Strategic Plan for the Use of Prescribed Fire to Restore Ecosystems in the Okanagan Region

Submitted By

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March 2006

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Ministry of Environment

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Executive Summary

The Okanagan Region represents one of the most biologically diverse regions of the Province. Low levels of precipitation, hot summers and mild winters provide a wide range of habitat for species that are unique to both British Columbia and Canada. This biological diversity is under considerable stress from a number of related problems associated with human population growth. Specifically these problems can be summarized as follows:

- Fire suppression has resulted in a change in fire regime (fire frequency and severity) throughout the region. Increasing tree densities and the resultant competition for moisture and nutrients have negatively impacted large areas of open grassland and forest. These changes have impacted forest health throughout the region.
- Habitats are shrinking, threatening and endangering many species. For example, only approximately 9% of the natural grasslands native to the region remain, due to roads, human development, and orchards.
- Introduction of exotic species threaten many of the native habitats.
- Overgrazing has also had a major impact on biodiversity by causing disturbance of soil and native vegetation, and by providing ideal conditions for the invasion and spread of exotic species.

While fire suppression is but one of many problems impacting biodiversity and ecosystem health in the region, it probably represents the single most important and spatially extensive issue that managers have the potential to impact. This report: 1) documents a rationale for prioritising prescribed burning as a restoration tool within the region; 2) uses GIS inventories and analysis tools to implement the rationale and spatially identify burn priorities, and; 3) outlines a five year plan to initiate the implementation of the project.

Prescribed burn priorities identified during a GIS analysis were field checked in several locations within the study area. For the most part, the results indicated that the algorithm developed to identify restoration priorities met the objectives of a coarse scale analysis. Following the field visit, identified treatment areas were summarized by priority within ownership categories, inside and outside of the Timber Harvesting Land Base (THLB), and by treatment complexity and associated costs.

Overall, a total of more than 36,000 ha have been classified as high priority for prescribed burning to facilitate restoration. However, much of this area (26,267 ha) is within the THLB on crown land and may be constrained by other land management objectives. Only 9,734 ha are outside of the THLB. Large areas, both within the THLB (334,152 ha) and outside the THLB (157,508 ha), have been classified as moderate priority for prescribed burning.

In addition to prescribed burn priority identification, the report addresses the development of a five-year burning plan, monitoring treated areas, and discusses treatment strategies.

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1.0 Introduction

Historically in British Columbia, ecosystem restoration (ER) has suffered from the lack of a strategic, integrated approach to planning and operations. Part of this is due to a common debate pitting the management of individual species, be they endangered species or commodity species, against the management of "ecosystems" (Weigand and Everett 1994). The scarcity of year-to-year consistency in funding, coupled with insufficient staff resources to run a program, has also led to a scattered approach to restoration. It is also possible that adequate trained and skilled resources to carry out a modest sized ER program are lacking in most regions.

Currently, ER programs could be described as being "reactive" in nature with treatment units identified by immediate priority and funded out of whatever dollars can be cobbled together. Agency personnel assigned to the task of implementing ER do not have the time or resources for long-range planning, and become little more than contract administrators for a program carried out largely by outside consultants and contractors. The one exception to the rule in BC, at least when it comes to higher level strategic planning, is the Kootenay-Boundary Land-Use Plan (KBLUP), which has taken large steps towards developing a strategic ER program. The KBLUP used the assignment of natural disturbance type 4 (NDT4) ecosystems based on biogeoclimatic ecosystem (BEC) zones. This information was used to guide restoration activities within the management area. NDT4 ecosystems include grassland, shurbland and forested communities that generally experience frequent, low severity fire regimes. Unfortunately, this plan also suffers from many of the same strategic planning shortfalls experienced in other parts of the province. The KBLUP plan has identified, in a coarse way, the target ecosystems for restoration in the NDT4; this could be referred to as "top-down" direction. The "bottom-up" direction of the plan (the local-level, long-term juxtaposition of objectives) is missing. Individual projects are not explicitly linked but appear to be reactionary and "single-species" focused, funding is inconsistent, program monitoring is inadequate, and resources are insufficient. These are "strategic" issues with the plan though from both a spatial sense and an objective-attainment sense.

A solution to the strategic ER planning issue is the development of regional ER programs focused on managing for ecosystem resilience (Wade 1988, Walker 1994) as opposed to managing for a single species. These programs require long-term direction from strategic plans in order to develop activities that will meet long-term landscape level objectives. These programs also require dedicated personnel resources and operations funding. While the latter is not part of this project, addressing the former would certainly provide strong rationale for increased resources to implement the program.

The approach to strategic planning put forward in this report comes from prior experience developing comprehensive ER programs in both the US and BC. In the case of the US southwest, strong cultural connections had to be made within the ER program because of long-standing Apache Indian traditions in land use. In the Squamish Forest District, socio-economic connections had to be made because the primary land-use was timber management. Regardless of the objectives of the overarching land management agency, there are ways to shape and adapt ER to meet strategic ER planning goals. The steps in this process are as follows:

1. Purpose and Need for Ecosystem Restoration. This may come from pre-existing agency documents that have established goals and objectives for the region. This should include strong scientific rationale for the program (*i.e.*, why, where, when and how). In the Squamish Forest District, extensive historic fire regime and stand structure studies were conducted to provide direction for the restoration program. These studies were designed to determine the historic or natural range of variation (RONV) and how it compared with current ecosystem structure and composition. Unfortunately, there are few Okanagan region studies of this nature; however, several surrogates do exist. Gray and Riccius (1999) in the Merritt area and Gray (2003) in the Sinlahekin Valley in Washington State provide some applicable data, while the coarse-scale historic natural fire regime (HNFR) and fire regime condition class (FRCC) models developed by Blackwell *et al.* (2003) provide further spatial direction. This foundation information is critical to enabling spatial prioritization of areas further along in the process. Defining the restoration program rationale is also critical for public education purposes. Glaring knowledge gaps in disturbance dynamics and ecosystem responses can be identified here and incorporated into program-level adaptive management and monitoring.
2. Data Collection, Collation, and Analysis. In this phase the gross area under management, past management activities, pre-existing and future management activities are investigated. Coarse- and fine-filter analysis systems (GIS-based) that will enable identification of future (5-year window) treatment priorities are built in this phase. The gross area of management needs to be reviewed in the context of biogeography (topography, physiography, vegetation characteristics), ownership (public, private), and primary land-use (timber harvesting, wildlife habitat). This becomes one of the key baseline layers for planning the feasibility and costs of various ER strategies. In addition, existing plans for future treatments are reviewed to see how they fit with the new model. There is insufficient funding in the system to discard prior work so every effort must be made to make some use of it. GIS-based filters and queries are used to help dial down to operational units once a hierarchical planning approach (agency goals, objectives and prioritization) has been developed. This stage incorporates the necessary environmental, ecological, and social values in a spatial context. Once individual treatment areas have been identified, further analysis is conducted to address treatment strategies, feasibility of success, risk, and cost. Issues such as down-wind smoke sensitive areas, adjacent area hazards (recent harvest/land clearing slash), adjacent area land-use conflicts (livestock vs native ungulates, etc.) are addressed here.

The Ministry of Environment (MOE) has not traditionally managed ecosystems. They have managed for specific species and/or attributes within ecosystems but they have not systematically planned for the management of ecosystem health (defined as inherent natural diversity and resilience (Wade 1988, Walker 1994) across their jurisdiction. Ecosystem management has been characterized by diffuse, single-focus treatments within a general ecological framework. There is no overarching strategy to manage all ecosystems in a resilient state starting with those in the furthest departed condition.

The Ministry of Forests and Range (MOFR) has not traditionally managed ecosystems either. They have managed for a specific objective (*i.e.*, timber and range) within ecosystems but they have not systematically planned for the management of ecosystem diversity and resilience across their jurisdiction. This has resulted in a dominant objective being managed for in a diffuse way. Management focus is scattered across the landscape in an attempt to answer to social and environmental impacts. Ecosystem health issues abound, attesting to the inadequacy of this approach.

The KBLUP plan could be seen as a compromise strategy between the two. The MOFR emphasis is de-emphasized to a certain degree (reduced stocking standards); ecosystem health can be maintained through repeated disturbance to promote diversity and resilience at the stand level. The MOE single species or habitat attribute emphasis, unfortunately, still prevails as can be seen in how treatments are prioritized. The most ecologically, socially and economically feasible areas are not the first to be treated, instead the prioritization of treatment is determined through the single-species/attribute approach. To make the KBLUP truly successful, the strategy for ecosystem health should shift to a prioritization based on landscape scale forest health factors and treatment funding should compliment and encourage this shift. Although it would be ecologically ideal to treat all areas that are departed from their natural state, social and economic constraints mean that this approach may fail to achieve landscape-level forest health objectives. With limited human and financial recourses, it is arguably more efficient to prioritize treatments first in areas that are less severely departed from their natural state. This ensures that these ecosystems are maintained in a healthy state, potentially enables more area to be treated and allows any remaining resources to be directed to treating more departed ecosystems.

The approach of this plan is to adopt a strategic direction focusing on landscape-scale ecosystem health. While definitions of ecosystem health are prevalent throughout the literature the central tenets are the creation and maintenance of naturally diverse (meaning "native" species) and resilient (elasticity following disturbance) ecosystems (Cairn 1988, Jordan 1988, Everett 1994, Kolb *et al.* 1994, DellaSala *et al.* 1995, Gayton 2001). This requires the ability to quantify "health" in a GIS platform. In the dry forest and grassland ecosystems of North America, altered fire regimes are at the core of ecosystem health (Everett 1994, Covington 1995, Fiedler *et al.* 1995, Rapport and Yazvenko 1995). Fires have either not occurred frequently enough (*e.g.*, historically open ponderosa pine bunchgrass ecosystems), or have occurred too frequently (*e.g.*, cheatgrass invasion areas). Using fire regime condition as a surrogate for ecosystem health, we can build a base layer from which additional data can be added to culminate in a landscape-scale strategy for ecosystem restoration activities.

2.0 Study Area

The study area encompasses 2,966,765 ha of the Okanagan (Figure 1 and Figure 2). The study area boundary is based on the MOE's Region 8 (Okanagan) jurisdictional boundary. The boundary's southern most edge runs along the Canada-US border. The eastern boundary starts between Grand Forks and Rossland, and roughly follows the Columbia Mountain Range to the north. The northern most point of the boundary is Mount Griffin Provincial Park, just below Revelstoke. The western boundary runs down between Merritt and Kelowna and then moves further to the west (to approximately 45 km west of Princeton) before meeting the Canada-US border.

The study area falls predominantly within the Southern Interior Forest Region (RSI). A small portion of the area overlaps with the Coast Forest Region (RCO). Several forest districts overlap with the study area. Within the RSI, these include the Okanagan Shuswap District, the Arrow Boundary District and the Cascades Forest District. A small portion of the RCO's Chilliwack District overlaps the study area's southwestern corner.

The terrain and climate within this area is highly diverse. The following biogeoclimatic (BEC) zones define the study area:

- Interior Douglas-fir (861,560.7 ha [29.0%]);
- Englemann Spruce-Subalpine fir (705,588.0 ha [23.8%]);
- Interior Cedar Hemlock (560,864.5 ha [18.9%]);
- Montane Spruce (559,649.7 ha [18.9%]);
- Ponderosa Pine (128,591.2 ha [4.3 %])
- Alpine Tundra (79,750.5 ha [2.7%]);
- Bunchgrass (61,938.9 ha [2.1%]); and
- Coastal Western Hemlock (8,821.2 ha [0.3%]).

