), partly as a result of changes in soil processes caused by intense burning that can produce hydrophobic soils (Box 3[45]). Post-wildfire salvage harvesting can further damage soils by compacting them, by removing vital organicmaterial, and by interacting with

***BOX 3. Hydrophobic Soils:*** *when plant matter is burned during an intense fire, a waxy substance is released and it penetrates the soil as a gas. When the soil cools, this waxy substance hardens around soil particles and the soil becomes hydrophobic. Hydrophobic soils repel water and the amount of water that can infiltrate the soil is reduced.*

hydrophobic soil conditions to increase the amount and duration of topsoil erosion and runoff, which in turn harms aquatic ecosystems. The potential for damage to soil and water resources is high when ground-based machinery is used.[10,46]

Another concern is the potential for increased erosion susceptibility associated with site preparation to control competing vegetation and remove slash. Site preparation techniques which inhibit growth of

vegetation may contribute to increased hillslope erosion in high-risk areas, especially when increased rainfall occurs.[20] Erosion impacts of road construction are among the main impacts of post-wildfire salvage harvesting on soil when the surface has been bared by wildfire. Skidding logs across bare ground disturbs and compacts soil. However, while compaction can be detrimental on clay-based soils, on sandy soils compaction may enhance plant growth.[8] Tractor harvesting and ground-based equipment on relativelylevel areas (<30 percent slope) cause the most soil compaction, although some effects can be mitigated by avoiding wet soils, harvesting over snow, and operating over slash rather than areas with thin forest floors.[8]

## Effects on water

Wildfires cause the loss of forest cover which can result in reduced interception of precipitation and increased snow accumulation amounts. Snowmelt rates may also increase due to increased net radiation, and reduced transpiration rates can result in increased soil erosion. These effects result in greater soil/groundwater recharge and greater runoff in the burnt watersheds during spring melt.[11,47] Following wildfire, numerous changes in water quality are possible, with variable rates of recovery. Potential effects include increased turbidity, nutrients (e.g., nitrogen and phosphorus), dissolved organiccarbon, heavy metals (e.g., mercury), and temperature.[47] As discussed above, intense wildfires can create hydrophobic soils that impede water infiltration into the soil profile, creating a functionally shallow soil. Wildfire-induced hydrophobicity is transient and often patchy.[8]

All of these effects can be amplified by salvage harvesting activities; especially the construction of roads, harvesting with ground-based equipment and cable yarding.[8,10,11,47] In a well-studied set of watersheds in western Alberta, sediment production was elevated in burnt and salvage-logged watersheds (nine and 37 times greater, respectively) compared to unburnt catchments. This effect has shown no recovery in the 11 years since the wildfire.[11] Dissolved organic carbon (DOC) and turbidity are water quality parameters that are important to drinking water providers. In the area, DOC concentrations of 4–5 mg/l (near or above which is known to pose additional water treatment challenges) were exceeded in salvage-logged, burnt and unburnt catchments about 50%, 8%, and 4% of the time, respectively. Turbidity exceeded the 10 Nephelometric Turbidity Unit (NTU) threshold about 18%, 10%, and 2% of thetime, respectively.[11] Long-term sedimentation impacts were also found following wildfire salvage in the western U.S., where sedimentation differences between control and ground-skidded plots worsened over time as the control plots recovered more rapidly.[48]

These results indicate that salvage harvesting may cause significant difficulties for water purveyors. Protection of source water may be more effective and less expensive than dealing with the impacts of salvage harvesting through increased levels of post-harvesting rehabilitation.[47]

Changes in hydrology can contribute to a statistically significant increase in numbers of landslides, floods, debris flows and other mass-movement events in susceptible terrain, following severe wildfire in snow-dominated environments.[12] Post-wildfire salvage harvesting may increase mass wasting and deliver more terrestrial sediment to stream channels than burnt watersheds without salvage harvesting. Salvage harvesting may increase the risk of sedimentation regardless of equipment type and amount of traffic.

