LODGEPOLE PINE AND WHITE SPRUCE CONSERVATION TARGET ASSESSMENT REPORT

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SOUTHERN EASTERN SLOPES CONSERVATION COLLABORATIVE

The Southern Eastern Slopes Conservation Collaborative (Collaborative) is a coordinated group of conservation-based environmental organizations working together to create a bold, detailed, proactive land use vision for public and private lands along Alberta's Eastern Slopes that prioritizes conservation, and unites ENGOs to work more strategically to change policy, and landscape protection and management.

The Collaborative comprises four core organizations:

- Canadian Parks and Wilderness Society – Southern Alberta Chapter
- Miistakis Institute
- Southern Alberta Land Trust Society
- Yellowstone to Yukon Conservation Initiative

While the core group is driving the process, other conservation organizations and individuals are critical to the process and have been engaged throughout. Organizations that attended at least on of the full-day workshops include:

- Alberta Native Plant Council
- Alberta Riparian Habitat Management Society (Cows and Fish)
- Bragg Creek Environmental Coalition
- Bow River Basin Council
- Elbow River Watershed Partnership
- Foothills Land Trust
- Ghost Community
- Ghost Watershed Alliance Society
- Nature Conservancy of Canada
- Oldman Watershed Council
- Trout Unlimited Canada

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THE CALGARY FOUNDATION

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SUMMARY OF FINDINGS

The lodgepole pine and white spruce target represents 15% of the landscape in the southern eastern slopes region. Lodgepole pine and white spruce were selected because these species make up the dominant forest stands in the forest landscape and play an important role in water provisioning, flood protection and as wildlife habitat. Lodgepole pine and white spruce are also stands predominantly targeted for forestry.

The current health of the lodgepole pine and white spruce target was rated as fair, defined as outside acceptable range of variation, and requires human intervention. The score was derived from the following key ecological attributes (KEAs):

- Total extent of the lodgepole pine and white spruce compared with a historical reference extent, indicates 12% loss in the study area.
- Total extent of lodgepole pine and white spruce old-growth remaining is 36% of the forest stands and of this, 32% occurs in protected areas. Under natural conditions for a forest with an average fire return interval of 120 years, approximately 50% would be older than 120 years. In addition, the average patch size is only 0.4 km2.
- Intactness of lodgepole pine and white spruce (areas remaining with no human footprint) was assessed by percentage of lodgepole pine and white spruce target that contributes to native habitat patches greater than or equal to 10 km2 in the study area. Currently, 36% of the lodgepole pine and white spruce target falls within intact native habitat patches.

Of the 10 **critical threats** identified that affect health of the lodgepole pine and white spruce target, 3 (see Table 1) were ranked **high**:

- commercial logging
- linear disturbance
- climate change – emerging threat1

A high-ranking threat is likely to seriously degrade the conservation target over some portion of the target's occurrence at the site.

Table 1: Critical Threats to Lodgepole Pine and White Spruce

Critical Threat	Lodgepole Pine and White Spruce
Commercial logging	High
Linear disturbance	High
Altered fire regime	Medium
Pine beetle management	Medium
Motorized recreation	Medium
Residential development	Medium
Surface disturbance	Medium
Non-motorized recreation	Low
Range management	Low
Terrestrial invasive species	Low

[1] Climate change was not rated as a threat that could be addressed the 10-year timeframe of this planning process; however, it is something that must be monitored closely and considered in both short- and long term strategies.

Indirect threats are factors that influence the lodgepole pine and white spruce target direct threats. Two were identified, but more dialogue is needed in this area:

- Lack of coordination (policies) for a single road network that services different industries.
- Non-transparent decision-making concerning harvesting of stands considered to be threatened by mountain pine beetle.

A number of **opportunities** were also identified that can influence target health:

- Case studies highlighting possibility of managing the forest for water provision rather than timber yield.
- Fire regime group formed through City of Calgary.
- South Saskatchewan Regional Plan – opportunity to promote burning as a management tool to promote forest health.

These threat results were used to form strategies, including objectives and actions aimed at improving the health of the lodgepole pole pine and white spruce target.

The following three **goals** were identified to improve lodgepole pole pine and white spruce target health and reduce critical threats:

1. Maintain natural age structures (represented as maintaining >50% of managed forest on southern eastern slopes as forest older than 116 years).
2. Maintain natural vegetation in current extent of pine–spruce forest.
3. Increase area of pine–spruce forests in intact natural vegetation patches (>10 km2) to >40% of the study area (short term) and >60% (long term).

BACKGROUND

The Collaborative is developing a conservation plan or blueprint for conservation groups to work toward maintaining a healthy landscape along Alberta's southern eastern slopes. The Collaborative is using The Nature Conservancy Conservation Action Planning (TNC CAP) process as the foundation for developing conservation strategies. Steps in the process include:

1. Scope and target identification workshop: held in Calgary in May 2016 with the broad conservation community, where the study area was agreed to and a number of conservation targets were identified, including foothills grassland, riparian areas, white spruce and lodgepole pine forest, wide-ranging mammals and native fish species.
2. Conservation target health and critical threat assessment: conservation target assessment approach developed for the first three conservation targets to determine current health of the target, and critical threats affecting the target.
3. Goal setting and strategy development: facilitated workshop held in Calgary in November 2016 and February 2018 with the broader conservation community to set conservation goals and develop strategies.
4. Target assessment report: Lodgepole Pine/White Spruce Conservation Target Assessment Report drafted to inform development of goals and conservation strategies to maintain and restore the lodgepole pine/white spruce target.

LODGEPOLE PINE AND WHITE SPRUCE CONSERVATION TARGET

The lodgepole pine (*Pinus contorta*) and white spruce (*Picea glauca*) conservation target represents 4146 km^2 or 15% of the total study area (not including national parks). These two tree species and their forest communities were chosen because they are the most prevalent in the study area, and are the main species targeted for harvest by the forestry sector (Cartar 2016).

Further, lodgepole pine is predicted to be very sensitive to climate change in Alberta. Research indicates that by the last 30 years of the 21st century, lodgepole pine could be nearly absent from much of its current range in the Pacific Northwest (Coops and Waring 2011). Other tree species in the study region are also sensitive to climate change, especially Engelmann spruce and five-needle pine[2] as they already occur at high altitudes and their ranges will disappear with warming climate (Morrison and Young 2016). Though these species have not been targeted for logging in the study region, Engelmann spruce might be a species to track as it appears that the forest industry has started to more frequently target this species.

The lodgepole pine and white spruce conservation target is shown in Figure 1, as depicted by the Alberta Vegetation Index (AVI) where the Species 1 category was identified as either lodgepole pine or white spruce (national parks are not included in AVI and were therefore not mapped or considered for this target).

ECOLOGICAL AND ECONOMIC IMPORTANCE

The lodgepole pine and white spruce species play an important role in sustaining downstream water supply and storage, providing flood mitigation protection and wildlife habitat, and supporting both forestry and recreational opportunities.

Water Provision – Quality and Quantity

Much of southern Alberta and parts of Saskatchewan rely on the headwaters of the Bow and Oldman Rivers for their water supplies. The headwaters of these watersheds lie in Banff National Park and provincial Green Zone lands, which are forested landscapes. Intact forests in these headwaters serve to absorb, retain, clean and release flows back into streams and rivers. Intact forests affect the timing and volume of flows. They slow down snowmelt in the spring, and reduce the severity of floods.

When ecological composition, structure and/or function are modified by human activities, water quality, quantity and/or timing of flow are also altered. The Southern Foothills Study states that water quality and quantity are declining in the southern eastern slopes due to the cumulative effects of forestry and other land uses, and will continue to decline even under best management practices (SFS 2007; 2015)

Forestry activity has been linked to the degradation of water quality and to the alteration of water levels and flow in the southern eastern slopes (Fiera 2013).