The study area contains features that were formed by uplifting of the earth's crust between one and two million years ago. The mountainous areas are made up of folded sedimentary and metamorphic rock, and form part of the Columbia Mountain Chain (consisting of the Purcell Mountains, Selkirk Mountains, Monashee Mountains and Cariboo Mountains). The Interior Plateau, which is to the west of the Columbia Mountains, was also formed by uplifting but was not folded or carved. However, erosion by rivers has resulted in uneven, rolling terrain. The Suhswap Highland, Okanagan Highland, Quesnel Highland, Thompson Plateau, Fraser Plateau and Basin and Nechacko Plateau form the Interior Plateau. Glacial action formed the Okanagan Valley (at the centre of the study area) roughly 10,000 years ago when the ice retreated.

The network of lakes and rivers left behind when the glaciers retreated influences the local climate. Because of the influence of these water-bodies on air currents, the Okanagan Valley tends to experience milder winters than the areas to its north and east. The Okanagan Valley's climate is described as mild and continental[1]. Summer tends to consist of hot days, cool nights and relatively low humidity. Winters are moderate to cold with cool, humid air. The central part of the valley (Kelowna and Peachland) averages 1,954 hours of sunshine per year and 29.8 cm of rain[2]. The southern part of the valley (Osoyoos and Penticton) is within the northernmost tip of the Great Basin Desert and has the driest climate in Canada (average rainfall of 28.0 cm per year).

Figure 1. Study Area Boundary

[1] http://www.britishcolumbia.com/information/details.asp?id=16
[2] source: environment Canada. Based on a minimum of 15 years data during the period 1971-2000.

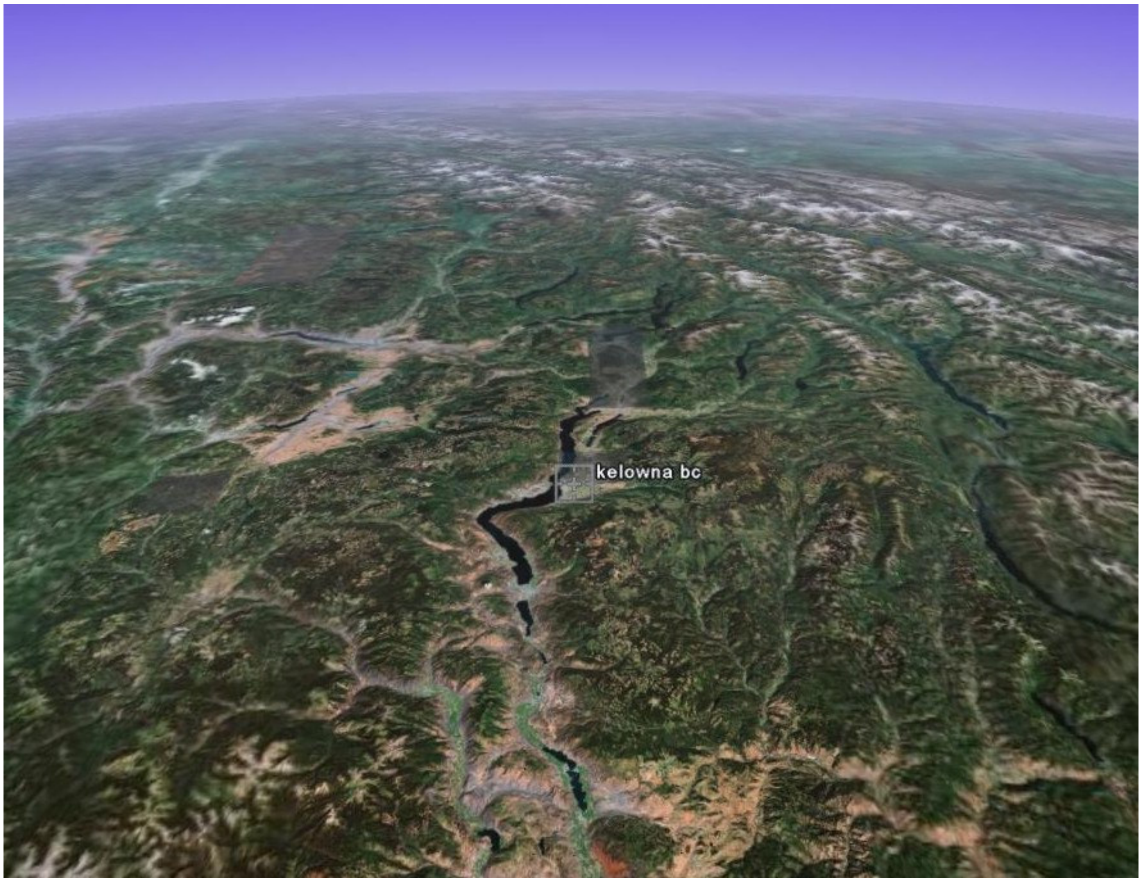

Figure 2. View of the approximate study area looking north (image sourced from Google Earth™)

3.0 Historic Fire Regime and Fire Regime Departure Layers

The model outputs for Historic Natural Fire Regime (HNFR) and Fire Regime Condition Class (FRCC) (Blackwell *et al.* 2003) incorporate the best available knowledge of pre-settlement fire history and the social and ecological consequences of departures in those fire regimes. Data used in the HNFR model includes top-down controls (regional climate), bottom-up controls (local vegetation classification, topography, and physiography), and process metrics from regional stand-level fire history studies. The FRCC model includes stand-level structural elements that impact fire behavior and fire regime characteristics and provides a qualitative assessment of potential fire-related consequences. At their core, these two models assess risk as probability (HNFR) and consequence (FRCC). Risk analysis should form the foundation of any ER program prioritization strategy. Probability and consequence can be configured in any number of ways depending on the management objectives for the land manager. In the case of the Ministry of Environment, a strong program emphasis is placed on managing ecosystem sustainability, diversity, and above all resilience.

The investigation of RONV provides us with the capacity to predict ecosystem component adaptability to the natural disturbance regime. Following a natural disturbance, the ecosystem components that are adapted to the disturbance should exhibit resilience. If they do not respond, it is likely that the characteristics of the disturbance regime (timing, intensity, etc.) have exceeded RONV (Meyer *et al.* 2005).

Why is RONV important? As a society and as professionals managing on behalf of society, we need to be able to confidently predict the impacts of our actions and the consequences of natural disturbances. The RONV condition provides us with a documented set of parameters based on stand and landscape patterns resulting from disturbance processes. If we choose to manage conditions outside RONV it is our responsibility to predict outcomes and inform managers of potential consequences.

4.0 Methods

There were three steps undertaken to identify and prioritize unconstrained areas for ecological restoration treatment (Figure 3):

1. Develop a Priority Treatment Rating using condition class, historic natural fire regime and forest health factors.

2. Develop a Treatment Complexity Rating using wildland urban interface and condition class.

3. Combine the Treatment Complexity Rating, Timber Harvesting Land Base (THLB) and Ownership to delineate the least constrained High Priority Treatment areas.

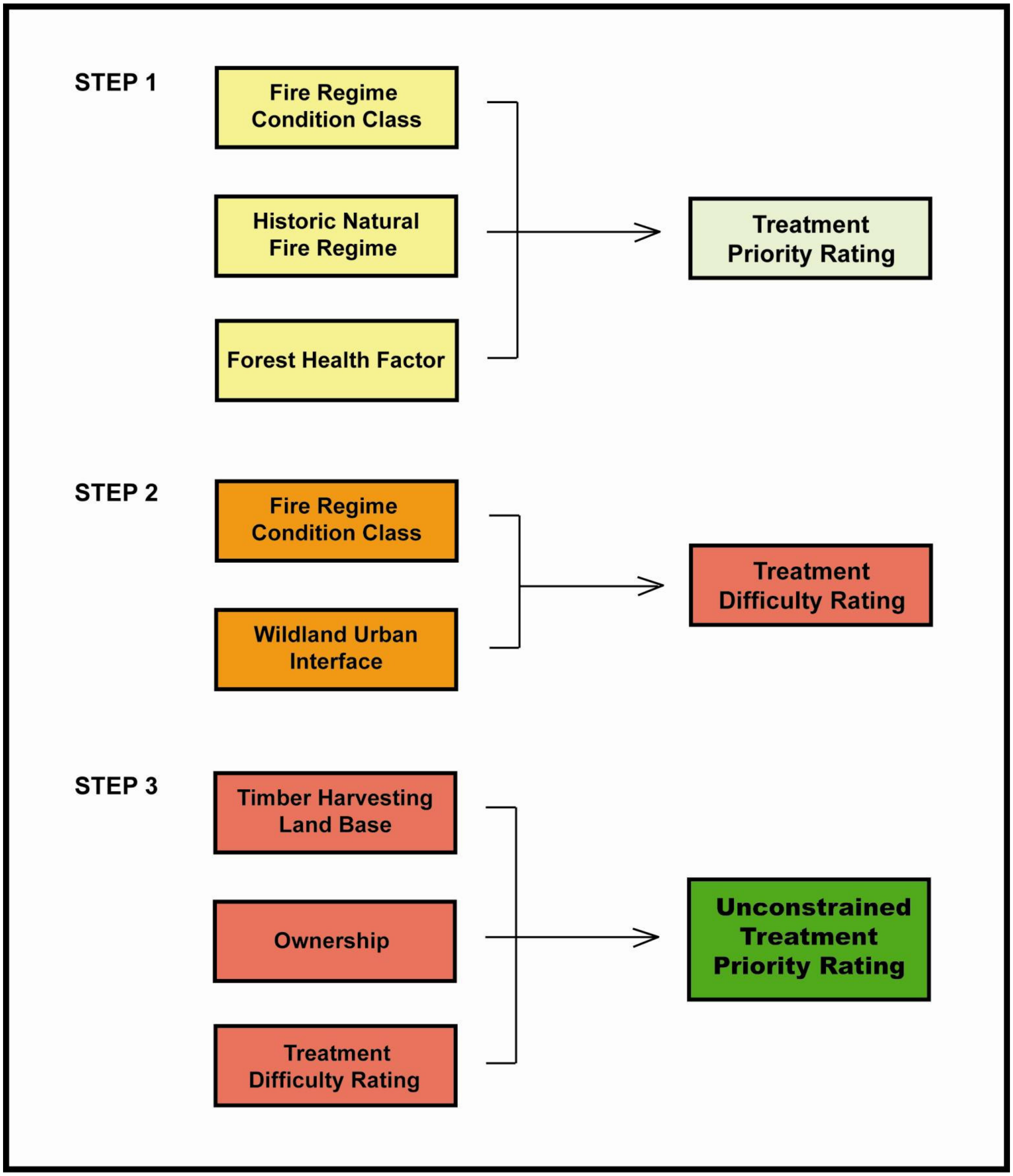

Figure 3. Steps undertaken to identify and prioritize unconstrained areas for ecological restoration treatment.

