THE RELATIONSHIP BETWEEN FOREST RESTORATION AND FOREST FIRE IN BOREAL FOREST

by

Baichuan Hui

FACULTY OF NATURAL RESOURCES MANAGEMENT

LAKEHEAD UNIVERSITY THUNDER BAY, ONTARIO

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Baichuan Hui

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Dr. Jian Rang Wang	Dr. Kevin Crowe
Major Advisor	Second Reader

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ABSTRACT

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Keywords: forest fire, forest restoration, boreal forest, restoration ecology.

Forest fire has a strong linkage with forest restoration. In this paper, we analyzed the relationship between forest fire and forest restoration in boreal forest by reading literature and consulting data. After a fire, the forest can recover from four core issues to carry out ecological restoration. The idea that forest fire can be a tool for ecological restoration has become widely recognized and proven in practice, we provide an example of prescribed fire restore forest ecology in Gifford Pinchot National Forest. In boreal forests, there is a close relationship between forest fire and forest restoration. Forest restoration can greatly reduce the damage caused by the disaster after the fire. At the same time, forest fire can also be used as a tool for forest restoration.

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1.0 Introduction

Forest fire and forest restoration have always been hot topics in forestry science. In recent years, the forest fires in Australia and the United States let the world see the power of forest fires, but also let the world realize the importance of forest ecological restoration. Forest fire and forest restoration are very closely linked. Exploring the relationship between the two is helpful for us to better understand the prevention and control of forest fires and the planning of forest restoration. This paper mainly focuses on the relationship between forest restoration and forest fire in the boreal forests, explores the connection between the two.

Before exploring the linkage, it is necessary to know the definition of both forest fire and forest restoration, their basic information and their applications to each other. The paper will provide definitions and basic information of these two terms, analyze the connections between them by reading and understanding the literature, and then draw a conclusion.

2.0 Literature Review

2.1 Forest fire

Forest fire, also called vegetation, bush or wildfire, is a disaster that spontaneously occurring in the forest and can occasionally be controlled (J.M.K.C, 2019). A forest fire can also be described as the act of burning or burning plants in a natural environment, such as forest, grassland, scrub or tundra, to consume the natural fuel and to disperse according to environmental conditions (e.g., wind, topography) (UN-SPIDER, 2017).

2.1.1 Cause of forest fire

There are mainly two causes of forest fire: nature caused and human activities (Gisborne, 1930). Naturally occurring forest fire can occur when the weather is dry. Under these conditions, usually green plants can be converted into dry, flammable fuel; Strong winds spread the fire rapidly; Warmer temperatures will promote combustion. With these elements, all that's missing is a spark -- in the form of lightning, arson, downed power lines or a burning bonfire or cigarette to wreak havoc. (Wolters, 2021). In boreal forest, fires are mainly caused by lightning strikes, with the average burning area about 2.5 million hectares annually (Government of Canada, 2019). Human activities caused fire includes unattended camps and ruins, discarded cigarettes and arson (Wolters, 2021).

2.1.2 Types of forest fire

There are three types of a natural forest fire: crown fire, surface fire and ground fire (Weise, 2018). Crown fire refers to the forest fire which burns the whole tree to the top. These are some of the most intense and dangerous wildfires (Government of Canada, 2019). Surface fire refers to the forest fire which burns only surface waste and garbage, it's been considered as the simplest fire to put out and cause minimal damage to the forest (Government of Canada, 2019). Ground fires, also known as underground or subsurface fires, which burning organic matter or humus in the soil, don't usually show up on the surface (National Geographic Society, 2019).

For fires caused by humans, there's a special type of forest fire called prescribe fire, which is used by some land manager to manages the forest (Soilmatter2011, 2020). Unlike ordinary fires, this kind of fire can help restore the forest.