[2] Whitebark and limber pine are considered endangered species in Canada:
whitebark pine: http://www.sararegistry.gc.ca/default.asp?lang=En&n=02473155-1
limber pine: http://www.sararegistry.gc.ca/default.asp?lang=En&n=B7CC307D-1

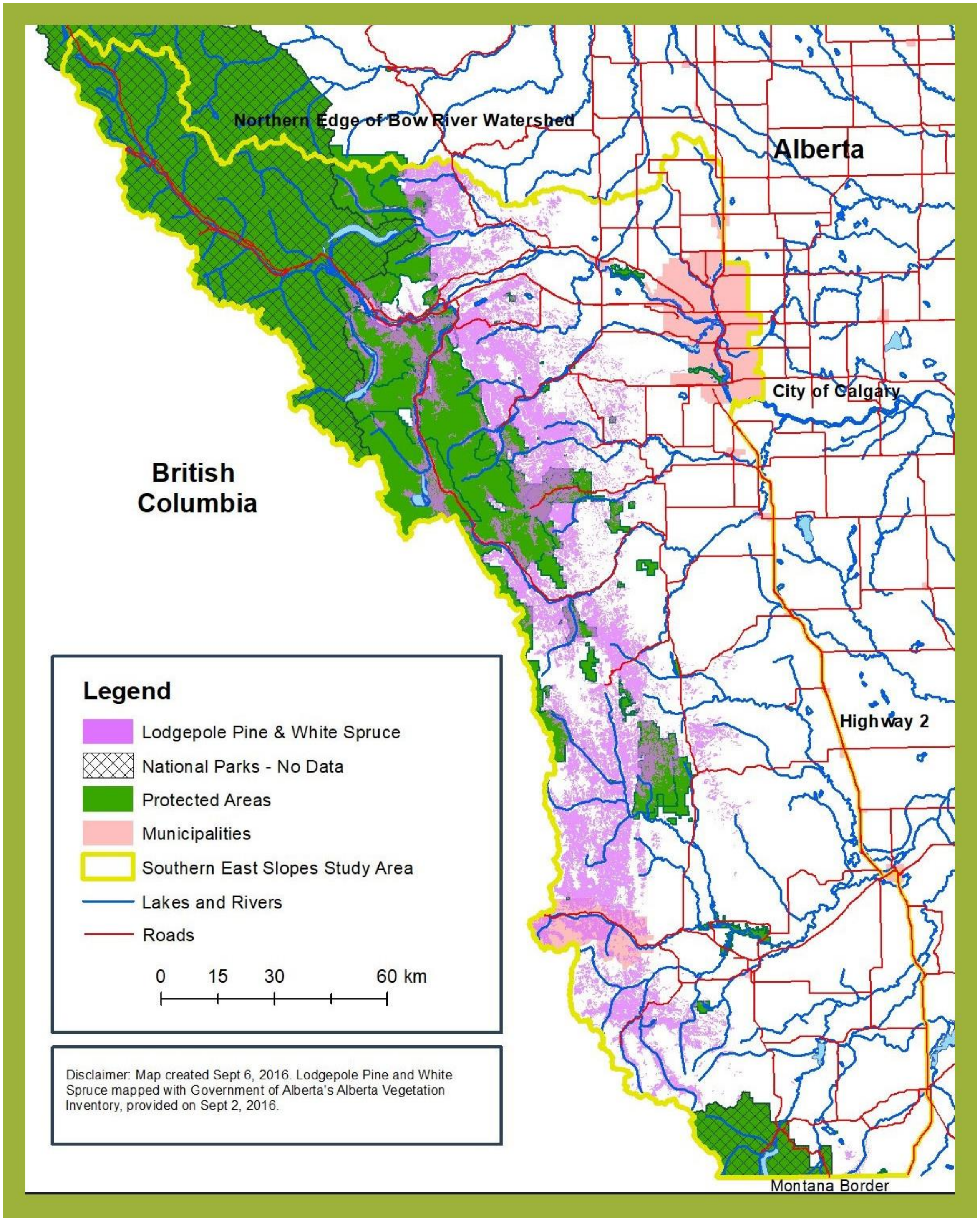


Figure 1: Map of the Forest Target – Represented by AVI Species Codes

Flood Mitigation

As noted, much of the headwaters of the two major watersheds in the study region are in forested landscapes. Intact forest canopies intercept and absorb moisture during extreme rainfall events, such as the precipitation event in June 2013.

Clearcut logging can increase both spring or peak flows and seasonal runoff (Swanson and Hillman 1977). An old, closed-canopy forest slows the force of water falling during a rainstorm. This means that during rainfall, soils are able to partially drain, giving them the ability to absorb the stormwater as it falls and avoid surface runoff and erosion. In places where closed-canopy forests have been removed, this buffering effect is lost, and the falling water is released immediately during the storm. Erosion, including landslides, and floods can result.

In snow-dominated portions of a watershed, openings like clearcuts and road corridors collect deeper snowpacks than are found under the multilayered canopies of older and old-growth forests. In the spring and summer, the deeper snowpacks in openings melt faster than the snowpack shaded by forests. Thus, the absence of forests can result in spring floods and fall water shortages, particularly in watersheds that depend on snowpacks for water.

Wildlife Habitat and Landscape Connectivity

The southern part of the Rocky Mountains exhibits a broad array of ecological conditions that support the most diverse, intact system of carnivores in North America (Apps et al. 2007) as well as prime habitat for ungulates and other species in a variety of life stages (Killeen et al. 2014). The southern Canadian Rockies represent one of the most important, intact landscapes for carnivores in the entire interior mountain bioregion stretching from Yellowstone National Park to the Yukon and beyond (Nature Conservancy of Canada 2016).

Furthermore, landscape connectivity in forested ecosystems might provide evolutionary migration routes for climate-affected species.

The loss of forest habitat and consequently, of landscape connectivity, in the southern eastern slopes has been quantified in several recent reports (Fiera 2013; Weaver 2013; SFS 2007; Lee and Hanneman 2011; Smith and Cheng 2016).

Roads and other disturbance footprints have negative impacts on wildlife habitat quality and their ability to move across the landscape (Trombulak and Frissell 2000). Roads can increase mortality risk for wildlife as a result of collisions with vehicles (Lode 2000), and they change the amount and arrangement of habitat patches, resulting in both direct and indirect habitat loss for many species (Andrews 1990).

Many species avoid roads and other large disturbances and in some cases, are unwilling or unable to cross these areas. This can lead to population isolation and reduced population viability (Forman and Alexander 1998; Frair et al. 2008). Road avoidance also influences habitat quality in areas adjacent to the road (Frair et al. 2008), extending the ecological footprint of roads up to several kilometres from the road edge (Forman 2000).

For example, a road density of 0.6 km/km^2 appears to be the maximum for a naturally functioning landscape containing sustained populations of large predators, such as wolves and mountain lions (Forman and Alexander 1998). A road disturbance threshold of 0.6 km/km^2 also applies to grizzly bear recovery in Alberta (Alberta Environment and Parks 2016). Moose, elk and other mammal populations also decrease with increasing road density. These species are differentially sensitive to the roadkill, road-avoidance and human-access dimensions of road density (Forman and Alexander 1998).

Forestry

According to the Government of Alberta (2014), forested lands in the Green Area comprise 16% of the south Saskatchewan region; of this, 48% is actively managed for timber. The government allocates forestry production on public lands via timber permits, timber quotas and forest management agreements (FMAs). Though under an FMA forest companies are expected to align with the principles of sustainable forest management, and consider a range of social, economic and environmental factors (e.g., watershed function, wildlife habitat), forestry management on public lands is primarily driven by timber quotas.

