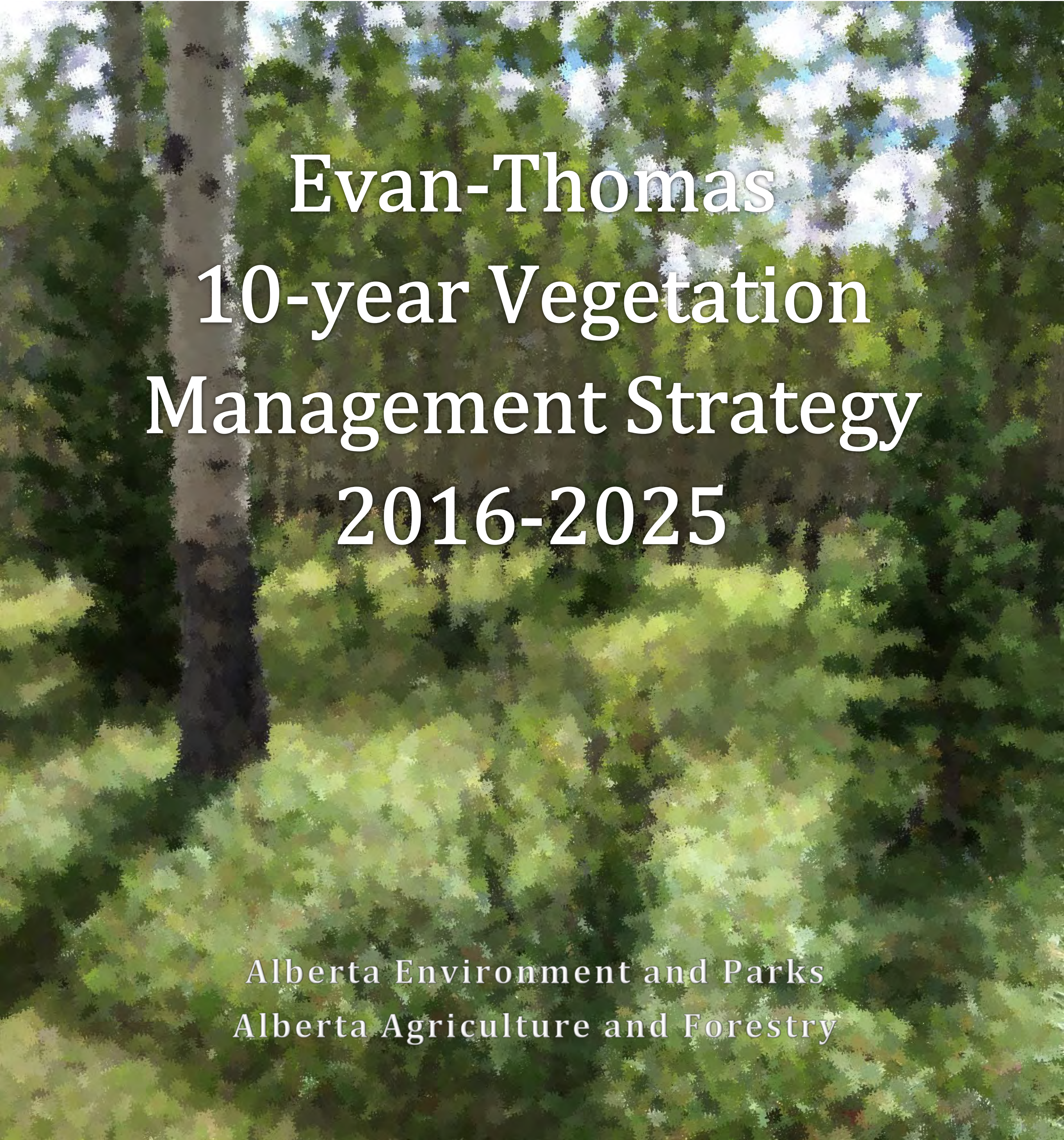

Evan-Thomas 10-year Vegetation Management Strategy 2016-2025

Alberta Environment and Parks

Alberta Agriculture and Forestry

Alberta Government

Evan-Thomas
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Alberta Environment and Parks, Parks Division, Canmore

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Executive Summary

The Evan-Thomas area of Kananaskis Country is a priority for vegetation management due to the need to protect important recreation and tourism values from wildfire and to maintain a healthy ecosystem. Over the last 80 years, effective wildfire prevention and suppression have nearly eliminated fire from this landscape which is causing dramatic changes to vegetation, reducing habitat quality, decreasing biodiversity, and altering the resilience of the ecosystem to natural disturbances and changing climate. These ecological impacts may have far reaching social and economic consequences such as making forests vulnerable to more severe and extensive wildfires or insect outbreaks such as mountain pine beetle. The focus of the strategy is to develop measures to deal with these complex issues.

The goal of the *Evan-Thomas 10-year Vegetation Management Strategy 2016-2025* (ETVMS) is to provide detailed strategic direction for the management of vegetation in the Evan-Thomas area of the Kananaskis Valley (Figure 1) to maintain, restore, and protect ecological, recreation, and tourism values. This strategy has five main objectives to achieve this goal:

1) Wildfire management
2) Restore habitat and species diversity
3) Restore ecosystem health and resilience
4) Reduce human-wildlife conflict
5) Maintain watershed integrity

The strategy proposes 15 measures to deal with fire and vegetation issues including the use of mechanical fuel reduction and prescribed fire involving about 1480 hectares (~7%) of the planning area. Prescribed fire is the most cost effective and ecologically beneficial tool and will be used mainly to restore aspen, grass, and shrub communities around facilities for fire protection and to maintain habitat quality. It is intended that most of the aspen will survive these low-intensity fires and the forest canopy will more or less remain intact. Grasses will quickly re-sprout and evidence of burning will not be visible to most visitors. Use of fire in this manner will result in an attractive, open ‘park-like’ or savannah appearance that will be scenic and may provide better wildlife viewing opportunities.

Most fires will be low-intensity surface fires that are relatively small (40-80 ha), of short duration (2-3 afternoons/days), and smoke impacts will be minimal. Prescribed fires will predominantly be undertakend in the spring and autumn outside of the busy tourist season. A paramount consideration of this strategy is to minimize the impact of prescribed fire activities including smoke on recreation and tourism. Consultation and communication with stakeholders will be an ongoing process to ensure that impacts are within acceptable limits. Good vegetation management may prevent larger and more extensive wildfires that can produce heavier smoke for longer periods of time, resulting in greater economic and health impacts.

Implementation of this strategy will follow an adaptive approach involving monitoring, research, and reporting to ensure objectives are being met and to avoid adverse effects on ecosystem components, recreation, or tourism. Vegetation management and restoration activities are long-term initiatives that require continual commitment. This 10-year strategy focuses on priorities that can be realistically achieved in a cost effective and sustainable manner in the period from 2016 to 2025.

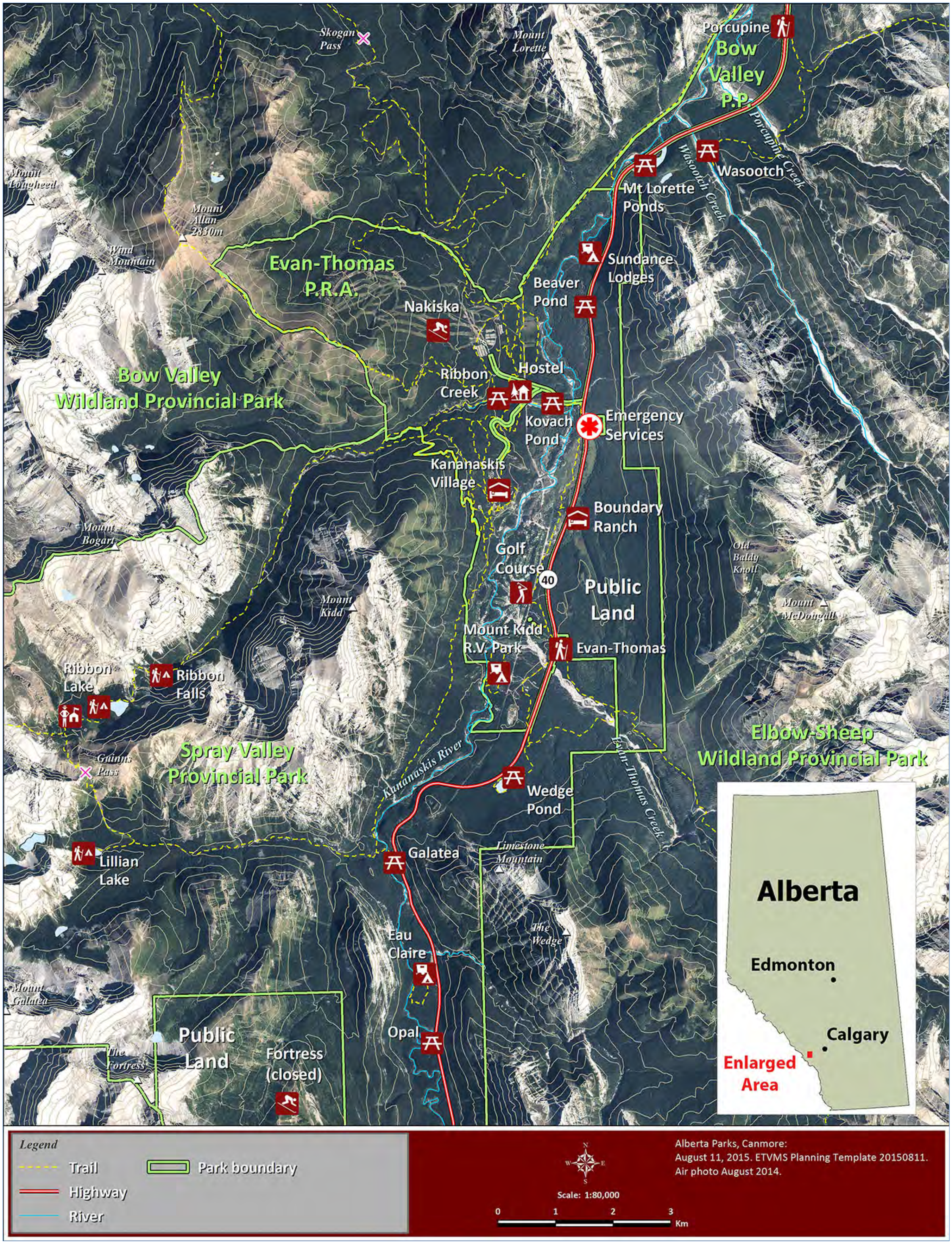

Figure 1: Evan-Thomas planning area.

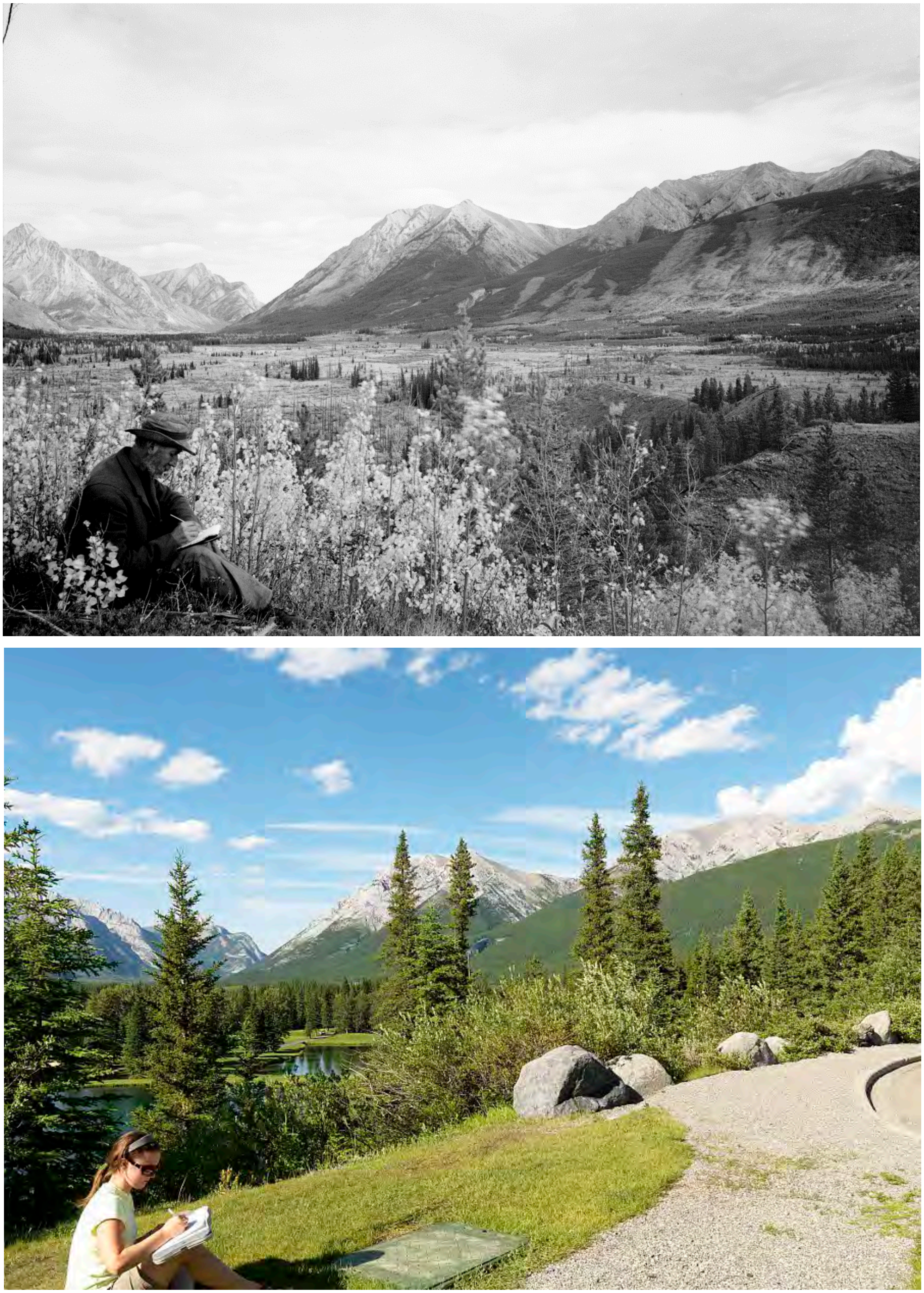

Figure 2: Photographs showing vegetation change at the golf course, *c.* 1904 and 2009.

