RED HILLS FIRE HISTORY

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Executive Summary

The Red Hills of Uncha Mountain Red Hills Provincial Park were identified in the Lakes District Land and Resources Management Plan and the Uncha Mountain Red Hills Management Direction Statement as having an issue of aspen trees encroaching on at-risk grasslands and scrub/steppe ecosystems. Several projects subsequently completed in the park include a vegetation management plan, descriptions of the grasslands and scrub/steppe ecosystems, a vegetation restoration and burn plan, and descriptions of pre-burn vegetation conditions. In 2008 a prescribed fire covering 4 hectares was completed along with monitoring of post-burn vegetation conditions in 2008 and 2016. A larger area to the east of the initial burn area was also identified for a future prescribed burn.

Despite the restoration activities in the park, there is a lack of knowledge of the fire history in the area that could assist the decision making process for future prescribed burns. This project was designed to address the lack of knowledge about the fire history.

Young aspen stands are not suitable for fire history studies, but an old Douglas-fir stand in the Red Hills was appropriate. Samples of 13 fire scarred trees were taken for scar dating and core samples from ten trees without fire damage were taken for cross-dating. Eight of the fire scarred trees were suitable for scar analysis, with all the scars coming from a fire in 1912 on trees that were alive from 1776 to the present time, a period of 241 years. Some unscarred trees had blackening on their bark indicating cool fires that did not leave fire scars, but these fires could not be verified; however, the lack in-growth in these Douglas-fir stands lends some support to this hypothesis. The fire history findings indicate that fires were not frequent on the landscape in this area, though fires could have burnt in areas other than that sampled.

The implications for park management and the use of prescribed fire are that perceived encroachment of aspen could be the result of vegetation recovery after a single infrequent fire, rather than as a result of a changed, less frequent, fire regime facilitating the spread of aspen into previously non-forested areas.

With this new insight, the results of previous studies on vegetation types and vegetation change were re-examined. Grasslands on lower slope sites with moister soils were found to be experiencing aspen encroachment that could be examined for restoration needs.

Drier, rockier middle to upper slope sites containing scrub/steppe ecosystems were found to be fairly stable, with the aspen mostly increasing in stature but not increasing in extent, and thus not in need of restoration. Furthermore, predicted warmer summers with stable precipitation regimes may make these sites less suitable for tree growth. Natural fire should not be supressed unless they are threatening values outside the park.

Additional vegetation work in the park could include quantifying the density of in-growth in the old Douglas-fir stands.

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1.0 Introduction

The Red Hills of Uncha Mountain Red Hills Provincial Park have been recognized in the Lakes District Land and Resources Management Plan (LRMP) (Government of British Columbia 2000) and the Uncha Mountain Red Hills Management Direction Statement (MDS) (Ministry of Water, Land and Air Protection 2003) as having an issue of aspen (*Populus tremuloides*) trees encroaching on the Red-listed saskatoon / slender wheatgrass (*Amelanchier alnifolia / Elymus trachycaulus*) scrub/steppe (SBSdk/81) and other grassland ecosystems. This type of forest encroachment has been identified as occurring in several areas of northwestern BC (Haeussler 1998, Veenstra and McLennan 2002). To address this issue it was recognized in the above documents that prescribed burning might be required to control the aspen and restore the saskatoon / slender wheatgrass scrub/steppe ecosystem.

As a result of the direction in the LRMP and MDS, a vegetation management plan for the park was developed (de Groot and Armitage 2007), the grasslands and scrub/steppe ecosystems in the park were described, a restoration and burn plan were written, and pre-burn vegetation conditions were described (Helkenberg and Haeussler 2008, de Groot 2008a). In 2008 a prescribed fire covering 4 hectares was completed along with monitoring of post-burn vegetation conditions (Haeussler and de Groot 2008) (Figure 1). In 2016 vegetation monitoring was conducted again (de Groot and Haeussler 2016). A larger burn area to the east of the initial burn area was also identified for a future prescribed burn (de Groot and Haeussler 2016).

Despite the restoration activities in the park, there is a lack of knowledge of the fire history in the area. Information on the fire history of the area could assist the decision making process for future prescribed burns.

The provincial historical fire database shows one fires in the area occurring in 1931; it partly overlaps the proposed future burn area (Figure 1). Aspen trees are not long lived and thus are not suitable for fire history studies. At the east end of the Red Hills, adjacent to the larger proposed prescribed burn area, are stands of Douglas-fir (*Pseudotsuga menziesii*) trees that the Vegetation Resource Inventory (VRI) indicates are up to 189 years old. These stands were determined to be of a suitable age and proximity for a fire history study.

