Natural Disturbance and Post-Disturbance Management Effects on Selected Watershed Values

Extension Note

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Abstract

This extension note summarizes the key findings of the chapter entitled "A synthesis of the effects of natural disturbance and post-disturbance management on streamflow, stream temperature, suspended sediment, and aquatic invertebrate populations" of FORREX Series 28, which is an overview of the available research on the effects of climate change, natural disturbance (focused on wildfire and insect infestation), and post-disturbance management actions (primarily clearcut salvage harvesting) on key watershed processes and values. The scope of the synthesis was limited to the magnitude and timing of streamflow, stream temperature, suspended sediment, and aquatic invertebrate population dynamics. In general, the effects on hydrologic processes and watershed functions are greater following post-disturbance activities; climate change is anticipated to further negatively compound these natural disturbances. To maintain the resilience of watersheds (that is, the ability of natural systems to recover from perturbation), management activities should be designed to maintain natural hydrologic and ecosystem function wherever possible. Key considerations to maintain resilience include: planning management activities at the site, watershed and landscape scales, maximizing riparian overstory retention within 10 metres of streams, minimizing the introduction of fine sediments into surface water bodies, and monitoring the effects of disturbances and management interventions to support adaptive management. Using the best available information, along with advice from qualified watershed professionals, is key to ensuring effective management.

KEYWORDS: natural disturbance; wildfire; climate change; insect infestation; watershed; hydrology; peakflows; low flows; stream temperature; suspended sediment; forest management

Introduction

Some of the most dramatic effects of climate change are expected to be to the hydrologic cycle. Increased air temperatures and changes in precipitation patterns (i.e., timing, amount, intensity, and form) have the potential to alter both the availability (seasonality and quantity) and quality of freshwater (Pike et al. 2010a). In addition, there is a high likelihood for increased frequency, severity, and areal extent of natural disturbances (Haughian et al. 2012) as a consequence of climate change, which will

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affect hydrologic regimes. Management responses to natural disturbances have the potential to act as either adaptive measures to reduce the negative effects of natural disturbance, or to amplify the negative effects, depending on the value of interest and the management goals.

Changes to the future mean climate conditions and variability in British Columbia (BC), such as increased air temperature and altered precipitation patterns, will have dramatic effects on the hydrologic cycle (Pike et al. 2010a). The provincial annual average temperature is projected to increase by 1.7°C by the 2050s, with relatively uniform seasonal patterns between the regions, compared to the 1961-1990 baseline period. While precipitation is projected to see an overall annual increase, this varies both seasonally and regionally; throughout the province precipitation is projected to decrease during summer and increase in all other seasons, except in the Northwest and Peace Basin, where summer precipitation is projected to increase (Pike et al. 2010a). During the winter season, this increased precipitation, combined with warmer air temperatures, will potentially alter the rain/snow ratio. During the summer season, projected declines in summer precipitation will result in drier conditions; the projected conditions in the Peace Basin and Northwest, with estimated increased summer precipitation, are dependent upon the magnitude of temperature increase. Increased precipitation may not be enough to offset the higher temperatures and may result in drier conditions. These climatic changes have the potential to alter both the availability (seasonality and quantity) and quality of freshwater.

This extension note summarizes some of the key results of a comprehensive synthesis of the effects of natural disturbances (focused on wildfire and insect infestation) and the incremental effects of post-disturbance management activities (primarily clearcut salvage harvesting) on selected watershed values (Redding & Leach, 2012). The purpose of this extension note is to outline the impacts to watershed values of both natural disturbances and the post-disturbance management activities applied in response to those disturbances. The key watershed values examined are changes in streamflow (peak and low flow magnitude and timing), stream temperature, suspended sediment, and aquatic invertebrate population dynamics. The research examined here on watershed effects of natural disturbances is focused on wildfire and insect infestations, as these disturbances are expected to have the largest effect on the forest landbase. Similarly, the review of post-disturbance management activities is focused on clearcut salvage harvesting, as this is the most widely applied and researched post-disturbance management response.