(Photos courtesy of Mountain Legacy Project)

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Defining the Problem

The Evan-Thomas area of Kananaskis Country is a priority for vegetation management due to the need to protect important recreation and tourism values from wildfire and to maintain ecosystem health. Over the last 80 years, effective wildfire prevention and suppression have nearly eliminated fire from this landscape. The amount of area burned by wildland fires in the southern Canadian Rocky Mountains (Alberta, British Columbia, and proximate areas) has declined precipitously over the last century, a phenomenon that is without precedent in the historic record (Hawkes 1979, Tande 1979, White 1985, Van Wagner *et al.* 2006).

There is growing concern that low fire frequency is having profound effects on ecosystems and linked social-ecological systems (Day 1972, Parks Canada 2004, Turner 2010). Low fire frequency may alter the structure and composition of vegetation communities by increasing amounts of older, closed-canopied conifer forest, reduce areas of young seral stage vegetation, and result in low aspen regeneration and the disappearance of grassland and shrub communities (Achuff *et al.* 1996, Rhemtulla *et al*. 2002, Gallant *et al.* 2003). Loss of vegetation heterogeneity may reduce species habitat and diversity, and older and less age-diverse forests may lack resilience to insect outbreaks, disease, drought, and changing climate (Keane *et al.* 2002, Perry *et al.* 2011). Increased forest contiguity and changes in fuel structure may make montane ecosystems more vulnerable to severe and extensive fires with greater potential for crown fires (Van Wagner 1977, Arno *et al.* 2000).

The focus of the strategy is to develop measures to deal with these complex issues. The preferred approach for management of vegetation in Alberta's protected areas is to allow natural processes to shape native vegetation without intervention (Alberta Tourism, Parks and Recreation, Parks Division 2009). This approach maintains healthy and more naturally resilient ecosystems. However, it is recognized that passive management is not always possible and that active vegetation management is sometimes necessary especially if restoration efforts are required to return a human-altered ecosystem to a native state. The current policy of suppressing all wildfires is one example of how vegetation is actively managed. Vegetation management is generally acceptable in the Alberta parks system when required for ecosystem protection, habitat restoration, visitor safety, facility protection, or to facilitate approved activities.

Vegetation management and restoration activities are long-term initiatives that require continual commitment. This 10-year strategy focuses on priorities that can be realistically achieved in a cost effective and sustainable manner in the period from 2016 to 2025.

GOAL

The goal of the *Evan-Thomas Vegetation Management Strategy* (ETVMS) is to provide detailed strategic direction for vegetation management in the Evan-Thomas area of the Kananaskis Valley to maintain, restore, and protect ecological, recreation, and tourism values (Figure 1).

OBJECTIVES

This strategy has five main objectives to achieve this goal:

1) Wildfire management
2) Restore habitat and species diversity
3) Restore ecosystem health and resilience
4) Reduce human-wildlife conflict
5) Maintain watershed integrity

OVERVIEW OF OBJECTIVES & APPROACHES

Wildfire Management

The current wildfire management mandate in Alberta is to provide measures to protect human life, communities, watersheds and soils, natural resources (including recreation and tourism values) and infrastructure from wildfire. These objectives will remain central in this strategy but the mandate is broadened to include the prescriptive use of fire as a measure to protect people and facilities as well as restore ecosystem health. Carefully managed precribed fires and mechanical fuel reduction will be used to reduce the extent of coniferous forest around facilities, restore native vegetation communities such as aspen, grass, and shrub, and maintain fuel breaks. This approach will halt the invasion of conifer and reduce the risk of more severe, damaging wildfires, as it is easier to protect facilities from fire in aspen stands than conifer stands due to high-intensity crown-fires that occur in conifer. This approach will also help to meet the other main objectives of the strategy.

A paramount consideration of this strategy is to minimize the impact of prescribed fire activities on recreation and toursim such as smoke impacts. Consultation and communication with stakeholders will be an ongoing process to ensure that impacts are within acceptable limits and air quality will be monitored.

Restoring Habitat & Species Diversity

Fire exclusion has altered habitat and species diversity in the Evan-Thomas area as well as throughout the broader region. This strategy will endeavor to maintain and restore habitat and species diversity by restoring natural vegetation characteristics that are representative of the natural region. This will be accomplished largely through the use of prescribed fire to emulate wildfire disturbance in as natural as way as possible. The primary approach for the first 10-year phase of this strategy will be restoring aspen, grass, and shrub communities using low-intensity prescribed fire.

This initiative will help meet objectives of the *South Saskatchewan Regional Plan* which states that terrestrial and aquatic diversity will be maintained and biodiversity and healthy, functioning ecosystems will continue to provide a range of benefits to communities in the region (Government of Alberta 2014).

Ecosystem Health & Resilience

Loss of fire from the landscape is changing the species composition, structure, and the diversity of vegetation communities making ecosystems less resilient to natural disturbances and having profound effects on linked social-ecological systems. For instance, low fire frequency is increasing amounts of older, closed-canopied conifer forest, reducing amounts of juvenile conifer forests, causing low aspen regeneration and the disappearance of grassland and shrub communities. This loss of vegetation heterogeneity and older and less age-diverse forests may create a lack of resiliency to insect outbreaks, disease, drought, changing climate, and may result in montane ecosystems being more vulnerable to severe and extensive fires. Restoring ecosystem health and resilience will be accomplished by reestablishing the role of fire on the landscape using prescribed fire and the same approaches used to restore habiat and species diversity.

Maintaining long-term ecoystem health and resiliency are objectives of the *South Saskatchewan Regional Plan* (Government of Alberta 2014).

Human-Wildlife Conflict

The strategy considers how human activity, fire, and vegetation influence the distribution of wildlife species and how fire and vegetation management can be used to reduce human-wildlife conflicts. Current challenges include conflicts between people and bears, elk habituation to the golf course, vehicle caused widlife mortality, and habitat alienation due to competing uses in important habitat and wildlife corridors.

Hydrology

This strategy is intended to mitigate changing hydrology resulting from human-induced vegetation change. Streamflows are declining in the Rocky Mountains in Alberta due to hydroclimatic changes and human activities (St. Jacques *et al.* 2010). Studies done for the area show that snowmelt yield is sensitive to forest cover (Pomeroy *et al.* 2012) and forest disturbance (Ellis *et al.* 2012).

The approach to meeting this objective is to restore vegeation diversity as this will maintain the variability in snow accumulation, snowpack retention, and runoff. The focus of this strategy in the first 10 years will be on restoring healthy aspen and reducing the exent of dense conifer which is expected to reduce snow sublimation and increase snow accumulation and retention.

Other measures in this strategy aimed at restoring ecoystem health will also have benefits in terms of hydrology as healthy ecosystems are resilient to natural disturbances which influence watershed health.

GUIDING PRINCIPLES

Several guiding principles have shaped the development of this strategy and will be considered in its implementation.

1. Fire protection measures will be placed closer to the facilities that they are intended to protect. This approach is based on an emerging consensus among fire managers and the scientific literature that protection measures employed closer to facilities provide higher levels of protection.
2. Fire protection will focus on protecting facilities, not forests. Forest will eventually burn despite our best fire protection efforts or eventually succumb to natural disturbances and processes. Strategies designed to protect forests may increase fire risk, impair ecological health, and have linked social and economic impacts.
3. The ecologial role of fire will be re-established to restore natural ecosystem structure, composition, processes, and function.
4. The prescriptive use of fire will be used to protect people and facilities from wildfire as well as restore the health of the ecosystem as the most cost effective and ecologically beneficial measure.
5. Restoration activities will emulate wildfire disturbance as closely as possible.
6. Vegetation in the montane portion of the landscape lends itself to the application of small, frequent, low-intensity surface fires rather than complex, high-intensity prescribed fires.
7. Vegetation management is a long-term necessity which must be done in a cost effective and sustainable manner.
8. Ecosystem restoration will follow a science-based approach.
9. This strategy will follow a flexible approach and take advantage of opportunities that arise for implementation, collaboration, and funding.
10. Implementation of this strategy will follow an adaptive approach involving monitoring, research, and reporting to ensure objectives are being met and adverse effects are avoided.

SCOPE

The focus of this strategy is on issues related to vegetation management in the Evan-Thomas area to maintain, restore, and protect ecological, recreation, and tourism values. This strategy does not address:

1. Fire detection or suppression
2. Ornamental vegetation which is governed by the *Vegetation Management Program Statement* and *Evan-Thomas P.R.A. Management Plan*
3. Vegetation management on power lines which is the responsibility of utility providers

4. Invasive or alien plant species control which is guided by the *Vegetation Management Program Statement* although invasive plant control will be integrated with this strategy

REPORTING & FUTURE PLANNING

1) An environmental screening is complete for this strategy.
2) Detailed operation plans will be done for each prescribed fire and fuel treatment project. These operation plans will include strategies to accommodate traffic.
3) Detailed operation plans will follow the approval process for both the Parks Division, and Wildfire Management Branch.
4) Detailed operation plans will be reviewed by the senior park ecologist and further environmental reviews will be prepared, if necessary, in accordance with the *Environmental Review Directive* (Alberta Environment and Parks, Parks Division 2015).
5) A historical resources review will be done and historical resource impact assessments completed (HRIA) if required for each component of the strategy that involves prescribed fire.
6) A communications plan will be developed prior to implementation of the strategy. This will include consultation with stakeholders, aboriginal groups, and the public.
7) Fire risk modelling will be completed to evaluate if the proposed measures will be effective at protecting facilities from wildfire.
8) Annual progress reports will be prepared to provide a summary of activities, actions, achievements, concerns, and issues associated with the implementation of this strategy.
9) This strategy will be reviewed in five years and it is recommended that the strategy be revised for 2025.

FIRST NATIONS CONSULTATION

First Nations were consulted on the strategy in accordance with *The Government of Alberta's Policy on Consultation with First Nations on Land and Natural Resource Management, 2013*. First Nations stated they would like to be notified about each fire prescription during the detailed planning stage. They also wish to be notified when prescribed fires will occur so that they may gather medicinal plants or perform ceremonies beforehand. The overall concerns raised were with regard to impacts to traditional plant use and wildlife. Alberta Parks recognizes the cultural importance of plants and animals and the need to incorporate traditional knowledge into the detailed planning process. During the detailed planning and implementation of the strategy, Alberta Parks and Forestry are committed to keeping First Nations informed and collaborating on research and monitoring opportunities where able.

VEGETATION MANAGEMENT PRIORITIES

The following strategic priorities are the focus for the years 2016-2025. Some priorities do not require any action at this time.

List of Priorities

Table 1: Summary of vegetation priorities.

1) FireSmart
2) Restoration of aspen, mixed aspen-conifer, grass and shrub
3) Complete and maintain existing fire mitigation projects a) Evan-Thomas Creek fuel break b) Douglas-fir restoration project c) Kananaskis Emergency Services fuel reduction
4) Enhance natural fuel breaks a) Roadside fire hazard reduction b) Evan-Thomas, Porcupine, and Wasootch Creeks
5) Boundary montane habitat restoration and fuel reduction
6) Treatment of Habitat Blocks
7) Ribbon Creek fuel break and habitat restoration
8) Wedge Mountain fuel break
9) Deadfall prescriptions
10) Bighorn sheep habitat restoration
11) Maintain old-growth at Skogan Pass as a fuel break
12) Natural regeneration of harvested areas
13) Further measures to reduce human-wildlife conflicts
14) Further measures for maintaining healthy hydrology
15) Vegetation management for species of special concern

Implementation Schedule

Whenever possible, prescribed fire and fuel reduction treatments will be done in the spring and fall, outside the busiest season to avoid impacts on recreation and tourism. FireSmart activities will generally be done during the winter. The implementation schedule will be adjusted year-to-year in response to weather conditions, funding, and other considerations.

Table 2: 10-year implementation schedule.

Priority Number ( )	Grass & Shrub (2)	Aspen (2)	Mixed Stands (2)	Evan-Thomas Creek (3a)	Douglas-fir (3b)	KES (3c)	Highway 40 (4a)	Porcupine Wasootch Evan-Thomas (4b)	Montane Habitat & Habitat Blocks (5)	Ribbon Creek (6)	Wedge Mountain (7)	Deadfall (8)	Bighorn Sheep (9)	Total*
	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
2007 - 2015	9	3		195	9	7					70			
2016 - 2017	50	50						14						114
2017 - 2018	15	25	25						50			5		120
2018 - 2019	15	25	50				3	5					32	130
2019 - 2020	15	25				7			50		35			132
2020 - 2021	15		25		9		2			98				149
2021 - 2022	15		25	100					52			5	32	229
2022 - 2023	15			200										215
2023 - 2024	15	25	50						50					140
2024 - 2025	15	25	25								35	5	32	137
2025	15	25	75											115
Total* (ha)	385		275	300	9	7	5	19	202	98	70	15	96	1481
Goal (ha)	382		285	300	9	7	5	19	202	98	70	15	96	1488

*Does not include FireSmart Prescriptions

1. FireSmart

This strategy recognizes the value of FireSmart fuel reduction treatments adjacent to facilities. FireSmart is coordinated by the Kananaskis Improvement District (KID) FireSmart Committee which includes representatives from both the Parks and Forestry Divisions.

