The Negative Effects of Fire Protection

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FRST 497
April 3rd, 2011

Abstract

B.C. has a history of fire suppression dating back to 1905 (Watts & Tolland, 2005). Since then the idea of fire protection has been developed to be used in conjunction with fire suppression. Fire suppression and protection techniques have improved over the last century and are used throughout the province as a means to protect communities. These communities benefit from the fire protection but what draw backs do these operations have? How can fire protection operations harm the community it was put in place to protect? This paper will look at the negative effects of fire protection on communities around B.C. and how these effects can be mitigated.

Keywords: Fire, Protection, Suppression, Prevention, BC, British Columbia, Communities, Negative

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Introduction

Fire has been present in BC's forests for thousands of years and is a natural part of many ecosystems. First nations used to set fire to their forests to stimulate the growth of various plants that produce edible berries, roots or bulbs. This practice also helped maintain fuel levels in forest lands around living areas and today we call it prescribed burning and use it primarily to reduce the fire risk in heavily fuelled forests.

After European settlement in the second half of the 1800s, most of the water accessible forests were harvested for lumber by foreign countries. Logging near water was easy since the trees could be felled into the water and towed to their destination. Fires would regularly escape camps and operations and cause massive wildfires in the province. People were also using fire as a means to clear land to make way for agriculture. These prescribed burns were unregulated and often escaped the area of the intended burn.

In 1874 the legislative assembly passed the Bush Fire Act which called for fines up to $100 and/or three months in jail for causing forest fires. (Watts & Tolland, 2005) The fire problems continued until 1905 when the first Fire Wardens and firefighting crews were created (Watts & Tolland, 2005) and fire suppression was introduced to BC. Since 1905 fire suppression has been becoming more efficient and effective in our province.

Major advancements were made with the development of the airplane after World War 2. Planes were used to deliver equipment and personnel to fire sites as well as a part of a fire warning system. As technology increased, fire guard towers were replaced with weather stations with lightning detection systems and planes became strong enough to serve as water bombers. These new systems reduced response time and increased the effectiveness of fire suppression.

Fire suppression is the term used when describing active methods of reducing the size and/or severity of an existing fire. This is contrasted to fire protection, which consists of the pre-emptive methods of reducing the fire hazard before a fire has broken out. The last is fire prevention which is reducing the chances of human caused ignitions (such as the Smokey the Bear campaign). Largely thanks to the airplane, we have had over 50 years of very effective fire suppression in BC.

Fire requires three things to occur: oxygen, heat and fuel. Since fire protection is pre-emptive there isn't any heat to reduce and reducing oxygen would be useless so the only element

that can alter at this point would be the fuels. The amount and types of fuels present, the amount of water in these fuels, the size of the fuel, topography, climate and likelihood of ignitions (human and natural) all contribute to the fire hazard of that forest.

The fuels found in forests are divided into three categories: Fuels that build up on the forest floors as litter falls from trees and understory plants are called surface fuels. Buried fuels such as roots and buried organic matter are called ground fuels. Tree branches and debris are considered aerial fuels. If aerial fuels are close to the ground they are considered ladder fuels. Ladder fuels provide a means for fires to spread from the forest floor to the tree canopies.

Wildfires start as surface fires where a source of ignition (lightning or cigarette butt for example) provides enough heat to start a fire in the dry forest floor. If a surface fire is intense enough and ladder fuels or high winds are present a surface fire can spread to the tree canopies. Surface fuels can be removed manually or, if conditions are ideal and the fire hazard isn't too high, a prescribed burn can be implemented. To reduce the chances of a crown fire occurring the ladder fuels can be removed by pruning trees up to a certain height. This height is called the height to live crown and is an important indicator of fire hazard. Aerial fuels can be reduced by thinning the stand to open up space between canopies and reduce the chances of having an active crown fire. Pruning and thinning operations create a lot of surface fuels that would have to be removed. Prescribed burns cause concerns around communities due to the risk of the fires escaping or becoming more intense than anticipated. Also, the smoke created by these prescribed burns can cause asthma or other respiratory problems in nearby communities.