The objective of this study was to determine the fire history of the Douglas fir stand on the Red Hills.

2.0 Methods

2.1 Field sampling and sample processing

An initial reconnaissance field trip was done on August 30, 2017 to determine if there were trees suitable for sampling in the target area. A number of trees of suitable age were found with fire scars during this trip.

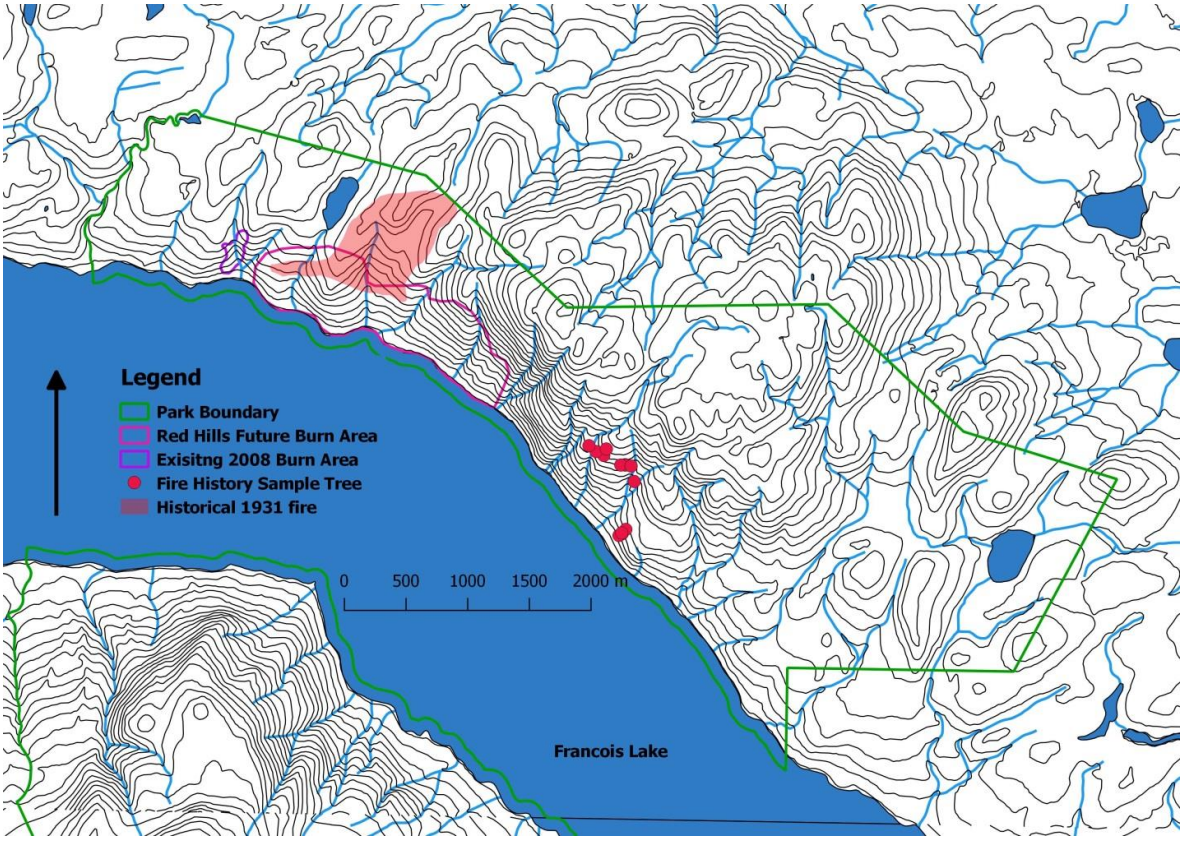

Figure 1. Location of sample area in Red Hills portion of Red Hills Uncha Mountain Provincial Park

A subsequent field trip to collect samples was completed on October 16th, 2017. Douglas-fir trees with visible evidence of features that might indicate the presence of fire, such as external wounds and bark scorch, were opportunistically sampled. A total of 13 trees were selected and cross sections were collected following methods in Cochrane and Daniels (2008) (Figure 2) that in ponderosa pine (*Pinus ponderosa*) does not significantly increase tree mortality (Heyerdahl and McKay 2017). Fragile samples were wrapped in plastic for transport to the lab. Sampling for ring-width chronologies used for cross-dating involved extracting a 5-mm increment core from 10 trees that showed no visible fire damage.