As this strategy places an emphasis on protection of facilities rather than forests, FireSmart treatments will play a greater role in facility protection. This strategy integrates existing and proposed FireSmart projects into broader fire protection measures which will make FireSmart treatments more effective.

FireSmart treatments will help mitigate human-wildlife conflicts by reducing hiding cover, increasing sight-lines, and removing bear attractants such as buffaloberry (*Shepherdia canadensis*) adjacent to facilities (Figure 3). It is important to note, however, that buffaloberry will proliferate in thinned conifer so FireSmart areas must be maintained to remove new buffaloberry growth. Another benefit of FireSmart is that it may improve traffic safety because of better visibility.

Low-intensity prescribed fire may be used for the long-term maintenance of some FireSmart treatments as prescribed fire is more cost effective and provides ecological benefits.

Estimated Area

35 ha completed (2007 to 2014)
49 ha proposed

Objectives

1. Provide a fuel break around facilities for wildfire protection
2. Reduce wildfire intensity, rate of spread, and crown-fire potential adjacent to facilities
3. Reduce human-bear conflicts around facilities by removing buffaloberry
4. Reduce wildlife hiding cover around facilities to discourage use by wildlife and increase visibility

Prescription

General prescriptions involve thinning and removal of advanced growth understory, coarse woody debris including dead and down trees, dead standing, and limbs. The following prescription details may be modified for different sites:

1) Retention of all healthy coniferous overstory
2) Retention all deciduous trees (unless damaged or unhealthy)
3) All coniferous regeneration patches (<6 m height) will be thinned to 4 m crown spacing
4) Coniferous advanced-growth understory (<6 m height) will be thinned to 4 m crown spacing, clumping may be acceptable. The order of priority for advanced-growth understory and regeneration thinning is: unhealthy or damaged trees, lodgepole pine, white spruce, and Douglas-fir (order of species may vary).

5) All residual coniferous trees >6 m height will be pruned to 2 m above ground level at the lowest point of the branch with no more than 1/3 of crown. Trees <6 m height are not to be pruned in order to retain live-crown ratio.

6) All dead standing trees to be removed unless they show signs of cavity nesting activity

7) All dead shrubs will be removed

8) All green or dead buffaloberry will be removed

9) All new and existing stumps will be flush-cut to ground level

10) All windthrow root-balls to be flush-cut as close as possible to the root-ball and tree boles will be removed

11) All debris created from fuel modification operations and all existing dead and down material greater than 7.5 cm in diameter will be removed. Tree boles in an advanced state of decay and not contributing to wildfire fuel load may be left for ecological purposes.

12) Burn piles will be seeded with native seed mix approved by the park ecologist

(Source: adapted from Walkinshaw 2013)

Special Considerations

All healthy coniferous overstory trees will be retained to reduce the potential for windthrow (see Schroeder 2006).

Cost

FireSmart with pile and burn treatments: $8,000 - $10,000 ha

FireSmart with chipping: $10,000 - $12,500 ha

Funding

- Forest Resource Improvement Association of Alberta (FRIAA) FireSmart Program
- FireSmart Community Grant Program (The maximum grant was $100,000 for the 2014-2015 fiscal year)

Figure 3: FireSmart projects completed and proposed.

2. Restoration of Aspen, Shrub, and Grass Communities

Restoring the natural vegetation structure and composition of aspen, grass, and shrub communities is a key strategy for protecting facilities from wildfire and for maintaining some of the most critical habitat in the region (Figure 9). The Evan-Thomas area has the highest concentrations of aspen and aspen-conifer forest in the Kananaskis Valley, making it vital for habitat diversity and a critical food sources for ungulates especially in winter months. Deciduous forest is important in terms of watershed health as there is no other forest species locally that allows for the accumulation and retention of the winter snowpack that helps feed rivers through summer months and restores groundwater.

It is fortunate that many facilities in the Evan-Thomas area are surrounded by aspen or mixed stands of aspen and conifer which have low crown-fire potential (Figure 4). Pure stands of aspen with high canopy have asbestos-like burning characteristics because of their low flammability. The following statement highlights the importance and utility of aspen as fuel breaks:

> *"Aspen's positive effects on fire behavior have made it a species of choice for fuel treatments in and around the wildland-urban interface throughout North America (Shepperd et al. 2006). Wherever ecologically appropriate, managers could plant aspen stands to function as fuel breaks and firebreaks around their communities. As a wildfire advances toward the community the fire would encounter the aspen stand and drop from the crowns and proceed as a low intensity surface fire or even stop (Alexander and Lanoville 2004). Fire suppression crews would utilize these aspen stands as safety zones as well as anchors for suppression operations."*

(Gray 2013, p.4)

Aspen forests in the Evan-Thomas area are generally healthy but there are signs of aspen decline (Figure 5), aspen regeneration is limited because of the lack of landscape disturbance, and conifer is encroaching on grass and shrub communities (Figure 6). As conifer matures, it out-competes aspen which eventually dies, increasing the potential for more extensive and severe wildfires. Fire protection measures that allow conifer encroachment will increase fuel loads and fire risk. There will be a significant decline in aspen in the next few decades if fire is not used to reduce conifer encroachment and stimulate aspen regeneration. Restoration is a long-term process that will take decades and will be more difficult and costly to restore if this process is delayed.

Over the next 20 years it is recommended that low-intensity prescribed fire be applied to some degree to most aspen, aspen-conifer, grass, and shrub communities. Prescribed fire applied to aspen, grass, and shrub may also be pushed into the margins of neighbouring forest cover to gradually reduce conifer encroachment. At some locations, repeated prescribed fire may be required to achieve desired objectives. Mechanical fuel treatments may be required in some areas because of fire risk or smoke. Stands with the highest priority are those immediately adjacent to or on the upwind side (south) of facilities.

These low-intensity prescribed fires will generally be small (40-80 ha), of short duration (2-3 afternoons/days), and smoke impacts will be minimal. Prescribe fires will usually be undertaken in the spring and autumn outside of the busy tourist season. In most cases, fire will result in a more open ‘park-like’ or savanna appearance and by summer, evidence of burning will not be visible to most visitors. Scenic and wildlife viewing opportunities will improve because of more open forest. The general prescription for these stands is low-intensity prescribed fire at appropriate intervals as described, within the historical range of variation (HRV). HRV may be defined as the appropriate frequency and intensity of fire for healthy stands of aspen to regenerate and persist on the landscape. Monitoring and research will help define the range of variation for these forest communities in the Kananaskis Valley.

Figure 4: Example of how aspen forest can protect adjacent facilities.

Estimated Areas

Aspen (including grass and shrub)	764 ha, 382 ha 10-yr treatment
Aspen-conifer	569 ha, 285 ha10-yr treatment

Aspen Objectives

Pure aspen stands for the purpose of this strategy are considered those with less than 10% conifer.

1) Maintain existing stands of aspen as fuel breaks and defensible spaces around facilities
2) Restore stand-age diversity and encourage regeneration of aspen
3) Increase the extent of aspen forest by using prescribed fire along the margins of aspen forest to compensate for conifer encroachment
4) Restore habitat diversity

Aspen Prescription

1) Low-intensity prescribed fire to cause carefully managed amounts of aspen mortality:
    a) The estimated historical mean fire interval (MFI) for aspen is 30 yr (3.3 % yr). This estimate is based on the estimated MFI for the Bow Valley which was 31 yr (range 13 – 43 yr) at lower elevations.
    a) Prescriptions should ensure low aspen mortality to encourage aspen regeneration with the historical range of variability. An initial mortality target is set at <8 % and cohort regeneration and survivorship >8 % derived from the target set for aspen-conifer (1/3 of 2.4% based on a 42 yr MFI).
2) It may be possible to do most of these prescribed fires in the spring, autumn or even winter months. Some prescribed fires may need to be done in the summer when aspen have high moisture content in order to reduce aspen mortality. Prescriptions may require pre-treatment of fuels (cutting or piling of dead and down wood).
3) Reduce conifer in aspen forest to approximately 50 stems per hectare among age cohorts. This is a somewhat arbitrary parameter that may be changed if a clearer ecological parameter emerges from research or monitoring.
4) Isolated patches of mature conifer or well isolated conifer trees will generally not be targeted for burning as they are not a significant fire concern and provide nesting opportunities within aspen forests
5) A buffer of forest cover may be left in some locations along Highway 40 to maintain connectivity for animals travelling near the highway or attempting to cross.

Figure 5: Aspen stand with white spruce regeneration.

Figure 6: Aspen forest in decline being replaced by spruce.

Aspen-conifer Objectives

Mixed aspen-conifer stands have 10-70 % conifer (Figure 9).

1) Reduce the potential for extensive and severe fires
2) Reduce crown fire potential
3) Maintain defensible spaces around facilities to protect from wildfire
4) Encourage regeneration and restore age diversity of aspen
5) Restore habitat quality and diversity
6) Mitigate human-bear conflicts by removing bear attractants (i.e., buffaloberry)

Aspen-conifer Prescription

1) Low- intensity prescribed fire to cause carefully managed amounts of aspen mortality and reducing conifer to <30 %
   a) An initial mortality target for aspen is set at <8 % (1/3 of 2.4 % based on a 42 yr MFI for aspen-conifer) and cohort regeneration and survivorship >8%. The estimated historical mean fire interval for mixed aspen-conifer is 42 yr (2.4 % yr) based on estimates for the Bow Valley (Jevons 2015).
   b) In order to reduce the amount of conifer in these stands to <30 % in a reasonably short time frame to meet fire protection objectives, prescribed fire could be done at a rate 4.8% per year for the first 20 years and still be within the historical range of variability. It may then appropriate to reduce the rate to 2.4 % if fire protection objectives can be met.
2) Reduce surface and ladder fuels
3) Increase proportion of aspen
4) Retain solitary mature Douglas-fir and other fire resistant tree species
5) Retain enough mature conifer (>80 yr) to provide a continuous supply of dead standing tree boles for birds, insects, and other wildlife to maintain habitat diversity:
   a) Based on 42 yr MFI, 19 % of conifer would normally be >80 yr. To provide a continuous supply of mature burned boles in stands reduced to <30% conifer, no more than 21% of conifer can be killed every decade, assuming adequate post-fire regeneration.
   b) Research shows that there is increased bird species diversity in young burned forest for about 28 yr post-wildfire (Hobson and Schieck 1999). A MFI of 42 yr will help maintain bird diversity.
6) Retain nesting and cavity trees for habitat
7) Remove buffaloberry near trails and facilities to decrease the potential for human-bear conflicts
8) Optimize process and treatment outcome by developing prescribed fire or mechanical fuel reduction treatments for aspen-conifer forests that are efficient and cost effective:
   a) Test the effectiveness of terra-torch on understory fuels during different seasons including winter

9) Mechanical fuel reduction may be required around facilities because of smoke issues or fuel loads may make it impractical to use prescribed fire. It is unclear how well prescribed fire can be applied to some of the mixed aspen-conifer stands because of varying stand structure and fuels loads. This is an opportunity to develop new and innovative approaches for reducing fuels in close proximity to facilities. Tools including the hand torch, terra torch, and single tree burning treatments may be employed.

Grass & Shrub Objectives

1) Restore health and spatial extent of grass and shrub communities, including forage quality and quantity, nitrogen availability (see Anderson *et al.* 2006) and species diversity to meet fire protection and ecological objectives (Figure 9)
2) Reduce encroachment of conifer
3) Maintain wolf-willow (*Elaeagnus commutata*) communities for ungulates

Grass & Shrub Prescription

1) Burning of grass and shrub will be done at the same time as adjacent aspen communities with a target frequency of every 30 years.
   a) The historic mean fire return interval for grass and shrub communities for the areas is approximately 20 yr (5% yr). The lowest estimate for montane forests on southwest slopes in the Bow Valley was 13 yr (7.7% yr) (Jevons 2015).
2) Aspen within grass and shrub landscapes will be burned to encourage aspen regeneration with aspen mortality maintained at <8%, the same mortality target set for aspen and mixed aspen-conifer communities.
3) Low-intensity prescribed fire to ensure that roots of wolf-willow survive and shrubs regenerate (see Figure 8):
   a) Grass and shrub burning will be distributed in patches in different areas of the landscape so that subsequent grazing intensity is well distributed.
4) Reduce the encroachment of conifer in grass and shrub communities:
   a) Margins of grass and shrub communities will be burned to increase their extent to compensate for previous conifer encroachment.
   b) Amounts of conifer in grass and shrub communities will be limited to 50 stems per hectare.
   c) Isolated patches of mature conifer or well isolated conifer trees will generally not be targeted for burning as they are not a significant fire concern and provide nesting opportunities within grass and shrub communities.

Figure 7: Aspen, grass, and shrub four years after prescribed fire.