Fire regime is an important factor that distinguishes ecosystems from each other. Fire regimes are classified by the size, type, intensity and frequency of fires in an ecosystem (Pyne, Andrews, & Laven, 1996). Fire-independent ecosystems are ecosystems that do not have fire as a part of their system and rarely have fires but when they do the effects are extreme. The plant species present are not adapted to fire and will take a long time to recover afterwards. Fire-dependant ecosystems are prone to fires and plant species have adapted to this by recovering very quickly after a fire. Removing fire from these ecosystems will allow non-fire adapted species to establish themselves and compete with the existing species. The non-fire adapted species would normally have kept from outcompeting the fire adapted species by being killed off in the fires. Without regular fires, the existing species may be overcome by the non-fire adapted species. The Fire-initiated ecosystems are ecosystems that 'reset' after infrequent high intensity

fires. These fires kill off most vegetation but the plant species present regenerate well after a fire although they are long lived and may take decades to re-establish the pre-fire conditions. Lastly, fire-maintained ecosystems are prone to common, low intensity surface fires that most plant species present will be able to survive. These low intensity fires reduce the fuel load and help thin the stand.

In an ecosystem fire can occur in any (or all) of three locations: Surface fires consume the fuels on the forest floor with flames up to a few meters tall. Ground fires smoulder underground with little or no open flames due to the lack of oxygen. Crown fires burn in the forest's canopy layer and are generally the most severe of the three fire types. Crown fires can be described in three different ways: intermittent crown fires occur where a surface fire causes the occasional tree to torch (fire spreads to the canopy), an active crown fire occurs where the canopy is burning at the same ground speed as the surface fire associated with it and independent crown fires occur when the canopy fire is spreading faster than the surface fire.

Decades of fire suppression have contributed to fuels building up for much longer than they normally would without the interference of humans. Instead of many small fires occurring, the fuels have built up increasing the chances of a large, high severity fire.. A good example of a large, high severity fire would be the Okanagan Mountain Park Fire which started late in the dry summer of 2003. Conditions were very dry and strong winds helped this fire grow to over 250 square kilometres in size. The conditions were ideal for a large, high intensity fire and even with almost 2,500 people fighting the fire, the fire still entered the interface zone and destroyed 239 homes. (Kelowna, 2009)

Hot, dry summers are always a fire safety concern to small communities throughout BC. Wildfire protection plans are drawn up for the most susceptible communities in B.C.'s forests to reduce the risk of damage to property and injuries/deaths. Wildfire protection plans are unique to their designated area based on the conditions of the forest and the layout and population of the community. This paper is going to look at how wildfire protection measures can affect communities in ways other than reducing the fire hazard. Two case studies will be presented: the first is the city of Kimberley in the Kootneys and the second is DeCourcy Island, a small gulf island just south of Gabriola Island.

Case Study #1: Kimberley

Kimberley started off as a mining town around the turn of the 20th century producing zinc, lead and silver. The mine was in operation for almost a century before it was closed in 2001. Since then the community has relied heavily on the tourism industry. Kimberley developed a ski resort on some of the nearby mountains and every winter the population swells as tourists are attracted by the slopes. The resort offers multiple alpine tracks as well as almost 40kms of nordic ski trails (Kimberley N. S., 2010). Kimberley relies on busy winter ski seasons to support itself through the rest of the year.

Kimberley is situated between the fire-dependant ponderosa pine/bunchgrass fire regime known for frequent, low severity surface fires and the fire-maintained eastern slopes of the Purcell Mountains known for frequent, mixed severity surface fires (R.W. Gray Consulting, Kimberley Fire Management Plan Phase II: Kimberley Nature Park and Nordic Ski Area, 2005). Being placed between two frequent fire regimes is quite dangerous for a community that bases most of its economy on outdoor recreation. While a fire in the middle of winter during peak ski season is unlikely, a large scale fire during the summer would shut down the resort for a period of time depending on the damage. To cope with this, the city of Kimberley has set up an extensive three phase Community Wildfire Plan.

Phase one of Kimberley's Community Wildfire Plan was presented in October of 2004 and focused on "Fuel Management on City-Owned Lands". It assessed the fire risk in city owned lots which were found very close to private and commercial properties. Eight lots were identified and each lot was given a priority based on size, fire hazard and the proximity to sensitive areas (such as homes and town facilities). Each lot was sampled and management recommendations were drawn up based on this data. These stand treatments ranged from volunteer crews manually removing fuel to specialized crews and equipment removing beetle killed pine. (R.W. Gray Consulting, Kimberley Community Wildfire Protection Plan: Fuel Management on City-Owned Lands, 2004)

The second phase of Kimberley`s Community Wildfire Plan focused on the nordic ski area adjacent to the town. This plan was presented in November of 2005 and the operations were to be carried out by Tembec over the winter and summer of 2006 (R.W. Gray Consulting, Kimberley Fire Management Plan Phase II: Kimberley Nature Park and Nordic Ski Area, 2005).