4.1 Treatment Priority Rating

4.1.1 Historic Natural Fire Regime

The HNFR layer is a combination of known and predicted fire regime metrics by BEC subzone plus topographic variables that affect fire behavior. A detailed description of how the HNFRs were constructed can be found in Blackwell *et al.* 2003. In the predictive model HNFR is ranked according to flammability of the dry forest types, which include the Ponderosa Pine and Interior Douglas-fir BEC zones. The most flammable fire regime is HNFR I which includes low elevation, dry ponderosa pine and Douglas-fir forests with grass and/or timber litter as the primary carrier of surface fire. Upslope and on cool aspects at low elevation from HNFR I is the HNFR II fire regimes which are characterized by slightly cooler and moister conditions than HNFR I. Fuelbeds in HNFR II range from grass and timber litter to compacted duff and moss. Further upslope and on cooler aspects is HNFR IV which has a shorter fire season than HNFR I. Fuels here typically ranged from compacted timber litter to heavy loading of timber litter and dead downed trees.

4.1.2 Fire Regime Condition Class

FRCC is a quantitative measure of fire regime departure from historic conditions. The more fire is removed from a fire regime the more the fire regime changes. This modeling system has as its basis the supposition that fire will eventually return to the fire regime. The more removed fire is, combined with the more frequent fire used to be within the system, the greater the environmental impact. This supposition is in marked contrast to the opinions of some professionals that once an historic fire regime has changed there is little value in considering a move back to historic trends. This professional opinion has its basis in the opinion that fire will not return to the system. The use of this model holds its value in presenting the range of consequences that could occur once fire returns to the system. Once again, the reader is encouraged to review Blackwell *et al.* 2003 for a detailed description of FRCC.

Applying in a predictive model FRCC can be used to derive two different metrics: a) time-since-disturbance, or b) complexity of treatment. Time-since-disturbance is a qualitative indicator of structural changes to the ecosystem due to the cessation of fire (*i.e.*, increased fuel loading, increased tree density, increased canopy closure, etc.). In Blackwell *et al.* (2003) FRCC is ranked from furthest departed (longest time-since-disturbance) to least departed. This ranking would identify sites with fuel load, tree density, etc., as the highest priority for treatment.

FRCC can also be used to gauge complexity of treatment, with complexity defined as both complex objectives, and high unit treatment cost. Canopy closure from forest cover inventories is an integral component of FRCC determination. FRCC 1 to 3 indicate increasing time-since-disturbance and increasing canopy closure (*i.e.*, increasing stand density). For example, a stand classified as FRCC 3 in an HNFR I fire regime has missed numerous surface fires and has likely experienced an increase in canopy closure. Ecologically, this may be the most appropriate stand to treat first within the framework of a prioritization model. Obviously with fuels and stand structure significantly departed from RONV these stands are at high risk to adverse impacts from wildfire and/or insects and diseases. Stand-level biodiversity and resilience would be impaired should a natural disturbance occur. However, several issues make this approach difficult to implement. A limited restoration program budget is one significant issue but a greater issue is the need to conduct very intensive pre-burning fuel modification treatments.

The very issues that make FRCC 3 stands good candidates to place at the top of prioritization make them very complex candidates to restore. High stand density, high fuel load, and high canopy closure make these sites very difficult and expensive to treat with prescribed fire alone. In our prioritization model, we have reversed the ranking order for FRCC and have identified FRCC 1 stands as the priority. This is from the perspective of relative complexity of treatment objectives and cost. With a limited annual budget and a small, developing burn program it was felt by the project team that this was a more appropriate approach for this project.

Another ideological reason for taking this approach is to treat FRCC 1 sites as a preventative measure, thus holding FRCC 1 sites from sliding into FRCC 2. This approach is being widely debated amongst our colleagues in the US who wrestle with this conundrum as well. Do we hold off maintaining a site in FRCC 1 because we are concentrating on restoring an FRCC 2 or 3 site? At the end of he day are we any further ahead? We chose to focus efforts on the former – preventing FRCC 1 sites from becoming ingrown.

4.1.3 Forest Health Factors

Since 1999, the MOFR has carried out aerial overview flights across the majority of forested land in BC to survey forest health (JCH Forest Pest Management 2002). The survey data has been used as a key source to document the Mountain Pine Beetle outbreak and a number of other important forest health agents in BC. The data is composed of pest infestation polygons and points each assigned a specific Forest Health Factor (pest code, damage agent or condition code).

The entire length of record (1999 to 2004) was used in this project. All point infestations were buffered by 100 m. This buffered coverage was then merged with the polygon infestation coverage to create a Forest Health Factor (FHF) coverage for the entire Okanagan Region.

4.1.4 GIS Processing

Each input coverage (FRCC, HNFR and FHF) was converted into 25 x 25 m raster cells and assigned ratings according to Table 1. Individual ratings for each raster cell were developed on 0 to 10 scales.

Table 1. Rating scale matrix for input coverages to establish Treatment Rating Priority.

Input Coverages		Rating
Fire Regime Condition Class	1	10
	2	5
	3	0

	None	0
Historic Natural Fire Regime	I	10
	II	8
	IV	5
	Others/None	0
Forest Health Factor	Present	10
	Absent	0

To create the Treatment Priority Rating, the rating for each raster cell was calculated as a weighted sum of the three input coverages as per the following equation:

(FRCC*0.33) + (HNFR*0.33) + (FHF*0.33) = Treatment Priority Rating

Table 2 shows final Treatment Priority Ratings.

Table 2. Final Treatment Priority Ratings

Rating	Priority
>/= 7.5	High
>/= 5.0 < 7.5	Moderate
>/= 2.5 < 5.0	Low
0 < 2.5	Very Low

4.2 Treatment Complexity Rating

4.2.1 Fire Regime Condition Class

FRCC 3 stands are considered the most difficult and costly to treat. See section 4.1.1 for a overview discussion of this issue.

4.2.2 Wildland Urban Interface

The Wildland Urban Interface (WUI) was used as an indicator of proximity to inhabited areas and was based on structure density from TRIM. All anthological building features were extracted from this data set and buffered such that structural classes could be assigned based on their density on the landscape.

Interface density classes were delineated as follows:

Undeveloped 0-1 structures/km^2
Isolated =1-10 structures/km^2
Mixed = 10-100 structures/km^2
Developed = 100-1000 structures/km^2
Urban = > 1000 structures/km^2

All WUI categories, except undeveloped, were buffered by 1 km. Difficulty to treat increases (i.e, cost, emissions mitigation, etc.) with increasing proximity to WUI and increasing WUI density class.

4.2.3 *GIS Processing*

Each input coverage (FRCC and WUI) was converted into 25 x 25 m raster cells and assigned ratings according to Table 3. Individual ratings for each raster cell were developed on 0 to 10 scales.

Table 3. Rating scale matrix for input coverages to establish Treatment Complexity Ratings.

Input Coverages		Rating
Fire Regime Condition Class	3	10
	2	8
	1	5
	None	0
Wildland Urban Interface	Urban	10
	Developed	9
	Mixed	7
	Isolated	5
	Buffer 1km	5
	Underdeveloped/None	0

To create the Treatment Complexity Rating, the rating for each raster cell was calculated as a weighted sum of the two input coverages as per the following equation:

$$(FRCC*0.5) + (WUI*0.5) = \text{Treatment Complexity Rating}$$

Table 4 shows final Treatment Complexity Ratings.

Table 4. Final Treatment Complexity Ratings

Rating	Priority
>/= 7.5	High
>/= 5.0 < 7.5	Moderate
>/= 2.5 < 5.0	Low
0 < 2.5	Very Low

4.3 Constrained Area

The Timber Harvesting Land Base, Ownership and Treatment Complexity result were all overlaid spatially to net out the unconstrained High Priority Treatment areas.

5.0 Results and Discussion

5.1 Field checking the GIS analysis

Once the initial mapping results were completed in GIS, map outputs of selected areas were created to check the results. Darke Lake Park provides a good example of one of the test areas visited during the field check. The following discussion summarizes some of the issues identified during the field checking process.

Darke Lake Park (Figure 4) and adjacent area provides a good example of the variables that were considered during the development of the prioritization model. This small park lies due west of Summerland in a narrow north-south oriented valley. Many of the planning issues apparent at Darke Lake are similar, if not identical to issues found throughout the Okanagan Region.

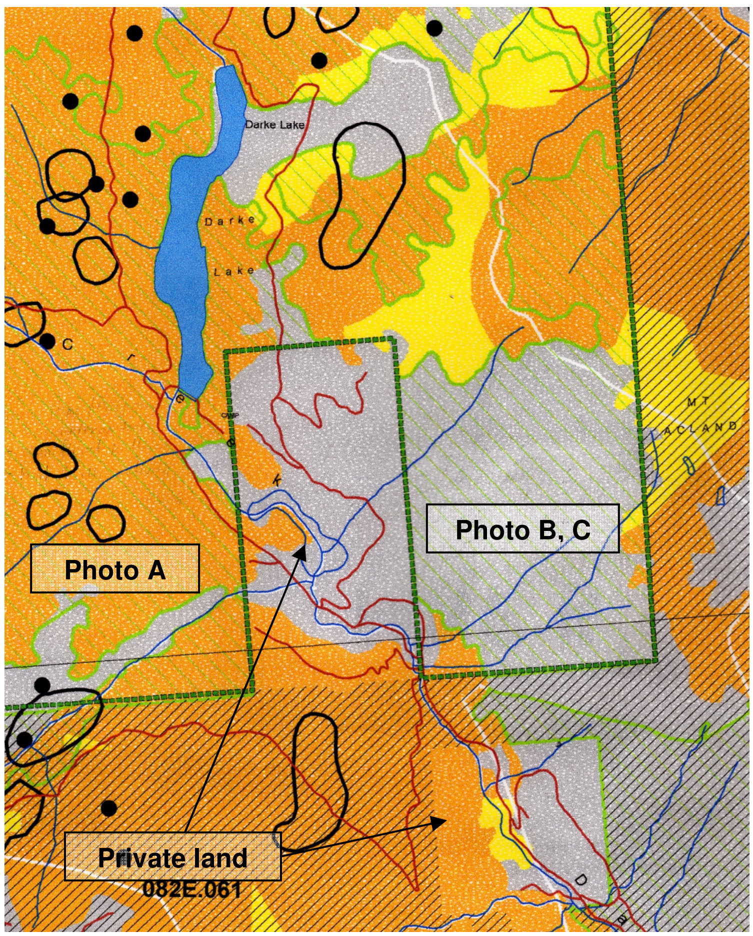

Figure 4. Section of Darke Lake Provincial Park showing interface of park with adjacent private land. Additional overlying layers include: FRCC, UWR, FHF, and OGMAs.

As is described in the introduction and methodology sections, we began with two layers: HNFR and FRCC. This area is in FRCC 3, the most departed condition and has stand-level fuels and tree density conditions similar to those pictured in Figure 5. This image is of the landscape at "Photo A" in Figure 4. Tree density is high and there is a high incidence of dead trees in the canopy. It was not possible to observe surface fuels due to snow conditions. The addition of Forest Health Factors, the black points and polygons in Figure 4, strengthens the case for placing these areas on the prioritization list. It is interesting to note that this area is designated as both an OGMA and UWR, which appears to be contradictory to sound biodiversity management considering its current condition. Current stand structure is significantly departed from historic structure and is jeopardizing the resilience of historic "old forest" structures. Land-use designations such as OGMA and UWR did not enter our prioritization model as planning elements for reasons that became apparent in this Darke Lake example. "Protection" of the inherent values in landscape-level designations such as OGMA and UWR should not be seen to be in conflict with active restoration provided that the "values" being protected are fully defined. These "values" tend to be specific structures such as snags, downed wood, densities of old trees by species, understory plant communities, etc. These are all elements of biodiversity and ecosystem resilience that can be addressed at the operational level (5.3.1 Setting Appropriate Objectives).