Increment cores and fragile cross sections were air dried and glued to wooden mounts. The samples were sanded with a belt sander and a series of increasingly finer grit belts. Sanding belts progressed sequentially through the following six levels of roughness; 40-, 80-, 120-, 220-, 320- and 400-grit. Surface preparation was complete when each sample had a surface on which anatomical features of the tree-ring were apparent under a 40x microscope (Stokes and Smiley 1968). Annual ring-widths were measured to the nearest 0.001mm using a Velmex "TA" System in conjunction with J2X software (version 5.0). Calendar dates were assigned to the cores and verified with the COFECHA 3.0 crossdating program (Holmes 1983; Grissino-Mayer 2001). COFECHA uses segmented cross correlation techniques to detect measurement and visual crossdating errors. For this study, the time series were partitioned into 50-year segments with 25-year lags and significance determined at a 99% critical level at a correlation of 0.320. A previously developed master chronology (AD 1749

to 2006) from a nearby site in Francois Lake (Wood and Smith 2014) was also used to verify cross-dating accuracy.

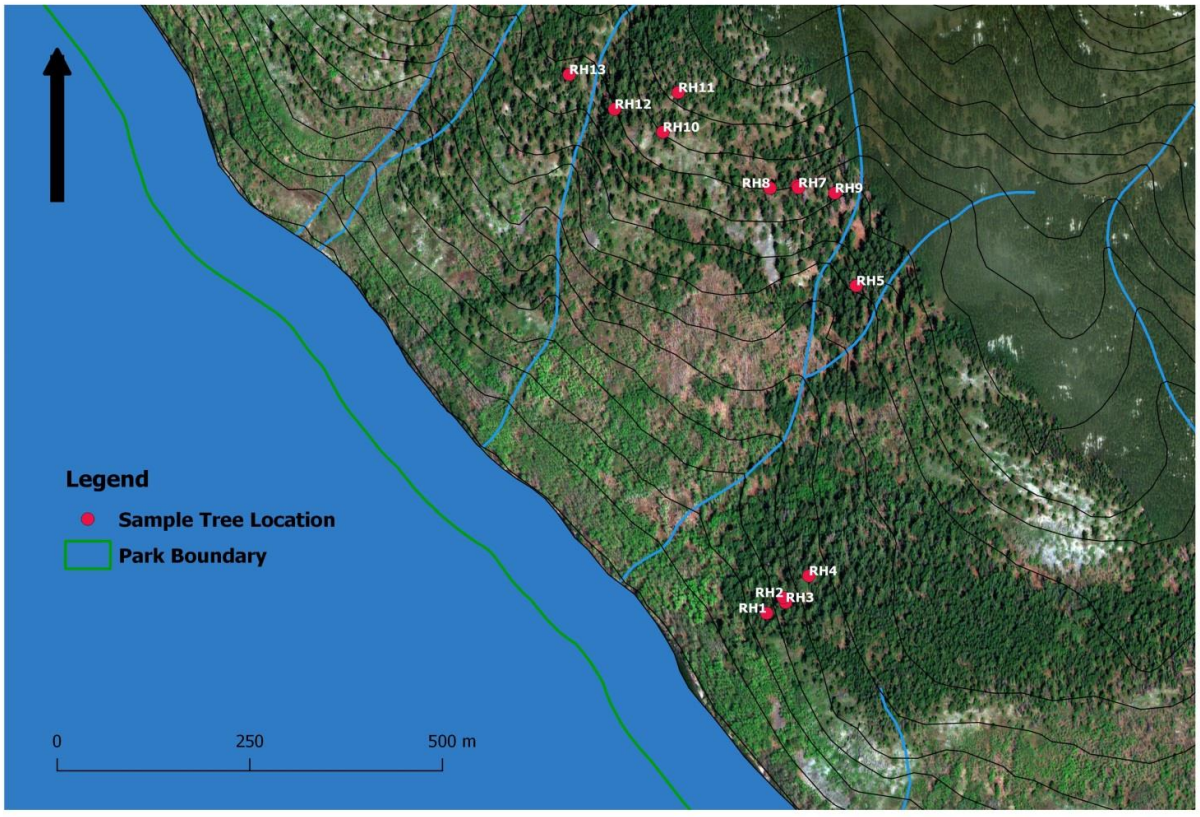

Figure 2. Location of sample trees within the Red Hills

Fire scars were dated based on their year of record in crossdated annual rings. Whenever possible, the fire season was assigned on the intra- or inter-ring position of the scar. Fire events were graphically represented using the *dplR* function *seg.plot*.