The plan covered an area of almost one thousand hectares and divided it into 8 fire management units (FMU) based on objectives, management constraints, topographic features, access, values to be protected, political boundaries, fuel types, major fire regime groups, etc.

Of the eight FMU, FMU 8 was only briefly mentioned because it was only 5.7ha in size and contained the ponderosa pine/bunch grass ecosystem. This FMU had its own management plan already approved to maintain this ecosystem. FMU 7 was also only briefly mentioned because, although it was never clearly stated, it was slated for harvest. This would make any treatments applied to this block redundant. Of the remaining six FMUs all were recommended for "a commercial thin where economically feasible...". In addition to the commercial thinning, three (FMU 2, 3 and 5) were recommended for "extensive manual fuel treatments" and four (FMU 1, 4, 5 and 6) were recommended for "spatial isolation of small areas of [various levels of] fuel hazards" where appropriate (R.W. Gray Consulting, Kimberley Fire Management Plan Phase II: Kimberley Nature Park and Nordic Ski Area, 2005). The harvesting and commercial thinning operations reduced the fire potential and also provided some revenue to help pay for the treatments.

The last phase of Kimberley's Community Wildfire Plan was introduced in May of 2009 and amended in October of 2009. This section of the Community Wildfire Plan focused on restoring the Kimberley Nature Park back to a previous set of ecosystem conditions. The nature park overlaps some of the nordic ski area and contains some nordic ski trails outside that area as well. This area is believed to have had a fire-maintained ecosystem prior to the implementation of fire suppression. The decades of fire suppression have resulted in heavily overstocked stands of small diameter trees. The community wildfire plan recommended the majority of the area should be manually or mechanically thinned or masticated and excessive fuels removed followed by prescribed burning (R.W. Gray Consulting, Kimberley Community Wildfire Protection Plan Phase III: Operational Treatments in the Kimberley Nature Park, 2009).

Kimberley's Community Wildfire Plan did a very effective job in reducing the fire hazard of the forests around the town. Fire suppression had left the area overgrown with very high densities of very small diameter trees which created a large amount of fuel. These operations were so thorough that they negatively affected the aesthetics, recreation and tourism of the area. In the second phase a number of the FMU had areas that were thinned down to as little as 100-200 trees per hectare. FMU 3 was particularly overgrown and had its stems per

hectare reduced by 93%. Of the six FMU that this plan focused on, a total of 77% of the Kimberley nordic ski area was thinned down to 100-400 stems per hectare.

The city of Kimberley's web page states "We invite you to enjoy nature in all its glory" (Kimberley, 2010). The town advertises the unspoiled natural state of the forests around Kimberley and the community wildfire plan has created over 650ha of very unnatural forest right beside the town. Many people spend a great deal of their leisure time outdoors and "...for these people, outdoor recreation experiences are shaped in part by the setting in which these activities take place..." (Watts & Tolland, 2005).

The main goal of the operations was to reduce the fire hazard in the area immediately around the town. Other goals were to maintain aesthetics, maintain recreational values, maintain tourism, and to generate revenue. A public document found on Tembec's website states that the operations around the nordic club would "Remove [mountain pine beetle] infested trees and reduce stocking of susceptible trees. Increase crown-base height, while maintaining features desired by skiers..." (British Columbia Forest Practices Board, 2010)Removing the infested trees will reduce the future fuel loads of these stands. Neither the public document on Tembec's website nor the wildfire plan mention anything about maintaining conditions for skiers. Some residents of Kimberley are unhappy with the results of the treatments. They don't understand why their forests had to be 'destroyed'. They saw the forest as a natural state and the heavy thinning that took place changed the landscape. There has been a serious lack of communication between the public and the operations.

Case Study #2: DeCourcy Island

The second case study which is a small island south of Gabriola Island off the East coast of Vancouver Island called DeCourcy Island. DeCourcy Island is just over 200 hectares in size and mostly private land with a provincial park at the south-east end of the island.

The Island has quite a rich history; large middens can be found along the beaches indicated that First Nation groups were present using the island for a shellfish cultivation. In the 1920's it was home to a cult where the leader, who called himself Brother XII, convinced some 8000 followers to give him all their worldly possessions so he could usher in the new era of man.