Figure 5. Hillslope on the west side of Darke Lake.

The modeling combination of HNFR, FRCC, and FHF would suggest that the west side of Darke Lake should be a good candidate for restoration. Ecologically, this makes a great deal of sense. However, when we consider operational-level complexity (difficulty of burning), this area ranks as very high difficulty. Given the high difficulty associated with treating this area both from a technical and cost perspective these areas ranked lower within this project's overall treatment priorization scheme. Essentially, those areas with the worst FRCC and FHF issues are also the most difficult and costly to treat. As a result, in this analysis they have a lower priority for treatment, which is the inverse of what would result if the prioritization ranking only considered HNRC, FRCC, and FHF.

Several factors make the west side of Darke Lake a very complex restoration project. First and foremost is its proximity to private land and dwellings. Two large parcels of private land are identified in Figure 4. The wildland-urban interface can be viewed two-ways in this analysis: as a significant socio-economic factor to consider, and as an impetus to treat. Any large-scale project utilizing prescribed fire becomes more expensive the closer it is to high values at risk. This type of burn area requires more resources on holding actions and mop-up when compared with burns further from the interface. Additionally, more effort is required to conduct public consultation and education, and smoke management becomes a more significant concern that can limit the burn window and may put more restrictions on the prescription.

The second contributor to complexity on the west side of Darke Lake is tree density and potential surface fuel load. This landscape would require extensive fuel modification, including the commercial removal of timber, before prescribed fire could be applied. Using prescribed fire alone is not advised because of issues identified in 5.3.1 Setting Appropriate Objectives. Identifying areas based on cost of treatment, which has been addressed in this analysis, can be further parsed to include areas requiring commercial thinning prior to wildland fire use. Where tree removal is considered appropriate under the MOE's new tree removal regulations, these areas could provide a stream of revenue that could be used to fund restoration-burning activities.

The east side of Darke Lake, Photo points B (Figure 6) and C (Figure 7), is modeled as FRCC 1, meaning it is least departed from historic conditions. From a landscape perspective (Figure 6) the forest is more open than the opposite side of the valley. At the stand-level (Figure 7) the rate of forest ingrowth becomes apparent.

Figure 6. Landscape view of the east side of Darke Lake.

Figure 7. Stand-level view of forest structure on the east side of Darke Lake.

This area, as a candidate for restoration, has definite advantages over the west side forests. Project complexity is reduced by the forest structure and fuelbed characteristics. A light spring burn, or even a fall burn, is possible here whereas on the west side of the valley only a fall burn would be feasible (due to aspect and fuelbed moisture). It would still be advisable to do some fuel modification prior to prescribed burning on a site such as this to gain a higher precision in meeting burn objectives (5.3.1 Setting Appropriate Objectives). Project cost in this situation would be greatly reduced compared with those across the valley but would still be high due to proximity to the WUI.

5.2 Analysis and Mapping Summaries

5.2.1 Distribution of Historic Natural Fire Regimes within the study area

Within the total study area of 2,966,765 ha, there were 850,000 ha (29%) assigned to a Historic Natural Fire Regime II (Table 5). A significant portion of the total study area (621,404 ha – 21%) was within other fire regime classes or was not classified due to problematic data (where forest cover data is missing), or alpine and alpine tundra (Figure 8). Table 5 provides an area summary of the HNFR classes. HNFR classes I, II, and IV accounted for 80% of the classified HNFR area and were primarily associated with the lower elevation valley bottom forests that occur within the study area. Vegetation within these areas are typically dominated by Douglas-fir and Ponderosa pine forests. These fire regimes represent the areas most heavily impacted by resource extraction and human development. The three fire regimes HNFR I, II, and IV were similar in their distribution; HNFR I, II, and IV accounting for 27%, 29%, and 24% of the study area respectively.

Table 5. Area summary of ownership and historic natural fire regimes within and outside of timber harvesting land base for the study area.

	HNFR			
	I	**II**	**IV**	**Other**
Inside THLB	**ha (%)**	**ha (%)**	**ha (%)**	**ha (%)**
Federal Ownership	0	0	0	0
Provincial Ownership	343,025 (22)	622,194 (39)	455,791 (29)	172,416 (11)
Private Ownership	0	0	0	0
No Data	0	0	0	0
Outside THLB				
Federal Ownership	27,306 (2)	7,423 (1)	1,442 (0)	28,001 (2)
Provincial Ownership	210,036 (15)	202,496 (15)	213,424 (16)	336,208 (25)
Private Ownership	211,878 (16)	26,011 (2)	14,850 (1)	84,364 (6)
No Data	55 (0)	32 (0)	106 (0)	157 (0)
Ownership Totals				
Federal Ownership	27,306 (1)	7,423 (0)	1,442 (0)	28,001 (1)
Provincial Ownership	553,061 (19)	824,690 (28)	669,215 (23)	508,623 (17)
Private Ownership	211,878 (7)	26,011 (1)	14,850 (1)	84,364 (3)
No Data	55 (0)	32 (0)	106 (0)	157 (0)

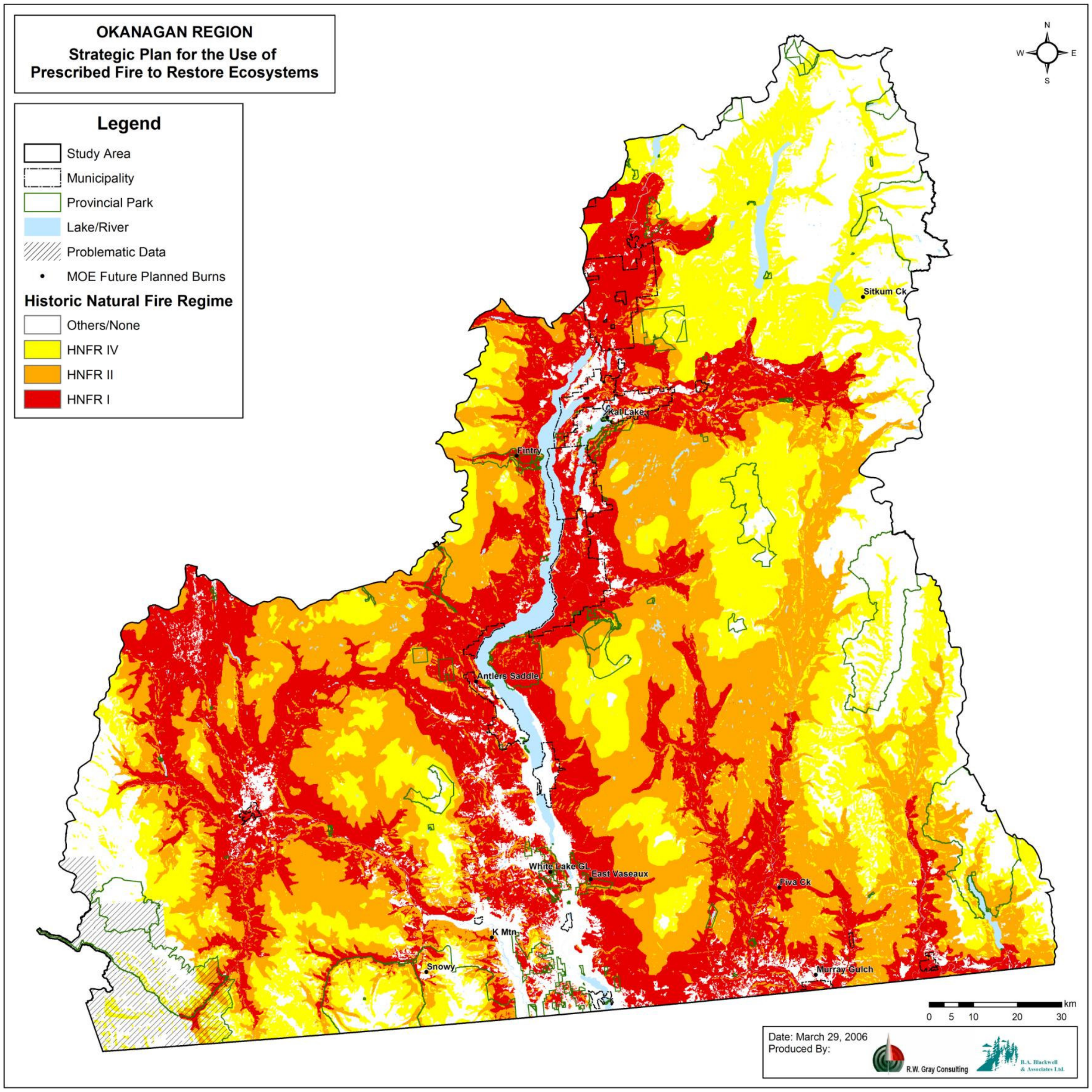

Figure 8. Historic natural fire regime within the study area.

5.2.2 Distribution of Condition Class Within the Study Area

As discussed early in the report condition class provides a good measure of ecosystems that require some form of restoration to improve biodiversity and forest health. For all ownership categories 45% of the study area was departed (Condition Class 2 and 3) from its historical condition in terms of fuel loading, vegetation composition, and structure (

	Condition Class			
	1	2	3	Other
	ha (%)	ha (%)	ha (%)	ha (%)
Inside THLB				
Federal Ownership	0	0	0	0
Provincial Ownership	606,142 (38)	359,321 (23)	619,182 (39)	8,781 (1)
Private Ownership	0	0	0	0
No Data	0	0	0	0
Outside THLB				
Federal Ownership	40,624 (3)	3,275 (0)	8,371 (1)	11,902 (1)
Provincial Ownership	352,033 (26)	115,229 (8)	184,328 (14)	310,573 (23)
Private Ownership	141,625 (10)	14,180 (1)	62,169 (5)	119,128 (9)
No Data	55 (0)	21 (0)	27 (0)	247 (0)
Ownership Totals				
Federal Ownership	40,624 (1)	3,275 (0)	8,371 (0)	11,902 (0)
Provincial Ownership	958,175 (32)	474,550 (16)	803,510 (27)	319,354 (11)
Private Ownership	141,625 (5)	14,180 (0)	62,169 (2)	119,128 (4)
No Data	55 (0)	21 (0)	27 (0)	247 (0)

Table 6. Area summary of ownership and condition class within and outside of the timber harvesting land base for the study area.

and Figure 9). The total area for all ownership categories in Condition Class 3 was larger (874,077 ha – 29%) when compared with Condition Class 2 (492,026 ha – 16%). Outside of the THLB, where the MOE has greater responsibilities the provincially owned area within condition class 2 and 3 was 115,229 ha (8%) and 184,328 ha (14%) respectively. The provincially managed area was significantly greater within the THLB where condition class 2 and 3 accounted for 359,321 ha (23%) and 619,182 ha (39%) of the total THLB.