2.1.3 Features of forest fire

Forest fire requires oxygen, heat and fuel to burn (fire ignition triangle), it's sudden strong; easy diffusion and hard to deal with (IDAHO, 2019). Most forest fires are started by lightning, which makes them extremely sudden and unpredictable. The forest is the paradise of fire, there's a lot of combustible stuff in the forest, and the wind helps. Wind not only moves wildfires across landscapes but also supplies oxygen that can cause fires to grow swiftly which leads to the spread of forest fires very easily. Figure 1 shows the requirement of forest fire ignition. Forest fires are difficult to control because many factors, such as terrain, wind, etc., control forest fire behavior (IDAHO, 2019). And these factors are often hard to predict. Based on figure 1, for example, in a naturally occurring

forest fire, the heat is provided by thunder and lightning, the dry trees and dead leaves in the forest provide combustible material, and the wind provides oxygen. The strength and direction of the wind are hard to predict, it will guide the direction of the fire, provide enough oxygen to the fire, and may even blow the flames elsewhere to start a new fire.

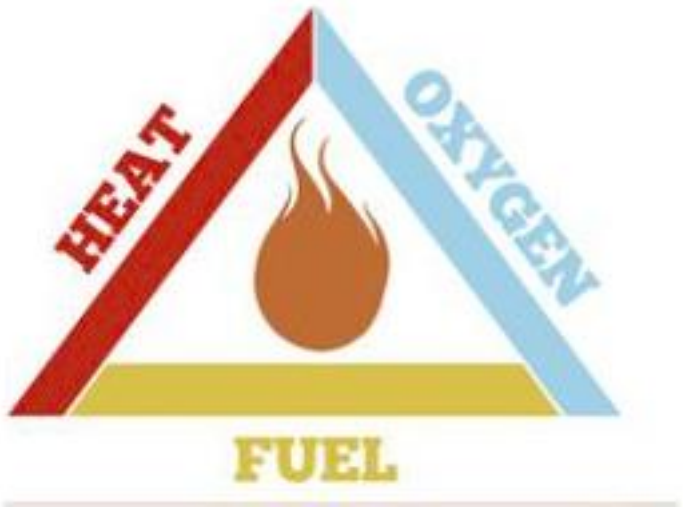

Figure 1: Forest Fire Ignition Triangle (IDAHO, 2019)

2.2 Boreal forest

The boreal forest is the second largest biome in the world, which contains approximately 33% of the world's forest with around 20,300 identified species (Ruckstuhl, 2008). The boreal forest is both a major depository and the major source of carbon (Ruckstuhl, 2008). The boreal forest is also home to various tree species, tree species in the boreal forest must have strong resilience and able to tolerate cold temperatures, poor soil quality and fires (RAMP, n.d.). The most common conifer species in the boreal forest include black and white spruce, balsam fir, jack pine and tamarack.

The deciduous trees most commonly found in boreal forests include silver birch, quaking poplar and balsam poplar (RAMP, n.d.).

Forest fires are a frequent occurrence in boreal forests, in other words, the ecology of the boreal forests is shaped by the forest fire (Michael, 2015). The species, communities, ecosystems of the boreal forest, all them are affected by periodic fires (Michael, 2015). Therefore, it is particularly important to study the relationship between forest fire and forest restoration in the boreal forests.

2.3 Restoration after forest fire

2.3.1 Ecological restoration concept

Ecological restoration is the process of assisting the recovery of the forest ecosystem which has been degraded, damaged or destroyed (Colorado State Forest Service, 2020). After forest fire, the restoration mainly is about assisting the recovery of the forest.

2.3.2 Purpose of restoration

Most people agree that restoration after forest fire is necessary because the importance of forests in environmental and economic fields (Ostergren, 2008). The purpose is to minimize the economic loss and environmental damage from the forest fire (Ostergren, 2008).

2.3.3 Restoration treatment after fire

After forest fire in boreal forest, there are four core elements of forest restorations: planting trees, improving soils, protecting wildlife corridors and managing land sustainably (Gustafson, n.d).