Special Considerations

High herbivory may significantly reduce aspen regeneration and survivorship as moose, elk, deer, and bighorn sheep will browse aspen suckers (Gray 2013). Careful prescriptions and managed amounts of aspen mortality will mitigate this potential consequence and monitoring is required to ensure that there is adequate aspen regeneration and survivorship. The target amount of acceptable aspen mortality may be changed based on monitoring results and new approaches may be considered to stimulate aspen growth or to protect aspen regeneration from excessive browsing by ungulates. These may include:

a) Fencing to protect aspen shoots from browse
b) Falling adjacent conifer trees to create a barrier to protect regeneration from browse
c) Retaining coarse wood debris may provide local-scale refuges from browsing pressure and opportunities for vegetation regeneration, especially aspen (Turner *et al.* 2003).

Conversely, burning of aspen can create dense stands of aspen that are impenetrable to ungulates and are of little value as habitat. Carefully managed amounts of aspen mortality are required to mitigate this potential consequence.

Cost

Aspen (including grass and shrub)	$150-300 ha
Aspen-conifer (prescribed fire)	$500-1500 ha
Aspen-conifer (fuel reduction, prescribed fire)	$8000-$10 000 ha

Funding

- Prescribed fire budget
- Ecological research may be funded through a combination of sources such as the Parks Research Fund and grants obtained by research partners
- Fire behaviour and effects monitoring will be done by the Fire and Vegetation Monitoring Program (FVMP)
- FireSmart

Figure 8: Example of low-intensity prescribed fire in grass.

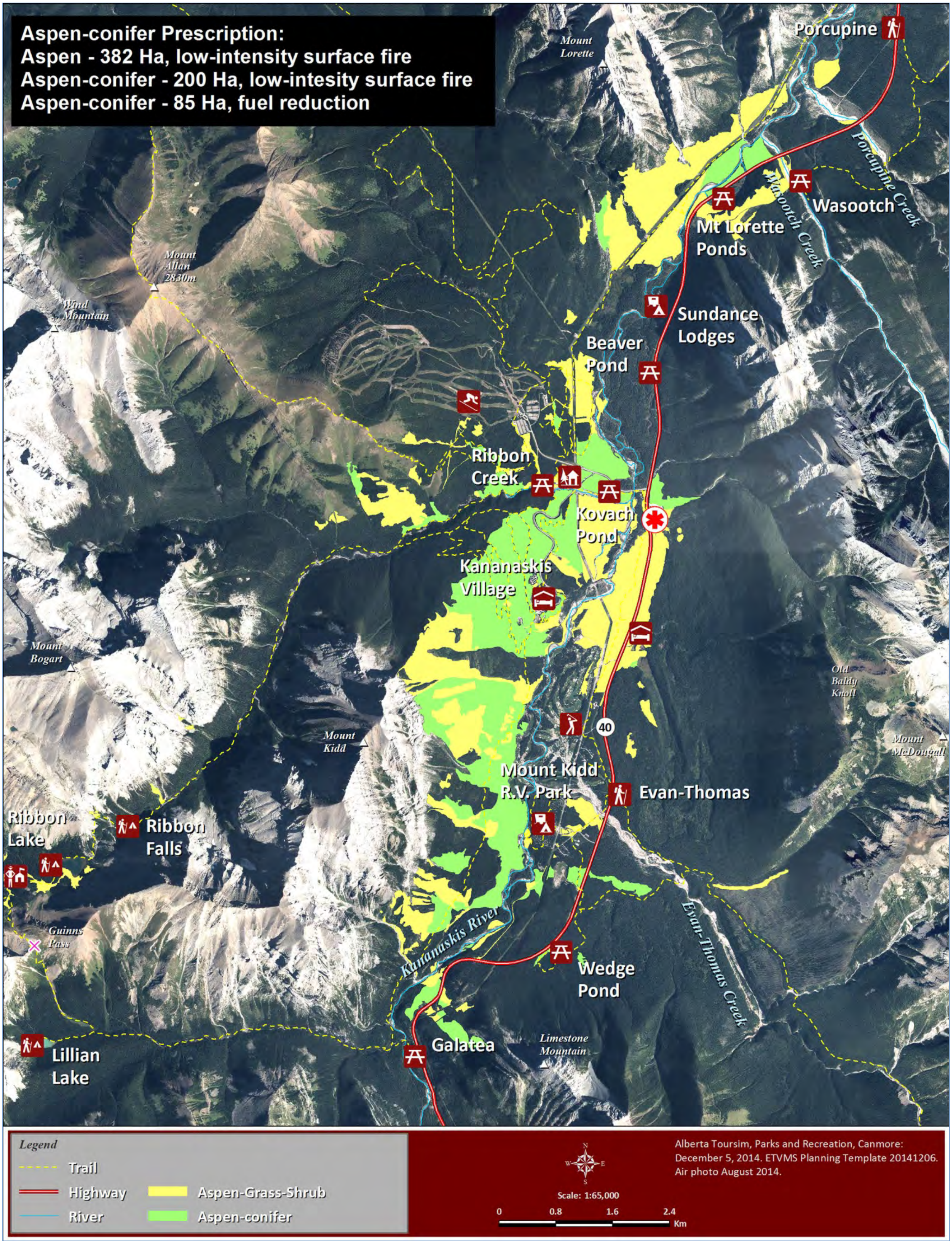

Figure 9: Aspen, aspen-conifer, grass, and shrub communities.

3. Complete and Maintain Existing Fire Mitigation Projects

Existing fire mitigation projects will be completed and maintained to ensure they offer fire protection as intended. Aside from FireSmart projects, these include:

1) Evan-Thomas Creek fuel break
2) Douglas-fir restoration at Kananaskis Emergency Services
3) Fuel reduction around Kananaskis Emergency Services

3a. Evan-Thomas Creek Fuel Break

The area burned by the prescribed fire at Evan-Thomas Creek in 2011 will be completed and maintained as a fuel break using prescribed fire (Figure 10). The site will need to be burned within 10 years to further reduce coniferous forest, new conifer regeneration, and fallen tree boles. Some areas that were not burned in the initial prescribed fire in 2011 may be targeted if conditions permit. The long-term vision is to maintain native grasses and shrub using low-intensity prescribed fire at intervals from 10-15 yr. Isolated trees or small stands of trees will be retained to provide habitat diversity, hiding and thermal cover for animals, wetland protection, and to provide a natural appearance.

One of the original objectives of the fuel break was to facilitate prescribed fires further east in Evan-Thomas Creek. If conditions permit and if funding is available, an area to the east of the fire break may be burned (192 ha). This will restore habitat and provide a larger fire break.

Objectives

1) Maintain a fuel break to prevent a large fire from entering the Kananaskis Valley from the Evan-Thomas Valley
2) Provide habitat diversity for a variety of species
3) Provide alternative habitat for elk which may reduce elk use of the golf course
4) Provide habitat for good production of buffaloberry along the periphery of the planning area for grizzly bear

Estimated Area

200 ha of 299 ha total (195 burned in 2011)

100 ha of 192 ha area to east (optional)

Prescription

1) Prescribed fire of 200-300 ha
2) Cause mortality of 80 % conifer regeneration
3) Further reduce coniferous forest, new conifer regeneration, and fallen tree boles
   a) Low to moderate intensity prescribed fire in areas burned in 2011
   b) Moderate to high intensity prescribed fire in areas not burned in 2011
4) Burn coarse woody debris (tree boles on ground – standing boles may be left standing)

5) Promote healthy grass and shrub communities
6) Retain the following tree species:
    a) Isolated conifer trees or small clumps of conifer
    b) Aspen and other deciduous species
    c) Isolated Douglas-fir trees
    d) Natural forest structure around wetlands

Special Considerations
Old Baldy Knoll is important mountain goat habitat and there is an important mineral lick used by goats adjacent to the site on the south side of Evan-Thomas Creek and Evan-Thomas Creek has pure genetic strains of westslope cutthroat trout. Protection of these species must be considered in all prescribed fire operations.

Cost
$1500 – 3000 ha

Funding
Provincial prescribed fire budget

3b. Douglas-fir Restoration Project

The area of the Douglas-fir restoration will be periodically burned by low-intensity prescribed fire to maintain open stand structure and reduce fuel accumulation (Figure 11).

Estimated Area

9 ha

Objectives

1) Maintain a healthy open stand of mature Douglas-fir that is resistant to wildfire
2) Maintain the area as fuel break to slow wildfires
3) Protect thermal cover for ungulates

Prescription

1) Low-intensity prescribed fire to reduce coarse woody debris and kill 80% of conifer regeneration

Special Considerations

The area of the Douglas-fir restoration may be too small to withstand high-intensity wildfire.

Cost

$1500 – 3000 ha

Funding

Provincial prescribed fire budget

3c. Kananaskis Emergency Services Fuel Reduction

This mechanical fuel reduction project was done in 2002 to protect the emergency centre. It will be maintained as needed with low-intensity prescribed fire to maintain open stand structure and reduce fuel accumulation (Figure 11).

Objectives

1) Reduce wildfire intensity, rate of spread, and crown-fire potential adjacent to facilities
2) Fire protection of facilities at the Kananaskis Emergency Services Centre

Estimated Area

7 ha

Prescription

1) Periodic low-intensity prescribed fir to reduce fuel accumulation and maintain open stand structure and kill 80% conifer regeneration
2) Aspen, deciduous shrub, native grass and mature Douglas-fir will be retained

Cost

$1500 – 3000 ha

Funding

Provincial prescribed fire budget

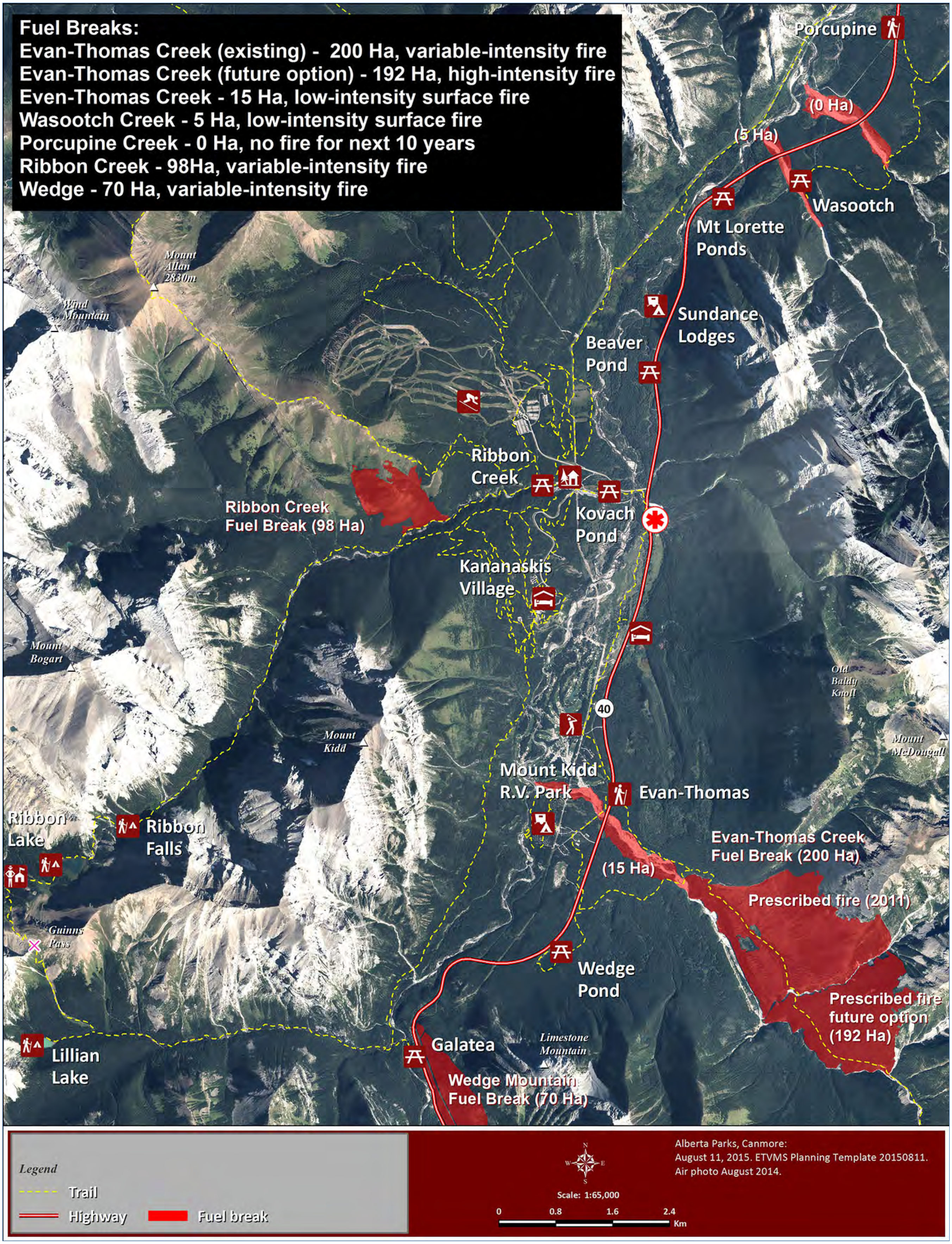

Figure 10: Existing and proposed fuel breaks.