	Condition Class			
	1	2	3	Other
	ha (%)	ha (%)	ha (%)	ha (%)
Inside THLB				
Federal Ownership	0	0	0	0
Provincial Ownership	606,142 (38)	359,321 (23)	619,182 (39)	8,781 (1)
Private Ownership	0	0	0	0
No Data	0	0	0	0
Outside THLB				
Federal Ownership	40,624 (3)	3,275 (0)	8,371 (1)	11,902 (1)
Provincial Ownership	352,033 (26)	115,229 (8)	184,328 (14)	310,573 (23)
Private Ownership	141,625 (10)	14,180 (1)	62,169 (5)	119,128 (9)
No Data	55 (0)	21 (0)	27 (0)	247 (0)
Ownership Totals				
Federal Ownership	40,624 (1)	3,275 (0)	8,371 (0)	11,902 (0)
Provincial Ownership	958,175 (32)	474,550 (16)	803,510 (27)	319,354 (11)
Private Ownership	141,625 (5)	14,180 (0)	62,169 (2)	119,128 (4)
No Data	55 (0)	21 (0)	27 (0)	247 (0)

Table 6. Area summary of ownership and condition class within and outside of the timber harvesting land base for the study area.

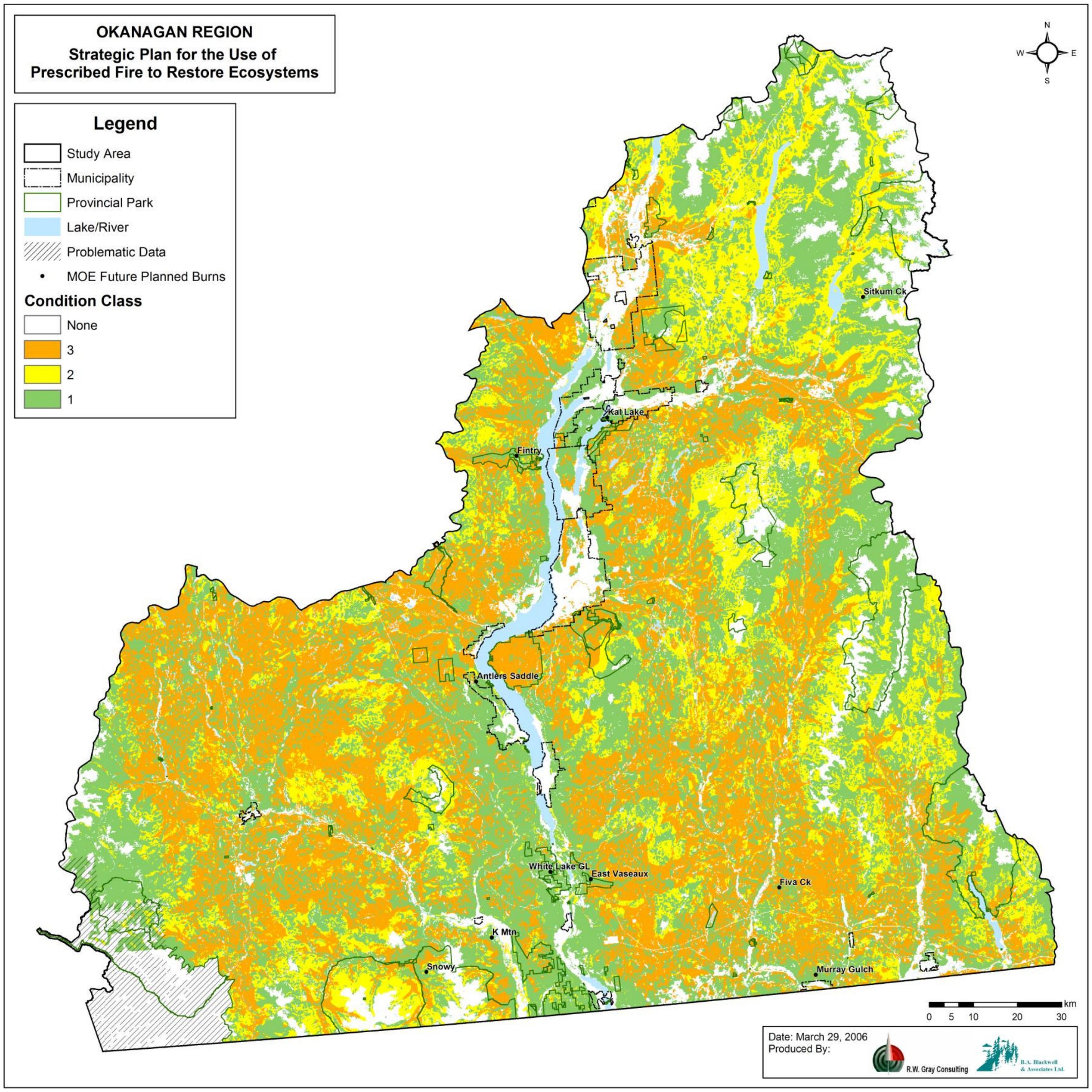

Figure 9. Condition class within the study area.

5.2.3 Distributions of Prescribed Burn Priorities Within the Study Area.

The overlay of HNFR, FRCC, and FHF created a stratification of prescribe burn treatment priorities for the study area (Table 7 and Figure 10). The ranking system identified 9,734 ha (1%) of high priority treatment area outside of the THLB and 26,267 ha (2%) within the THLB. A large portion of the study area was classified as moderate priority 157,508 ha (12%) outside of the THLB and 334,152 ha (21%) within THLB. This was primarily a function of the large area within condition class 2 and 3 that was not overlapped by forest health factors. The forest health factor data used in the analysis was incidence mapped between 2000 and 2004. Additionally, the forest health factor data provided for this projected was mapped as points rather than polygon incidence and this limited the spatial extent of the data. These two issues have likely impacted our ability to create more resolution/stratification of the moderate priority area.

Within the area inside of the THLB, further priority should be given to static reserves such as OGMAs and UWR for restoration treatment using prescribed fire. If ranked high and moderate these areas may be at a greater risk of being impacted negatively by wildfire and would difficult to replace if they were destroyed by fire.

	Priority Rating			
	High	**Moderate**	**Low**	**Very Low**
	ha (%)	**ha (%)**	**ha (%)**	**ha (%)**
Inside THLB				
Federal Ownership	0	0	0	0
Provincial Ownership	26,267 (2)	334,152 (21)	1,179,377 (74)	53,629 (3)
Private Ownership	0	0	0	0
No Data	0	0	0	0
Outside THLB				
Federal Ownership	154 (0)	18,586 (1)	38,103 (3)	7,321 (1)
Provincial Ownership	9,734 (1)	157,508 (12)	548,819 (40)	245,843 (18)
Private Ownership	3,349 (0)	73,597 (5)	235,871 (17)	24,251(2)
No Data	0 (0)	11 (0)	136 (0)	204 (0)
Ownership Totals				
Federal Ownership	154 (0)	18,586 (1)	38,103 (1)	7,321 (0)
Provincial Ownership	36,002 (1)	491,661 (17)	1,728,196 (58)	299,472 (10)
Private Ownership	3,349 (0)	73,597 (2)	235,871 (8)	24,251 (1)
No Data	0 (0)	11 (0)	136 (0)	204 (0)

Table 7. Area summary of ownership and prescribe burn priority rating within and outside of the timber harvesting land base for the study area.

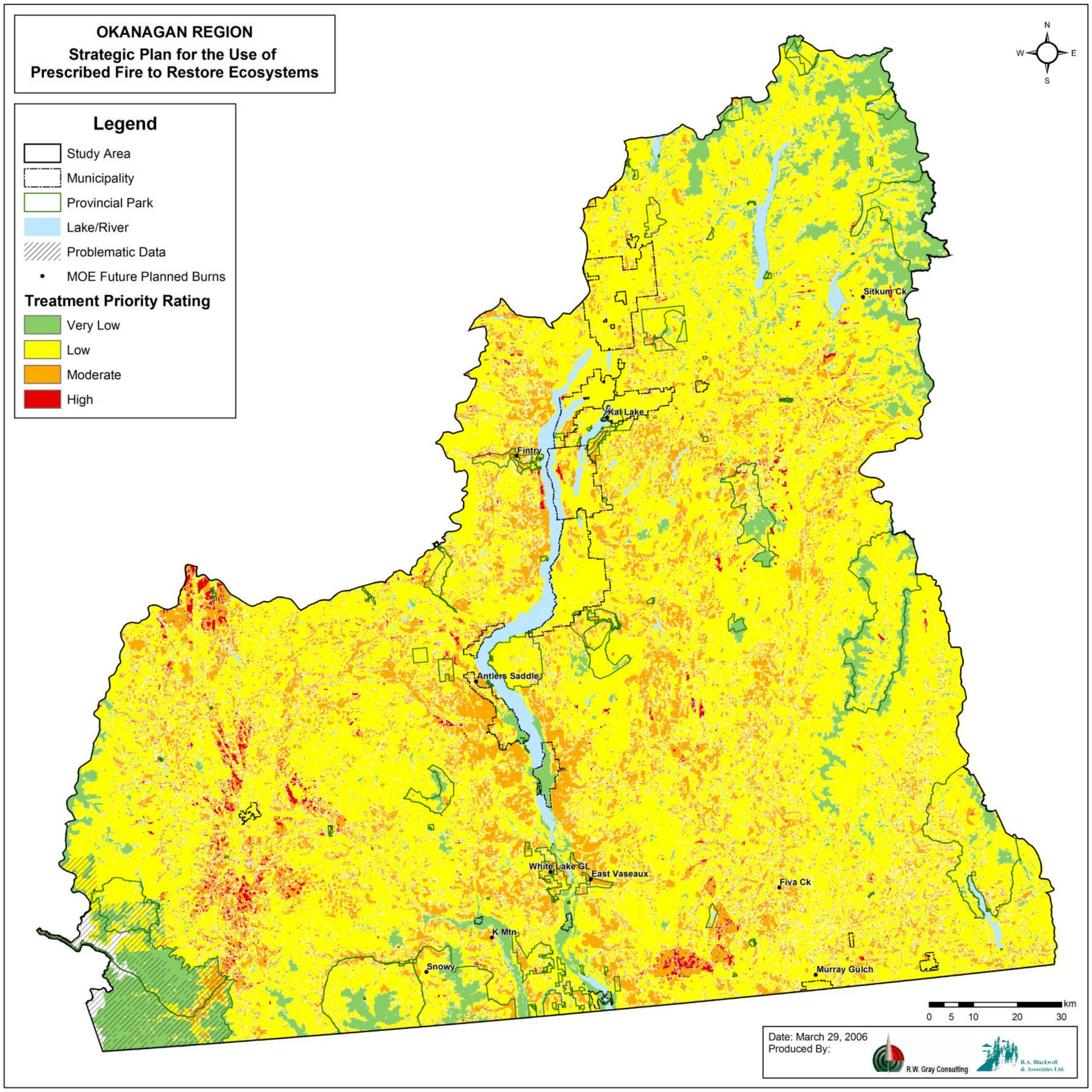

Figure 10. Treatment Priority Rating within the study area.