Planting trees after fire, also called reforestation. It is the process of establishing a new stand on former woodland after a fire disturbance (Barkley, 2019). In other words, it's about planting seedlings and plant native trees (Gustafson, n.d). There are two ways to rebuild the stand: Natural regeneration and artificial regeneration. Natural regeneration is when you let nature handle the work of restoring the tree, whereas artificial regeneration is when you bypass nature, seed or plant your own site (Barkley, 2019).

Improving soils is about adding organic material to the soil and soils need micro-organisms and organic matter to thrive. The heat of fire sterilizes the upper layers of the soil through killing the microbes in the soil. Fire burns up much of the carbon stored in the soil and alter the soil's ability to absorb and hold water. Blazing fires burn the forest floor, leaving bare soil that can produce water-resistant soil (Soilmatter2011, 2020). By improving soils, forests can be fundamentally altered to support restored forest health (Gustafson, n.d).

Protecting wildlife corridors: forest fires are not particularly costly to wildlife. When the fire strikes, the animals sense the danger and run away. But biological corridors are particularly important for forest ecosystems, a swimming-pool-wide corridor allows animals to move between forest debris, which could greatly improve their chances of

survival, reproduction and prosperity (Gustafson, n.d). It is crucial to protect the corridors.

Managing land sustainably: forest fires cause not only ecological damage, but also great economic damage. A good recovery requires rational planning of forest blocks and vigorous development of agriculture and forestry in order to minimize the economic damage.

2.4 Forest fires restore forest

There are two steps of ecological restoration, which can be simply categorized into passive restoration and active restoration (Brown, 2004).

Passive restoration is considered as the first step of the treatment, it's about stopping the activities which cause the degradation (Brown, 2004). Active restoration is about to thinning and prescribed fire (Brown, 2004). For thinning, mainly focus on the removal of trees, while prescribed fire focuses on using forest fire as a tool, by using different types of forest fire to restore the forest (Ryan, 2010).

2.4.1 Prescribed fire

Prescribed fire, also called controlled fire. It's about to manage a forest by using fire. (U.S. National Park Service, 2020). This is a very typical forest fire restoration strategy. North Americans indigenous people have a long history of using prescribed fire in management of wasteland for specific resources. They also use prescribed fire to reduce the presence and number of harmful species that reduce the quality and quantity of desirable plants (Kane, 2020). With the passage of time and the progress of science and

technology, prescribed fire has been used more and more professionally in more fields. In the field of forest restoration, prescribed fire could improve ecosystem health in forests by reducing competition, decreasing diseases and pests and promote seed germination (Kane, 2020). It is considered as one of the most important tools to restore a forest today.

Prescribed fire could selectively remove nutrition-hungry weeds and harmful insects from plants, which greatly reduces competition, effectively promotes forest health and successfully achieves the goal of forest restoration (Soilmatter2011, 2020). Also, some species need fire to germinate their seeds. For example, species like jack pine, which is very common in boreal forest, the seeds of jack pine are sealed resin binders that require high temperatures to open and release the seeds. Prescribed fire could help promote jack pine seeds' germination (Soilmatter2011, 2020).

2.4.1.1 Choice of prescribed fire

Undoubtedly, no single strategy is suitable for all conditions, especially in a complex environment such as the boreal forest, where managers need to consider a number of factors to ensure success. The difference between wildfire and prescribed fire is how the foresters use it (Tamara, n.d.). Once foresters use fire in an improper way, a controlled fire that could have been used to restore forests could have turned into a disaster. There are many factors that should be considered when foresters make decisions. Figure 2 shows the sequence of decisions making in using a prescribed fire. From the figure, we can see it very clearly that the factors should be considered when using prescribed fire can be simply summed up in five parts: Outcome, environmental condition, fire behavior, real-time burn decision and fire effects.

For a decision, of course, planners need to know what's the ideal outcome. In other words, what do we hope to achieve through this fire. Planners should list their preferred, acceptable and unacceptable objectives. This is the core of the whole plan, but also related to the plan of follow-up arrangements and operations. Test burn outcome is indispensable, it can provide us with simulated information and results to make future decisions more reliable. In real-time burn decision part, planners need to decide whether to continue burning, modify fire patterns, or stop burning. The practice here is tied to a specific target.