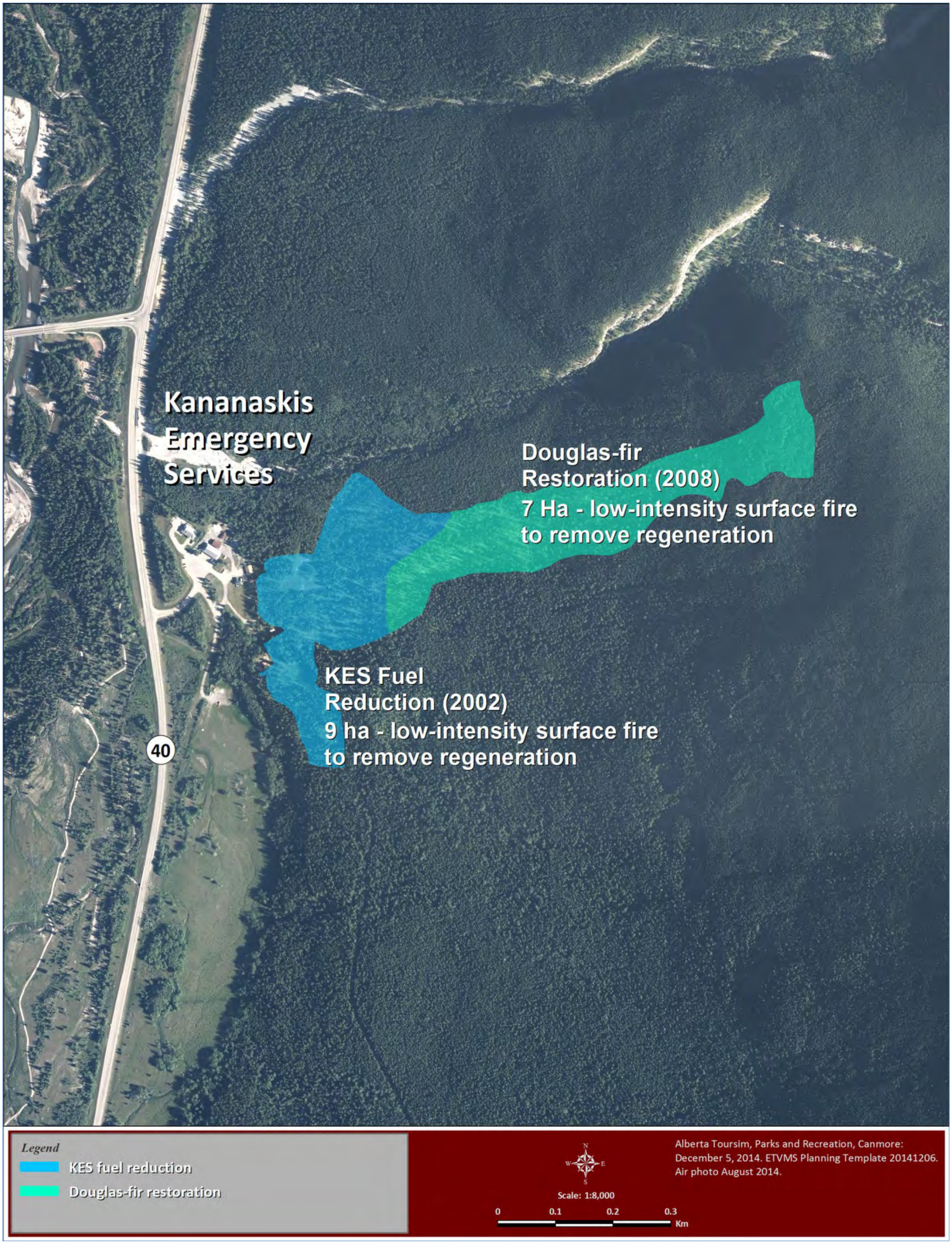

Figure 11: Douglas-fir restoration and KES fuel reduction.

4. Enhance Natural Fuel Breaks

Fuel breaks can be used to facilitate prescribed fire or to control the spread of wildfires. There are many existing natural and human-made fuel breaks in the area that will be maintained or enhanced. Examples include Highway 40, the golf course, and the floodplains of major creeks. The flood in June 2013 substantially widened several creeks including Evan-Thomas, Ribbon, Porcupine and Wasootch Creeks presenting an opportunity to maintain these as natural fuel breaks. There also may be an opportunity to make fire protection enhancements to the golf course as it is rebuilt over the next few years.

4a. Highway 40 - Roadside Fire Hazard Reduction and Fuel Break

In the 1980s, fire hazard reduction was done by removing woody fuels to a distance of 20 metres on the upslope side of roads in forests along Highway 40 and the access roads to Nakiska and the hotels. The objective of the project was to reduce the likelihood of fires spreading from the roadway into the forest.

Roadside treatments are not required at this time as surface and ladder fuels are still sparse in the treated areas, however, buffaloberry is proliferating along the road edges attracting grizzly bears. Buffaloberry may be removed if funding is available using mechanical thinning or low-intensity prescribed fire.

Estimated Area

Highway 40 from Porcupine Creek to Galatea Day Use for 20 m into forest - 65 ha (20 ha proposed for 2016-2025)

Objectives

1) Maintain Highway 40 as a fuel break to reduce wildfire intensity and rate of spread
2) Provide strategic locations for fire suppression activities
3) Reduce risk of fires spreading from roadway into surrounding forest
4) Reduce vehicle-caused grizzly bear mortality by removal of buffaloberry as an attractant
5) Reduce human-wildlife conflicts by preventing bears from feeding on buffaloberry along Highway 40

Prescription

1) Mechanical thinning to FireSmart standards or low-intensity prescribed fire
2) Evaluation of buffaloberry density along highway 40 and removal of dead and live buffaloberry as required

Special Considerations

Hiding cover is required at strategic locations to maintain wildlife connectivity along creeks and roadways.

Cost

Buffaloberry removal $800 per hectare

Funding

To be determined

4b. Fuel Breaks at Evan-Thomas, Porcupine, and Wasootch Creeks

Estimated Area

1) Porcupine Creek: total area 38 ha, treatment area 24 ha, 10-yr plan 0 ha
2) Wasootch Creek: total area 20 ha, treatment area 8 ha, 10-yr plan 5 ha
3) Evan-Thomas Creek: total area 50 ha, treatment area 21 ha, 10-yr plan 14 ha

Objectives

1) Enhance natural fuel breaks to control wildfires by reducing intensity, rate of spread, and crown-fire potential
2) Provide strategic locations for fire suppression activities
3) Provide fuel breaks to facilitate prescribe fires

Prescription

Maintain open stand structure adjacent to creeks using low-intensity prescribed fire to removing coarse woody debris, surface fuels, and tree regeneration.

Special Considerations

Some hiding cover at strategic locations is required to maintain wildlife connectivity at key locations along creeks, roadways, and facilities.

Cost

$150 – 300 ha

Funding

Provincial prescribed fire budget

5. Boundary Montane Habitat Restoration & Fuel Reduction

There is an area east of Highway 40 near the golf course that is a good candidate for restoration as the existing forest stand structure is characteristic of montane stands affected by frequent surface fires. This is partly due to stand thinning that occurred in the 1980s (Figures 11 and 12). Low intensity prescribed fire will be used to maintain low stem density, promote aspen regeneration, and maintain healthy grass and shrub. More open stand structure will promote good buffaloberry growth which can be maintained with appropriate prescriptions. This may have benefits of attracting bear and elk away from the golf course and may slow the spread and reduce the intensity of wildfires and augment the fuel breaks formed by the habitat enhancement blocks to the southeast and the Evan-Thomas Fuel Break. Maintaining an open stand structure will also optimize snow accumulation and retention of snowpack.

Estimated Area

142 ha

Objectives

1) Restore vegetation composition and structure of montane lodgepole pine
2) Promote regeneration of aspen
3) Restore habitat quality for grizzly bear, elk, and other ungulates
4) Maintain good buffaloberry production
5) Provide alternate high quality habitat to reduce elk and grizzly bear use of the golf course
6) Maintain open stand structure to reduce spread and intensity of wildfire
7) Diversify vegetation structure to restore variability of snowpack accumulation and retention

Prescription

1) Low-intensity prescribed fire (75 - 100% of 142 ha) to maintain open stand structure of pine, promote aspen regeneration, and maintain buffalo berry production
2) Mortality of conifer 5-18 % (maximum based on expected mortality for 50 yr MFI)
3) <8 % aspen mortality and cohort regeneration and survivorship >8 %
4) Maintain or increase buffaloberry stems and fruit productivity 5 yr post-burn
5) Periodic prescribed fire at approximately 25-40 year intervals to kill conifer regeneration and maintain open stand structure

Special Considerations

High herbivory may significantly reduce regeneration potential of aspen. Careful prescriptions and monitoring are required.

Regeneration of pine may increase after the first prescribed fire so a second prescribed fire may be required within ten years.

It is recognized that further reduction in stand density may increase windthrow which may be burned when fallen boles are dry.

Cost
$150 – 300 ha

Funding
Provincial prescribed fire budget


Figure 12: Example of pine stand for montane restoration.

6. Treatment of Habitat Blocks

Habitat enhancement areas (67 ha) were harvested *c.*1985 to mitigate habitat loss from construction of the Kananaskis Golf Course (Figure 13). Further treatment is required as forest regeneration is lowering habitat value. The blocks will also serve as fuel breaks. Treatment may including prescribed fire, mechanical thinning, or a combination of both. Detailed planning is required.

Estimated Area
Evan-Thomas Creek Habitat Enhancement Blocks: 67 ha

Objectives
1) Restore habitat quality to mitigate habitat loss from golf course development
2) Act as a fuel break

Prescription
To be determined

Cost
To be determined

Funding
Provincial prescribed fire budget

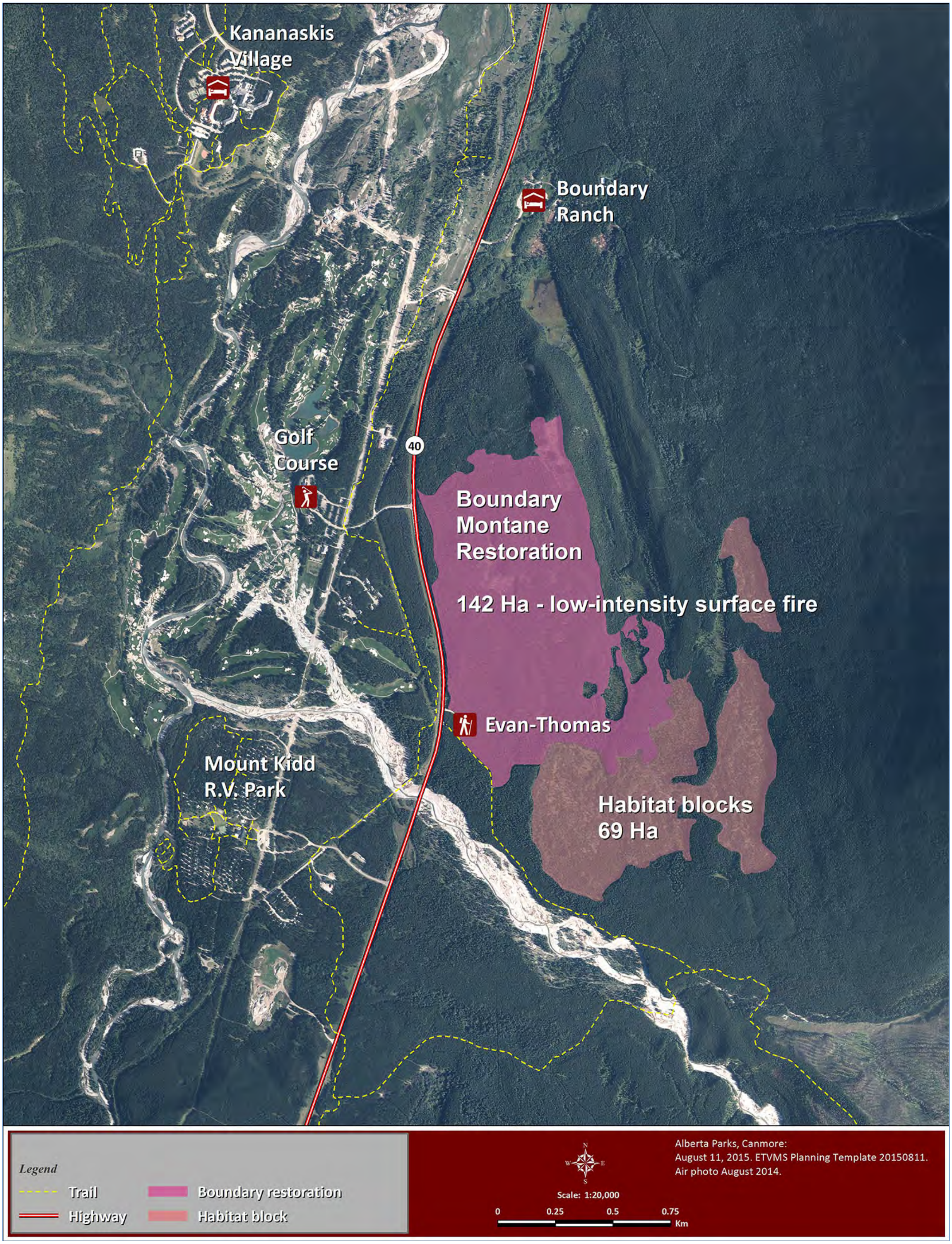

Figure 13: Boundary montane restoration and habitat blocks.

7. Ribbon Creek Fuel Break and Habitat Restoration

There is a natural fuel break of grass and aspen on the north side of Ribbon Creek that will be expanded and enhanced using prescribed fire (Figure 10). This will reduce the potential for a wildfire to spread from Ribbon Creek into the Kananaskis Valley near the hotels and ski area and will create younger seral stage vegetation that will be beneficial for grizzly bear, bighorn sheep, and other ungulates. An area above the fuel break will also be burned for bighorn sheep habitat restoration (28 ha) which will increase the size of the fuel break.