The increased sediment production and consequent deterioration in water quality associated with salvage should be understood as a trade-off against the positive values of salvage harvesting.[49]

Specific best management practices are needed to mitigate the hydrologic impacts of post-wildfire salvage harvesting to reduce the impacts on post-wildfire sediment production and delivery to the stream network.[46,48] The potential for salvage harvesting to cause soil disturbance should be considered in consultation with soils specialists prior to commencing any operations.[50]

## Effects on aquatic and riparian ecosystems

Even small changes in water quality can have significant impacts on aquatic ecology, resulting in greater algal production, increased aquatic invertebrate abundance, and shifts in invertebrate community structure.[47] Increased runoff and erosion resulting from salvage harvesting alters river hydrology by increasing sediment loads and the frequency and magnitude of high flows. These changes alter the character of river channels and may cause harm to a range of aquatic species.[10,59]

The behaviour of wildfires in riparian zones is complex and results in a variety of responses; many riparian organisms can recover rapidly after wildfires. Unless constrained by other factors, fish may not be affected[11] or will rebound relatively quickly. Erosion events associated with wildfires can contribute wood and coarse sediment that can create and maintain productive aquatic habitats.[47]

Given that wildfire in riparian areas creates conditions that may not require intervention to sustain long-term productivity, post-wildfire riparian zones should be provided with the same environmental protections they received before they burned.[60]

The effects of salvage logging within riparian management areas (RMAs) have been studied in relation to trees killed both by insects and by fire.[61,62,63,64] In both cases, the removal of the large woody debris (LWD) supply is seen as one of the lasting impacts of harvest, which decreases habitat value not just for fish, but also amphibians and the mammals that rely on riparian vegetation for survival.[65] Burnt timber may remain standing for 15+ years and, combined with any surviving live trees that are often found in wetter riparian areas, they provide a consistent source of wood to the channel and the surrounding area. The removal of burnt timber may create LWD deficiencies for a century or more until the new forest is mature enough to start contributing to the channel. Riparian soil compaction from heavy machinery disturbance can severely reduce the infiltration capacity of soils, increasing surface flow from precipitation and snowmelt until new vegetation is established.[66] Fine sediments associated with such flow increases may impact fish and fish habitat even through connected non-fish streams.[64]

## Effects on wildlife and biodiversity

The effects of wildfires on wildlife and biodiversity are mixed. In part, this is due to the differential effects of the 2017 BC wildfires on specific wildlife habitat. For example, although less than 1% of the area in WHAs was affected, over 20% of the shoreline areas set aside for American White Pelicans was affected. However, more generally, species associated with the trees in closed forest canopies decline following crown fires, whereas those associated with open forest conditions and snags increase their populations. Species associated with early successional shrub and herb understories (e.g., ungulates) generally benefit following wildfire, whereas those associated with large woody debris may decrease until new, downed wood is recruited.[8]

The effects of post-wildfire harvesting are somewhat less ambiguous. While wildfire has a positive or neutral effect on cavity-nesting birds; post-wildfire harvesting usually has a negative effect. Lewis' woodpecker (*Melanerpes lewis*) may benefit from limited post-wildfire harvesting because it accelerates the development of open stands. Black-backed woodpeckers (*Picoides arcticus*) and three-toed woodpeckers (*P. tridactylus*) are associated with dense stands and snags, and would likely not benefit from post-wildfire harvesting.[8]

There are relatively few studies which have examined effects of post-wildfire harvesting on early-seral species that may benefit from salvage. A study of the effects of post-wildfire harvesting sites on relationships (i.e., trophic dynamics) between wolves (*Canis lupus*), three ungulate species and ungulate forage biomass during the first three years after a large burn in the Canadian Rockies found that wolves selected post-wildfire harvesting that was close to roads and had high forage biomass because of the logged openings. This translated to the highest predation risk for elk in post-wildfire logged areas. Ungulates avoided post-wildfire logged areas because of the predation risk and despite enhancements to forage biomass.[67] The authors of the study concluded that managing hunting-related access was a principal and relatively easily managed concern related to post-wildfire harvesting.[67]