2.2 Climate data

Mean monthly temperature and total monthly precipitation records were retrieved from the Adjusted Homogenized Canadian Climate Database. Climate records at the Fort St James station (station code 1092970) were considered representative of climate variability in the immediate study area. Temperature and precipitation records extend from 1895 to 2010. Missing values within the climate records were few (<1%) and where present, were replaced with long-term averages calculated over the period of each instrumental record. Departures from the long-term average were used to highlight hot/dry or cold/wet periods.

2.3 Fire-climate relationships

Timing of the fire events was compared to the temperature and precipitation records to determine if conditions were conducive to fire occurrence.

Figure 3. Examples of disc sample trees

3.0 Results

3.1 Fire history

A total of 9 cross sections from fire-scarred Douglas-fir trees were used in the study. The remaining 4 samples (RH1d, RH104d, RH8d, and RH11d) contained significant amounts of decay that obscured the identification of the rings and were removed from further analysis. One fire scar in the year 1912 was identified in 8 of the samples covering a period of AD 1831 to 2017 (Table 1, Figure 4, Figure 5). Sample RH3d (AD 1776 to 1906) did not extend to the fire scar year. The position of the 1912 scar date occurred within the growing season and during latewood development.

Table 1. Details of sampled trees					
Sample Trees	**DBH (cm)**	**Health**	**Scar year**	**Time span**	**Tree age**
Disc Sample Trees					
RH1	48.8	Dead	Not used – too much decay	1833-2006	174
RH2	93.6	Live	1912	1854-2017	164
RH3		Dead	Not used – no scar	1776-1906	131
RH4	59.5	Live	Not used – too much decay		
RH5		Live	1912	1839-2017	179
RH6	30.7	Live	1912	1833-2017	185
RH7	37.8	Live	1912	1831-2017	187
RH8		Live	Not used – too much decay		
RH9	55.0	Dead	1912	1908-2016	109
RH10	52.0	Live	1912	1852-2017	166
RH11	30.0	Live	Not used – too much decay		
RH12	89.2	Live	1912	1848-2017	170
RH13	65.0	Live	1912	1905-2017	113
Cored Trees					
101	64.6	Live	n/a	1836-2017	182
102	116.5	Live	n/a	1840-2017	178
103	93.0	Live	n/a	1761-2017	246
104	77.0	Live	n/a	1848-2017	170
105	-	Live	n/a	1841-2017	177
106	85.8	Live	n/a	1862-2017	156
107	-	Live	n/a	1797-2017	221
108	-	Live	n/a	1826-2017	192
109	-	Live	n/a	1863-2017	155
110	-	Dead	n/a	1833-2006	174

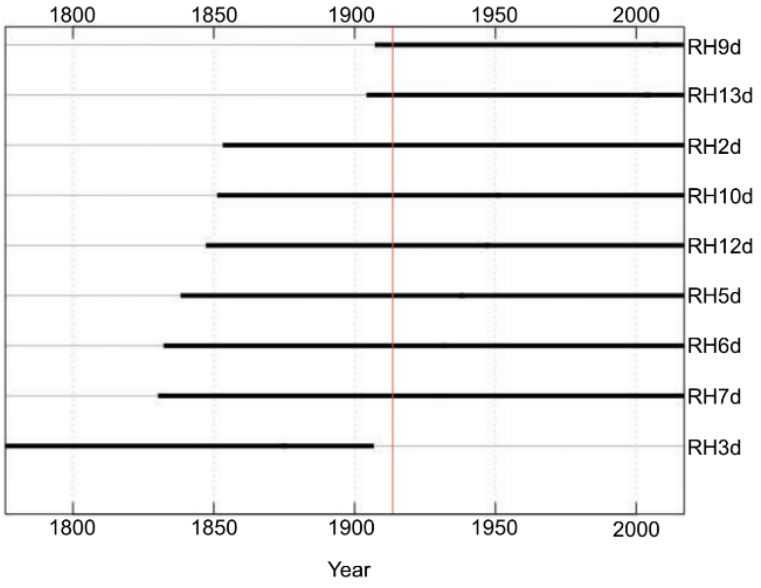

Figure 4. Segment plot showing the fire history from samples collected at Red Hill near Francois Lake, BC. Bold lines represent the length of each series and the red vertical line indicated the 1912 fire event.

Figure 5. Disc Sample RH7 collected from a live Douglas-fir tree showing the 1912 fire scar (series length AD 1831 to 2017).

Comparisons with total precipitation in summer (Jun-Aug) and fall (Sep-Nov) shows that the 1912 fire date occurred during a period of dry weather (Figure 6). Fall precipitation departures during 1912 were the second driest on record. Summer precipitation departures indicate a period of successive dry conditions, starting in 1910 and extending to 1912. No notable relationships with temperature were observed.