Estimated Area

98 ha

Objectives

1) Expand and enhance an existing fuel break of grass and aspen using prescribed fire
2) Provide a strategic location for fire suppression activities to prevent a fire from spreading from Ribbon Creek into the Kananaskis Valley
3) Restore habitat quality for grizzly bear, bighorn sheep, and other ungulates

Prescription

1) Low-intensity prescribed fire in aspen communities to promote regeneration, and cause minimal mortality to aspen: <8 % aspen mortality and cohort regeneration and survivorship >8 %
2) Higher intensity prescribed fire in conifer to achieve 75-100 % mortality
3) Periodic prescribed fire at 10-15 year intervals to kill conifer regeneration

Special Considerations

High herbivory may significantly reduce regeneration potential of aspen. Careful prescriptions and monitoring are required.

Cost

$1500 – 3000 ha

Funding

Provincial prescribed fire budget

8. Wedge Mountain Fuel Break

This location was chosen for a fuel break because of its strategic location and the ease that it can be developed using prescribed fire (Figure 10). The fuel break will be of low complexity and cost effective to develop and maintain. The area is sparsely forested at this time and differential drying on south facing slopes will allow for spring burning when surrounding forests are still relatively wet. Aspen, grass, and shrub will be encouraged to grow on the site and conifer regeneration will be burned occasionally. The resulting vegetation composition may be beneficial for bighorn sheep.

Estimated Area

70 ha (not including powerline)

Objectives

1) Develop a fuel break using prescribed fire
2) Provide a staging site for fire crews to prevent fire from spreading north of Galatea Creek
3) Restore habitat for bighorn sheep

Prescription

1) Low-intensity prescribed fire in aspen communities to promote regeneration, and cause minimal mortality to aspen: <8 % aspen mortality and cohort regeneration and survivorship >8 %
2) Low to moderate intensity prescribed fire in conifer forests to achieve 75-100 % conifer mortality (except for mature Douglas-fir)
3) Periodic prescribed fire at 10-25 year intervals to kill conifer regeneration

Special Considerations

1) A power transmission line runs through this area
2) Whitebark pine may exist in the area near treeline

Cost

$1500 – 3000 ha

Funding

Provincial prescribed fire budget

9. Deadfall Prescriptions

Forests often contain areas of deadfall resulting from natural processes and disturbances such as age, fire, disease, insects, windthrow, or storm damage. Areas of deadfall provide habitat for smaller mammals and regeneration opportunities but large areas of deadfall may be impenetrable to large mammals and may increase fire risk.

Prescribed fire may be used as a measure to remove large areas of deadfall (and partial windthrow) for fire protection or ecological objectives. Deadfall may be safely burned in the spring when surrounding forest is still too wet to burn and repeated burning can create openings that provide habitat diversity for animals, opportunities for forest regeneration, as well as increase snowpack accumulation and retention. Prescribed burning of deadfall will be done only for large areas of deadfall while smaller areas will be left for small-mammal habitat. Deadfall burning will not be done in old-growth forests where decaying trees are a more prominent structural feature.

No areas have been identified for deadfall burning at this time.

References:

Girard, F., L. De Grandpré, and J. Ruel. 2014. Partial windthrow as a driving force of forest dynamics on old-growth boreal forests. Canadian Journal of Forest Research 44: 1165-1176 dx.doi.org/10.1139/cjfr-2013-0224.

10. Bighorn Sheep Habitat Restoration

There are concerns about forest encroachment on sheep habitat and loss of young vegetation communities in subalpine habitats. Prescribed fire will be used to burn stands of conifer at higher elevations to restore vegetation diversity for bighorn sheep and other ungulates in the Ribbon Creek drainage (Figure 14). These fires will contribute to restoring the structural composition of forests in the valley.

Estimated Area

96 ha

Objectives

1) Restore structural and compositional diversity of vegetation
2) Use prescribed fire to reduce dense forest cover and restore open habitat for bighorn-sheep and other ungulates

Prescription

1) Removal of dense forest cover and restoration of open habitat using high intensity prescribed fire. Residual charred tree boles will remain.
2) 50-100% conifer mortality
3) <8% aspen mortality and cohort regeneration and survivorship >8%

Special Considerations

1) Prescribed fires must be done outside of the critical periods for bighorn sheep such as spring lambing
2) The response of sheep and other ungulates should be measured to ensure prescriptions meet the intended objective.
3) The resulting vegetation composition and structure should be measured before and after prescribed fire.

Cost

$1500 – 3000 ha

Funding

- Prescribed fire - provincial prescribed fire budget
- Research and monitoring – park research fund / research partners

Figure 14: Bighorn-sheep habitat restoration.

11. Maintain Old-growth at Skogan Pass as a Fuel Break

Old-growth forests at Skogan Pass will be preserved to prevent wildfires from spreading over the pass into either the Bow or Kananaskis Valleys (Figure 15). Skogan Pass has predominantly mature forests of spruce and pine that date to fires that occurred in the 1720s and 1860s while most of the surrounding forest burned between 1896 and 1936. These higher elevation forests are typically cooler and wetter than surrounding forests which may a reason these forests have survived when adjacent forest burned. Prevailing wind patterns in both the Bow and Kananaskis Valleys may cause blocking winds that prevent fires from burning over Skogan Pass.

This area is part of the Marmot Creek Research Basin which is a long-term experimental basin for hydrology and climate research that contributes significantly to the national hydrology and climate research network. The Centre for Hydrology, University of Saskatchewan, describes the importance of this research site:

"Marmot Creek Research Basin in the Kananaskis Valley, Alberta was established as an experimental basin in 1962 by the Canadian and Alberta Governments. It became an outdoor research laboratory to examine the principles of mountain hydrology and how forest management could be used to influence streamflow generation. Research flourished for 25 years and provided the basis for a better understanding of hydrology, hydrochemistry and forest management that influenced headwater basin management for many years. In 2004, the basin was reactivated by the University of Saskatchewan, University of Calgary and Environment Canada and has since been the subject of process hydrology, climatology, ecohydrology and hydrological modelling research that is underpinning the next generation of hydrological models and forest management strategies. The Coldwater Laboratory was established in 2009 at the University of Calgary Barrier Lake Field Station to maintain intensive research in the basin. The long term record of high altitude streamflow, precipitation, snowpack, groundwater, vegetation and mountain meteorology observations in Marmot Creek makes it a unique laboratory for understanding and assessing environmental change in the Canadian Rockies."

(University of Saskatchewan, Centre for Hydrology 2014).

Estimated Area

1100 ha

Objectives

1) Prevent fires from crossing Skogan Pass into the Bow or Kananaskis Valleys by maintaining the cool and wet old-growth forests and taking advantage of blocking wind patterns
2) Protect the integrity of this long-term hydrology and climatology research site
3) Maintain old-growth forest diversity in the Kananaskis Valley

Prescription
Existing old growth forest composition and structure will be maintained in the identified area.

Cost
Not applicable

Funding
Not applicable

12. Natural Regeneration of Harvested Areas

There are several areas south of Skogan Pass that were previously harvested for research purposes (*c.*1974). These areas are now at an age-class that is younger than most forests in the valley and will allowed to regenerate naturally to take advantage of the structural diversity and habitat value they offer.

Estimated Area

Twin Creek Research Cut Blocks: 46 ha

Objectives

1) Maintain habitat diversity
2) Allow natural regeneration of harvested areas to maintain vegetation structural and age-class diversity

Prescription

Allow natural regeneration

Cost

Not applicable

Funding

Not applicable

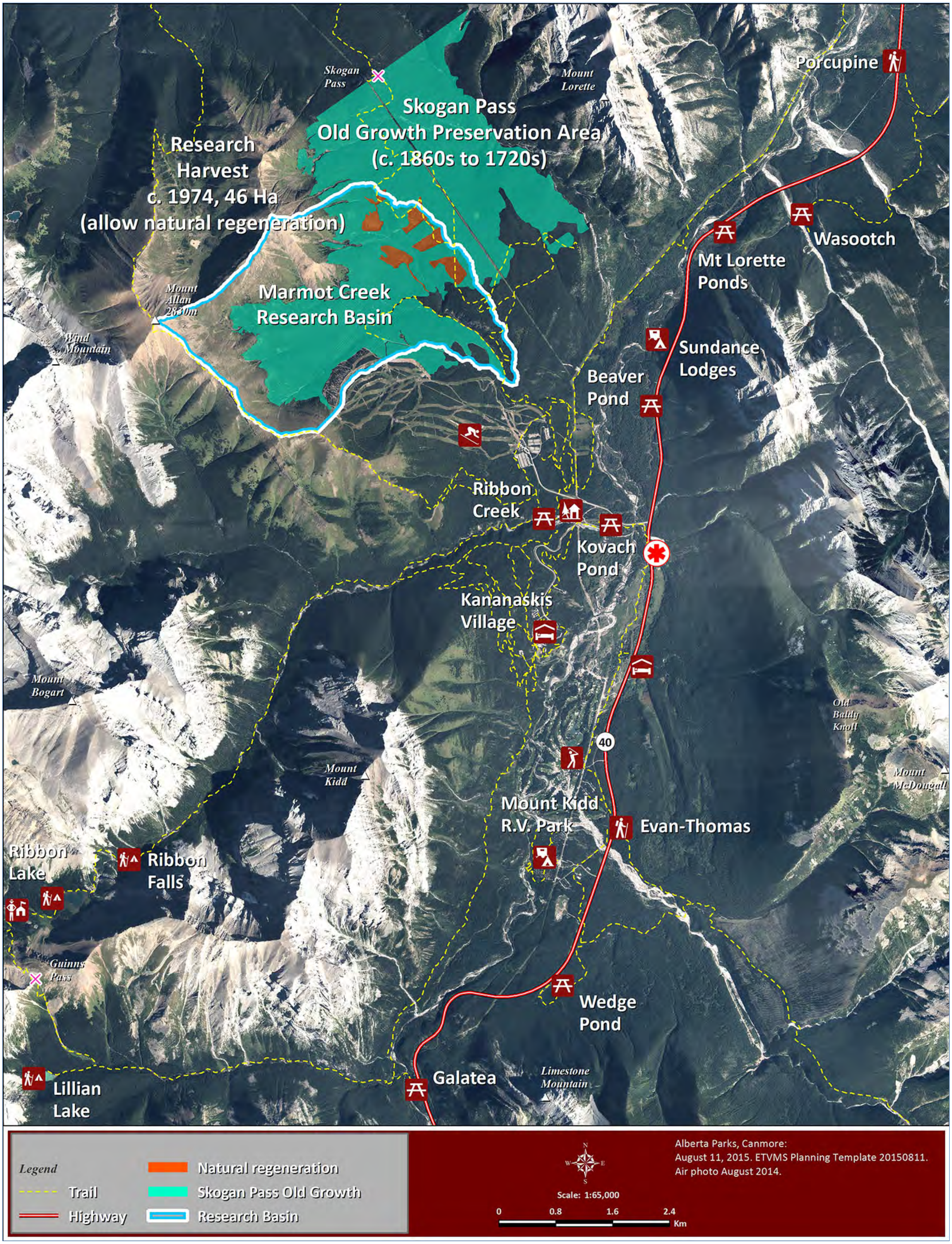

Figure 15: Skogan pass old-growth and natural regeneration areas.

13. Further Measures to Reduce Human-Wildlife Conflicts

This strategy provides several measures for reducing human-wildlife conflicts such as the restoration of habitat quality in areas away from roads and facilities or removal of buffaloberry and hiding cover near roads and facilities. Research suggests that density of male shrubs (within 3.99 m radius, 50 m^2) increases pollen availability and fruit set (Johnson and Nielsen 2014, Hamer 1996, Humbert *et al.* 2007, Nielsen *et al*. 2004). This suggests that a reduction of buffaloberry stem density using prescribed fire should reduce both the number of plants and fruit production. Several further measures are proposed here.

Several facility leaseholders are active in removing buffaloberry around their facilities and report that it is an effective measure to reduce human-wildlife conflicts. However, leaseholders find they do not have adequate resources to complete buffaloberry removal and they observe the regrowth of stems cut several years ago. Alberta Parks will explore opportunities to work collaboratively with leaseholders to remove buffaloberry. FireSmart projects will continue to include the removal of buffaloberry. A collaborative approach will benefit both Alberta Parks and leaseholders as it will reduce amounts of human resources that are needed to deal with human-wildlife conflicts.

Other measures to reduce human-wildlife conflicts will be considered as part of this strategy:

1) Buffaloberry and other bear attractants will be removed along trails and other areas where there is a history of human-bear conflicts
2) Buffaloberry may be left to grow along power lines as a food source for bears except where there are recognized trails along power lines or in locations where trails intersect power lines
3) Any informal trails that develop in wildlife corridors or important habitat should be promptly reclaimed to reduce human-wildlife conflict and preserve habitat effectiveness
4) Trail and facility development will be directed away from avalanche slopes and run out zones which provide high quality seasonal habitat for wildlife species
5) Important wildlife corridors and wildlife habitats will be identified to inform management decisions
6) Hiding cover needs to be maintianed for wildlife around wildlife corridors, important habitat patches, and some road crossing locations
7) Prescribed fire will restore habitat quality for ungulates which may increase utilization of the area by wolves. This has the potential to restore predator-prey assemblages and distribution of wildlife on the landscape. A potential benefit is reduced ungulate use of the golf course.
8) Vegetation management treatments must not create new trails or roads

Objectives

1) Reduce human-wildlife conflicts and wildlife-highway mortality
2) Reduce human resources required to deal with human-wildlife conflicts
3) Maintain secure hiding cover for wildlife
4) Restore habitat quality for wildlife

Special Considerations

Habitat restoration may change the habitat-use patterns in the Evan-Thomas area and it may be important to monitor wildlife movement and habitat use patterns including wildlife highway-crossings and locations of wildlife mortality on the highway. Additional signage may be required.