A meta-analysis across 24 species groups revealed that salvage harvesting significantly decreases numbers of species of eight taxonomic groups. Richness of taxa dependent on dead wood (i.e. saproxylic organisms) decreased more strongly than richness of non-saproxylic taxa. In contrast, taxonomic groups typically associated with open habitats increased in the number of species after salvage harvesting.[13] The authors concluded that any negative effects of salvage harvesting could be partly mitigated by employing a green tree restoration approach and by leaving substantial amounts of deadwood on site to reduce the impact of salvage harvesting on biodiversity.[13]

In BC, salvage harvesting as a management response to the mountain pine beetle outbreak has been shown to have some negative effects on ecosystem resilience; primarily because salvage harvesting creates homogeneous landscape structure and composition that is less resilient to future disturbances.[68,69] In contrast, un-salvaged stands create heterogeneous forests that can recover more quickly, as a significant portion of biological legacies (e.g., surviving trees, snags and logs, patches of intact vegetation, seedbanks in tree crowns or in the soil) of that particular ecosystem remain intact. These early-successional forest ecosystems – known as ‘complex early seral forests’ – that develop after natural disturbances, are diverse, and often rich in biological legacies. Management activities, such as post-disturbance harvesting and tree planting, can reduce the richness within and the duration of early-successional ecosystems. Where maintenance of biodiversity is an objective, the importance and value of these natural early-successional ecosystems are key.[70,71]

## Uncertainty

There are numerous sources of uncertainty influencing post-wildfire recovery. Some of these can be anticipated and addressed; others cannot. First, there may be mismatches between relevant scales of processes of interest, and the metrics used to evaluate them. For example: stand-level processes like generation of sedimentation; or declines in species’ reproductive rates linked to the absence of key habitat elements such as snags may not be detected by harm prevention assessments at the landscape- level, such watershed-level assessments of sedimentation; or population-level counts of species presence.[37,82] These sources of uncertainty can (at least in theory) be corrected, reconciled or minimized, by involving the appropriate experts, and using better data to inform decision making.

Other sources of uncertainty may be anticipated, but poorly quantified. For example, we expect directional climate influences in the affected forests, but there are broad predictions in the magnitude and timing of these changes, with multiple plausible outcomes. Yet other sources of uncertainty may not even be anticipated – “the unknown unknowns”; for example, the recovery pathways that could occur in the wildfire landscapes following multiple past and ongoing, interacting disturbances.

While they are affected by multiple, widespread, severe disturbances, there is inadequate understanding about the ''boundaries'' of resilience (Box 2) in the ecosystems burned in the 2017 wildfires. The consequences of exceeding resilience boundaries are similarly unknown, particularly giventhe uncertainty around future climate.

The idea of ecological resilience and thresholds in the context of climate change should make us realize that systems under management are capable of producing unexpected, non-linear responses to management actions in surprising circumstances.[14,30,72]

These types of uncertainty, dubbed "deep uncertainty" to describe their intractable aspects, are a particular type of "wicked" public policy problem – one that calls for a response beyond the ordinary.[73–76] In the case of the wildfires: a scoped and planned, future-focused, risk-averse approach to salvage harvesting and restoration that minimizes long-term regrets. Our main basis for policy and practices should derive from our inability to predict losses due to uncertainty.[77] This uncertainty is the harm prevention lens through which practitioners should consider salvage harvesting.

## Conclusion

Salvage harvesting has consistently been shown to have some negative effects on ecosystem services (Millennium Ecosystem Assessment[9]), over and above that of wildfires themselves; particularly those services related to soil productivity,[8,10] water quality,[11] water regulation[12] and habitat.[13]

As the MPB epidemic did previously, the 2017 wildfires suggest a reconsideration of the extent and severity of disturbance that is possible under climate change. Similarly, the time and pathways to recovery in these landscapes may not conform to existing knowledge and assumptions.[30,72] It is difficult to assess and quantify the effects on recovery of ongoing climate change and the multiple, extensive, interacting disturbances that have already occurred in these landscapes. However, much of the forest that burned in 2017 was retained on the landscape to serve as a source of stand and landscaperecovery, following the previous MPB disturbance and salvage harvesting. In the landscape context, the wildfires have increased the emphasis placed on the recovery capacity within the remaining, unburnt and low to moderately burnt forests. The possibility that natural disturbance thresholds have been breached, and the possible, undesirable outcomes of this scenario (i.e., delayed recovery, loss of ecological resilience, breaching of species' minimum habitat requirements), should be considered in designing restoration strategies.