Natural disturbance and post-disturbance management activities alter numerous hydrological processes. It is beyond the scope of this extension note to provide a detailed overview of disturbance effects on hydrology; for further detail, see Redding and Leach (2012) and the relevant chapters of Pike et al. (2010b):

Chapter 6: Hydrologic processes and watershed response

Chapter 7: The Effects of forest disturbance on hydrologic processes and watershed response

Chapter 8: Hillslope processes

Chapter 9: Forest Management effects on hillslope processes

Chapter 12: Water quality and forest management

Chapter 15: Riparian management and effects on function

Chapter 16: Detecting and predicting changes in watersheds

Chapter 19: Climate change effects on watershed processes in British Columbia

Summary of anticipated effects of climate change, natural disturbance, and post-disturbance management activities on watershed processes/values

Hydrologic regimes in British Columbia can be divided into two broad categories: 1) rainfall dominated, where annual streamflow patterns are dominated by rainfall events (largely coastal regions, where high winter streamflows correspond with winter rainstorms); and, 2) snowmelt dominated, where annual streamflow patterns focus on a single annual peak related to snowmelt runoff (largely watersheds in the interior). This level of categorization, while an oversimplification relative to the four-regime classification proposed by Eaton and Moore (2010), was chosen to summarize the effects of climate change and natural disturbance, as it demonstrates the largest differences between regions and watersheds. The impact to watershed values and processes associated with natural disturbances, post-disturbance activities, and climate change are described below.

The streamflow response of a watershed is primarily driven by climate and weather (precipitation and temperature), with land-use activities being secondary effects that must be considered at the landscape scale (e.g., equivalent clearcut area [ECA]). For stream temperature, suspended sediment, and aquatic invertebrate communities, watershed land-use (e.g., riparian harvesting, road construction, stream crossings, hillslope-channel connectivity) have a strong effect and must be considered at both the site and landscape scales. The cumulative effects of disturbances (both natural and human) within a watershed must be considered at the watershed scale with an eye to how they will manifest at the local scale (Scherer 2011). Increases in air temperatures and changes in precipitation related to climate change have the potential to alter both the availability and quality of freshwater. In all cases, the effects of post-disturbance forest management activities increase the effects of the initial natural disturbance (Redding & Leach, 2012). For a detailed review of watershed hydrology and the effects of forest management, natural disturbance, and climate change, see Chapters 6, 7 and 19 in Pike et al. (2010b).

Streamflow

Streamflow encompasses the magnitude, timing, duration, and frequency of high and low flows and is dependent upon complex interactions between various watershed properties (e.g., forest cover, physiography, soil properties and geology) and climatic drivers (e.g., precipitation amount, timing, duration, intensity, as well as energy available for snowmelt) (Winkler et al. 2010a).

Peakflows are generated by rain events, rain-on-snow events, snowmelt, glacier melt, or in special circumstances, debris dam failures. The timing of rainfall generated peakflows is more sensitive to the timing of the precipitation event than to alterations within the watershed; however, watershed disturbances can alter the timing of peakflows by orders of hours to days (Winkler et al. 2010b). The timing of snowmelt generated peakflows is one of the key hydrologic changes of concern, and is more sensitive to watershed disturbance, as removal of the forest canopy can result in earlier and faster snowmelt (Winkler et al. 2010b). Currently, quantitative relationships between forest cover removal or regrowth, and peakflows at the watershed scale are not readily available in BC.

Low flows are the periods of low, or the total absence of, streamflow, and are often defined by the lowest average flow over a given time period (e.g., a 7-day period) (Winkler et al. 2010a). Within BC, low flows are controlled by precipitation and temperature at seasonal to multi-year time scales, and by the storage and transmission characteristics of the watershed. The water sustaining low flows typically is dominated by infiltrated precipitation through deep subsurface flows, groundwater aquifers, or shallow subsurface flow paths of high porous or interconnected macropores or preferential flow paths. Increased peakflows have the potential to negatively impact infrastructure, water quality, and aquatic habitat. Longer durations or lower flow volumes during the low flow period can impact water supply for humans and aquatic ecosystems and lead to higher stream temperatures.

