Fire Effects on Rangeland
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture, Food and Fisheries

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Factsheet 1 of 6 in the Fire Effects on Rangeland Factsheet Series

Fire Effects on Rangeland Ecosystems

Fire has played an integral role in forming British Columbia's rangeland ecosystems. In fact, by chance many organisms have actually developed characteristics that enable them to succeed in either the presence or absence of fire. The extent of these adaptations varies depending on the ecosystem in question. Some ecosystems, such as alpine or arctic tundra ecosystems, have evolved largely in the absence of fire whereas others require fire to survive in their present form. Some individual organisms also depend on fire to fulfill a requirement within their lifecycle. For example, in order for some plants to germinate, fire is first needed to heat and scar their seeds. Other organisms require fire to create habitat for them by damaging or burning trees. These species include various forms of insects, pathogens, birds, reptiles, small mammals, etc.

Depending on severity, fire can also benefit some organisms by increasing soil nutrient availability or negatively impact others by producing hydrophobic (water repelling) soils and indirectly increasing erosion. In general fire can have an infinite number of effects on an ecosystem. Every ecosystem component, including water, soil, insects and pathogens, plants, livestock and wildlife, can and will be affected depending on fire residence time, intensity and behaviour. While the effect of fire on abiotic (non-living) components is typically determined by fire intensity and fire residence-time its influence on biotic components is not only dependant on these characteristics but is also highly dependant on fire regime. The fire regime predetermines an organism's ability to avoid, escape, or endure fire. For example, some organisms may survive by either fleeing the area (wildlife) or by developing mechanisms to endure high temperatures (many plants). Since these adaptations are often time specific, if a fire occurs too soon or too late for an organism, its presence within an ecosystem may be greatly reduced.

Fire Effects on Plants

The most obvious and visible fire influenced changes within an ecosystem typically occur within the plant community. This response is dependant on numerous adaptations including germination, rapid growth and development, fire resistant bark and foliage, adventitious or latent axillary buds (growing points) and serotinous cones. All of these adaptations have the potential to influence plant community dynamics following a fire. Germination adaptations can include hard-coated seeds that lie dormant until a fire passes and the seed is scarified. Rapid growth and development adaptations allow plant species to complete a life cycle quickly and enable them to provide seed in the event of two closely spaced fires. Fire resistant foliage and bark are typically critical factors in determining plant survival as both may allow a plant to survive fires of low to moderate severity. Finally, adventitious or latent axillary buds and serotinous cones, all allow a plant to rapidly respond following a fire. All of these, or combinations of these characteristics, determine how a plant community will respond to a fire. When describing individual plant response, many authors have embedded the aforementioned characteristics into the following categories (After Ryan 2002):

Mode of regeneration and reproduction:

Vegetative reproduction -based

- V species – able to resprout if burned in the juvenile state;
- W species – able to resist fire in the adult state and continue growth after it (although fire kills juveniles)

Reproductive plant part dispersal-based

- D species – with highly dispersed propagules;
- S species – storing long-lived propagules in the soil;
- C species – storing propagules in the canopy.

Did you know?
A serotinous cone is a cone that may be opened by the heat of fire thus allowing the cone to release its seeds (lodgepole pine)

A propagule is any part of a plant capable of growing into a new plant (includes seeds and roots)

Community Relationship:

- T species – tolerants that can establish immediately after a fire and can persist indefinitely thereafter without further severe disturbances;
- R species – tolerants than cannot establish immediately after fire but must wait until some requirement has been met (e.g.,, for shade);
- I species – intolerants that can only establish immediately after a fire. Includes rapid growth pioneers that tend to die out without recurrent disturbances.

How a species responds following a fire is primarily attributed to its regeneration and reproduction strategies. As discussed in Ryan (2002), species that rely on vegetative reproduction to survive (V and W above) depend on the depth of burn relative to the depth of the meristematic tissue. Therefore, the survival of these species is primarily dependent on fire severity. Survival of species that reproduce by seeds (S and C species) or from off-site dissemination (D species) is also dependant on fire severity, albeit to different extents. S species are influenced by burn depth (deeper burns equal increased destruction of soil seed bank). The survival of C species however, is reduced by severe heating in intense surface and crown fires and is relatively unaffected by the depth of burn while the regeneration of D species is affected by the quality of the seedbed and the amount of early post-fire competition, both attributed to the severity of the fire.