In general, even in the absence of multiple disturbances in quick succession, the advice in the scientific literature points to the long-term cost-effectiveness of supporting natural processes of recovery and using intervention to mitigate further impacts.[10] Leaders in the field of natural disturbance ecology have recently suggested that there are benefits from natural disturbances, like wildfires, that can be retained with proper management based on the notion of 'quarantining' (not managing) areas that become refugia (i.e., undisturbed by further management through salvage harvesting) for ecosystem processes and elements, and by developing prescriptions for areas that will be managed (salvage logged), regulating the number and type of biological legacies to retain.[79]

This perspective suggests that there are opportunities to address the ecological and social values that are at risk in the absence of salvage (i.e., potential habitat degradation and losses to climate change; potential mid-term timber losses to further DFB activity, recovery of partially damaged stands to merchantable volume). However, the current conditions and the magnitude of disturbance in these landscapes suggests that restoration planning should place the consideration of the long-term provision ofecosystem values over the short-term economic gain obtained from salvaging the burnt timber.

Thus, planners can develop a framework in the context of best management practices for salvage harvesting, to set management objectives and execute these through strategic, tactical and operational plans. In this case, the primary objective of salvage is to "*specify...management pathways for attaining desired combinations of species, forest structure and ecological function...*"[53] This will often include leaving biological legacies in stands and landscapes through partial cutting and/or restoration of snags andlive trees in short-term or long-term reserves.

Ongoing climate change points to the need for salvage harvesting plans to also consider tactical management strategies for climate adaptation – i.e., identify those areas currently most vulnerable to climate change, and their likely pathways of recovery, including possible shifts to grassland or to forests with altered species composition. Likewise, the ongoing DFB and other forest health issues suggest that planners can take a calculated approach in the rehabilitation strategy, to target salvage in areas that will benefit most from minimizing the impacts of further disturbance.

Focusing on mitigating short-term disturbance impacts with best management practices for salvage and retention is key. Best management practices for salvage are those that lead to deliberate strategies to create the desired future condition; managing wildfire-affected stands and landscapes to meet objectives for wildlife habitat, climate change, fuel reduction, recovery and social and economic values.[53]

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# APPENDIX 3 – A description of joint APEG-ABCFP guidelines pertinent to watershed assessments.

Qualified professionals conducting watershed assessments - will be consistent with the following joint ABCFP-APEG guidelines and as they may be updated from time to time:

1. Watershed assessment and management of hydrologic and geomorphic risk in the forest industry (2020)
2. Guidelines for management of terrain stability in the forest sector (2008)
3. Guidelines for professional services in the forest sector – terrain stability assessments (2010)
4. Guidelines for professional services in the forest sector – forest roads (2012)
5. Guidelines for professional services in the forest sector – crossings (2014)

## Watershed assessment and management of hydrologic and geomorphic risk in the forest industry (2020)

These guidelines were prepared by a team comprising members of the Association of British Columbia Forest Professionals (ABCFP) and Engineers and Geoscientists British Columbia (Engineers and Geoscientists BC) Joint Practice Board with contributions from members of the College of Applied Biology. These guidelines have been formally adopted by the Councils of ABCFP and Engineers and Geoscientists BC.

These guidelines set a standard of practice for forest professionals who are responsible for managing hydrologic and geomorphic risks to values, including requiring development of a watershed risk management framework that establishes risk tolerance criteria, identifies when and what type of Specialist assessments are to be carried out, and determines how risks are to be evaluated and managed for watershed values. As well, the disturbances and watershed processes to be investigated are described, and guidelines for carrying out hydrologic assessments are referenced (as distinct from Watershed Assessments). These guidelines are consistent with existing (2020) national and international language for risk management.