Potential effects on peakflow magnitude and timing

- Predicted changes in temperature and precipitation differ from south to north and with elevation, complicating the ability to generalize effects on peakflows.
- The effects of climate change on peakflows from snowmelt-dominated watersheds will be partly related to watershed elevation, since elevation has an influence on precipitation type (rain vs. snow). It is expected that climate warming will cause the seasonal snow cover boundary to shift upwards to higher elevations. Watersheds with a large proportion of their area remaining above the seasonal snow cover boundary may experience little change or an increase in peakflow magnitude due to increased winter snowfall. Those watersheds that experience an increase in area lying below the seasonal snow cover boundary may have lower peakflows due to reduced snow accumulation and increased winter rains. Similarly, the timing of peak flows from lower elevation watersheds is likely to occur earlier due to warmer temperatures, leading to earlier melt. At higher elevations timing will likely stay about the same, depending on the change in air temperatures. The timing of peakflows is not expected to change for rainfall-dominated watersheds. Peakflow magnitudes in rainfall-dominated watersheds are expected to respond to more frequent large rainfall events, leading to larger peakflows and longer durations of high flows.
- The primary effects of wildfire on hydrologic processes is through a decrease in interception due to loss of canopy, reduced infiltration due to water repellency (potentially for a relatively short duration, 2-6 years [Curran et al. 2006]), and limited transpiration due to the loss of live canopy. Past research has shown that wildfire either increases or does not change the magnitude of peakflows. The changes in peakflow magnitude and timing following fire, or any disturbance that removes or kills the forest canopy, are strongly influenced by the weather; so, a severe disturbance may not result in significant increases in peakflow magnitude, if followed by a period of low precipitation. In snowmelt-dominated watersheds, the loss of canopy cover due to wildfire and/or salvage harvesting reduces shading of the snowpack, leading to earlier snowmelt and peakflows.
- The primary effect of mountain pine beetle (MPB) on peakflows is through the death of the forest canopy, which decreases the interception of precipitation, resulting in snow melting earlier and more rapidly. Stands or watersheds with a larger proportion of pine cover have the potential for larger effects on peakflows, while greater understory vegetation may somewhat reduce these effects (Huggard 2011). It is predicted that, following MPB infestation, the frequency distribution of peakflows will change such that events of a given magnitude may occur more frequently, or conversely, events of a given frequency (e.g., a 1 in 10 year event) will be of larger magnitude (Schnorbus et al. 2011). The size of the effect is dependent on the areal extent of the disturbance, with greater area disturbed generally leading to greater change in peakflow regime.
- Without watershed specific assessments of the amount, timing, and spatial arrangement of clearcut salvage harvesting, it is difficult to specify the incremental effects of post-disturbance management activities on peakflows. In general, however, clearcut salvage harvesting and other post-disturbance treatments that remove canopy trees from the watershed will magnify any reductions in interception, infiltration, and evapotranspiration, resulting from the natural disturbance, and lead to increased peakflow magnitudes above levels caused by natural disturbance alone. Some of the effects of salvage harvesting are related to the construction of roads, which can alter infiltration and drainage patterns (intercepting

shallow groundwater flow and channelling it in ditches), resulting in faster and greater volumes of surface runoff to streams.

Potential effects on low flow magnitude and timing

- The effect of climate change on summer low flows is expected to vary geographically throughout BC, with decreased flows in Southern BC and potential for increased flows in northern BC (Pike et al. 2010a). These expected changes in low flows are related to predicted changes in the seasonal distribution of precipitation (declining summer precipitation in southern BC; increased summer precipitation in northern BC). Increased winter flow volumes may occur in snowmelt-dominated watersheds due to the expected change in winter precipitation from snow to rain.
- It is generally assumed that disturbances (natural or human-caused) reducing the forest canopy cover over a watershed will result in more water available to sustain summer low flows (Carver et al. 2009).
- Post-wildfire low flow levels may increase due to a decrease in interception and evapotranspiration losses, resulting in more water being available to recharge aquifers or for runoff. The potential effects of hydrophobic soils in reducing infiltration and recharge on low flows are unknown.
- The effects of insect infestations or post-disturbance management activities on low flows are highly uncertain due to a lack of field-based or modelling research. Based on the hydrologic processes involved, it would be expected that greater water should be available to recharge groundwater following stand death (and salvage harvest), as less water is being returned to the atmosphere through evaporation and transpiration (Winkler et al. 2010b)
- No research was located examining how low flow magnitude and timing respond to wildfire and subsequent post-fire treatments. It would be expected that post-fire management activities that result in faster regeneration rates (such as tree planting) may lead to more rapid hydrologic recovery, while post-fire treatments that delay regeneration may, in turn, delay hydrologic recovery.