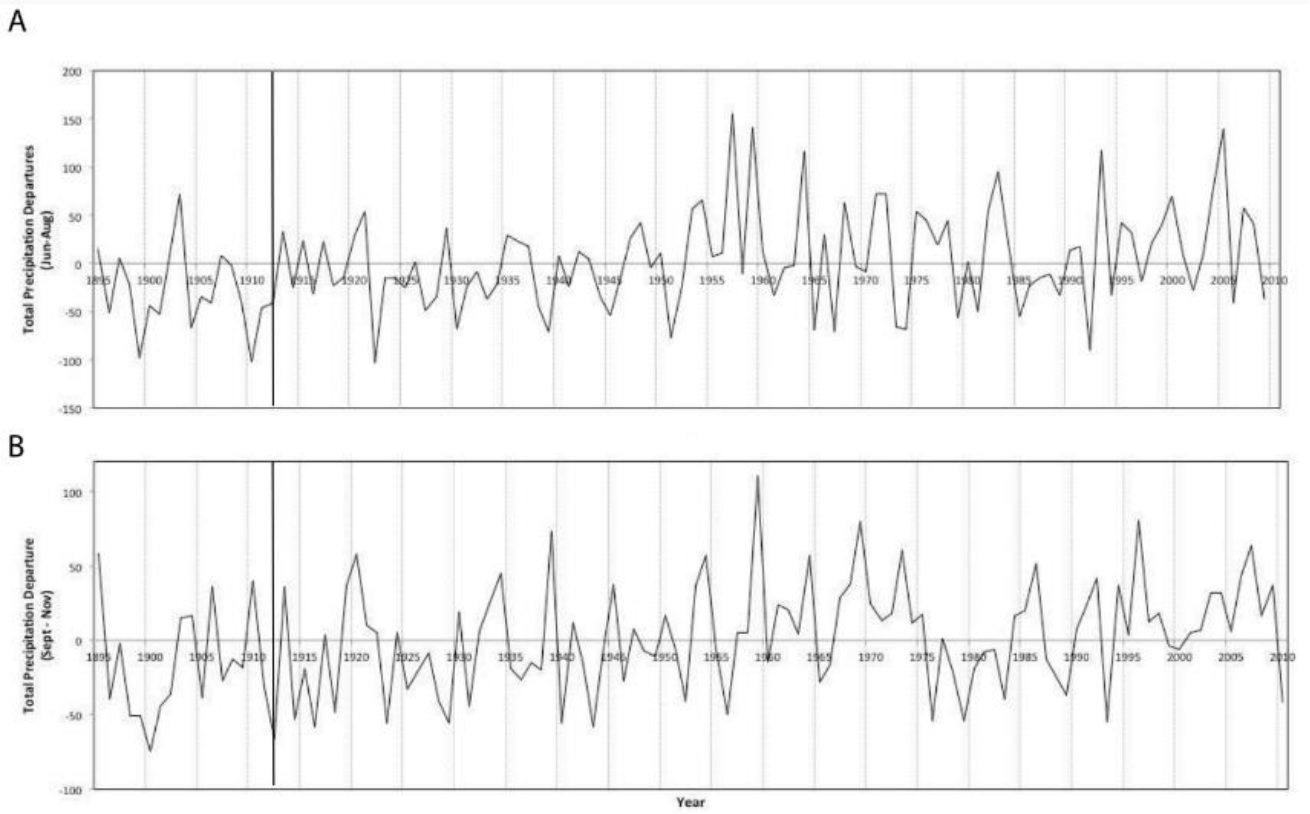

Figure 6. Total precipitation departure records for the Fort St James weather station for A) summer and B) fall. Vertical line indicates 1912 fire.

4.0 Discussion

4.1 Fire History

Over the period of time spanned by the trees sampled, 241 years from 1776 to 2017, only one fire was identified. Fires could have occurred in the area though, but have been cool enough to not have burnt through the bark of the trees, thus not producing scars. Trees with blackening on the bark were commonly seen (Figure 7, Figure 8) with fire being the most likely cause. Also, the aspen stands to the west where restoration activities have taken place could have burnt without burning the Douglas-fir dominated area.

While conducting the sampling it was observed that the Douglas-fir stands did not contain dense young Douglas-fir regeneration or in-growth. This lack of in-growth could be due to low intensity ground fires that swept through the forest understory, killing young regenerating trees. In-growth has been reported from other parts of the province in Douglas-fir stands that have not had stand-maintaining ground fires that kill young Douglas-fir trees that are not resistant to fire but do not kill old Douglas-fir trees that are resistant to fire (Newman *et al*. 2004). A similar situation of little in-growth has been observed in parts of the nearby Sutherland River Provincial Park (M. Parminter *pers. comm*.).