In 2012, the forest sector employed almost 13,000 workers in Alberta through direct and indirect employment (Government of Alberta 2013, Government of Alberta 2014). In the Southern Eastern Slopes are one major FMA holder (Spray Lake Sawmills), two community timber programs and four coniferous timber quotas, in addition to small manufacturing facilities (e.g., sawmills, round-wood processing facilities, log home manufacturers and re-manufacturing plants) (Government of Alberta 2014).

Recreation

Recreational activities such as hiking, hunting, fishing, ATV use, camping and mountain biking are very popular in the area due to its proximity to Calgary. The protected areas in Kananaskis Country are the most heavily used recreation areas in the province (Government of Alberta 2012). This area hosts over three and a half million visitors per year (Alberta Community Development 2004), of which 80% were day-use visitors. Since 1988, day use in Kananaskis Country has been increasing by approximately 5% per year (from about 1.6 million to about 3 million visitors per year between 1988 and 2000). These statistics are outdated, however, as annual provincial reports no longer contain data on specific parks, but news articles and radio reports highlighted that the summer of 2015 had one of the highest visitation rates on record (e.g., CBC 2015).

Around the Ghost/Waiparous and McLean Creek areas, the number of ATVs, especially quads and motorcycles, and approved guides and outfitters (e.g., equestrian, hiking, whitewater) operating in Kananaskis Country has increased in recent years (Government of Alberta 2012).

CURRENT STATUS OF CONSERVATION TARGET

KEAs were identified to determine the current status of the forest target, including size, condition and landscape processes that are important to target health. Table 2 lists the KEAs, indicators and health ratings (and justification for the ratings) of each forest target KEA. Health scores were derived from expert opinion, and were informed by spatial analysis and literature review. For the analysis approach and results (including maps) for each key attribute, see Appendix A, which also describes important limitations and data gaps in this process.

Table 2: Target Viability Assessment – Lodgepole Pine and White Spruce Target

Conservation Target	Category	KEA	Indicator	Poor	Fair	Good	Very Good
Lodgepole pine/ white spruce	Size	Size/extent of characteristic communities/ ecosystems	Percentage of target not affected (no buffer) by human footprint (ABMI layer)	0–50%	51–75%	**76–90%**	91–100%
Lodgepole pine/ white spruce	Condition	Percentage old-growth	Percentage of forest >120 years (old-growth)	<20%	**20–35%**	36–49%	>50%
Lodgepole pine/ white spruce	Landscape context	Intactness of native habitat	Patches >10 km^2 of native habitat	0–40%	**41–60%**	61–80%	81–100%

Overall, current condition of the forest target is fair, defined as outside acceptable range of variation, and requires human intervention. Two KEAs (percentage of old-growth and intactness of native habitat) were rated as fair. The third KEA (extent of characteristic ecosystems) was objectively rated as good, but the reviewers acknowledged that the analysis on which this ranking was based did not account for some important factors. For example, the region contains steep slopes and valley bottoms that are not easily logged. Additionally, if trends in human disturbance continue in this region, the extent of disturbance could push this target into fair condition.

Goals for the lodgepole pine and white spruce target should therefore focus on conserving the remaining core patches, and reducing fragmentation of the forest landscape. Because of the relatively low proportion of old-growth forest across the region, logging intervals should reflect the natural fire interval of approximately 120 years, and include plans to conserve older forests to maintain a natural range.

We also recommend analysis of large mammals as a target to address the ecological impacts of the linear disturbance levels and native habitat patch size. A 10-km^2 patch size was chosen to represent the average daily home range of a female grizzly bear (Gibeau 2000) and for consistency of fragmentation ratings among targets (e.g., foothills grasslands target). This threshold, however, might not be relevant for all life requirements for many wide-ranging mammals, some of whose home ranges might be two factors larger in size.

Data Gaps

An important data gap is no measure for the resiliency of the forest system at either the tree or the stand level (i.e., no condition scores). Therefore, information on forest species resilience over the long term is lacking.

Another gap in the analysis was a lack of available data on age class distribution in the study area. The classification of forest ages in the AVI data required a number of assumptions, such as the origin type (dominant tree species) of modified stands (natural disturbance and/or clearcuts) before the modification.

To determine the origin of a stand, therefore, any stand identified in AVI as modified that was overlapping or adjacent to a lodgepole pine or white spruce stand was classified as having a stand origin of the stand type with which it overlapped. For example, a modified stand adjacent to a lodgepole pine stand would also be classified as lodgepole pine. After careful assessment, we were not confident that we understood the historic or current age structure based on existing available data and chose to focus on percentage of old-age stands as a surrogate indication of stand health. We recognize this as a data gap and limitation of the assessment.

CRITICAL THREATS

To determine the critical threats for the forest target, the sources of stress affecting KEAs were first determined. Sources of stress are typically degraded KEAs, so for the forest target reduced forest extent, poor age-class diversity or a shift to younger age classes, and decreased structural intactness were identified as key sources of stress. Each of the sources of stress was ranked for severity and scope based on expert opinion.

Critical threats were identified as issues or activities that affect the source of stress, such as commercial logging, which directly affects the extent of the forest conservation target. Each critical threat was ranked according to its contribution and irreversibility. Lastly, threats that might have a future impact on the forest target were identified.

For more information on stress and critical threat ratings, see Appendix B. Of the threats identified for the forest conservation target (see Table 3), two were ranked **high** – commercial logging and linear disturbance.

Table 3: Forest Target – Threats and Ratings

Threat	Lodgepole Pine and White Spruce
Commercial logging	High
Linear disturbance	High
Altered fire regime	Medium
Management of pine beetle	Medium
Motorized recreation	Medium
Residential development	Medium
Surface disturbance	Medium
Non-motorized recreation	Low
Unsustainable range management	Low
Terrestrial invasive species	Low

Current Threats

Commercial Logging – High Threat

The commercial logging threat was rated as high because of the impact of logging activity on the water provisioning role of lodgepole pine and white spruce stands, and loss of diverse age structure of forest habitat to support wildlife.

Forestry is one of the major land uses in the study area. Forestry activity is driven by the FMA in the northern portion and the C5 Forest Management Unit in the southern portion, including the Porcupine Hills. According to ALCES (2007), the landscape is currently experiencing significant logging. From a management perspective, the entire “net” landbase[3] will be harvested once every 100 years. Clearcutting is the preferred harvest method. The “business as usual” or BAU scenario for the Southern Foothills Study[4] projected that the industry will log at least 1000 ha annually over the next 50 years. The total cutblock edge is projected to increase from a recent 2500 km to over 6500 km by 2055 (ALCES 2007). During the past several decades, the amount of cutblock area has increased, but this value should generally stabilize as the area of new cutblocks is offset by the area of old cutblocks that are now considered forests older than 20 years (ALCES 2015).

In addition to the actual harvest of the cutblock, forestry companies build in-block trails, access roads and landings to pile the trees for transport. According to ALCES (2015), these forest sector

[3] Net landbase excludes areas that are non-productive, too steep, and too close to water.
[4] The study area for the Southern Foothills Study aligns closely with the study area for this report.

cumulative footprints can lead to increased surface water runoff and erosion, particularly during heavy rain events. Increased surface water runoff can also reduce the amount of water that seeps into the ground and recharges aquifers. A reduction in the amount of water stored in surficial groundwater can result in lower streamflow during mid- to late-summer months (ALCES 2015; Fitch pers. comm.).

The loss of trees (and their influence on water retention after snowmelt) could have a significant impact on riparian zones. This concern might be heightened due to climate change, as Lapp et al. (2005) predicted through a modelling exercise a potential loss of 40% of current snow volume.