Stream temperature

Stream temperature controls many aspects of stream ecology and is influenced by various energy exchanges with the atmosphere (e.g., solar radiation and air temperature), riparian vegetation, channel (e.g., hyporheic exchange, groundwater inflows), and watershed (e.g., catchment elevation, etc.). It is also indirectly controlled by changes in streamflow (volume, peakflow timing, annual and diurnal variability) and channel morphology; shallower streams are more sensitive to heat inputs than deeper streams. Downstream reaches tend to be warmer than headwater reaches; however, riparian vegetation, as well as wetlands and lakes, also impact the stream temperature.

Stream temperature response to disturbance occurs because of canopy cover reduction, interaction with timing and magnitude of streamflow (particularly low flows), changes in channel form due to erosion or debris, and groundwater contributions to streamflow (Moore et al. 2005). Detailed reviews of the controls on stream temperature are provided in Moore et al. (2005) and Pike et al. (2010c). Elevated stream temperature, the primary concern related to climate change, can result in a number of aquatic effects, including increased biological activity and associated decreases in dissolved oxygen, loss and fragmentation of habitat, and increased risk of local extinction for coldwater aquatic species (Tschaplinski & Pike 2010). On the other hand, it is important to note that not all changes (increases) in stream temperature result in negative effects on aquatic organisms (Tschaplinski & Pike 2010).

Potential effects on stream temperature

- Stream temperature is related to both air temperature and streamflow volume; therefore, changes to these variables as a result of climate change will have an impact on stream thermal regimes.
- Any disturbance that reduces the riparian forest cover will result in increased solar radiation reaching the stream surface and may increase temperatures, depending on the level of mortality in the riparian forest. Standing dead canopy trees and intact understory vegetation that covers the stream may provide some shade, but this must be determined on a site-specific basis. These effects may be moderated by stream-groundwater interactions, which are also site specific and difficult to predict.
- The effects of salvage harvesting in the riparian zone following natural disturbance may have both direct (by removing shading trees) and indirect impacts (altering channel morphology) on stream temperature.
- In some cold, nutrient-poor stream systems, riparian disturbance resulted in increased stream temperatures, which lead to increased productivity of salmonids (Tschaplinski & Pike 2010). This highlights the need to consider the potential effects on individual watersheds, and to be clear about the management objectives for a given watershed or stream.

Suspended sediment

Suspended sediment consists of fine materials (< 0.2mm diameter) carried in suspension within the water column, or medium and coarse loads (0.2-2mm diameter) in faster flowing water, and either may be transported in suspension or as bed load. Fine sediment in a water column can be expressed quantitatively as either suspended sediment or as turbidity (Gomi et al. 2005). Sources of suspended sediment are typically eroded material being transported from hillslopes to streams, or erosion within the stream channel. For increased erosion to contribute to suspended sediment within the stream, it is necessary for the location of available sediment to be hydrologically connected to the stream channel. Connections can be natural (e.g., ephemeral channels, landslide tracks) or man-made (e.g., ditches, stream crossings). The erosion process may also be triggered by changes in the hydrologic regimes, such as rain events or snowmelt; water repellent soils; roads and trails; tree throw; exposed soils; diversion or alteration of natural drainage patterns; as well as a decline in vegetation cover and root strength to provide soil stability, resulting in bank erosion. Any disturbance that increases the susceptibility of soils to erosion has the potential to result in increased sediment supply to channels. In addition, disturbance that increases peakflows has the potential to increase downstream in-channel erosion through channel erosion and scouring. Suspended sediment is an important water quality variable because it impacts drinking water quality, as well as aquatic organisms and their habitat. Detailed reviews of suspended sediment dynamics in forested watersheds can be found in Gomi et al. (2005) and Pike et al. (2010c).