Figure 7. Open Douglas-fir stand with blackening on the base of the stems

Figure 8. Douglas-fir tree with extensive blackening of stem but without a fire scar

The lack of a clear fire history does not give definitive direction for park management. We know fire occurs, but not the frequency. The focus of management direction for vegetation management in the park is the maintenance of natural values in the park, especially the encroachment of aspen and shrubs into the Red-listed saskatoon / slender wheatgrass scrub/steppe ecosystem and grassland ecosystems (Ministry of Water, Land and Air Protection 2003), with prescribed fire recommended as the best management option (de

Groot and Armitage 2007). It is possible that the perceived encroachment of aspen could be the result of vegetation recovery after a single, infrequent fire, rather than as a result of a changed, less frequent, fire regime that resulted from fire control facilitating the spread of aspen into previously non-forested areas.

This new information led to a re-examination of previous work done in the park. de Groot and Armitage (2007) looked at four areas within the Red Hills and the Shannon Property portion of the park (Figure 9) for aspen encroachment using historical imagery, with several of these areas subsequently visited and ecological data collected (de Groot 2008). These areas were re-examined, and used additional information on a historical fire from 1931 that was not available in 2008. The sites were of two types, with very different site and vegetation characteristics, moist lower slope sites and dry, rocky middle to upper slope sites.