By making these assumptions about plant characteristics as well as communal relationships, we attempt to identify how a plant will react to different fires and thus, how the ecosystem will respond to a fire. For example, following a fire with a low depth of burn, both V and W species will be favoured. It is here however, where communal relationships also become important. Species with a V regeneration capability and a T communal relationship ability will typically establish immediately following a fire especially when compared to a species that generally requires more shade (e.g.,, R species) (Ryan 2002). In addition, fires that burn deep into the soil profile will typically favour species that regenerate from canopy-stored seed (C species) or species with capabilities for long dispersal (D species) (Ryan 2002). Finally, in the absence of fire, or in ecosystems subjected to low fire frequencies, shade tolerant, late successional, CR species are generally favoured over early successional, shade intolerant CT species.

In general, numerous different combinations of these characteristics can be described, depending on fire severity, frequency, and extent. Furthermore, the effect of fire on an ecosystem can be significantly altered by changing any one of these parameters. For example, as described in Ryan (2002), variations in fire severity can influence the type and amount of seed and belowground organs that will survive a fire, as well as the communal relationships that exist at all levels within an ecosystem. In addition to fire frequency, fire size and severity also plays a role. Typically, following a large fire, the disturbed area commonly consists of unburned to severely burned sites. The lightly burned to unburned sites may provide refuge for fire sensitive plants and animals whereas the severely burned commonly become dominated by early successional and invader species. For more information on this subject, please refer to **Factsheets 3 and 4** of the Fire Effects on Rangeland Factsheet Series.

Fire Effects on Livestock and Wildlife

As is the case with plants, the influence of fire on livestock and wildlife has also been extensively studied. Most of the effects identified are secondary, and have focused primarily on habitat requirements of mammals and bird species. Depending on species involved, fire can create, destroy, enhance, or degrade favourable fauna habitat (food supply, cover, shelter, physical environment natal/breeding). These effects determine the occurrence and abundance of fauna species within a burned area and thus affect the overall impact of a fire on an ecosystem. As with all other ecosystem components, the effect of fire on fauna is highly variable and determined directly by fire intensity, duration, frequency, location, shape, extent, season, fuels, site, and soils and indirectly by how other ecosystem components respond to these. In general, the effect of fire on livestock and wildlife is primarily determined by the plant response to fire. The following paragraphs will attempt to describe how a fire affects various species, all of which impact the influence of fire on an ecosystem. For more information on this subject, please refer to **Factsheet 4** of the Fire Effects on Rangeland Factsheet Series.

Mammals
Small mammals tend to be most affected by fire due to their reliance on small home sizes (limited mobility for escape). Most of these species rely on plant community structure to survive. Some species prefer the lack of structure due to fire, while others prefer multi-layered plant communities resulting from varied fire return intervals or fire-suppression. When considering the effect of fire on grazing animals, you must consider the lag in forage availability. For example, if a fire occurs during late summer or fall, forage availability in the burned areas will be non-existent until at least the following growing season. If however, the fire occurs early in the growing season, forage will not only be available in the same year as the fire, it also tends to hold its quality longer into the late summer and fall. The response to carnivores is primarily dependant on the response of herbivores. That is, if prey populations increase so will the population of carnivores. Overall, as is the case with plants, fire effects on livestock and wildlife is determined by fire intensity, severity, frequency, seasonality, and extent.

Birds
The following classification taken from National Wildfire Coordinating Group (2001) hypothesizes how different bird species respond to fire:

- Fire-intolerant species decrease in abundance after fire and are present only in areas characterized by very low fire frequency and severity. These species are typically closely associated with closed canopy forests and generally prefer a dense nesting and foraging cover.
- Fire-impervious bird species are unaffected by fire; they neither increase nor decrease because of fire.
- Fire-adapted bird species increase in abundance after a fire. These species generally prefer to use fire-opened habitat.
- Fire-dependent bird species only occur in early succession areas such as those influenced by fire.

Insects
Fire affects insects by benefiting some at the expense of others. Numerous insects are attracted to fire, particularly those whose life cycle depends on fire while others prefer ecosystems dominated by shade tolerant plant communities. Overall any impact that fire, or lack of fire, has on insect communities can have huge implications on the overall ecosystem. In fact, some researchers suggest that both insect and pathogen outbreaks are occurring over larger areas due to an increase in habitat quality resulting from fire suppression. These outbreaks not only impact insect communities, they can also influence the fire regime of an area. Any change in fire regime would impact all levels of an ecosystem.

Pathogens
As with insects, fire impacts pathogens in a number of ways including:

1. Direct impact;
2. Directly impacting an organism that has formed a symbiotic relationship with them;
3. Alternating stand dynamics in such a way that it influences pathogen incidence, distribution, and control;
4. Providing a point of entry on the host plant for infection to occur (e.g.,, heart rot fungi);
5. Increasing or decreasing host vigour;
6. Influencing the activities of pathogens; and
7. Affecting physical and microbial environments

As with insects, any change in pathogen community dynamics will significantly influence how a fire affects an ecosystem. This includes a change in fire regime.