The impact of fire suppression is uncertain: Rumsey et al. (2004) identified inappropriate harvest prescriptions and/or fire suppression as a major threat to the region, but Johnson et al. (2001) argued that fire suppression in boreal and subalpine systems in Alberta has not had a significant impact on fire regime. While logging attempts to emulate fire patterns, fire and logging do not have the same ecological effects. Based on the notion that logging does not mimic fire, the rate of harvesting and where it occurs on the landscape should fall within the natural range of variation that includes large natural fires.

A study on the impacts of logging and linear disturbance on watershed health in the Crowsnest watershed indicated the majority of sub-watersheds in the Crowsnest watershed are at high risk for erosion and stream channel damage (Mayhood et al. 2004). Landslides are more likely to occur once clearcuts have been created in forested landcapes (Furbish and Rice 1983; Robinson 1988; Hungr et al. 2005). Additionally, landscapes are often less-productive once clearcuts have been created, as a result of soil compaction, erosion and changes in microclimate (Cartar 2016).

Other impacts of tree removal include enabling invasive species to take root, as disturbed land is a prime target for invasive species. Lastly, commercial forestry activity (and its accompanying noise pollution) affects wildlife behaviour on the landscape (Cartar 2016; Forman and Alexander 1998).

Linear Disturbance – High Threat

The linear disturbance threat was rated as high because of the proliferation of roads and other linear features in the study area and because roads are rarely remediated to a natural state. Even forestry roads, which are often planned to be a temporary landscape feature, are seldom completely restored to a natural state; this is particularly true when motorized recreation users begin using roads as trails or when they do not respect road closures in place for road remediation efforts.

The effects of the forestry sector also include the contribution of linear features (e.g., roads) to fragmentation and edge effects. The energy sector removes trees and other natural vegetation as they construct roads, pipelines, well sites, processing plants and seismic lines. These features fragment the landscape, allow greater access to humans and rapidly reduce secure areas typically used by mammals (Stelfox et al. 2005).

According to ALCES (2007), the landscape is becoming increasingly fragmented due to new roads, industrial development from the energy and forestry sectors, and new residential acreages. The Southern Foothills Study[5] (ALCES 2007), predicted that the road network will increase from 7136 km in 2005 to more than 16,200 km in 2055. Roads have among the most damaging impacts on intact landscapes, particularly regarding hydrological function and habitat fragmentation (Forman and Alexander 1998). Linear corridors, such as seismic lines, roads and pipelines, are "sources and vectors for non-native species invasion" (Bradley 2003). Trombulak and Frissell (2000) identified the spread of invasive species[6] as one of the primary potential effects of linear disturbances on terrestrial and aquatic habitats.

[5] The Southern Foothills Study area is very closely aligned with the Collaborative's study area, so the results of the Southern Foothills Study are presented as an important source of information throughout this section.

[6] For this process, terrestrial invasive species are considered an indirect threat under surface disturbance given the linear disturbances that are created in tandem with surface disturbance.

Drainage patterns and water quality in watersheds can be altered by increases in the compacted surface area. Seismic cutlines are of particular concern because regeneration is difficult due to soil and root disturbance, grass competition and continued use for vehicle access (Oldman Watershed Council 2010). Fiera (2013) found that 71% of sub-watersheds in the Oldman Basin were considered to be at moderate or high erosion risk due to high linear feature densities (>0.6 km/km^2).

Water is affected by land-based recreation activities[7], including fishing, hiking and off-road vehicle travel, which occur on linear disturbances like trails, seismic lines and roads. The use of these linear disturbances during wet periods, particularly by motorized vehicles, can cause surface compaction, trail rutting and widening, reduced infiltration of precipitation, increased speed of water moving downslope on these linear features, and ultimately, further erosion and increasing sediment pulses to stream systems during precipitation events. Although this is discussed in the riparian areas target report, it is worth mentioning here because linear features affect the hydrological cycle in the study region.

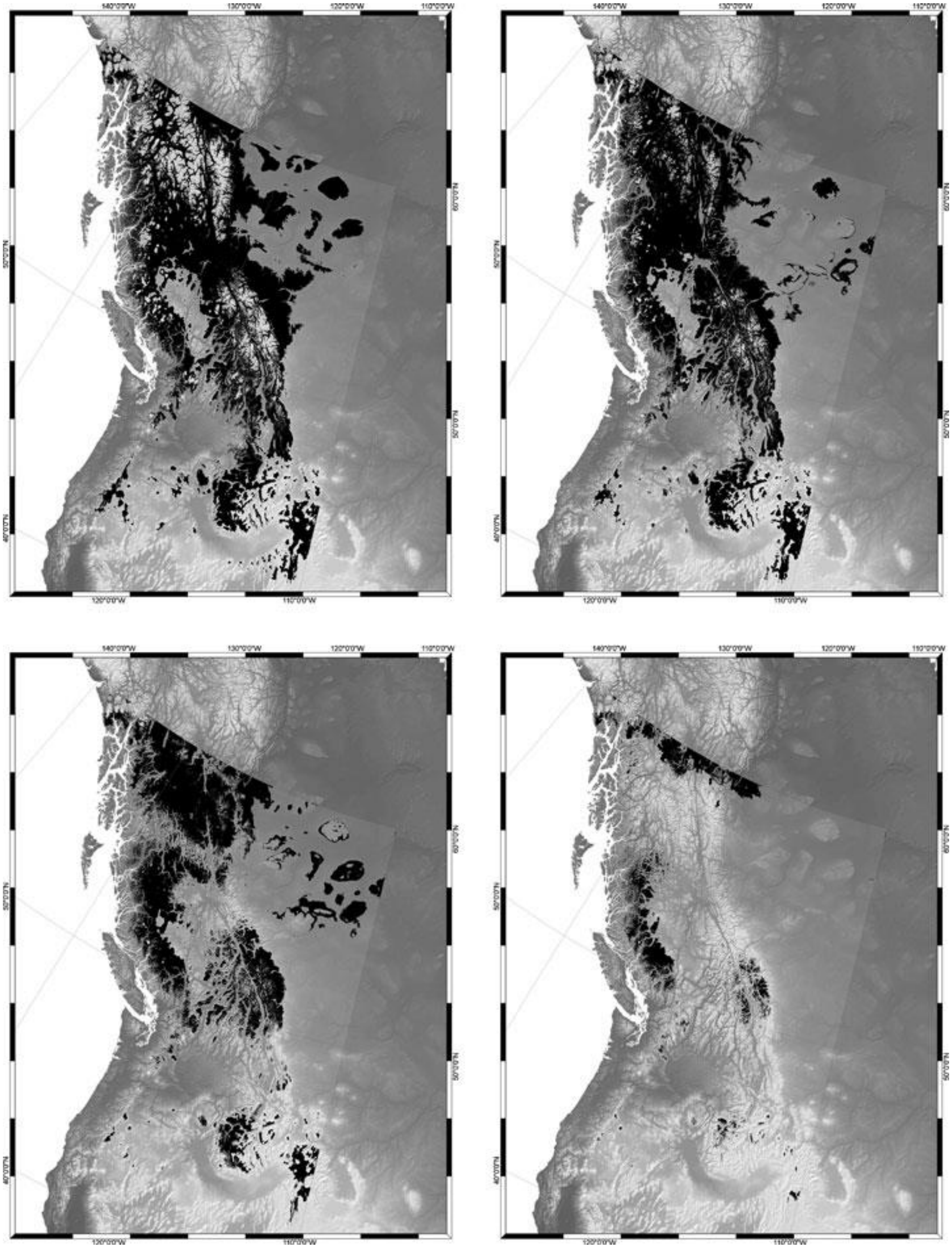
Emerging Threats

Climate Change – High Threat

Though climate change was not assessed as a threat within the 10-year timeframe of this planning process, it is something that must be monitored closely and considered in both short- and long-term strategies.