After the cult failed the island was given to a woman who invested a particularly large sum of money in the cult. She kept the island for a number of years before selling it to a Swiss brother and sister in 1943 who turned the island into a productive, self sufficient community. The island was sold again in 1965 to developers who started dividing up the land into small properties and selling it slowly. Over the decades the island has been divided into around 160 private lots of various sizes. There is no permanent population on the island; most property owners are present only for a portion of the summer months. A significant portion (42ha) of the island is a private farm that is still in operation today as a hobby farm. The farm includes a small sawmill that will be discussed later.

The topography of the island is quite characteristic of the islands in the area. The islands are slanted sandstone running north-west to south-east resulting in shell beaches on the eastern shores and impressive cliffs on the western shores. This unique topography produces a series of ridges across the island and results in 'pools' of deep soils, ridges of thin soil and wet lands running laterally down the middle of the south part of the island. The island is found in the Coastal Douglas-fir dry maritime BEC zone with small patches of the Gary Oak ecosystems on some sections of the rocky cliffs.

A few veteran Douglas-fir (*Pseudotsuga menziesii*) that survived the last logging operations in the 1940's still remain scattered over the landscape. Evidence of past fires can be found as fire scars on the trunks and branches of some of these veteran trees. These ecosystems are quite moist and would be more likely to have surface fires than canopy fires.

A large population of deer have taken up residence on the island causing browse pressures to be very high and regeneration to be very low. There are some species the deer prefer not to eat, such as salal (*Gaultheria shallon*), which are present in large quantities.

Pirate's Cove Provincial Marine Park is a peninsula that takes up 24 hectares of the south eastern part of the island. It shares the ecosystems found on the rest of the island and is connected to it by a 150 meters wide section of marsh. There is a path that leads from the main part of the island, over the marsh, and through the park. The park also has 6 campsites that are available for overnight camping for a modest fee. There are no roads running through the park. The campgrounds and the 4km trail both see a lot of traffic during the summer months from locals and visitors.

With so much human traffic during the dry summer months the chances of ignition on this island are quite high. Generators, campfires, barbeques and cigarette butts are just a few of the possible sources of ignition. Since most of the island is private property it is up to the owners how they want to manage the forest fuels. No official fire prescription has been done for DeCourcy Island but the owners are urged by the DeCourcy Island Community Association (DICA for short) to follow the FireSmart manual (http://www.pssg.gov.bc.ca/firecom/) as best they can. Firesmart is not suitable for DeCourcy in all aspects because some of recommendations aren't possible. Firesmart recommends a certain radius of no fuels around a house, followed by a larger radius of low fuels. These radii are too large to implement on DeCourcy's one hectare lots. There are condensed guidelines regarding fire safety for homeowners distributed by the DeCourcy Island Fire Safety Committee which outline good fire safety protocols to help prevent fires from igniting and the proper protocol should a large fire break out.

DeCourcy has seen no major fires in the last 70 years and the fuels started building up in the provincial park. There are campsites in the park and the residents of island are concerned that careless campers could start a wildfire. Initially, there were campsites on both the park and private side of the bay. The residents who were concerned about campfires escaping and causing wildfires and campers 'exploring' the rest of the island and trespassing on private properties, took it upon themselves to move the campsites to a better location on the park side of the bay.

There are a few topics that have caused tension on the island between different property owners. The DeCourcy Island Community Association has roughly 90 members right now and is the group where community members can share their opinions and concerns with the rest of the community. The group discusses and does its best to resolve important issues that the island is facing, one of which is fire protection.

Some residents have fire-proofed their property, others have not and have no plans of doing do. There are a variety of reasons for not wanting to fire-proof your property: some owners do not spend a lot of time on the island and do not want to spend that time fire-proofing their properties, some do not want to fire-proof their property because they want to keep their property 'natural' or forest fuels are not seen as a problem. Many people want to keep the understory around their property to maintain the level of privacy that the plants provide them.

A point of controversy over the fire protection was when the island came up with a fire preparedness plan that addressed concerns of high fire potential on both the private properties

and in the provincial park. The result of this plan was active encouragement of the residents to keep their properties clean and the purchase of a fire truck. It was the first step in setting up a volunteer fire crew (which is now is now operational) to respond to any small or medium fire found on the island. Those opposed to the fire truck said it was a waste of money and not necessary on an island of this size. The fire truck is a great tool for fire suppression on the island because the response time of the fire crew would be very short. With such a fast response time the crew would have a good chance of putting out a fire before it got out of hand.