Potential effects on suspended sediment

- Wildfire-related disturbance has the potential to increase sedimentation amounts and rates due to the loss of vegetation cover and forest floor organic layers, which expose more easily eroded soils and increase the potential for overland flow if water repellent conditions are present. The actual suspended sediment response within any watershed will depend on a range of factors, such as fire severity, frequency and intensity of post-fire precipitation, application of erosion prevention treatments, and the rate of vegetation recovery.
- The effects of insect infestation alone will likely not have a large effect on sus-

pended sediment unless there is an increased incidence of blowdown in riparian zones, increased fire risk, and/or mass movements that are connected to stream channels.

- Empirical research on the effects of salvage logging indicates that the primary source of sediment from forest management activities is associated with roads and stream crossings, as a result of the direct physical connectivity between the disturbed soil and the stream channel.

Aquatic invertebrates

Aquatic ecosystems host a wide range of organisms that occupy the range of available habitats and perform various functions. Macroinvertebrate communities consist of a range of species, each differing in tolerances to environmental conditions and habitat requirements (Gordon et al. 2004). Many are responsive to disturbance-related shifts in flow regime, habitat availability, water quality, level of suspended sediment, and stream temperature. As a result, invertebrates are commonly used indicator organisms for biological monitoring of freshwater ecosystems (Weiler et al. 2010) and have been included as an indicator in the FREP Routine Riparian Evaluation Procedure (Tripp et al. 2009, Tschaplinski 2010).

Potential effects on aquatic invertebrates

- The primary effects of climate change on aquatic invertebrate population dynamics are likely going to be the result of changes in the duration and magnitude of low flows which will effect stream temperature, habitat availability and hence aquatic ecosystem productivity.
- While there is little available research on the effects of wildfire, insect infestations or post-disturbance management activities on aquatic invertebrates, they provide a valuable indicator of aquatic ecosystem health.

General management recommendations

Interactions between climate change, natural disturbance, and post-disturbance management activities are complex due to the interplay of the physical landscape and weather. Given that the expected future effects of climate change are increased intensity and spatial extent of natural disturbances, it is likely that questions about the effects of natural disturbance and management are going to become increasingly frequent. Potential effects of post-disturbance management activities must be considered at landscape, watershed, and site scales to sustain resilience of forested watersheds, and should be designed to maintain natural hydrologic and ecosystem function. Key management considerations include maintaining riparian reserves and management zones; minimizing the introduction of fine sediments into streams; and monitoring the effects of disturbances and management activities to support adaptive management. Many of the management recommendations discussed below will have benefits for multiple watershed values. There are likely to be numerous opportunities for innovation in post-disturbance management practices and initiation of adaptive management trials. To supplement the information herein, the reader is directed to recent general management practice recommendations to protect stream environments by Rex et al. (2009; 2011), Winkler et al. (2008), and Tschaplinski (2010).

To effectively manage for peakflow hazards, it is necessary to consider the effects of disturbance and management practices at a range of scales, from stand, hillslope, and subcatchment to watershed scales (Winkler et al. 2008; Grainger & Bates 2010; Milne & Lewis

2011). While equivalent clearcut area (ECA) is not an ideal measure of peakflow hazard, it does provide a relatively straightforward index of potential impacts of disturbance on watersheds (Winkler et al. 2010b). To better understand the potential effects of salvage harvesting following disturbance, the model developed by Lewis and Huggard (2010) provides a starting point to evaluate the ECA tradeoffs between salvage harvesting and retaining dead canopy and understory trees. While the data may not be available in all locations to fully implement this model, the conceptual framework allows management and operations staff to make informed decisions about salvage harvesting (Huggard 2011). This analysis could take the form of a formal risk analysis to assist in making decisions on where and how much salvage harvesting is appropriate (Grainger and Bates 2010; Milne and Lewis 2011). Qualified watershed professionals (hydrologists, geomorphologists) should be consulted to ensure decisions are made with the best available information.

Management practices at the local scale should be integrated with larger scales through coordination between tenure and/or license holders at the watershed or landscape scale (e.g., Forest Practices Board 2009). For example, at the watershed scale, there may be opportunities to design a management approach in such a way that snowmelt is desynchronized, which will lead to smaller increases in peakflows (Winkler et al. 2008; Milne & Lewis 2011).