The literature indicates that the Rocky Mountains could experience shorter, warmer winters (estimates of 40–50% decreases in annual snowpack and increased fall precipitation), resulting in diminished spring/summer runoff (Leung and Ghan 1999; Lapp et al. 2005). Climate change is predicted to only slightly reduce the extent of lodgepole pine over the next 30 years. However, conditions will then favour other species, and models predict a potential long-term reduction in the range of lodgepole pine to the point of local extinction (see Figure 2). Management decisions affecting this forest type should aim to conserve areas of climate refugia and increase the resiliency of the forest to climate change.

[7] For this process, recreation is considered an indirect threat under surface disturbance given that recreation takes place on linear features in the forest reserve.



Top Left = Current Condition Top Right = 2020 Bottom Left = 2050 Bottom Right = 2080

(Source: Copps and Waring 2011)

Figure 2: Climate Change Impacts on Lodgepole Pine

Indirect Threats

Indirect threats are contributing factors that drive direct threats and must be considered in strategy development. The indirect threats presented here are not exhaustive and additional discussion should occur with any future strategy development. For the lodgepole pine and white spruce target, the following indirect threats were identified:

- Lack of coordination (policies) for a single road network that services different industries.
- Non-transparent decision-making concerning harvesting of stands considered to be threatened by mountain pine beetle.

OPPORTUNITIES

The following opportunities were identified as important to consider for strategy development:

- Successful case studies in which forests were managed for water provision and conservation rather than for timber quotas.
- Fire regime group forming through City of Calgary.
- SSRP – Opportunity to promote burning as a management tool to promote forest health.

The opportunities presented here are not exhaustive and additional discussion should occur before any future strategy development.

STRATEGIES

The next step in the process is to develop goals/objectives and strategic actions to address critical threats and/or improve target health. Objectives tend to be measurable statements of what we as a community want to achieve relative to the pine–spruce forest target. Objectives can include activities related to policy and law, stewardship protection of land, water or species management, education and awareness, and livelihood, economic and other incentives.

Goals, objectives and example actions were identified through a workshop with ENGOs, community members and stakeholders interested in protecting the southern eastern slopes. Participants were asked to review KEAs, critical threats, indirect threats and opportunities for the pine–spruce target.

Goals

Goals and objectives and strategic actions developed to address critical threats/improve target health include the following:

1. Maintain natural age structures (represented as maintaining >50% of managed forest on southern eastern slopes as forest older than 116 years).
2. Maintain natural vegetation in current extent of pine–spruce forest.
3. Increase area of pine–spruce forests in intact natural vegetation patches (>10 km2) to >40% of the study area (short term) and >60% (long term).

Goal 1: Maintain natural age structures (represented as maintaining >50% of managed forest in southern eastern slopes as forest older than 116 years).

Objective 1: Adopt a new system of forest management to prioritize ecological values and watershed health over timber.

Objective 2: Prohibit harvest of old-growth in the southern eastern slopes.

Objective 3: Develop incentives for conserving natural age structure, including on public and private lands.

Objective 4: Use prescribed fire as a management tool in the southern eastern slopes.

Example Actions:

- Increase social acceptance of prescribed burns through education on the role of fire in natural systems.
- Increase coordination between land management agencies (municipal, provincial parks, public land, national parks).

Goal 2: Maintain natural vegetation in current extent of pine–spruce forest.

Objective 1: Allow no more than 12% human disturbance in historic extent of target regardless of natural vegetation type under climate change.

Objective 2: Conserve existing intact forests on public and private land.

Example Actions:

- Create new protected areas in intact forest patches.
- Develop private land conservation tools on forest private land.

Objective 3: Change public values by expanding cohort of people who care about forests.

Example Actions:

- Increase public awareness of the consequences of BAU forest management practices now and in the future.
- Increase Albertans' on-the-ground experience in the southern eastern slopes.
- Increase education on the value of public lands.

Objective 4: Maximize net economic public good of land and resources in the eastern slopes.

Example Actions:

- Examine economics of current timber harvest.
- Explore and promote alternative economies (e.g., quiet recreation and tourism).

Objective 5: Increase public involvement in public land management.

Objective 6: Develop and implement recreation management policies and plans on public lands, including designated camping areas, designated trails and supporting infrastructure (e.g., trash bins, outhouses, signage) in appropriate areas.

Example Actions:

- Support and strengthen subregional planning initiatives (Biodiversity Management Framework, Land Footprint Management Plans, Recreation Plans).

Objective 7: Develop policies for limiting urban expansion into forested areas.

Goal 3: Increase intact natural vegetation patches (>10km^2) to >40% of the study area (short term) and >60% (long term).

Objective 1: Use relevant data for forest regrowth standards, including climate modelling and predictions.

Objective 2: Create policies on linear features and recreation planning with a maximum linear density threshold of 0.6 km/km^2, including open motorized roads and trails, and restricted industry roads.

Objective 3: Restore linear features.

Example Actions:

- Development of an offset policy for industrial roads and motorized trails, where any new road development is offset by removal of an existing road.
- Identify trails that need to be restored, and enable natural restoration process by preventing access and/or accelerating restoration through terrain contouring and replanting.

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APPENDIX A: VIABILITY ASSESSMENT METHODS AND RESULTS

This appendix describes the KEAs and indicators used to measure the health of the forest conservation target. Indicators were developed considering target size (extent), condition and landscape processes, as described in the TNC CAP process. KEA analysis was undertaken by Ken Sanderson, and health scores for all indicators were rated based on the expert opinions, of Dr. Ralph Cartar, Katie Morrison, Dr. Hilary Young, Rachelle Haddock and Tracy Lee.

Health score rating thresholds were developed for each indicator the following defined categories in the TNC CAP process:

- Very Good – Ecologically desirable status; requires little intervention for maintenance.
- Good – Within acceptable range of variation; some intervention required for maintenance.
- Fair – Outside acceptable range of variation; requires human intervention.
- Poor – Restoration increasingly difficult; could result in extirpation of target.

The following data sets were used in the analysis:

- Alberta Biodiversity Monitoring Institute (ABMI) Human Footprint Inventory for 2012 conditions (Version 3) was used to represent anthropogenic features on the landscape. This data layer is updated by ABMI every two to three years and can therefore help monitor anthropogenic changes on the landscape at a provincial scale. More information on ABMI can be found at: http://www.abmi.ca.
- ABMI Wall-to-Wall Land Cover Map Version 2.1 (ABMIw2wLCV2010v1.0).
- Alberta Vegetation Inventory, Government of Alberta. Delivered Sept. 8, 2016. (The AVI dataset does not cover national park lands or the Alberta White Zone.)
- Alberta Parks and Protected Areas, Government of Alberta.

KEY ECOLOGICAL ATTRIBUTES – LODGEPOLE PINE AND WHITE SPRUCE TARGET

SIZE: Extent of Characteristic Communities/Ecosystem

To understand the loss of lodgepole pine and white spruce over time, current extent of the target was compared with a historical extent, or reference condition. The area of lodgepole pine and white spruce remaining without human impact was calculated and presented as a percentage of the reference area to understand extent of lodgepole pine and spruce forest loss over time.

Methods

The size of the lodgepole pine and white spruce target was calculated in km^2 in a GIS environment using AVI. To understand the extent of loss of lodgepole pine and white spruce over time a reference layer was developed to represent historical extent. The reference layer for lodgepole pine and white spruce stands was identified using modified stands in AVI that intersected within 10 m of known lodgepole pine and white spruce stands. Modified stand types included clearcuts (including site improved, seedbed prepared and planted and/or seeded), burns, windfalls, disease, insect kill, unknown kill and weather-related kills.