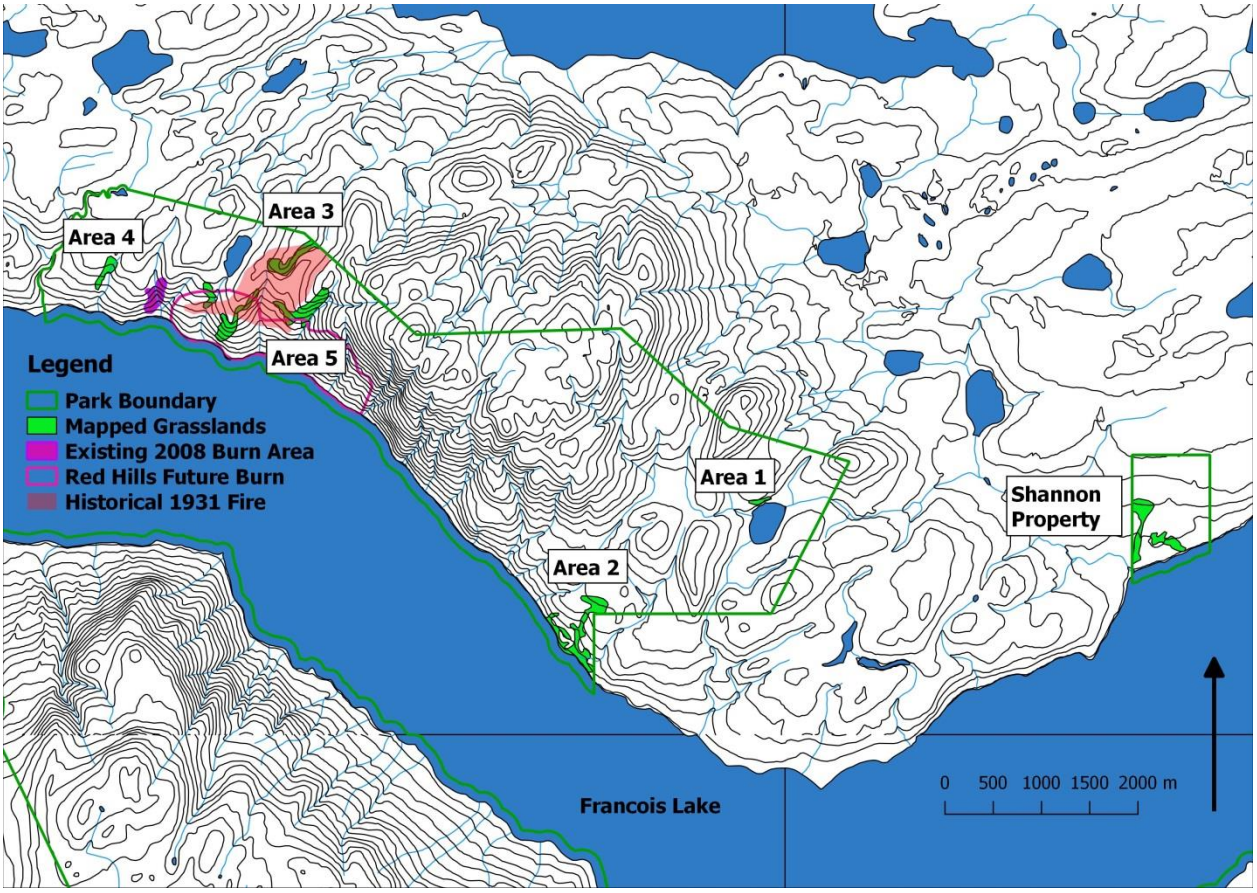

Figure 9. Location of examined grassland areas

4.2 Moist Lower Slope Sites

The two areas in the park with the most encroachment are on moist lower slope sites and they have very different vegetation from the drier, rocky middle to upper slope sites. The grasslands in the Shannon Property area of the park, which were likely the bluegrass – slender wheatgrass (SBSdk/82) ecosystem before modification, have evident encroachment. These grasslands may be natural openings but they have a long history of grazing and are dominated by naturalized grass species with few shrub species present (Figure 10) (de

Groot 2008). Area 2 in the southeast corner of the Red Hills also had identifiable encroachment (de Groot and Armitage 2007). This area contains a cow parsnip ecosystem, with a high grass component, on moist rich soils that is analogous to the cow parsnip – large-leaved avens ecosystem described by Haeussler (1998) (Figure 11) (de Groot 2008). The aspen encroachment in these areas indicates that the objective of protecting natural values is not being met in these two areas.

Figure 10. Modified grassland in the Shannon Property

Figure 11. Cow parsnip ecosystem, Area 2 of the Red Hills

Based on plot data, these two sites are not as steeply sloping and are moister than the prescribed fire area that was burnt in 2008. This will have implications for any prescribed burn plan, influencing for example the timing of snow melt in spring and the ability of the

terrain to carry a fire. Prescribed fires in these areas would be complicated by the need for boat access to one of the sites, being located close to park boundaries and because natural barriers to fire are not well defined.

4.3 Drier, Rockier Middle to Upper Slope Sites

Four areas in the Red Hills on drier, rockier middle to upper slope sites (Figure 9, Figure 12) were examined: Area 1, Area 3, Area 4, and a new area called Area 5.

Area 1 is located in an area where aspen is a minor component of the forest cover. It was designated as a low priority area for restoration by de Groot and Armitage (2007) due to the rocky nature of the terrain likely being unable to support large trees. This recommendation is still valid.

Area 3 is mostly located within the boundaries of the 1931 fire. de Groot and Armitage (2007) note that much of the tree development was by conifers, and aspen has been increasing in stature, as well as in area. The changes are likely due to the tree layer recovering from the 1931 fire, and not due to encroachment on persistent scrub/steppe ecosystems.

Figure 12. Example of SBSdk/81 site in the Red Hills

Area 4 contains a mixture of aspen leading stands at lower elevations and on southwest-facing slopes, and spruce leading stands at higher elevations. After a closer examination of this area, the issue of encroachment does not appear to be a serious as indicated by de Groot and Armitage (2007).

A new area southeast of Area 3, called Area 5, in the proposed future prescribed fire area showed very little encroachment between 1971 and 2007. Rather, it appeared that the crowns of the aspen have increased in size (Figure 13).