Fire Effects on Erosion

One of the most significant indirect impacts of a fire is erosion. This impact is facilitated by slope position and vegetation disruption and/or removal on all slopes. Whether or not erosion occurs is not only dependant on fire-influenced changes (bare soil, soil structural changes, altered hydrology etc) but also on a variety of topographical factors, such as slope and aspect, and climatic factors, such as precipitation. Since the root systems of top-killed shrubs and trees assist in maintaining soil stability, erosion may not occur immediately; instead, it may be delayed several years following a fire. The overall extent of erosion varies considerably from excessive to no differences from unburned sites. Other factors such as soil texture also influence erosion. For example, coarse-textured soils are considered more erodible than fine textured soils. Overall, all factors including slope steepness, vegetation recovery time, the amount of residual litter and duff and climatic factors such as the timing, intensity, and amount of precipitation interact with one another and determine a site's susceptibility to erosion. The agent responsible for erosion is dependant on local climatic and topographic parameters. For example, past studies have found post-fire erosion to be facilitated by wind, water, and/or gravity. This includes all of the following types of erosion that have been described in post-fire environments:

raindrop splash, sheet and rill erosion, soil creep, and mass wasting.

Once erosion occurs, upland ecosystems can be permanently altered by a reduction in organic matter, loss of A-horizon, or removal of fines (clay and silt), all of which can permanently change the plant community and/or increase the probability of drought occurring. Aquatic communities can also be altered due to increases in nutrients and turbidity levels, both of which are related to increased sedimentation. Increased nutrients can increase algae growth and thus decrease dissolved oxygen levels. Sediment can also embed spawning gravel beds. Both effects can be very detrimental to aquatic ecosystems. Any reduction in vegetation, litter, or humus will tend to increase runoff. This combined with hydrophobicity (water repellency), a common fire effect on soil, can seriously impact ecosystems within a watershed, particularly if fire has disturbed a significant portion of the watershed. Overall, erosion has the potential to significantly impact both aquatic and terrestrial ecosystems. For more information on this subject, please refer to **Factsheet 2** of the Fire Effects on Rangeland Factsheet Series

Community Effects

Ecosystems dominated by thick-barked species such as Douglas-fir and ponderosa pine tend to be relatively resistant to low or moderate fire intensities. This resistance however, is dependant on fire intensity and stand structure. For example, if the fire is severe and/or sufficient ladder fuels are available to promote crowning, fire can and will kill these trees regardless of bark thickness. Both of these species also have other characteristics that enable them to respond quickly to and/or tolerate a fire. For example, Douglas-fir is able to establish quickly following a fire due to the ability of its lightweight and winged seed to blow vast distances. Ponderosa pine on the other hand, due to its needle-casting characteristic, facilitates future reproduction by reducing grass and shrub competition and providing fuel for a future fire. This fuel, while significant enough to promote a fire, reduces its intensity to a level that doesn't kill the tree but does produce the right temperature to facilitate reproduction.

Various broadleaf trees (aspen, birch etc.) and shrubs (snowberry) are able to regenerate rapidly from their root crowns, lateral roots, or aerial crowns. This sprouting ability is typically intensive enough to facilitate the rapid recovery of these ecosystems following a fire. Other ecosystems however, such as those dominated by lodgepole pine, often have very complicated reactions to fire. For example, lodgepole pine has the ability to be either an evader (serotinous cones) or an invader due to its ability to rapidly colonize a site following fire. The formation of a mature forest however, is often very slow, as the trees tend to regenerate into vast, crowded clumps. These clumps produce small branches, cones, and needles and as a result produce very minimal fuel loads. Thus, these stands can be virtually dormant for hundreds of years, or at least until insect infestations and/or shade tolerant trees (true firs and spruce) produce enough fuel (especially ladder fuels) to promote a fire.

REFERENCES

National Wildfire Coordinating Group. 2001. Fire Effects Guide. Available online: http://www.nwcg.gov/pms/RxFire/FEG.pdf. 313 p.

Ryan, K.C. 2002. Dynamic interactions between forest structure and fire behavior in boreal ecosystems. Silva Fennica 36(1): 13-39.

Fire Effects on Rangeland Factsheet Series

A Fire Effects on Rangeland Factsheet series has been developed to assist you in assessing and managing rangeland affected by fire. The titles of these factsheets are:

1. Fire Effects on Rangeland Ecosystems
2. Fire Effects on Soils
3. Fire Effects on Grasses and Forbs
4. Fire Effects on Tree and Shrubs
5. Fire Effects on Livestock and Wildlife
6. Post-fire Livestock Management

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