Clearcuts were included in the modified category because while the area may be replanted with a similar tree composition, changes in water and soil processes and biodiversity from logging activities likely persist beyond reforestation. A limitation of this approach is that modified polygons that were once lodgepole pine or white spruce not currently in contact with existing stands might be missed in the analysis. This is a conservative estimate of historic extent. To determine current extent, the ABMI human footprint layer was clipped out of the target extent and the total area remaining was calculated.

Results

The historic (pre-settlement) lodgepole pine and white spruce distribution based on our estimate was 4372 km^2. Current extent of the unmodified lodgepole pine and white spruce target is 3829 km^2, indicating a loss of 12% from the reference condition. Figure A-1 shows historic extent (yellow) and current extent (purple).

The size/extent of characteristic communities/ecosystems key attribute was rated as good. While this extent rating reflects the current state of this indicator, trends suggest that ongoing disturbances on the landscape could push this target into a fair rating in the future. Given BAU modelling projections, the industry will log at least 1000 ha annually over the next 50 years (ALCES 2007). While regrowth on older clearcuts will return the forest structure, disturbances to soil and full forest function might not be equal to undisturbed forest areas.

CONDITION: Proportion of Forest Target That is Old-Growth

The condition of the lodgepole pine and white spruce target was considered by reviewing the percentage of old-growth remaining on the landscape. Under natural conditions, we would expect to find a diverse age structure. Commercial logging, however, will cause a diversion from the natural age structure, as described by Wagner (1978). Cartar (2016) proposed that the analysis include a comparison of the actual age-class distribution with the age structure of unlogged lodgepole pine and white spruce forest. For a number of reasons, age structure of unlogged forest could not be determined in the target area, so percentage of old-growth was used as a proxy for addressing this concern as it is the most "at risk" age class in the forest.

Methods

Using AVI, lodgepole pine and white spruce stands were classified using their origin date. Any stand with an origin of 1900 (older than 116 years) or earlier was considered old-growth. To determine the amount of old-growth occurring in provincial protected areas (Alberta Parks and Protected Areas layer) old-growth in parks was calculated as a percentage of the total.

Results

Total extent of lodgepole pine and white spruce with an origin of 1900 or older is 1473 km^2, with average patch size of 0.4 km^2. Therefore, 36% of the lodgepole pine and white spruce is old-growth stands. Of this, 32% occurs in provincial protected areas. (Due to data limitations, national parks were not included in the analysis, but provincial parks were). Figure A-2 shows the old-growth in black, and highlights where on the landscape old-growth occurs.

The condition KEA was rated as **fair** despite the results of the analysis barely falling within the "good" category by 0.7%. Based on the disproportional distribution of the remaining old-growth in the northern part of the study area, and largely in riparian corridors, the reviewers opted to give this KEA a fair rating. Research studies in similar forest systems have found it is optimal to have old-growth stands represent 50% of age classes to represent the natural system (Bergeron et al. 2001).

Andrén (1994) reviewed the literature on mammals and birds in habitat patches in landscapes with different proportions of suitable habitat and concluded that for these groups critical threshold levels are between 10% and 30% of suitable habitat. In a landscape with less habitat availability, loss of species, or decline in population size, will be greater than expected from habitat loss alone. This finding provided the basis for creating a conservative upper target for the poor category of <20% old-growth using the 30% threshold established by Andrén (1994) out of the 50% old-growth target established by Bergeron et al. (2001).

It was also noted that a large amount of the lodgepole pine and white spruce old-growth stands in the study area (32%) were located in parks and protected areas. Further, it is concerning that the majority of old-growth is located in the northern end of the study region, with decreasing amounts of old-growth toward the southern end. Average size of the remnant old-growth stands is a scant 0.4 km^2, which represents minimal core habitat for species dependent on old-growth.

While we acknowledge that too much old-growth in a system can also be an issue, upper limits were not placed in the rankings as there is little literature that defines upper limits on old-growth, and given the intense use of this forest there is little concern about having too much old-growth.

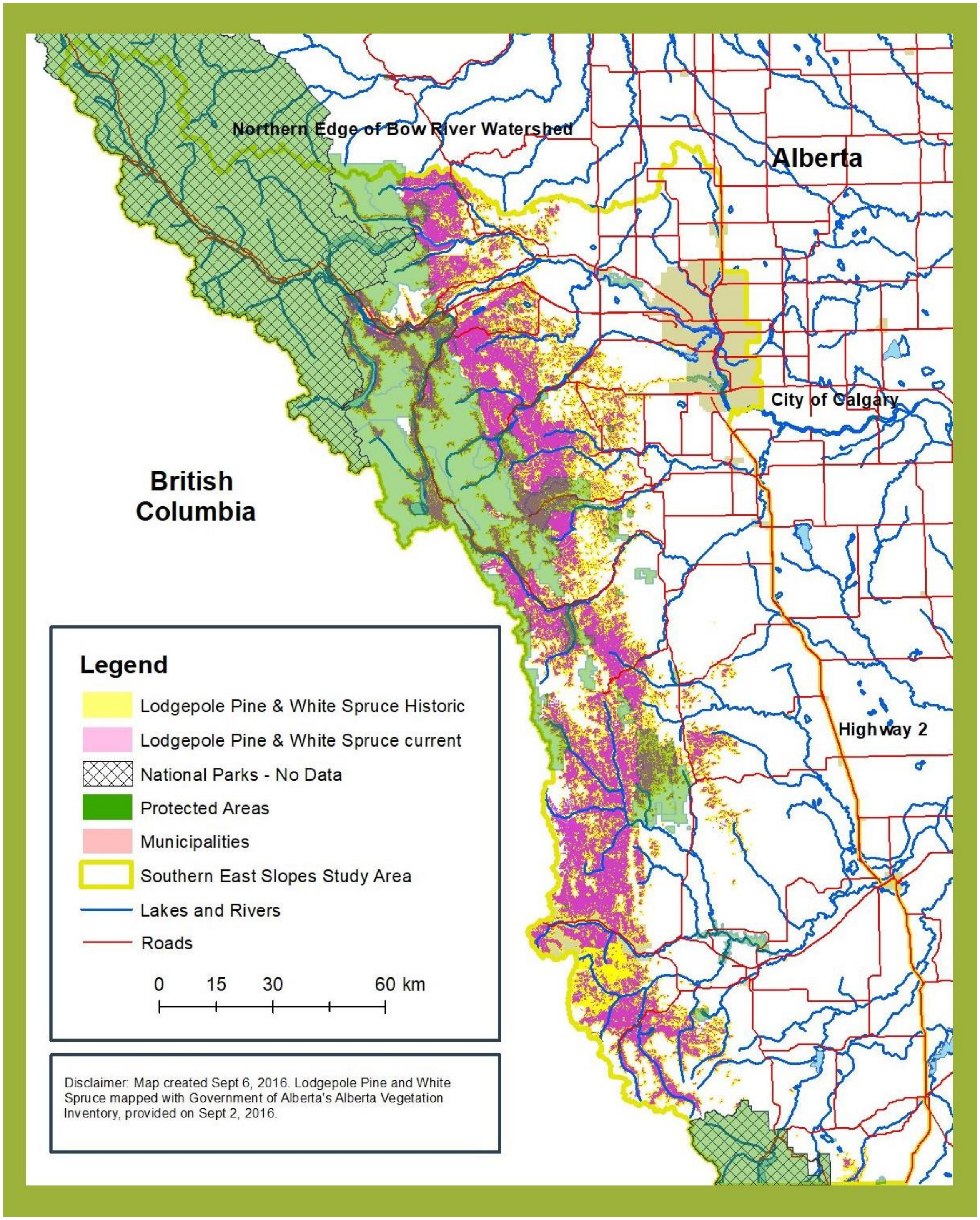

Figure A-1: Historic and Current Extent of Lodgepole Pine and White Spruce Target