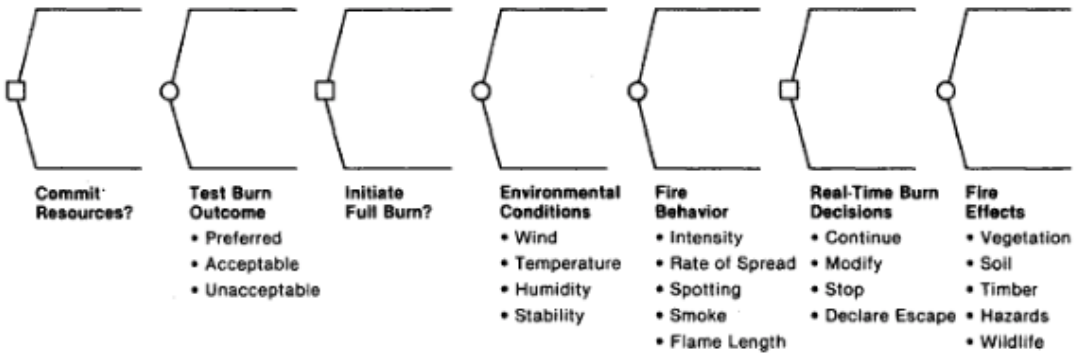

Figure 2: Sequence and Factors of Decisions Making in Using a Prescribed Fire (Cohan, 1984)

The environmental condition is important while making decisions. The boreal forest is relatively cold, which creates a great condition for safe burns (Sundogs, n.d.). In areas with drought, high temperatures and high winds, prescribed fire can be difficult to ensure safety (Sundogs, n.d.).

The choice of fire behavior depends on many factors, such as terrain, desired fire behavior and the goal. Strip fires are the most common type of fire due to that fires can

be controlled by changing the number of lit strips and the distance between the strips (Kane, 2020). By the way, terrain plays a significant role in the selection of prescribed fire, especially the slope of the terrain. The direction and speed of fire depend largely on the slope and wind direction. The fire intensity on the upwind slope is the least and the speed of fire propagation is the slowest. The fire intensity on the downwind slope is high and the speed of fire propagation is fast. The fire intensity and speed of fire propagation on the plane are moderate (Kane, 2020).

After all the steps, we need to think about the impact of prescribed fire. Fire has a huge impact on soil, wood, vegetation, wildlife. The purpose of prescribed fire is to restore the forest ecology, and we should not ignore other ecological factors in order to achieve this goal.

2.4.2 Example of forest fire restore forest (Gifford Pinchot National Forest)

Gifford Pinchot national forest is a big forest, which ranges from Washington state all the way to Portland, Oregon. In the forest, harvest of old growth and second growth stands provides numerous timbers in the area, planners started using prescribed fire to burn logging slashes in the clear-cut area since 1940s in order to prepare planting sites and to reduce the hazard of wildlife (Cohan, 1984). In the planning process, scientists concerned all the factors including Outcome, environmental condition, fire behavior, real-time burn decision and fire effects. Especially for the fire behavior and environmental condition process. For fire behavior process, if the used prescribed fire was too big, protected trees and wildlife around the area may be harmed, if the used

prescribed fire was too small, then the objectives could be hardly meet. For environmental condition process, the region's climate is highly uncertain. Finally, through the analysis, Scientists decided to mobilize for and subsequently ignite a burn (Cohan, 1984). In 1983, a number of sites were successfully burned, in most sites' objectives were meet through the prescribed fire (Cohan, 1984). Figure 3 shows the analysis of decision and budget considerations for the use of prescribed fire. This measure promoted the ecological development of the forest to a large extent and successfully restored the forest ecology through prescribed fire. In this case, planners clear the logging slashes for later planting by burning them with the prescribed fire. It also reduces the hazard of wildlife by burning logging slash.