It is difficult to develop general prescriptions around low flows, given the limited knowledge regarding aquifer characteristics and a sparse hydrometric network in BC. In general, management practices that maintain relatively natural flow regimes and water quality are desirable. For more details on management practices that support this goal, please see the management recommendations in Winkler et al. (2008).

The current recommended riparian reserve zone, based on the Forest Practices Code (FPC) and Forest and Range Practices Act (FRPA), is 0m for S4 streams and those non-fish bearing streams that are direct tributaries to fish-bearing streams. However, to reduce the risk of elevated temperatures, maintain large woody debris inputs, and reduce sediment inputs, recent research (Rex et al. 2009; 2011) and monitoring (Tschaplinski 2010) studies recommend enhanced retention within 10m of the stream channels for S4 streams. Within BC, Tschaplinski (2010) indicated that maximizing retention within 10m of the channel for all small streams has the greatest benefit for maintaining functioning stream environments, as buffers of less than 10m are not as effective in providing stream shade and avoiding stream heating (Nordin et al. 2009b; Krauskopf et al. 2010; Rex et al. 2011). This includes leaving dead trees within the riparian reserve zone, as they provide shade to the stream channel (Krauskopf et al. 2010; Leach & Moore 2010; Tschaplinski 2010) and will eventually fall into the stream and become large woody debris (LWD), providing channel structure and aquatic habitat (Rex et al. 2011).

To reduce the potential for the introduction of fine sediments into stream channels as a consequence of post-disturbance management activities, it is recommended that the number of road crossings of water courses and the amount of exposed soil are both minimized, that ditches are kept clear and roads maintained, and that riparian retention in reserve zones or riparian management zones are maximized (Winkler et al. 2008; Nordin et al. 2009b).

To maintain populations of aquatic invertebrates, the provision of riparian management areas appears to be the most effective management practice (Nordin et al. 2008; 2009a), and, as such, the riparian retention suggestions above are relevant. For recommendations for range managers and range users to maintain water quality, see Fraser (2009).

Additional information sources

The following lists provide information sources to support decision-making in relation to watershed effects and management following natural disturbances. It is important that decisions are informed by the best available information, along with input from qualified professionals within government (e.g., regional specialists at Ministry of Environment and Ministry of Forests, Lands and Natural Resource Operations) or private consultants.

Sources of further information

Maps and database of susceptible pine stands in Southern Interior, BC MFR: http://www.for.gov.bc.ca/hfp/mountain%5Fpine%5Fbeetle/stewardship/hydrology/index.htm#maps

General effects of MPB and management suggestions for dealing with MPB (Winkler et al. 2008).

Overview of watershed considerations for post-MPB salvage harvesting (Milne and Lewis 2011).

Watershed risk analysis methods (Grainger and Bates 2010) and assessments carried out in the southern interior (Milne and Lewis 2011).

Pacific Climate Impacts Consortium (PCIC) climate change projections and tools: http://pacificclimate.org

The Compendium of Forest Hydrology and Geomophology in BC – This publication is a reference on both the science and management of forested watersheds in BC, and contains chapters related to assessment methods and monitoring methods (Pike et al. 2010).

Creed et al. (2011a) have developed a set of hydrologic principles for conservation of water resources within the forest landscape.

Beckers et al. (2009) developed selection criteria and model rankings to assist natural resource managers and professionals in choosing hydrologic models for operational purposes. A similar product has also been developed by Creed et al. (2011b).

Decision Making Tools:

Interior and Coastal Watershed Assessment Protocols: http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/wap/WAPGdbk-Web.pdf

MPB-Salvage ECA model (Lewis and Huggard 2010; Huggard 2011).

Identifying the risk of wet ground (Rex and Dubé 2009).

Model for prediction of effects of forest harvesting on stream temperature in central BC (Mellina et al. 2002; Mellina 2006).

Low Flow Hazard Model for Fraser Basin (Carver et al. 2009) [model requires further testing and refinement].