These guidelines provide a common level of expectation with respect to the degree of effort, due diligence, and standard of practice to be followed when managing watershed risks and carrying out watershed Assessments in BC. These guidelines are not a manual of procedures for conducting the various technical components of a Watershed Assessment or for prescribing Risk control measures.

## Guidelines for professional services in the forest sector – terrain stability assessments (2010)

These guidelines establish a standard of care for carrying out terrain stability assessment (TSA) related to planning and operations in British Columbia. They can also assist a terrain specialist and his/her client to establish the scope of work in an agreement to conduct a TSA. In addition, these guidelines describe the skill sets required by a member to be competent to carry out a TSA. Consistent with ABCFP/APEGBC Joint Practice Board's (JPB's) terms of reference, these guidelines apply solely to members of ABCFP and APEGBC and to TSAs associated with forest development in British Columbia.

The guidelines set out the purpose and objectives of a TSA, describing when they are commonly conducted. They specify the roles and responsibilities involved and the guidelines for professional practice, including: the responsibilities of the terrain specialist; necessary preliminary work; the types of fieldwork involved; the structure and potential content of reports and supporting rationales; and the types of quality assurance work that should be carried out by specialists who have completed TSAs.

## Guidelines for management of terrain stability in the forest sector (2008)

These guidelines are intended to assist in the management of terrain stability by providing guidance for establishing, implementing, and updating a Terrain Stability Management Model (or simply model). A model should provide guidance:

- as to when and where a TSA should be carried out;
- for managing terrain stability, whether or not a TSA has been carried out;
- for establishing risk criteria for specified values (elements at risk);
- for selecting Forest Development strategies that are consistent with the risks; and
- for establishing a consistent and logical decision-making process to analyze and
- document decisions concerning the management of terrain stability.

A model is intended to help optimize the use of TSAs by focusing such assessments on areas where Forest Development may pose an unacceptable risk to the interests of the public, worker safety and the environment. These Guidelines set out general standards of professional practice related to establishing, implementing, and updating a Terrain Stability Management Model for the forest sector. They should not be considered as a guideline for professional practice for other, non-forest-related development.

## Guidelines for professional services in the forest sector – forest roads (2012)

The objective of these guidelines is to establish a standard of care for planning, constructing, and maintaining forest roads, by:

- identifying professional tasks, roles, and responsibilities.
- identifying considerations that need to be addressed
- identifying outputs in the form of deliverables

These guidelines describe the professional practice associated with forest roads. These guidelines can assist a member and his/her client or employer to establish the scope of work required to complete the identified forest road activities. These guidelines describe:

- The scope of professional practice in the planning, construction, maintenance, and deactivation of forest roads.
- The skills and knowledge a competent member should have prior to undertaking the professional work identified in the forest road activities.
- Factors to be considered in the selection of road design standards and how standards will influence various factors.
- Road layout and survey objectives and considerations.
- Road design considerations including drainage, clearing width, geometric road design and assessments by specialists.
- The proper documentation of the road design (road plan) and reviews of road construction and conformance to the road plan.
- Inspection, maintenance, and deactivation planning.
- Requirements for quality assurance.

## Guidelines for professional services in the forest sector – crossings (2014)

These guidelines are intended to establish standards of practice that members should meet to fulfill professional obligations, including the duty to protect the safety, health, and welfare of the public and the environment. Failure to meet the intent of these guidelines could be evidence of unprofessional conduct and may give rise to disciplinary proceedings by the ABCFP or the APEGBC.
These guidelines apply to all phases of a professional engineer's or forest professional's involvement in a crossing project including guidance and considerations for:

- Project organization and assignment of responsibilities,

- Planning and design,
- General considerations,
- Hydrology and hydraulics,
- Plans and supporting documents,
- Approaches and alignment,
- Foundations and substructures,
- Superstructures,
- Construction and field reviews, and
- Crossing Assurance Statement.

These guidelines establish the requirements for and specify the tasks that should generally be performed by the coordinating registered professional (CRP) and the professional of record (POR), to assist them in fulfilling their professional obligations related to public and worker safety and protection.