DeCourcy Island already has a number of factors that help reduce the forest fuels already found on the island. The farm has a small mill that is quite efficient at using some of the trees on the island. The operator of the mill selects dead or dying trees on the farm and removes them from the stand to produce lumber. This lumber is used for construction on the island. There are a number of root disease centers on the island and by removing these dead and dying trees the mill operations are reducing the fuels. The mill site itself is very clean and provides a small amount of firewood for the island residents. The operations are too small to make exporting lumber off the island cost effective because barging the product off the island would increase the cost to high to be competitive with the rest of the market.

In addition to the mill processing large trees the residents use quite a bit of firewood for heating, hot water and cooking. The residents who live on the island for several months of the year use a lot of firewood while other residents who are only present a few weeks a year use very little. An informal network of sharing wood (from those who do not need it to those who do need it) has set itself up on the island. This helps reduce fuels on most properties that have full or part time residents.

The deer on the island are also keeping the fuels down in some degree. The deer are very successfully suppressing understory growth and regeneration. This means there will be less fuel in general and significantly less ladder fuels in the medium and long term. Even though the chance of a canopy fire is low, there is still the danger of a surface fire. Residents are urged to keep the surface fuels to a minimum on their properties.

The deer population is causing some tension on the island. The heavy browse pressures are suppressing not only fuels, but nearly all plants up to about one meter in height. Residents are concerned about the lack of wildflowers in the Garry oak ecosystems, the lack of regeneration of western red cedar (*Thuja plicata*) and the health of personal gardens. Gardens have to have

fences 6 or 7 feet tall around them to keep the deer out. There are discussions currently going on of removing the deer to reduce the browse pressure and allow for more regeneration on the island. If the residents decide to reduce or remove the browse pressure then the understory would start regenerating again and more fuel treatments would need to be implemented in the future. The residents are currently looking into ways to humanely reduce the deer browse pressure and thin some of the stands to allow more resources for the understory. Many residents don't want to see the deer harmed, so further discussions are needed to see how the deer could be removed humanely, how many deer should be removed and how this will affect the forest's fuel levels.

Discussion

The two case studies are different in many ways. First and foremost they have different fire regimes. While both naturally have fire in their ecosystems, Kimberley's forests had a much higher wildfire potential than DeCourcy Island currently has. The people of Kimberley depend on outdoor recreation for jobs so the potential secondary effects of a wildfire could be much worse as well. The people on Decourcy Island have homes on the island but their livelihoods lie elsewhere.

The existing factors reducing the wildfire hazard on DeCourcy have been outlined: the use of firewood, the mill operations and the current browse pressures. These factors, especially the browse pressures, are nearly emulating the vegetation reduction effects of low severity surface fires. Kimberley doesn't have any of these advantages to reduce fuels. Deer do live in the area but are not abundant enough to impose strong browse pressures on the local species. In addition to this, the mountain pine beetle has killed a large number of lodgepole pine in the area which increases the fire hazard. Because of all of this, Kimberley needed to have its forest fuels treated much more than DeCourcy.

DeCourcy Island is also unique in that there is only a very small market for wood products. This market is comprised solely of building materials used for building houses or sheds on the island. Barging costs are much too high to ship wood products off the island and compete with mainland companies. Kimberley on the other hand does not have any restrictions like this

and thus has a large market for wood products. Any thinning operations on DeCourcy would likely go towards firewood whereas thinning operations near Kimberley could generate revenue which may encourage harvesting.

In addition to this the planning process is carried out by different parties in each case. The city of Kimberley hired a consultant and a major logging company (Tembec) to draw up plans and execute the operations. On DeCourcy, the responsibilities fall on a consolidated group of property owners. These property owners hold much different values than a consultant and logging company. The benefit of having consolidated management is that everyone who is participating in DICA can express their goals for the project. The downside to this option is the group uses a majority voting system to make decisions which can leave some residents unhappy with the outcome. Consolidated management caters to a broader array of management goals than other management strategies. The benefit of having a consultant managing a project is they are a professional, familiar with the practices of the project at hand. However, consultants may hold different values than the client and are costly.