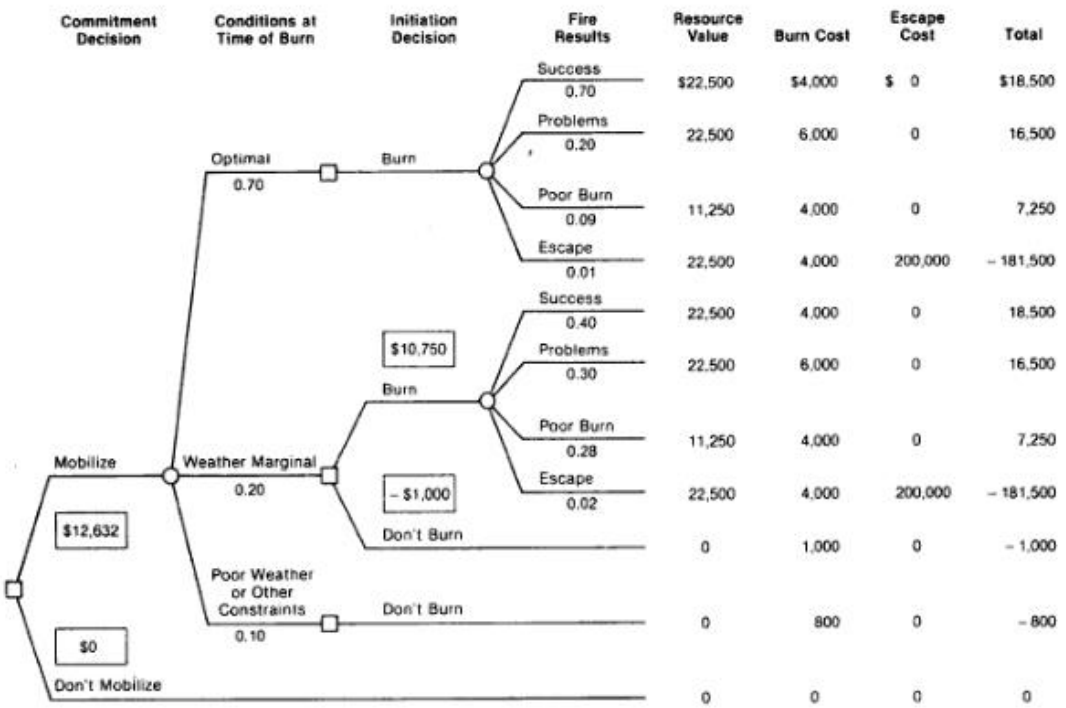

Figure 3: analysis of decision and budget considerations for the use of prescribed fire in Gifford Pinchot National Forest (Cohan, 1984)

3.0 Material and Method

By reading and understanding the literature which been found from the website and get the conclusion of the essay. From the literature, we have a definition of ecological restoration, and a definition of forest fire, different forest types, what it causes. We provide an example of forest fire restore forest in Gifford Pinchot National Forest to illustrate the statement. Through the expression of the two and the logical relationship of application, the final conclusion is draw.

4.0 Discussion

Forest restoration refers to the process of assisting the recovery of the forest ecosystem which has been degraded, damaged or destroyed (J.M.K.C, 2019). Forest fire is a kind of natural disaster, and ecological restoration after fire is essential. Therefore, forest restoration is the rebuilding work after a fire. Conversely, forest fires can also be used as a tool for forest restoration, mainly through reducing competition, decreasing diseases and pests and promote seed germination to promote the completion of ecological restoration (Kane, 2020). The example of using prescribed fire in Gifford Pinchot National Forest to restore the forest prove this statement.

5.0 Conclusion

Through the demonstration and analysis, we can confidently draw the conclusion that there is a close and inseparable relationship between forest restoration and forest fire in the boreal forest. Forest restoration can be done by planting trees, improving soils, protecting wildlife corridors and managing land sustainably four core steps to minimize the damage caused by forest fires (Gustafson, n.d). Forest fires can be a tool for forest restoration through reducing competition, decreasing diseases and pests and promote seed germination. The two complement each other and are closely linked.

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