5.2.4 Distribution of Treatment Complexity Classes within the Study Area

Treatment complexity was classified based on the degree of ingrowth and proximity to the wildland urban interface. Areas that were classified as condition class 3 and were classified as urban, developed or mixed interface density were ranked high for treatment complexity. Within the study area, a total of 196,479 ha (7%) were classified as having high treatment complexity rating (Table 8). The area classified as moderate was 1,004,965 ha (34%) of the study area.

Similar to burning priority this treatment complexity is influenced significantly by the area of condition class 2 and 3, which dominate a large part of the study area.

Outside of the THLB the are ranked with high treatment complexity is 40, 882 (3%) on crown land , while inside the THLB this area is 96,281 ha (6%). Greater than 50% of the study area is ranked as low to very low in terms of treatment complexity. The low and very low area represents 1,755,138 ha or 60% of the study area.

	Cost Rating			
	High	Moderate	Low	Very Low
	ha (%)	ha (%)	ha (%)	ha (%)
Inside THLB				
Federal Ownership	0	0	0	0
Provincial Ownership	96,281 (6)	610,503 (38)	879,168 (55)	7,474 (0)
Private Ownership	0	0	0	0
No Data	0	0	0	0
Outside THLB				
Federal Ownership	4,185 (0)	29,911 (2)	28,130 (2)	1,939 (0)
Provincial Ownership	40,882 (3)	221,685 (16)	449,916 (33)	249,422 (18)
Private Ownership	55,114 (4)	142,866 (10)	136,402 (10)	2,687 (0)
No Data	17 (0)	19 (0)	95 (0)	220 (0)
Ownership Totals				
Federal Ownership	4,185 (0)	29,911 (1)	28,130 (1)	1,939 (0)
Provincial Ownership	137,163 (5)	832,188 (28)	1,329,084 (45)	256,896 (9)
Private Ownership	55,114 (2)	142,866 (5)	136,402 (5)	2,687 (0)
No Data	17 (0)	19 (0)	95 (0)	220 (0)

Table 8. Area summary of ownership and potential treatment complexity within and outside of the timber harvesting land base for the study area.

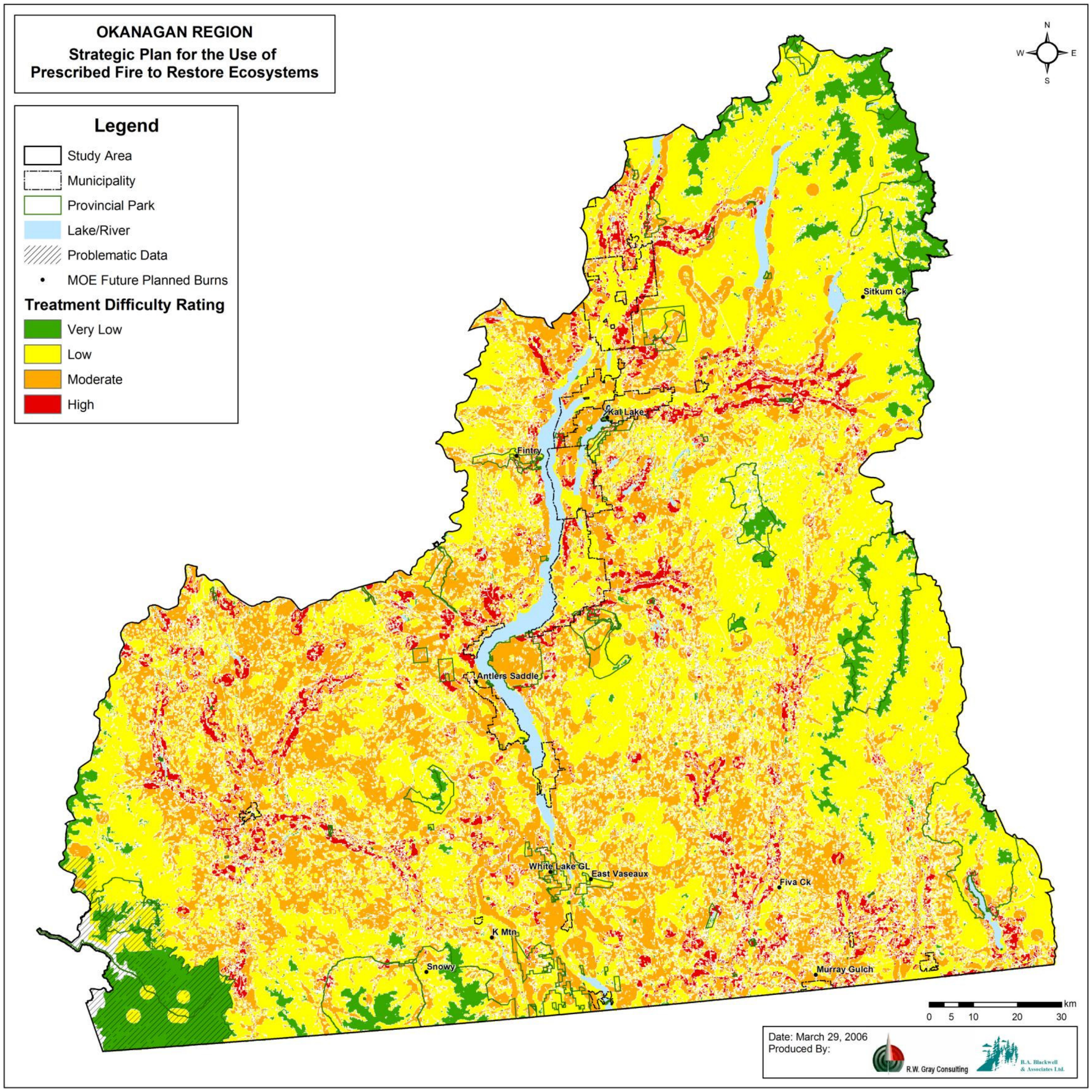

Figure 11. Treatment complexity Rating within the study area.

5.3 Treatment Strategies

5.3.1 Setting Appropriate Objectives

Our model uses a number of data sets to craft a proxy condition for threats to ecosystem resilience and biodiversity – a condition referred to as "ecosystem health." As was stated in the introduction, most authors list the following as threats to ecosystem health:

- Increased tree density in dry forest types;
- Increased fuel load;
- Increased incidence of insect attack and disease; and
- Decreased biodiversity.

The first three variables can easily be quantified; RONV target numbers versus current condition numbers were used in the prioritization model. Dry forest resilience and biodiversity are threatened by the structural conditions that lead to catastrophic fire and insect and disease epidemics. High-density stand types, high fuel loads, and or insect or diseased forests are the targets for treatment. The fourth variable, biodiversity, is an "affected" attribute stemming from the influence of density, fuels and forest health that are outside of RONV. This variable is much more difficult to quantify at the coarse-scale, hence it's omission in the prioritization model. For the ER program to be effective appropriate treatment objectives need to be developed that recognize the relationship between "causal" agents and the "affected" structures. The steps in this secondary process include:

- Identifying fine-scale structural features key to maintaining and enhancing treatment-level biodiversity;
- Identifying key structural targets for treatment;
- Identifying desired future condition (*i.e.*, what to restore to); and
- Identifying how to attain desired future condition.

Candidate restoration units will need to undergo a secondary level of analysis prior to moving to operational treatment status. The results of the prioritization modeling reveal some coarse-scale aspects of current condition and geographic location; both important elements in choosing the most appropriate treatment strategy. This coarse level of analysis, however, does not provide enough fine-scale information to set appropriate quantifiable objectives that are necessary to guide operational plans. At this stage in planning key structural features that could be negatively or positively impacted by the treatment such as live trees, snags, downed logs, or specific plants need to be identified. The relationship between these structures and fire must also be understood. If the objective is to retain these structures there must be a solid understanding of the fire ecology of the specific structure. For example, snags are a significant element of biodiversity in dry forest types being highly sought after for habitat for a wide range of organisms. Unfortunately, attempts to "protect" snags from either mechanical/manual thinning or prescribed fire – two commonly employed treatment strategies – are often unsuccessful (Gray and Blackwell 2006). Nonetheless, these structures need to be identified and, if possible, mitigation measures employed in an attempt to minimize their damage or loss (Figure 12).

Figure 12. Large downed log being consumed in a cool, spring prescribed burn. Most attempts to save these structures, through constructed firebreaks or avoidance firing, are unsuccessful (R. Gray photo).

The "target" in restoration treatments is typically trees, understory plants, and/or fuels. If the objectives include killing, top-killing, or consuming any of the above structures a fairly precise inventory is required followed by an investigation of the fire ecology of the structure. Structural inventory provides key arrangement conditions that help guide the appropriate treatment strategy. The juxtaposition of these structures relative to key biodiversity elements is also critical. For example, attaining a Douglas-fir encroachment reduction objective is possible with the right combination of surface fuels, foliar moisture content, canopy bulk density, and canopy base height (Figure 13). However, if a key element of biodiversity, in the case of Figure 13 a large diameter, old Douglas-fir tree, is situated in the middle of the target structure it may be advisable to entertain a different treatment strategy.

Figure 13. Large diameter, old Douglas-fir killed as a byproduct of thinning young Douglas-fir encroachment (K. Iverson photo).

In ecosystem restoration, what do we restore to? The notion of ecological restoration rests on the premise that the entire ecosystem will function best under the conditions to which its component organisms have become adapted over evolutionary time (Covington 1995). For much of the project area there is little to no stand-level and landscape-level ecosystem structure RONV information to help guide restoration projects. The HNFR and FRCC models provide some coarse-scale direction but suffer at the finer scale of individual treatment units. Certain structural attributes, assemblages of attributes, and record of disturbance regimes provide contemporary clues to historic conditions. Long-lived tree species, such as ponderosa pine and Douglas-fir, are evidence of historic plant community composition. The arrangement of long-lived species provides clues to past structure (Wong 1999, Gray *et al.* 2004). And, the record of disturbance regimes, both biotic (insects) and abiotic (fire, drought), provide clues to the historic characteristics of surface fuel, Coarse Woody Debris, and understory community composition (Gray *et al.* 2002, Gray 2003, Gray *et al.* 2004). Starting with what structures are present today we can work backwards to determine a range of historic conditions. Determining a point to stop at – the desired future condition – has much to do with the resilience of biodiversity attributes when faced with current and future disturbance. For example, if a desired future condition is a moderately stocked stand of ponderosa pine, the test for resilience is the stands' ability to survive the range of probable disturbance agents likely to affect it in the future. Would the structures that are key to biodiversity likely survive either wildfire or bark beetles? If not this structure or desired condition would not be considered resilient and further planning would be required.

How we attain the desired future condition is the core of operational planning. Once objectives have been set it's time to determine the best way to meet those objectives. While there is a strong emphasis in this project to use prescribed fire it should be pointed out that prescribed fire may not always be the most appropriate tool or the only tool to be used on a project. It is our strong recommendation that the Ministry of Environment strive for a very high level of treatment precision. This target is warranted considering the potential for irreversible, cascading secondary and tertiary effects of wildland fire use.