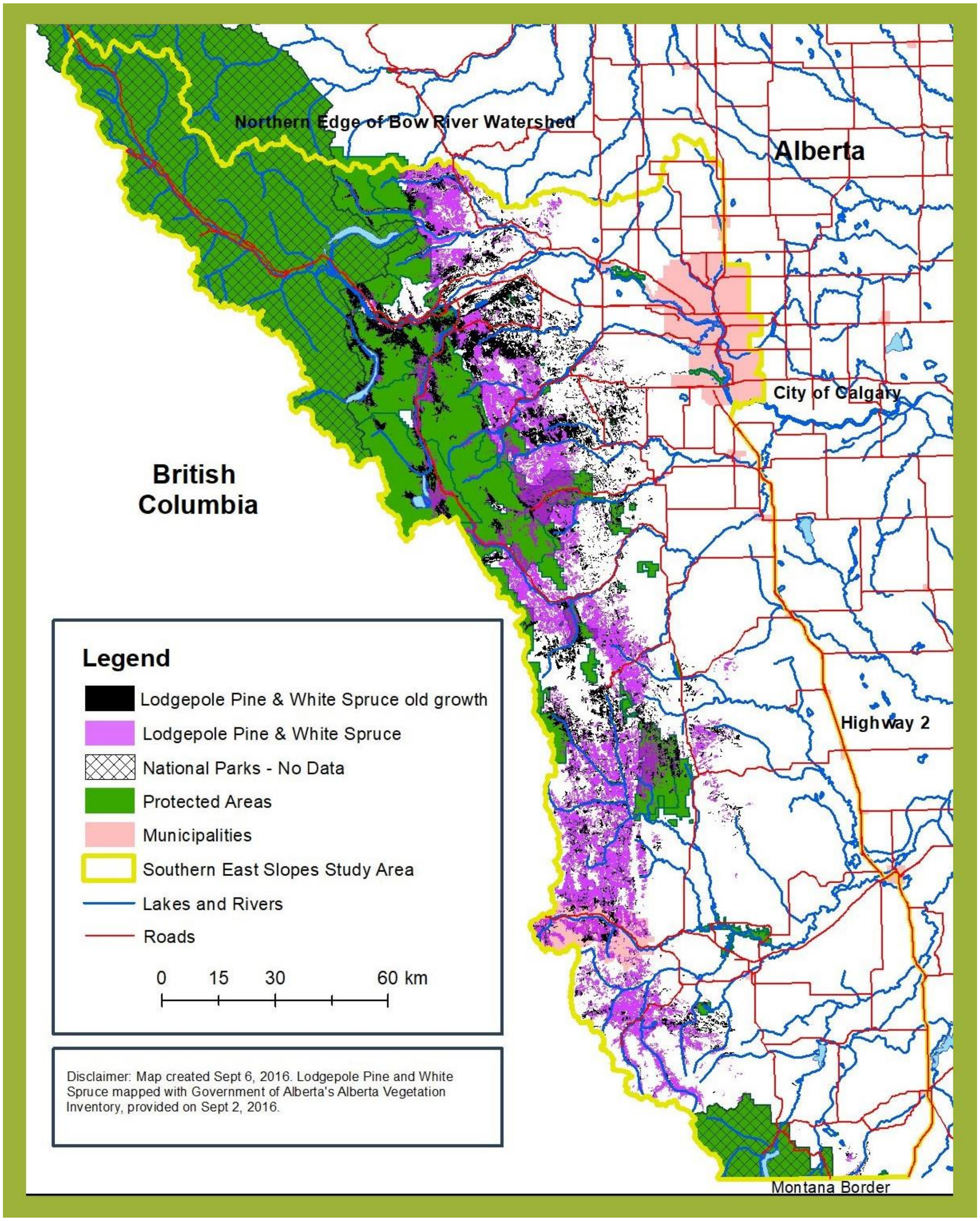

Figure A-2: Old-Growth Stands of Lodgepole Pine and White Spruce Forest Target

LANDSCAPE CONTEXT: Intactness of Native Habitat

Intactness of habitat or the degree of structural habitat connection between lodgepole pine and white spruce patches is affected by habitat loss and fragmentation of the landscape. To assess the level of target fragmentation, the percentage of lodgepole pine and white spruce contributing to native habitat patches >10 km^2 in the study area was assessed. The foothills grasslands target occurs in a mosaic landscape of deciduous trees, shrubland and grassland and we considered fragmentation relative to the landscape mosaic as opposed to the individual target of lodgepole pine and white spruce. Although the patch size of 10 km^2 is somewhat arbitrary, it represents the average daily home range of a female grizzly bear (Gibeau 2000). We also assumed that larger patch sizes represent better opportunities for biodiversity and ecosystem services to persist over time than more numerous smaller patches (Forman and Alexander 1998).

Methods

Using the ABMI Wall to Wall Landcover dataset, we selected the following classes to represent native habitat in the study area: shrubland, grassland, coniferous forest, broadleaf forest and mixed forest. Then, the ABMI human footprint layer was buffered by 100 m and used to erase the target layer to create core areas (defined as areas ≥10 km^2).

Results

Figure A-3 shows the resulting native habitat patches greater than 10 km^2 in dark green; the lodgepole pine and white spruce target is displayed in a light purple. An overlap of 1687 km^2 occurs between the lodgepole pine and white spruce and the native habitat patches greater than 10 km^2. Therefore, 41% of the lodgepole pine and white spruce conservation target contributes to the 10 km^2 native habitat patches. The remaining 59% is in patches smaller than 10 km^2. The landscape context KEA was rated as **fair.**

It is challenging to tease apart the effects of patch size and isolation of patch size. Most of the literature on this topic focuses on modelling approaches; once there is a certain amount of area and connectivity loss, habitat fragments become isolated (Morrison and Young 2016). Typically, patch size involves measuring core habitat for a specific species.

It is challenging to find consensus in the literature about general patch size thresholds as it is very specific to context. For instance, grizzly bears require much larger core habitat patches compared with smaller organisms like rodents and insects that might require smaller habitat patches, but might experience edge effects more strongly.

The total size of native habitat patches over 10 km^2 is 7344 km^2, representing 34% of native habitat. The average patch size is 50 km^2 – the patch size needed to support wolverine, one of the species that requires extensive secure areas (Blouin 2006).