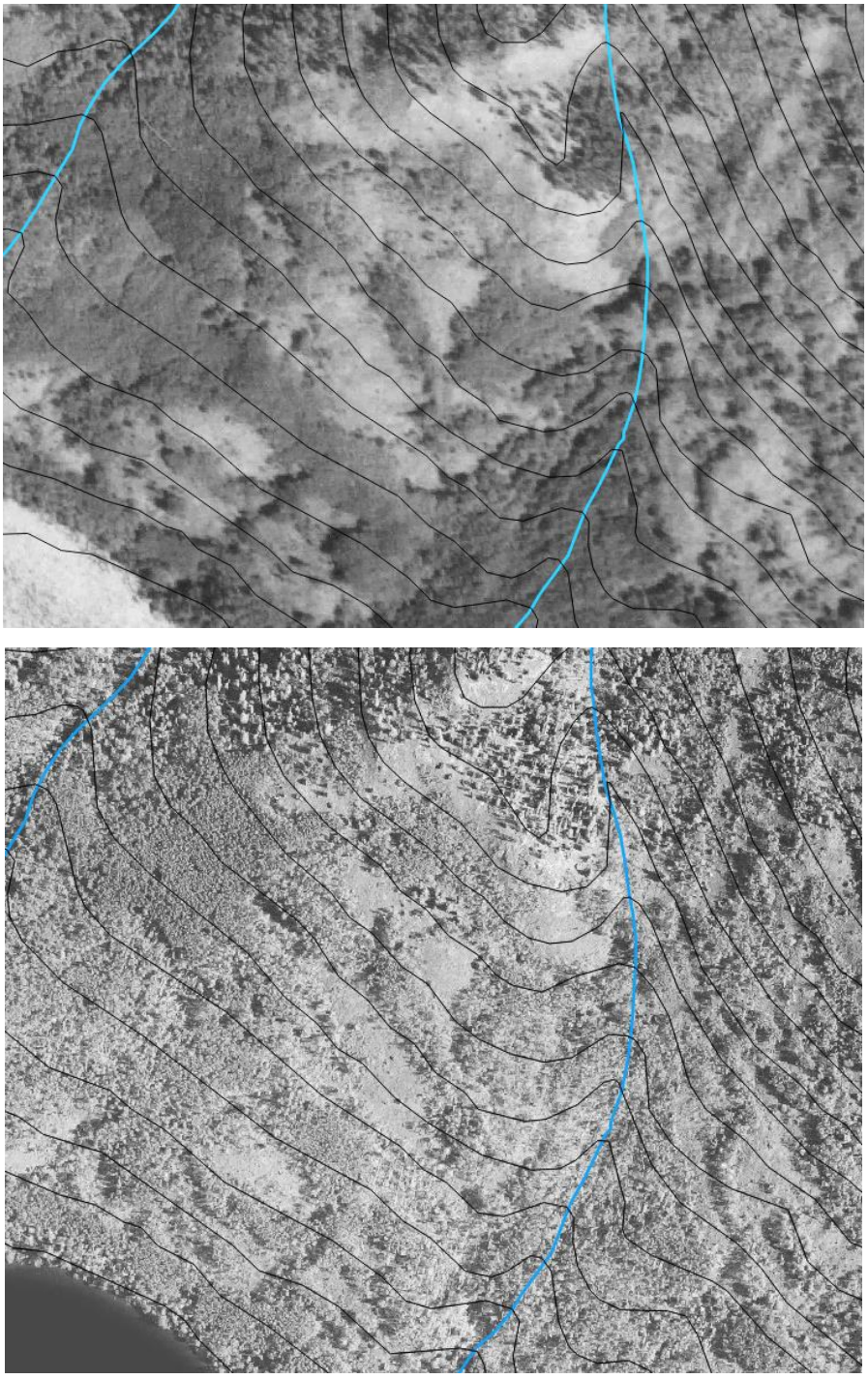

Figure 13. Comparison of vegetation in Area 5 in the Red Hills in 1971 (top) and 2007 (bottom)[1].

[1] The photos are slightly offset from each other due to registration issues. The 1947 imagery of this area was too blurry to be of use.

Areas 1, 3, 4 and 5 which appear to be much less affected by aspen encroachment than the Shannon Property and Area 2, are on drier sites that contain the saskatoon / slender wheatgrass scrub/steppe ecosystem. The lower level of encroachment is likely due to the soils being too dry and rocky to sustain tree species. With the climate of the area projected to have warmer summers with similar amounts of precipitation (Table 2) (Wang *et al*. 2016) these dry conditions would be expected to be exacerbated, further restricting tree growth on these dry sites.

Table 2. Selected climate parameters for the Red Hills[1]

Parameter	Normals 1951-1980	Normals 1981-2010	2025[2]	2055	2085
Mean Annual Temperature (°C)	2.1	3.0	4.0	5.1	5.7
Mean Annual Precipitation (mm)	529	502	531	549	558
Summer Mean Temperature (°C)	12.4	13.1	14.2	15.3	16
Summer Precipitation (mm)	138	137	132	133	132
Frost-free Period (days)	89	96	115	131	140

1 – parameters obtained from the ClimateBC model (Wang et al. 2016) which allows climate data for a specific location to be extracted

2 - mean of 15 General Circulation Models with greenhouse gas emission scenario RCP 4.5

5.0 Recommendations

The two areas of grassland with encroachment should be investigated further to determine the extent of the encroachment and the possibility of using prescribed fire to control the aspen if needed. Tree cores could be taken to age trees to determine a time frame for the progression of the aspen into the grassland areas.

Do not proceed with reburning the area that was burnt in 2008, or with the larger burn area that was proposed in de Groot (2016).

Further investigation of the Douglas-fir stands where the fire history sampling was done to quantify the density of stand in-growth, including the sampling of the Douglas-fir stands on the south shore of Francois Lake.

Any restoration activities need to include monitoring to determine their effectiveness.

Natural fires in the park should not be supressed if they are not threatening values outside the park.

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