The potential for post-wildland fire insect infestation in the treatment area and beyond is significant (Figure 14). Bark beetles such as Douglas-fir beetle (Dendroctonus pseudotsugae Hopkins), western pine beetle (D. brevicomis LeConte), mountain pine beetle (D. ponderosae Hopkins), and red turpentine beetle (D. valens LeConte), can have a profound impact on the success of the treatment. With current and projected beetle populations in the Okanagan this is a significant consideration. Excess "collateral" damage, in the form of excess crown scorch, bole scorch, or root damage, can often lead to an infestation of secondary scolytids – bark beetles (Edmonds *et al.* 2000, Kelsey and Joseph 2003). Once the infestation gets established it is difficult to predict the amount of damage it can do.

Figure 14. Pitch tubes resulting from a post-prescribed burn infestation of red turpentine beetles in a ponderosa pine. On this particular unit no crown scorch was recorded yet 20% of the mature pine were killed by bark beetles within two years of the burn (R. Gray photo).

Another significant secondary effect of treatment is a "reburn" of the treated site. Treatment units containing high loading of dead downed fuel including duff risk significant site productivity impacts if burned under very low fuel moisture. It has been a pattern in the past to "thin" dense, dry forest stands with fire as opposed to a mechanical or manual thinning followed by prescribed fire. While this approach can be successful in meeting objectives some of the time – especially in situations of very simple structure and simple objectives – it can often lead to long-term problems. Thinning trees with fire, if the target trees are considered to be a structure outside of RONV, means that the trees must be removed from the site incrementally through combustion. The initial tree-killing burn is simply the first step in moving stand-level fuel load toward RONV. Following the initial treatment the fire-killed trees will fall to the forest floor and accumulate as surface fuel. Depending on initial stand density and overstory mortality from the burn this loading can be high. This accumulated fuel poses a direct threat to soil stability and site productivity. A series of burns are then required to incrementally "remove" this fuel through planned combustion. Leaving it to a summer wildfire could potentially result in significant site impacts through what is called a "reburn" (Figure 15).

Figure 15. This site was burned in a 1979 wildfire and "reburned" in 2002 in a subsequent wildfire. The effect of the two fires, especially the second fire which burned through a considerable fuel load of fallen fire-killed trees, was catastrophic (R. Harrod photo).

6.0 Monitoring Prescribed Fire

6.1 Monitoring Fire Behavior

Fire behaviour monitoring needs to be implemented in addition to standard fire effects monitoring. The prescribed use of fire is intended to meet a range of fire effect objectives. Fire effects are a product of fire behaviour, or burning conditions. In order to meet these conditions a predicted level of fire behaviour is modeled in the burn prescription. Input variables can include Fire Weather Index System moisture codes (FFMC, DMC, DC), direct measures of fuel moisture by size class, windspeed, wind direction, temperature, relative humidity, fuel type or model, etc. Determining whether or not the burn met its intended objectives is met through a comparison of predicted fire behaviour and actual fire behaviour. Monitoring this comparison is easily met by quantifying the fire behaviour outputs, flame length (FL) and rate of spread

(ROS). These variables should be measured at a number of locations and times throughout the burning operation. Flame length is easily measured against a stationary object such as a tree and doesn't need to be overly accurate. Rate of spread is a distance/time measurement, measured in m/min, and can be derived by lighting a spot fire below the main fire and measuring the time it takes to cover a set distance. More accurate measurements can be taken if test locations are established ahead of time and points are measured out and marked on the ground.

If predicted values do not match actual values within a relative range, chances are burn objectives were not met. This indicates problems with either the accuracy of input values or the fire behaviour model or both. This problem then would need to be corrected, as part of adaptive management, prior to proceeding to the next project.

6.2 Vegetation And Forest Structure Monitoring

For each prescribed burn, permanent plots should be established within each major vegetation type, within each treatment type and within unburned, untreated control areas adjacent to the burn area. Plots should photographed and established with rebar stakes. Wildlife monitoring is described in Section 6.5.

There are four generalized sets of objectives for forested areas:

1. Plant community response to burning;
2. Understory and overstory tree mortality;
3. Physical damage to range improvements; and
4. Response of mule deer and red- and blue-listed species to burning.

There are four generalized sets of objectives for grassland encroachment areas:

1. Plant community response to burning;
2. Encroachment mortality;
3. Physical damage to range improvements; and
4. Response of mule deer and red- and blue-listed species to burning.

There are three generalized sets objectives for grassland areas:

1. Plant community response to burning;
2. Physical damage to range improvements; and
3. Response of mule deer and red- and blue-listed species to burning.

6.3 General Monitoring for all areas

6.3.1 Response of red and blue listed plants

A rare plant survey should be conducted by walking the burn area. Voucher specimens should collected (unless there are a very limited number of specimens), and the position of rare plants located using a GPS. If any rare plants are located that are sensitive to burning, strategies for maintaining these rare species should be developed within the burn plan.

6.4 Monitoring for specific areas

6.4.1 Forested Area

Plot establishment

For each of 3 monitoring locations:

- establish one 50m long transect,
- establish 30m triangle (using a random starting bearing),
- establish three fixed radius plots at the apices of the triangle.

Burn pins

Establish 40 plots (using random grid locations) within the burn area only.

Photopoints

Establish photopoints for each transect and each triangle.

Plant community response

Plant community response should be measured by establishing ten 20cm X 50cm plots at systematic locations (one every 5m starting at 1m) on each 50m long transect (for a total of 30 plots) prior to burn operations. For these plots, all plants and canopy cover would be recorded. Additionally, the number of seed culms for large bunchgrasses (bluebunch wheatgrass and *Stipa* spp.) would be recorded (as a measure to correlate to productivity). These plots would then be re-measured the first summer post-burn, and again 1, 3 and 5 years following the first re-measurement. Shrub intercept should be recorded along transects (this would include measuring the intercept of trees less than 10m tall). For all sites, starting one meter from the start and end of each transect, the first 5 individual bunchgrasses that are intercepted will have basal diameter measurements recorded (along with the location of the bunch along the transect). This will give a total of 20 bunches at each monitoring site.

The results of the monitoring should be tied in with re-introduction of domestic livestock grazing on the site. Grazing should not be re-introduced until seed stalk production, cover and basal diameter data meets or exceeds pre-treatment levels for bluebunch wheatgrass and *Stipa* spp.

Forest structure

At each of the three triangles, three fixed radius plots are established at the apices of the triangle for a total of nine plots. For each of these plots stand density, crown closure, mineral soil exposure, and height to live crown should be measured. These plots should be re-measured 1-2 weeks post-burn in order to let scorched needles completely lose their chlorophyll and turn red.

Fuels

Along each leg of the triangle, < 1cm and > 1cm fuel loading should be measured. Post-burn, depth of burn should be measured. At each of the 40 rebar pins, eight duff pins should be installed.

6.4.2 Grassland Areas

Plot establishment

For each of 3 monitoring locations:

- establish one 50m long transect,
- establish 30m triangle (using a random starting bearing),

Plant community response

Plant community response should be measured by establishing ten 20cm X 50cm plots at systematic intervals (one every 5m starting at 1m) on each 50m long transect (for a total of 20 plots) prior to burn operations. For these plots, all plants and canopy cover would be recorded. Additionally, the number of seed culms for large bunchgrasses (bluebunch wheatgrass and *Stipa* spp.) should be recorded as a measure to correlate to productivity. Shrub intercept should be recorded along transects (this would include measuring the intercept of trees less than 10 m tall). For all sites, starting one meter from the start and end of each transect, the first 5 individual bunchgrasses that are intercepted will have basal diameter measurements recorded (along with the location of the bunch along the transect). This will give a total of 20 bunches at each monitoring site.

The results of the monitoring should be tied in with re-introduction of domestic livestock grazing on the site. Grazing should not be re-introduced until seed stalk production, cover and basal diameter data meets or exceeds pre-treatment levels for bluebunch wheatgrass and *Stipa* spp.

Fuels

Along each leg of the triangle, < 1cm and > 1cm fuel loading should be measured. Additionally, the 20cm X 50cm plot frame should be randomly tossed 6 times and the vegetation within the plot should be clipped to 1cm height to measure grass and forb fuel loading.

6.4.3 Timing of Measurement

All plots should be established and measured prior to the burn. Vegetation should be re-measured the first summer post-burn and again 1, 3, and 5 years later. Forest structure plots and fuel transects should be measured 1-2 weeks post burn once scorched needles have completely lost their chlorophyll and turned red. Forest structure plots should be re-measured again 1 and 5 years later. Duff pins should be remeasured once following the burn.

6.5 Wildlife Monitoring

Monitoring recommendations for wildlife species found in each critical habitat type are given both pre-treatment to assess the use of the habitat by red- or blue-listed species and following prescribed fire treatments to ensure that management objectives are met.

6.5.1 Douglas-fir habitats (along slopes and crests of hills)

When burns are planned between early May and August in these habitat types, surveys to determine flammulated owl presence should be conducted in the prior field season. If owls are found nesting in the site, burns should be planned for before of after this nesting period or a 50m no burn buffer should be maintained around the nest tree. Townsend's big-eared bats forage in these habitats from late June and August and they may roost in snags during the same time period. It is unlikely that prescribed fires will be conducted during this period, but if so, extra care must be taken to protect snags and live trees with cavities to ensure that no bats are injured. Post-treatment monitoring of flammulated owl re-occupancy is required to ensure treatments did not affect flammjulated owl habitat use.

6.5.2 Very open forest

Surveys for Lewis' woodpecker should be conducted in these habitat types prior to prescribed burning if burning is planned between early May and late July. Any nest trees found should be removed from the treatment areas or timing of fire should be changed.

Western-small-footed myotis and Townsend's big-eared bat may nest in cavities in these habitats so if burining is planned in July or August extra care must be taken to protect snags and cavity trees from fire. Fire retardant or fire shelter material can be used to protect scarred trees that are particularly prone to damage from fire.

Monitoring the retention of snags and wildlife trees in these areas should be conducted to ensure adequate snag retention was achieved.

6.5.3 *Grasslands*

Any areas with a big-sage component should be surveyed for Brewer's sparrow and sage thrasher prior to any burns being conducted. Areas occupied by sage thrashers should be removed from the burn area. Areas occupied by Brewer's sparrow should be treated to retain some sage cover by spot burning or removing from the treatment area.

Open grasslands should be surveyed for sharp-tailed grouse, long-billed curlews and upland sandpipers so that they can be accommodated in the burn prescription. Sharp-tailed grouse begin appearing at the open grassland lek sites in mid-March and continue into early May. They are unlikely affected by prescribed fire during this period and should quickly re-occupy the lek after the fire has passed. Burning after about 9:00 am will ensure that grouse are not present on the lek during the burn. Sharp-tailed grouse may begin nesting as early as mid-April so fires should not be conducted within 1km of known lek sites between then and late August. Long-billed curlew nest in grasslands between early April and mid-August and upland sandpipers nest between May and September. If these species are confirmed in an area, burn timing should be planned outside of those times.

Other species using these habitats are generally mobile enough to avoid fire, only use them as foraging habitat and are not at risk from prescribed fire.

Surveys in occupied sites should be conducted for each of these species following treatment to evaluate the effectiveness of the treatment and the species response. Prescriptions can then be modified as required.

6.5.4 *Cultivated field*

If cultivated fields are considered for prescribed burning, they should be surveyed for bobolinks before prescriptions are developed. Presently bobolinks have not been recorded in the area and there are no implications for managing hay fields. However, if they are recorded, burning should be conducted outside of the nesting season for bobolinks, late May to early August.