A major goal to consultants and logging companies is revenue. Without revenue the consultant and logging company would not take on the project. The group on DeCourcy relies on onside sources of revenue therefore it is not a major value to their project. However, maintaining the lowest costs possible is still a major value on both projects. Values such as recreational value, aesthetic value and intrinsic value are very important to the DeCourcy Island group because they own the property. These values are less important to the consultant and logging company but are still considered because they are important to the people living in the community.

Looking at the values of the two case studies we see that the consultant hired by the city of Kimberley valued fire hazard reduction over all other goals. This is shown by the extensive thinning that negatively affected aesthetics, recreation and tourism. The group on DeCourcy values aesthetics and recreation more than fire hazard reduction because instead of thinning or pruning stands, they purchased a fire truck. Residents in Kimberley are not happy with the outcome of the thinning operations but the fire hazard has been reduced. The majority of residents on DeCourcy Island are happy with the fire truck but they have not actually addressed the fire hazard: there are still private properties that are not fire smart. The fire truck also acts as a compromise point between the people who believe the fuels are a risk to the island and the

people who don't. It has settled the fire protection debate temporarily and allowed the community to continue to function but has not solved the problem.

Conclusion

Fire protection operations will always affect aesthetics in some way. More intense operations will affect aesthetics greatly while less intense operations will affect it very little. Recreation and tourism are not directly affected by fire protection operations unless the fire protection is applied directly to a key area of either category. Where possible, fire protection operations should be implemented where they have the least negative effects on these goals. Operations will always affect aesthetics but if the operation site is high priority (recreational, touristic areas) then this should be taken into consideration. High priority sites should have the fuels reduced with the least negative effects on the other goals. This can be costly but a good way to ensure that his is accomplished is include some of the users of the site in the planning operations. Communication between parties is very important. Low priority sites can focus more on fire protection and less on the secondary goals.

Kimberley's forest will regenerate with time and "It is anticipated that there will be a significant quantity of dead downed material and density of sapling stems post-thinning that would contribute to a fire hazard." (R.W. Gray Consulting, Kimberley Fire Management Plan Phase II: Kimberley Nature Park and Nordic Ski Area, 2005). Kimberley's Wildfire Protection Plan acknowledges a potential fire hazard increase after the operations but makes no mention of future plans to clear this fuel. It does state that Tembec would not be able to address these fuels without a subsidy.

DeCourcy Island is still developing its plan to deal with fuels. During this time property owners are encouraged to keep their lots clean but not much more than that is being done to directly reduce the fire hazard. If a decision is made to reduce the browse pressures on the island then addition operations would have to be planned.

Bibliography

British Columbia Forest Practices Board. (2010, 02 03). *Appendix A*. Retrieved 04 03, 2011, from Legislative Assembly of British Columbia Legislative Library: http://www.llbc.leg.bc.ca/public/pubdocs/bcdocs2010/463206/11c022f6-e579-457d-92d3-0ce15a544bfc.pdf

Kelowna, C. o. (2009). *Okanagan Mountain Park Fire*. Retrieved 04 03, 2011, from City of Kelowna : http://www.city.kelowna.bc.ca/CM/page129.aspx

Kimberley. (2010). *Welcome to the City of Kimberley*. Retrieved 04 03, 2011, from City of Kimberley: http://www.city.kimberley.bc.ca/siteengine/activepage.asp

Kimberley, N. S. (2010). *Kimberley Nordic Club Home Page*. Retrieved 04 03, 2011, from Kimberley Nordic Club: http://www.kimberleynordic.org/

Pyne, S., Andrews, P., & Laven, R. (1996). *Introduction to wildland fire.* New York: John Wiley & Sons.

R.W. Gray Consulting, L. (2004). *Kimberley Community Wildfire Protection Plan: Fuel Management on City-Owned Lands.* Chilliwack: R.W. Gray Consulting Ltd.

R.W. Gray Consulting, L. (2005). *Kimberley Fire Management Plan Phase II: Kimberley Nature Park and Nordic Ski Area.* Chilliwack: R.W. Gray Consulting Ltd.

R.W. Gray Consulting, L. (2009). *Kimberley Community Wildfire Protection Plan Phase III: Operational Treatments in the Kimberley Nature Park.* Chilliwack: R.W. Gray Consulting Ltd.

Watts, S. B., & Tolland, L. (2005). *Forestry Handbook.* Vancouver: The Forestry Undergraduate Society.