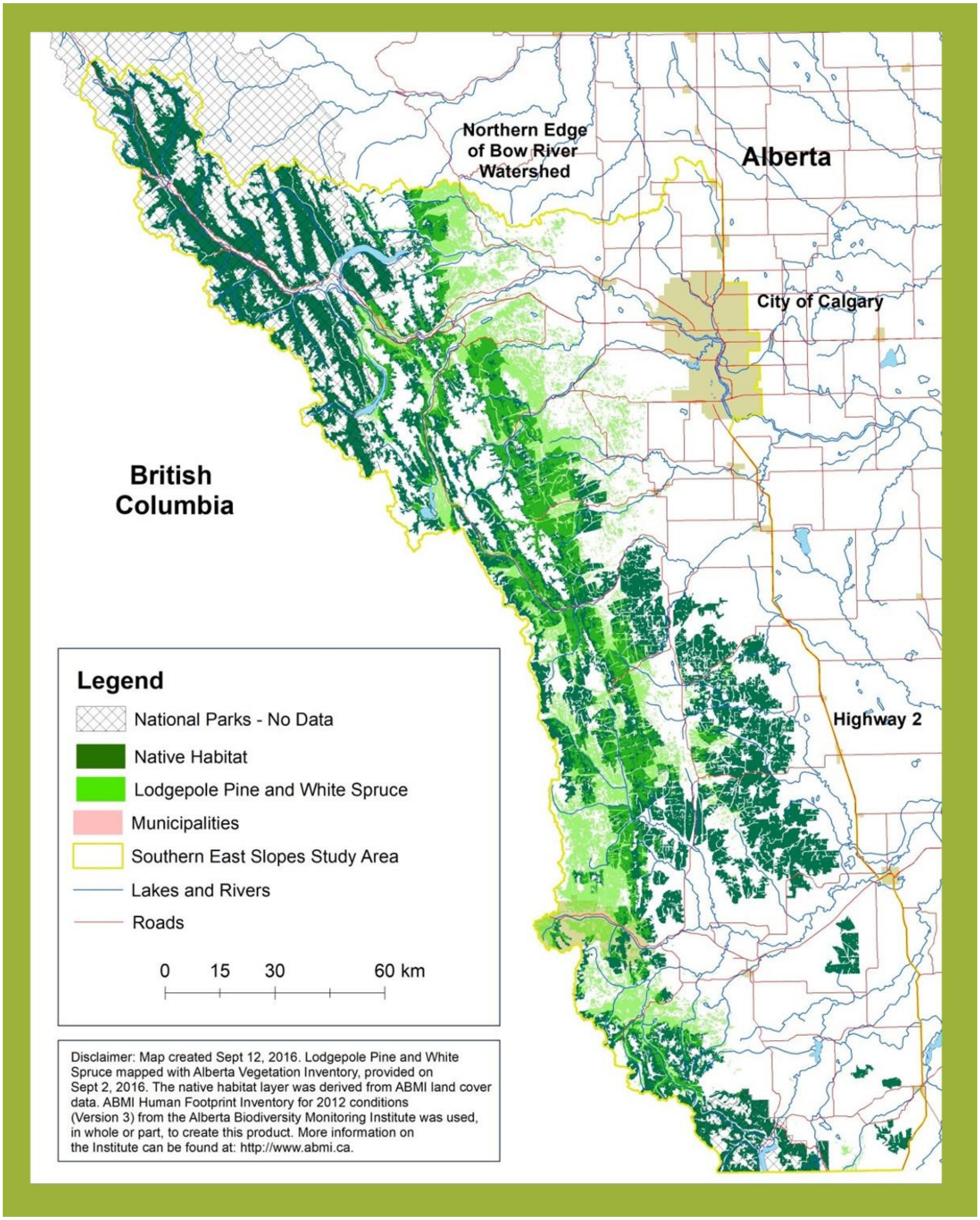

Figure A-3: Landscape Connectivity – >10 km2 Native Habitat Patches/Target

APPENDIX B: TARGET THREATS AND STRESSES

For each KEA identified for lodgepole pine and white spruce forests, sources of stress were identified and rated for their severity and scope based on categories defined by the TNC CAP process (TNC 2007). Stresses (see Table B-1) and threats (see Table B-2) were rated based on the expert opinions of Katie Morrison, Dr. Hilary Young and Rachelle Haddock. Each source of stress was rated in terms of its contribution and irreversibility.

Contribution is defined (TNC 2007) as the expected contribution of the source, acting alone, to the full expression of a stress under current circumstances:

- Very High: The source is a very large contributor of the particular stress.
- High: The source is a large contributor of the particular stress.
- Medium: The source is a moderate contributor of the particular stress.
- Low: The source is a low contributor of the particular stress.

Irreversibility is defined as the degree to which effects of a source of stress can be restored:

- Very High: Source produces a stress that is not reversible.
- High: Source produces a stress that is reversible, but not practically affordable.
- Medium: Source produces a stress that is reversible with reasonable resource commitment.
- Low: Source produces a stress that is easily reversible at relatively low cost.

Table B-1: Sources of Stress for Lodgepole Pine and White Spruce

Stresses	Severity	Scope	Stress Rank
Reduced forest extent	Medium	High	Medium
Poor age class diversity of old-growth	High	High	High
Decreased structural connectivity	High	High	High

Severity considers the level of damage to the conservation target that can reasonably be expected within 10 years under current circumstances (continuation of existing situation):

- Very High: The threat is likely to destroy or eliminate the conservation target over some portion of the target's occurrence at the site.
- High: The threat is likely to seriously degrade the conservation target over some portion of the target’s occurrence at the site.
- Medium: The threat is likely to moderately degrade the conservation target over some portion of the target’s occurrence at the site.
- Low: The threat is likely to only slightly impair the conservation target over some portion of the target’s occurrence at the site.

Scope is defined as geographic scope of the impact on the conservation target at the site that can reasonably be expected within 10 years under current circumstance (continuation of existing situation):

- Very High: The threat is likely to be widespread or pervasive in its scope and affect the conservation target throughout the target’s occurrence at the site.
- High: The threat is likely to be widespread in its scope and affect the conservation target at many of its locations at the site.
- Medium: The threat is likely to be localized in its scope and affect the conservation target at some of the target’s locations at the site.
- Low: The threat is likely to be very localized in its scope and affect the conservation target in a limited portion of the target’s location at the site.

Table B-2: Threats for Lodgepole Pine and White Spruce Target

Threats – Source of Stress		Reduced Forest Extent	Poor Age Class Diversity	Increased Fragmentation	Threat to Target Rank
Stress		1	2	3	
Rank		Medium	High	High	
1	Threat	Commercial logging			High
	Common Taxonomy				
	Contribution	Very High	Very High	Very High	
	Irreversibility	High	Medium	High	
	Threat Rank (override)				
	Threat Rank	Medium	High	High	
2	Threat	Linear disturbance			High
	Common Taxonomy				
	Contribution	Medium	-	High	
	Irreversibility	Medium	-	High	
	Threat Rank (override)				
	Threat Rank	Low	-	High	
3	Threat	Motorized recreation			Medium
	Common Taxonomy				
	Contribution	Low	Low	High	
	Irreversibility	Low	Low	Medium	
	Threat Rank (override)				
	Threat Rank	Low	Low	Medium	
4	Threat	Management of pine beetle			Medium
	Common Taxonomy				
	Contribution	Low	Low	Low	
	Irreversibility	High	High	High	
	Threat Rank (override)				
	Threat Rank	Low	Medium	Medium	
5	Threat	Altered fire regime: Age class distribution			Medium
	Common Taxonomy				
	Contribution	Low	Medium	Low	
	Irreversibility	Low	Medium	Low	
	Threat Rank (override)				
	Threat Rank	Low	Medium	Low	
6	Threat	Altered fire regime: Increased fire risk			Medium
	Common Taxonomy				
	Contribution	Medium	Medium	Medium	
	Irreversibility	High	Medium	Medium	
	Threat Rank (override)				
	Threat Rank	Low	Medium	Medium	
7	Threat	Non-motorized recreation			Low
	Common Taxonomy				
	Contribution	Low	Low	Low	
	Irreversibility	Low	Low	Medium	
	Threat Rank (override)				
	Threat Rank	Low	Low	Low	
8	Threat	Terrestrial invasive species			Low
	Common Taxonomy				
	Contribution	Low	Low	Low	
	Irreversibility	Low	Low	Low	
	Threat Rank (override)				
	Threat Rank	Low	Low	Low	
9	Threat	Residential development			Medium
	Common Taxonomy				
	Contribution	Medium	Low	Medium	
	Irreversibility	High	High	High	
	Threat Rank (override)				
	Threat Rank	Low	Medium	Medium	
10	Threat	Unsustainable range management			Low
	Common Taxonomy				
	Contribution	Low	Low	Low	
	Irreversibility	Low	Low	Low	
	Threat Rank (override)				
	Threat Rank	Low	Low	Low	
11	Threat	Surface disturbance			Medium
	Common Taxonomy				
	Contribution	Low	Low	Medium	
	Irreversibility	Medium	High	High	
	Threat Rank (override)				
	Threat Rank	Low	Medium	Medium	