6.5.5 *Aspen copses, Aspen forest, Open Water, Vernal Ponds and Rock or Talus*

These habitat types will generally not be treated.

6.5.6 *Shrubland*

Yellow-breasted chat surveys should be conducted in shrublands in riparian areas and should not be treated if occupancy is confirmed. This habitat type is primarily used for foraging by other species of interest and no pre- or post-treatment monitoring is required.

6.5.7 *Monitoring for mule deer*

Snow Depth

Since snow depth can limit the availability of habitat for deer, snow depth transects are suggested. Snow depth should be measured after snowfall events (when track counts are conducted) as well as other times to measure snow persistence. Snow depths can be related to stand and site characteristics and to deer use patterns. Prescriptions can then be adjusted to specific site conditions. Snow depths should be taken concurrently in areas with no tree cover to evaluate the snow-reducing effect of tree canopies.

Deer use of treated and untreated sites

Winter track counts are relatively inexpensive to conduct and give will give strong evidence of deer use patterns. Track counts should be conducted a few days after significant snow events (greater than 6 cm accumulations) so that only recent tracks are tallied. These use patterns can be related to forage abundance data and to snow depths to adapt prescriptions to better meet deer winter habitat requirements.

Deer diets can be evaluated by fecal analysis

This information will help guide longer term management plans for deer in the protected area. Diet of deer when a range of forage sources is available will enable managers to assess the frequency of various forage types in the diet and plan to maintain the appropriate proportion of the habitat types over the landscape.

6.5.8 *Monitoring for California bighorn sheep*

The population declines seen in bighorn sheep in CCPA are due to a number of small cumulative impacts which may include fire suppression, cattle grazing, forest encroachment, cougar predation, human-caused mortality and harassment, disease, and displacement by livestock and other wild ungulates. Any benefits to sheep populations from prescribed fire may not be apparent if any other of the impacts has an equivalent negative effect on population recruitment or mortality. Habitat increases from reduced forest encroachment and improved forage quality through fire will certainly have a beneficial effect on sheep populations but that effect may take some time to manifest and may be difficult to attribute solely to fire.

A proposal is currently being prepared to identify a monitoring methodology that will identify the magnitude of various stressors to bighorn sheep populations in the CCPA. Monitoring recommendations from that report should be included in the fire management monitoring. Monitoring recommendations for wildlife species found in each critical habitat type are given both pre-treatment, to assess the use of the habitat by red- or blue-listed species, and following prescribed fire treatments to ensure that management objectives are met.

7.0 Transition from Old Program Priorities to Newly Identified Priorities

The MOE has a series of previously planned projects already developed and paid for within the study area. These projects were identified using different criteria from those we developed as part of this report. This does not create a significant contradiction in direction for MOE. Some of the criteria used in the past focused on maintaining "open" forest and grassland conditions as proxies for high value ungulate habitat. This also met the general funding guidelines of the Habitat Conservation Trust Fund, the primary contributor to the restoration program. Existing treatment units were overlaid on the treatment prioritization map (Figure 10) to see where new model results were in agreement with past criteria and where results departed. As can be seen in Figure 10, most existing treatment units fall into the "moderate" ranking for treatment priority. This downgraded ranking is due mostly to a lack of Forest Health Factors within the proposed treatment area. The lone existing unit with a "high" ranking is Sitkum Creek, situated northeast of Silver Star Provincial Park, which is impacted by FHF. Only one existing unit received a "low" ranking, Murray Gulch, which has no FHF and is classified as HNFR III. Our priorities for ranking were the Ponderosa Pine and Interior Douglas-fir biogeoclimatic zones, followed by all others. This produced an HNFR ranking of HNFR I, followed by HNFR II and IV, followed by all others. The Bunchgrass biogeoclimatic zone falls into HNFR III, frequent stand-replacement fire regimes, with "stand-replacement" referring to >80% overstory top-killed or killed by fire. In the case of grassland and shrubland communities, the appropriate definition is "top-killed." Murray Gulch, therefore, received a low ranking – "0" – for both HNFR and FHF. Without too much difficulty, this ranking can be altered if MOE wishes to upgrade the BG BEC (HNFR III) ranking.

Past and future treatment units will be focusing on similar stand structure types, referred to as FRCC 1 in this report, while in the past they were identified as "open" forests and grasslands. The primary objective of maintaining "open" conditions, by retarding forest ingrowth and encroachment, are identical to the proposed objective of maintaining FRCC 1 before it degrades to FRCC 2 or 3. The FRCC layer simply quantifies this objective. This project has deviated from the past direction by incorporating FHF as an indicator of priority. With the current state of forest health, especially in dry forest types, and the threat FHF pose to landscape- and stand-level biodiversity and resilience, it was important to add the incidence of FHF to the prioritization ranking. This ranking suggests to managers that a threat to landscape-level attributes exists, therefore the area should be attended to. It also suggests to the operational team that, because of the incidence of certain forest health agents, certain measures should be taken to limit the potential effects of these agents as a result of treatment.

In addition to the criteria overlap between the two site selection systems, additional data layers that provide MOE with a ranking system for project complexity have been incorporated. This does not appear to have been an explicit component of the previous site selection system. With limited funds and a young and still learning operational team, it was felt that a measure of project complexity was warranted to save time in operational planning and treatment, and in providing a method for segregating treatment strategies (see Section 5.3.1 Setting Appropriate Objectives).

8.0 Five-year Plan

The coarse scale nature of this study precludes detailed delineation of specific units, however the work does identify specific areas within the region that should be targeted over the next five years. Given the current level of funding and resources committed to the program, treating the delineated area outside of the THLB alone, in a timely way, will be a major challenge to the organization.

The development of a 5-year strategic plan is the next stage in the process and follows on from the ranking illustrated in Figure 10 and Table 2. Past treatment site selection appears to have been focused on the central Okanagan Valley and BC Park units. This has likely met the criteria of the time; however, with significant threats from wildfire and forest health factors, and rapidly changing land and resource management initiatives (*e.g.*, Future Forest Ecosystems of BC, Future Forests for Tomorrow, etc.), a more strategic and integrated approach is necessary.

The burn priority ranking in Figure 10 strategically identifies those areas of high priority based on the criteria developed in this project. The first issue that becomes quite evident is that significant area ranked high priority is outside of the central Okanagan Valley. Secondly, most of these candidate sites lie outside Parks and Protected Areas on non-THLB lands. Additionally, there is a significant area that is ranked high priority within the THLB, which is three times the area identified outside of the THLB. Moving the program out to these areas has a number of benefits. These include reduced constraints, complexity, and cost. Sites that are good candidates for prescribed fire use, but are situated in the central Okanagan Valley, are heavily constrained by emissions issues and liability associated with public safety and property protection. Burn windows are heavily constrained by smoke management issues and a significant effort is needed in the areas of public education and consultation. Costs are further escalated within these areas through increases in the requirement for post-burn holding action (mop-up). Targeting units farther afield, in areas with reduced smoke issues, public safety and property protection requirements should increase the burn window and reduce costs.

The 5-year burn program needs to be integrated with other fuel mitigation initiatives in order to benefit from areas of overlap. Wildland urban interface fuel reduction treatments and or forest harvesting could be utilized as strategic fuel breaks and allow prescribed fire in areas currently constrained. Because of the incorporation of FHF into the model there should be a strong correlation between areas of focus under the new Future Forests for Tomorrow program and the ER program. This may permit an infusion of additional funds into the regions restoration program budget for application on areas of common interest. The use of the WUI layer also benefits the program by tying ER to WUI fuel hazard abatement where funding could be granted through the fuel management program coordinated by the UBCM and Protection Branch. One other area of possible collaboration is in the application of landscape-scale fuelbreaks and other wildland fire use initiatives being contemplated by Protection Branch in the soon to be released Provincial Strategic Fire Management Plan. Landscape-scale units identified through this project could be incorporated into strategic landscape fuelbreaks following some additional fire behavior analysis. Treatment units identified through the Provincial Strategic Fire Management Plan would likely correlate well with priorities established in the modeling approached developed in this project. Treatment design would then need to be a compromise between the objectives of MOE and MOFR. Considering the threats to biodiversity and threats to forest resilience created by FHFs and wildfire, there should not be significant disagreement in a collaborative approach.

The acceptance of the priority ranking and modeling approach developed in this project will direct the development of operational plans for individual treatment units. Given an estimated annual program budget of $150,000, and an estimated average unit treatment cost of $2,000/ha, only 75 ha/year can be treated. Less complex objectives can stretch the area treated to possibly 300-500 ha but this implies very low treatment cost/ha and reduced burn complexity. This would also suggest that treatment objectives could be easily obtained. With an increased emphasis on setting, meeting, and properly monitoring appropriate objectives, it is more likely that the number of hectares treated will be lower rather than higher until the program matures from a funding and resource personnel perspective.

9.0 Recommendations

The development of this plan has identified the potential new areas to consider for restoration treatment within the Okanagan Region of the Province. It has highlighted a large area of potential treatment with a significant are identified outside of the main Okanagan Valley. Based on the modeling completed to date and our improved understanding of the issues that must be addressed to implement this plan we provide the following recommendations;

1. MOE should attempt to integrate this ER program with other fuel/forest health management initiatives wherever objectives are compatible.

2. Majority of analysis area falls into the “moderate” ranking. This area should receive additional attention in order to further segregate into priority units.

3. If MOE accepts the model conclusions, which identifies almost 10,000 ha’s of high priority treatment area outside of the THLB, the agency will need to consider developing a strategic plan for treating this entire area within a specified time period. It does not make much sense to identify a problem of this magnitude and then set out to address it at the rate of 5% or less per year (e.g., 10,000 ha treated at rate of 500 ha/year). Work in the east Kootenays has identified the scale of the problem and the minimum rate of treatment. In that particular region grasslands are being lost at the rate of 3,000 ha/year yet the ER program is only effectively treating in the range of 1,500 to 2,000

ha/yr. The ER program being suggested for the Okanagan will require dedicated and qualified staffing and budgets if the resolution of the problem and the long-term commitment to maintenance, are to be realized.

4. The area of high ranking inside THLB is almost 3 times the identified area outside of the THLB. MOE is not the land manager within the THLB and has jurisdiction for conservation and biodiversity management on these lands. We recommend MOE work closely with licensees and MOFR to explore opportunities for meeting compatible objectives wherever possible. This may mean coordinating with forest health and wildfire fuels management initiatives that are compatible with MOE management goals.

5. MOE should increase the use of both pre commercial and commercial thinning activities within their jurisdiction as pre-cursors to the use of prescribed fire where appropriate. This would serve two functions: a) providing off-setting funding for the ER program, and, b) lowering the complexity of burn projects by simplifying stand structure and lowering fuel loads.

6. MOE should entertain a higher use of manual and mechanical fuel modification prior to prescribed burning. While this increases the overall immediate cost of the project on a per hectare basis it dramatically increases burn success and limits liability associated with an escape. Good pre-burn fuel modification can lower the long-term unit cost of maintenance by reducing the need for costly maintenance burns. Units with little pre-burn fuel modification, but with tree thinning objectives, require an expensive regime of maintenance burns designed to gradually remove heavy fuels. These repeated burns have both emissions and cost issues. Multiple treatments concentrate resources on a limited area and preclude program expansion to new treatment areas.

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