Special consideration will be given to vegetation management in key locations near roads and in wildlife corridors to maintain wildlife connectivity.

Performance Measures

1) Decrease density of informal trails in identified wildlife corridors and critical habitats
2) Increase in spatial extent of buffaloberry removal in high conflict areas such as facilities, roads, and trails
3) Reduction in human-wildlife conflicts
4) Reduction in wildlife-vehicle collisions

Cost

TBD

Funding

Alberta Parks will work with leaseholders to find resources for buffaloberry removal.

14. Further Measures for Maintaining Healthy Hydrology

Many of the restoration measures in this strategy will help maintain the natural resiliency and health of the watershed simply by restoring the compositional and structural diversity of vegetation and natural processes like fire and flooding.

This strategy does not provide any direct measures to maintain healthy riparian areas, floodplain vegetation, or alluvial fans. This is best accomplished by maintaining a natural flood regime as much as possible and prohibiting development of facilities in the floodway, flood fringe, flood plain, meander plan, and alluvial fans along with the preservation of wetlands, including ephemeral wetlands.

As part of this strategy, these hydrological features will be mapped and described to inform management planning. Wet Areas Mapping will also be done for the area. This digital product has two components, predicted depth to water, and predicted stream channel lines (AESRD 2014).

Protecting the Marmot Creek Research Basin will help facilitate long-term hydrology and climatology research which is conducted by the University of Saskatchewan. This research will also help to inform management of the Evan-Thomas area.

Objectives

1) Map and describe hydrological features including streams, wet areas, floodway, flood fringe, flood plain, meander plain, alluvial fans, and wetlands
2) Provide data and information to inform management planning

Measures

1) Mapping of hydrological features
2) Complete Wet Areas Mapping

Cost

No extra costs will be incurred

Funding

No extra costs will be incurred

15. Vegetation Management for Species at Risk

Special measures may be required to protect or enhance survival opportunities for species at risk such as whitebark pine, limber pine, grizzly bear, and westslope cutthroat trout. Whenever there is potential for species at risk to be impacted or opportunities to enhance species survival, Alberta Parks will work with recovery teams to help protect these species.

RESEARCH, MONITORING, and REPORTING

Implementation of this strategy will follow an adaptive approach involving measurement, monitoring, and reporting to ensure objectives are being met and to avoid adverse effects on ecosystem components, recreation, or tourism. Alberta Parks and the Wildfire Management Branch will seek to collaborate with researchers and institutes to develop long-term research partnerships that focus on fire ecology.

The following are research and monitoring priorities at this time (responsible agency in brackets):

1. Perform a knowledge gap assessment to assess uncertainty and determine what additional knowledge is needed in relation to the implementation of this strategy (Parks)
2. Collaborate with First Nations to integrate traditional knowledge into the strategy and its implementation (Parks)
3. Establish permanent vegetation sample plots (Fire and Vegetation Monitoring Program [FVMP], Parks) to measure vegetation change related to prescribed fire and fuel treatments
4. Maintain a GIS database to provide a detailed history of fire, fuel treatments, and other vegetation management (Parks)
5. Measure fire effects on aspen, grass, and shrub regeneration and survivorship (FVMP, Parks)
6. Refine vegetation structure and habitat objectives for willow, aspen, grass, and sheep habitat by measuring outcomes of prescribed fire treatments and utilization by wildlife (Parks, Fish & Wildlife)
7. Model the present wildfire risk (how many days in the fire season are conditions out of control) with Promethius in comparison to risk after implementation of the strategy. Establish the number of unacceptable risk days. Construct landscape scenarios with various amounts of aspen/grass/shrub/mixed aspen-conifer to meet wildfire protection goals (Forestry)
8. Model prescribed fire risk scenarios for each prescribed fire (Forestry)
9. Validate the fuel grid (Forestry)
10. Develop wildlife studies to monitor the effects of vegetation management on large mammals (Parks)
11. Acquire Wet Areas Mapping for the planning area to provide information about hydrology (Parks)

12. Map and describe hydrological features for management planning including streams, wet areas, floodway, flood fringe, flood plain, meander plain, alluvial fans, and wetlands (Parks)
13. Determine key wildlife highway crossing locations and any changes that occur during the implementation of the strategy (Parks)
14. Monitor vehicle-wildlife collision locations to determine success of the strategy in terms of reducing human-wildlife conflicts (Parks)
15. Identify important wildlife corridors, habitats, and ecologically sensitive areas (Parks and Fish & Wildlife)
16. Monitor prescribed fire and fuel treatments for invasive plants (Parks)
17. Optimize process and treatment outcome by developing prescribed fire or mechanical fuel reduction treatments for mixed aspen-conifer forests that are efficient and cost effective such as testing the effectiveness of terra-torch on understory fuels during different seasons including winter (Forestry)
18. Monitor air quality impacts from prescribed fires (Forestry)

DESCRIPTION of PLANNING AREA

The planning area is shown in Figure 1.

Natural Regions and Vegetation

Lower elevations of the valley are part of the montane natural subregion (~1400 m to 1850 m), which is warmer, drier, and has a longer snow-free period than most of the surrounding higher elevation landscape. Lodgepole pine (*Pinus contorta* Douglas ex Loudon) is the dominant tree species in the montane except in riparian areas where white spruce (*Picea glauca* [Moench] Voss) is more common. The Evan-Thomas area has the highest concentrations of trembling aspen (*Populus tremuloides* Michx.) and aspen-conifer forest in the Kananaskis Valley. Other tree species found throughout the montane in lesser amounts are Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), limber pine (*Pinus flexilis* James) and cottonwood (*Populus angustifolia* James). As elevation increases the montane transitions to the subalpine subregion (1850 m to 2300 m), which is dominated at lower elevations by lodgepole pine and Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) and at higher elevations by Engelmann spruce and subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.). Whitebark pine (*Pinus albicaulis* Engelm.) is sparsely distributed at treeline at the edge of the alpine subregion (>2200 m).

Fire Regime & Fire History

Fire and vegetation characteristics observed in historic photos (*c*.1904) suggest that the lower elevation valley bottom portion of the Kananaskis Valley had a mixed-severity fire regime with frequent, low-intensity surface fires and occasional higher intensity fires. Historically, many of the lower intensity fires may have been from aboriginal burning. At higher elevations, conifer forest in the Kananaskis Valley and tributaries burned less frequently at higher intensity.

Historic Fires

A large portion of the Evan-Thomas area was burned by a stand-replacement wildfire in 1936 (~8400 ha). The 1936 fire was so extensive that it is difficult to map the extents of earlier fires. Fire scars and stand dating suggests fires occurred in the Evan-Thomas area in 1613, 1631, 1685, 1699, 1726, 1739, 1742, 1749, 1774, 1766, 1778, 1784, 1788, 1803, 1808, 1870, 1881, 1853, 1858, 1864-5, 1870, 1891, 1909-10, 1920, 1925 (Johnson and Fryer 1987). There were likely many other lower intensity fires that are undetectable.

Fires 1930 to 1960

Data for fires in the area between 1930 and 1960 have not been summarized but it is not likely that any large fires occurred.

Fires 1961 to 2012

Between 1961 and 2012 there were 43 reported fires. All were small, less than 0.1 ha except for a fire in 1991 of unknown cause that burned 12 ha. Most were caused by campfires, five were caused by lightning.

There is a decreasing trend in number of fires with time: 1970s (13) and 1980s (11) to 1990s (3) and 2000s (7).

Historical fire frequency

Historical fire frequency in the adjacent Bow Valley (pre 1910) was found to vary as a function of variation in aspect and elevation. Mean fire interval (MFI) varied from 23 years at lower elevations (1300 m) to 77 years at higher elevations (2300 m) except for south facing slopes which varied from 13 to 43 years. Tributaries off the main valley had mean fire intervals 1.4 times longer compared to the main valley (S. Jevons, unpublished data). These fire frequency estimates are likely shorter than the Evan-Thomas area which is moderately higher in elevation and is not influenced by the same physiographic or human use patterns as the larger Bow Valley.

In comparison, White (1985) estimated that the historical MFI for the montane natural subregion in Banff National Park was 42 years, lower subalpine was 90-130 years and upper subalpine was 181 years. Hawkes (1979) found the MFI was 101 years in the lower subalpine and 304 years in the upper subalpine in Peter Lougheed Provincial Park. These longer MRI may be attributed to higher precipitation and cooler climate related to elevation and topography. Johnson and Larson (1991) estimated a MFI of between 50 and 90 years for the Kananaskis Valley. Tande (1979) estimated a MFI of 27 years for montane lodgepole pine forests and 74 for subalpine forests in Jasper National Park, which are very similar to estimates for the Bow Valley.

These studies suggest that montane areas of the Kananaskis Valley had a historical MFI between 13 to 42 years, lower subalpine 74 to 130 years, and upper subalpine 74 to 181 years, varying with elevation and aspect, and tributaries may have a MFI at least 1.4 times that of the main valley.

The 1936 Galatea Fire

The 1936 Galatea fire is important as it provides a historical benchmark about the behaviour of fires during extreme fire and weather conditions.

The weather pattern that summer was dominated by a large blocking high-pressure system. No rain fell from June 25 to August 13 at Calgary and only 3.82 mm at Banff. Lightning started the fire August 3 in the upper part of Galatea Creek. High winds on August 9 drove the fire more than 10 km down the valley. Based on observations, spread rate must have been 80-130 m/min^{-1}. Fire spotting of 5.5 km was observed. Forestry personnel reported the valley was on fire for a distance of 9.7 km in length by 4.8 km across the valley on the evening of August 9. Total area burned was 8426 ha (20 820 acres, 32.5 square miles). Most of the trees in the path of the fire were killed but several patches survived.

(Source: Fryer and Johnson 1988)

History of Vegetation Management in the Evan-Thomas Area

Timber allotment berths in the Kananaskis and Bow Valleys were surveyed in 1883 by L.B. Stewart (Figure 16). Stewart observed that large areas of forest were burned at different times with stands of young forest as well as mature trees.

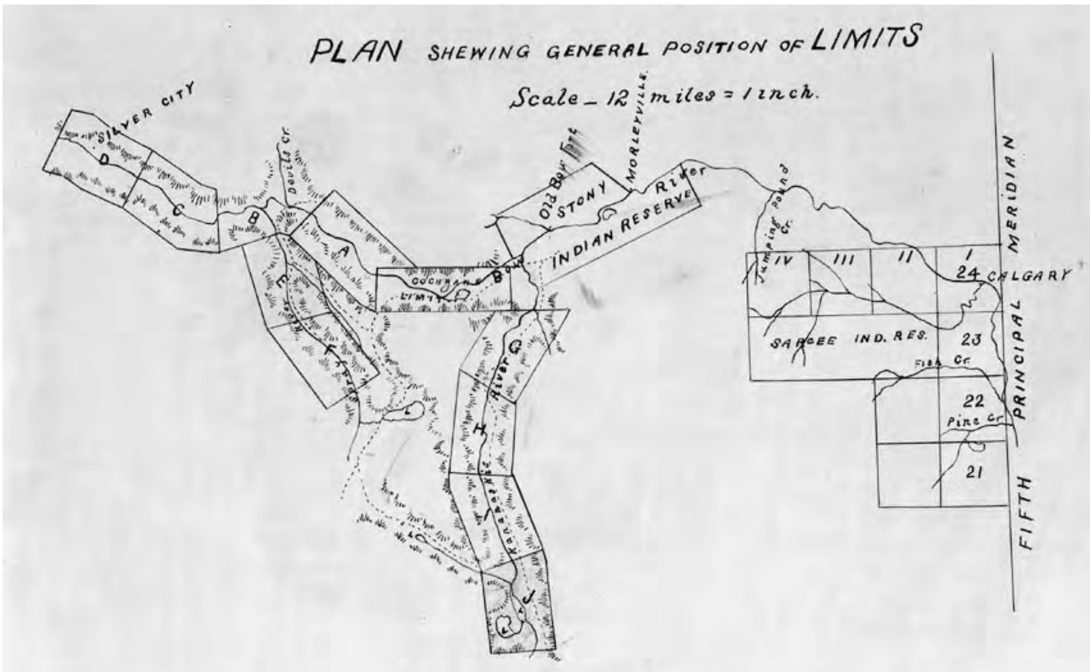

Figure 16: Map showing the location of the timber berths surveyed by in 1883.

The present location of Evan-Thomas Provincial Recreation Area is in the southern half of berth G and the northern half of berth H.

(Map by L.B. Stewart [1883], Glenbow Archives NA-1015-5)

Johnson and Fryer (1987) provide a history of logging in the valley:

> *"In 1886 the Eau Claire & Bow Lumber Co. began the first organized logging operation in the Kananaskis Valley. Engelmann spruce, lodgepole pine and some subalpine fir were trees sought. Spruce was preferred for saw timber because of its larger size, but pine was also harvested as it was straight and excellent pole lumber (Eau Claire & Bow Lumber Co. papers, unpublished Glenbow-Alberta Institute Archives)."*

Winter camps were located in berths H and I and log drives started in 1887 and continued until 1944 (Johnson and Fryer 1987). A large fire occurred in 1920, burning portions of berths H, I, and J. In 1936 another fire burned most of the trees in berths G and H (Johnson and Fryer 1987). After the 1936 fire, Eau Claire Sawmills salvage-logged material. The company began the cleanup in the late autumn of 1936 and continued operating each winter until 1945-46. In addition, several permits were issued each year to pit-wood contractors for the cutting of burned timber for pit props. Increased coal production during the Second World War created extra demand for pit props. Four-foot fuel wood was also supplied to the lime kiln at Kananaskis. Material not suitable for either pulpwood or kiln fuel was used as firewood at the Kananaskis Forest Experiment Station (Kirby 1973). No harvesting was ever done in berth J as a logjam prevented use of the river for log drives (Johnson and Fryer 1987).