Identification of Temperature Sensitive Streams (BC MoE, In development): http://www.env.gov.bc.ca/wld/frpa/tss/index.html

Identification of Fisheries Sensitive Watersheds (BC MoE, In development): http://www.env.gov.bc.ca/wld/frpa/fsw/post.html

Monitoring tools:

Reference Condition Approach for aquatic biomonitoring. The Canadian system is built around the Canadian Aquatic Biomonitoring Network (CABIN) coordinated by Environment Canada: http://www.ec.gc.ca/rcba-cabin/default.asp?lang=En&n=72AD8D96-1

This approach has been applied in BC by staff from MoE as well as some academic research groups.

FREP Routine Riparian Effectiveness Evaluation method (Tripp et al. 2009) designed to evaluate the effectiveness of riparian management practices in BC: http://www.for.gov.bc.ca/hfp/frep/indicators/table.htm#fish

FREP Water Quality Effectiveness Evaluation method (Carson et al. 2009): http://www.for.gov.bc.ca/hfp/frep/indicators/table.htm#water

Conclusions

In general, the potential for negative effects on natural hydrologic processes and watershed functions are increased following post-disturbance management activities; however, available research and past management practices are primarily limited to clearcut salvage harvesting. Given potential interactions with climate change and projected intense and spatially extensive disturbances, there are great opportunities for innovation and adaptive management trials. It will be important to examine both short- and long-term effects and recovery trajectories of various management options. It will also be important to identify those watersheds with high values, whether human (e.g., drinking water or flood risk to infrastructure) or ecological (e.g., high value salmonid habitat). For those watersheds with high values, a formal risk assessment is advisable (e.g., Grainger & Bates 2010). This comprehensive assessment ensures minimal risk to the values while potentially optimizing both economic and ecological benefits of activities on the landbase. This will allow for a more transparent assessment of economic and ecological costs and benefits of salvage harvesting or other management interventions.

To maintain the resilience of watersheds in light of climate change and predicted increases in natural disturbance, management activities should be designed to maintain as much natural hydrologic and ecosystem function as possible. To accomplish this, the potential effects of management interventions must be considered at both landscape and site scales. Key management considerations to maintain resilience include maintaining a riparian reserve zone, or maximizing overstory retention (including dead trees), within 10m for S4 streams and non-fish bearing streams that are direct tributaries to fish-bearing streams (Tschaplinski 2010); minimizing the introduction of fine sediments into stream channels through proper road construction and maintenance practices; and monitoring the effects of disturbances and management interventions to support adaptive management practices. Further support for adaptive management must also be provided through continued research to address knowledge gaps in our understanding of post-disturbance management interventions on watershed functions. It is imperative that managers use the best available information, along with qualified watershed professionals, to ensure optimal management decisions.

For more information

This summary is based on information contained in the full synthesis article:

Redding, T. & J. Leach. 2012. A synthesis of the effects of natural disturbance and post-disturbance management on streamflow, stream temperature, suspended sediment, and aquatic invertebrate populations. FORREX Forum for Research and Extension in Natural Resources, Kamloops, BC: FORREX Series 28.

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Test Your Knowledge

How well can you recall the main messages in the preceding article?
Test your knowledge by answering the following questions.

Natural Disturbance and Post-Disturbance Management Effects on Selected Watershed Values

1. This report assessed the impact of natural disturbance and post-disturbance activities on four watershed values. Which value was not included in this assessment?
    - a) Streamflow
    - b) Suspended sediment
    - c) Aquatic invertebrate
    - d) Watershed land-use

2. The current recommended riparian reserve zone, based on the Forest Practices Code (FPC) and Forest and Range Practices Act (FRPA), is 0m for S4 streams and those non-fish bearing streams that are direct tributaries to fish-bearing streams. To maintain resilience, within what distance from S4 streams is maximizing riparian overstory retention recommended?
    - a) 5m
    - b) 10m
    - c) 50m
    - d) 100m

3. Which of the following is not a primary effect of wildfire on hydrological processes?
    - a) a decrease in peakflows
    - b) a decrease in interception due to loss of canopy
    - c) reduced infiltration due to water repellency
    - d) limited transpiration due to the loss of live canopy

ANSWERS: 1=d; 2=b; 3=a