After trees were felled and limbed, and cut into proper lengths, the logs were dragged directly to rollways on the Kananaskis River or to skidways where they would be loaded on sleds for transport to the river. Roads, skidways and sleds were used only in more level parts of the main valley or in large side valleys such as Ribbon and Evan-Thomas Creeks. Steep slopes were not usually logged because of the difficulty of removing logs by horse (Alberta Community Development, Parks and Protected Areas Division 2004).

Logging also occurred around the Mount Allan (Ribbon Creek) coal mine. Logging at the coal mine was a small operation and used timber primarily from around the mine and Ribbon Creek. Most of the area near the mine was burned by the 1936 fire.

In the 1960s the Ribbon Creek coal mine was reclaimed and revegetated with a grass-legume mixture, covering an area of 6.5 ha. This site is clearly visible on the lower slopes of Mount Allan today.

In the 1960s the Canadian Forestry Service thinned 125 ha of closed coniferous forest in the Marmot Creek drainage to study the hydrological effects of thinning.

In 1961, the Canadian Forestry Service planted Russian Spruce for a growth-yield experiment near the present site of Sundance Lodges.

In 1974, the Canadian Forestry Service harvested six areas in the Marmot Creek drainage for experimental purposes, covering a total area of 46 ha. The purpose of the research was to study the hydrological effects of clear-cutting. The harvested areas were reforested and now contain young coniferous growth.

In 1985 approximately 67 ha of mature forest on the north side of Evan-Thomas Creek were logged to create elk range as mitigation of golf course impact on traditional winter and spring range.

In the 1980s, thinning was done in lodgepole pine stands south of Boundary Ranch for habitat enhancement.

Between 1985 and 1987, bighorn sheep habitat enhancement projects were initiated on Mount Allan and Wind Ridge to provide alternate range to compensate for the loss of habitat due to development and human activity at the approved ski hill. Twenty-one ha were hand cleared and piled at four sites on Mount Allen in 1985 and 1986. A 9 ha site was cleared and piled on Wind Ridge in 1986 and1987. Three sites totalling 12.6 ha in West Wind Valley were treated with herbicide to control aspen growth during the summer of 1986 and cleared and piled with heavy machinery in 1987. It was intended that the slash piles on all sites be burned but this did not occur (Davie and Wisely 1987).

In the late 1980s a fire hazard reduction project removed woody fuels along Highway 40 and access roads into Nakiska ski hill and the hotels. The purpose of this project was to reduce the likelihood of forest fires spreading from the highway right-of-way. Dead standing saplings and trees, lower branches, and deadfall were removed from the upslope side of the roads for a distance of approximately 20 m into the forest, and piled and burned during the winter months (Alberta Community Development, Parks and Protected Areas Division 2004)

Fuel reduction was conducted around the Kananaskis Emergency Centre in 2002 (9 ha). Further fuel reduction was done around the emergency centre in 2008 (7 ha) as part of a Douglas-fir restoration project.

A prescribed fire (25 ha) was conducted in the meadow south of the Kananaskis Emergency Centre in 2008.

FireSmart projects were started in 2007 at the golf course housing (4.6 ha), Mt. Kidd campground housing (7.3 ha) in 2010, and around Kananaskis Village (23 ha) in 2011.

The Evan-Thomas Creek Prescribed Fire was conducted in 2011 after the felling of trees the previous winter to provide cured fuels for burning in lower indices. Approximately 195 ha of a 300 ha unit was burned. It is intended that this area will be burned again within the next 10 years to further reduce course woody debris and kill conifer regeneration.

REFERENCES

Achuff, P.L., I. Pengelly, and J. Wierzchowski. 1996. Vegetation: cumulative effects and ecological futures outlook. Pages 4i to 4-47 in: J. Green, C. Pacas, L. Cornwell, and S. Bayley, editors. Ecological outlooks project. A cumulative effects assessment and futures outlook of the Banff Bow Valley. Prepared for the Banff-Bow Valley Study. Department of Canadian Heritage, Ottawa, Ontario, Canada.

Alberta Community Development, Parks and Protected Areas Division. 2004. Evan-Thomas Provincial Recreation Area Management Plan. Canmore, Alberta.

Alberta Tourism, Parks and Recreation, Parks Division. 2009. Vegetation Management Program Statement. Edmonton, Alberta.

Alberta Environment and Parks, Parks Division. 2015. Environmental Review Directive. Edmonton, Alberta.

AESRD (Alberta Environment and Sustainable Resource Development. 2014. Wet areas mapping. <http://esrd.alberta.ca/>. Accessed October 10, 2014.

Alexander, M.E. and R.A. Lanoville. 2004. The International Crown Fire Modelling Experiment fuel treatment trials (abstract), page 222 in: R.T. Engstrom, K.E.M. Galley, and W.J. de Groot (editors). Proceedings of the 22nd Tall Timbers Fire Ecology Conference: Fire in Temperate, Boreal, and Montane Ecosystems. Tall Timbers Research Station, Tallahassee, Florida.

Anderson, R.H., S.D. Fuhlendorf, and D.M. Engle. 2006. Soil nitrogen availability in tallgrass prairie under fire-grazing interaction. Rangeland ecology & management 59: 625-621.

Arno, S.F., D. J. Parsons, and R.E. Keane, editors. 2000. Mixed-severity fire regimes in the northern Rocky Mountains: consequences of fire exclusion and options for the future. USDA Forest Service Proceedings RMRS-P-15-Vol-5.

University of Saskatchewan, Centre for Hydrology. 2014. Marmot Creek Basin Workshop. University of Saskatchewan. Saskatoon. <http://www.usask.ca/hydrology/MarmotCrkWshop2013.php>. Accessed July 22, 2014.

Davie, J.W. and A.N. Wisely. 1987. Mount Allen and Wind Ridge Bighorn Sheep Habitat Enhancement. Alberta Natural Resources, Fish & Wildlife Division. Edmonton, Alberta.

Day, R.J. 1972. Stand structure, succession, and the use in southern Alberta's Rocky Mountain Forest. Ecology 53: 472-478. DOI: org/10.2307/1934235.

Ellis, C.R., J.W. Pomeroy, and T.E. Link. 2012. Modelling increases in snowmelt yield and desynchronization resulting from forest gap-thinning treatments in a northern mountain headwater basin. Water Resources Research 49: 936-949. DOI: 10.1002/wrcr.20089.

Fryer, G.I. and E.A. Johnson. 1988. Reconstructing Fire Behaviour and Effects in a Subalpine Forest. Journal of Applied Ecology 25: 1063-1072.

Gallant, A.L., A.J. Hanson, J.S. Councilman, D.K. Monte, D.W. Betz. 2003. Vegetation dynamics under fire exclusion and logging in a Rocky Mountain watershed, 1856–1996. Ecological Applications 13: 385-403.

Gray, R.W. 2013. Trembling aspen stands as firebreaks: what options are available for stimulating aspen stand expansion. R.W. Gray Consulting, Chilliwack, British Columbia.

Girard, F., L. De Grandpré, and J. Ruel. 2014. Partial windthrow as a driving force of forest dynamics on old-growth boreal forests. Canadian Journal of Forest Research 44: 1165-1176 dx.doi.org/10.1139/cjfr-2013-0224.

Government of Alberta. 2014. South Saskatchewan Regional Plan 2014-2024. Edmonton, Alberta.

Hamer, D. 1996. Buffaloberry (*Shepherdia canadensis*) fruit production in fire-successional bear sites. Journal of Range Management 49:520–529. DOI: 10.2307/4002293.

Hawkes, B.C. 1979. Fire history and fuel appraisal study of Kananaskis Provincial Park, Alberta. Prepared for Resource Assessment and Management Section Planning and Design Branch, Parks Division, Alberta Recreation and Parks . Department of Forest Science, University of Alberta, Edmonton, Canada.

Hobson and Schieck. 1999. Changes in bird communities in boreal mixedwood forest: harvest and wildfire effects over 30 years. Ecological Applications 9: 849-863. DOI.org/10.1890/1051-0761(1999)009[0849:CIBCIB]2.0.CO;2

Humbert, L., D. Gagnon, D. Kneeshaw, C.Messier. 2007. A shade tolerance index for common understory species of northeastern North America. Ecological Indicators 7:195–207. DOI: 10.1016/j.ecolind.2005.12.002.

Jevons, S.R. 2015. Historical fire frequency of the Lower Bow Valley, Alberta, Canada. Alberta Environment and Parks, Parks Division, Canmore.

Johnson, E.A., and C.P.S. Larson. 1991. Climatically induced change in fire frequency in the southern Canadian Rockies. Ecology 72: 194-201.

Tande, G.F. 1979. Fire history and vegetation patterns of coniferous forests in Jasper National Park, Alberta. Canadian Journal of Botany 57: 1912-1931. DOI: 10.1139/b79-241.

Turner, M.G., W.H. Romme and D.B. Tinker. 2003. Surprises and lessons from the 1988 Yellowstone fires. Frontiers in Ecology and the Environment 1: 351-358

Johnson, E.A., and G.I. Fryer. 1987. Historical vegetation change in the Kananaskis Valley, Canadian Rockies. Canadian Journal of Botany 65: 853-858.

Johnson, K.M., and S.E. Nielsen. 2014. Demographic effects on fruit set in the dioecious shrub Canada buffaloberry (*Shepherdia canadensis*). PeerJ 2:e526. DOI: 10.7717/peerj.526.

Keane, R.E., K.C. Ryan, T.T. Veblen, C.D. Allen, J. Logan and B. Hawkes. 2002. Cascading effects of fire exclusion in Rocky Mountain ecosystems. USDA Forest Service General Technical Report RMRS-GTR-91.

Kirby, C .L. 1973. The Kananaskis Forest Experiment Station: history, physical features and forest inventory). Environment Canada, Forestry Service, Northern Forest Research Centre, Information Report NOR-X-5l.

Nielsen, S.E., R.H.M. Munro, E. Bainbridge, M.S. Boyce, G.B. Stenhouse. 2004. Grizzly bears and forestry II: distribution of grizzly bear foods in clearcuts of west-central Alberta, Canada. Forest Ecology and Management 199:67–82. DOI: 10.1016/j.foreco.2004.04.015.

Parks Canada. 2004. Report on the state of conservation of Canadian Rocky Mountain parks. Periodic report on the application of the World Heritage Convention. <http://www.pc.gc.ca/>. Accessed 16 August 2013.

Perry, D.A., P.F. Hessburg, C.N. Skinner, T.A. Spies, S.L. Stephens, A.H. Taylor, J.F. Franklin, B. McComb, and G. Riegel. 2011. The ecology of mixed severity fire regimes in Washington, Oregon, and Northern California. Forest Ecology and Management 262: 703-717. DOI: 10.1016/j.foreco.2011.05.004.

Pomeroy, J., X. Fang, and C. Ellis. 2012. Sensitivity of snowmelt hydrology in Marmot Creek, Alberta, to forest cover disturbance. Hydrological Processes 26: 1891-1904. DOI: 10.1002/hyp.9248.

Rhemtulla, J.M., R.J. Hall, E.S. Higgs, and S.E. Macdonald. 2002. Eighty years of change: vegetation in the montane ecoregion of Jasper National Park, Alberta, Canada. Canadian Journal of Forest Research 32: 2010-2021.

Schroeder, D. 2006. Considerations for mitigating windthrow due to forest fuel treatments. Forest Engineering Research Institute of Canada, Wildland Fire Operations.

Shepperd, W.D., Rogers, P.C., Burton, D., and D.L. Bartos. 2006. Ecology, biodiversity, management, and restoration of aspen in the Sierra Nevada. USDA Forest Service General Technical Report RMRS-GTR-806. Fort Collins, Colorado.

St. Jacques, J., D.J. Sauchyn, and Y. Zhao. 2010. Northern Rocky Mountain streamflow records: Global warming trends, human impacts or natural variability? Geophysical Research Letters 37: L06407. DOI: 10.1029/2009GL042045

Tande, G.F. 1979. Fire history and vegetation patterns of coniferous forests in Jasper National Park, Alberta. Canadian Journal of Botany 57: 1912-1931. DOI: 10.1139/b79-241.

Turner, M.G. 2010. Disturbance and landscape dynamics in a changing world. Ecology 91: 2833-2849.

Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. Canadian Journal of Forest Research 7: 23-34. DOI: 10.1139/x77-004.

Van Wagner, C.E., M. Finney, and M. Hethcott. 2006. Historic fire cycles in the Canadian Rocky Mountain parks. Forest Science 52: 704-717.

Walkinshaw, S. 2008. Kananaskis Country Vegetation Management Strategy. Prepared for Alberta Sustainable Resource Development and Alberta Tourism, Parks, Recreation and Culture. Canmore, Alberta.

Walkinshaw, S. 2013. Town of Canmore, crown land fuel modification project, phase 1. Montane Forest Management. Canmore, Alberta.

White, C. 1985. Wildland fires in Banff National Park. Occasional Paper Number No. 3. Environment Canada, National Park Branch, Parks Canada, Ottawa, Ontario, Canada.