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FOREST AND FIRE MANAGEMENT STRATEGY

Cypress Hills Interprovincial Park Alberta

Presented to:

ALBERTA TOURISM, PARKS AND RECREATION
PARKS DIVISION
SOUTHEAST MANAGEMENT AREA

Presented by:

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EXECUTIVE SUMMARY

Cypress Hills Provincial Park contains many natural and cultural values that contribute to a unique ecology in the province and a diversity of attractions for park visitors. Annual visitation is over 250,000 to this 200 km^2 park.

One of the less obvious features to visitors is the pervasive historical role of wildfire that has maintained the ecological integrity of the Cypress Hills for over 10,000 years. Mature coniferous forests and fescue grasslands form the majority of park vegetation. The current age and composition of the vegetation combined with frequent fire weather conditions (hot and dry with significant winds) create the potential for a catastrophic wildfire in the park that would put significant values at risk.

The values at risk in order of priority include:

- Human Life
- Public and private infrastructure including:
    - 280 cottages
    - A hotel/condo development, service station, ski hill, and restaurant
    - Numerous ranches and facilities adjacent to the park
    - Park infrastructure, including administration facilities, the visitor centre, municipal water and sewer system, over 500 campsites and associated facilities, 56 km of hiking trails, vehicles and equipment
- Biodiversity and Ecology
    - Under present vegetative conditions a fire would be likely to burn extremely hot and damage soil structure. This can result in the inability of current plant communities to reestablish and/or colonization of burnt areas by invasive species.
- Local tourism economy
    - Cypress Hills is a key draw for tourism in the SE part of Alberta. With over 250,000 visitors to the park annually, the impact of a catastrophic wildfire would have a significant effect on the regional economy.

Four primary objectives from the *Cypress Hills Interprovincial Park-Alberta Management Plan* (2009) are addressed by this report:

- establish the role of fire in the park;
- reduce the threat of a catastrophic fire;
- manage forests for ecologically and age diverse communities that are representative of the Cypress Hills environment; and,
- protect the gene pool integrity of the Cypress Hills forests.

Since the 1870s, Euro-Canadian influence has altered the natural processes that were at work in the Cypress Hills. Prolonged fire suppression has increased the fuel load, allowing significant aging of the forests and encroachment of forest and shrub species onto the grasslands. The forests are currently in an advanced and over-mature successional stage, which has implications for forest and grassland health in the park including increasing susceptibility to pests and pathogens.

Effects of fire on forest ecosystems depend on many associated factors including fire intensity, season and previous fire history as well as post-fire disturbances and climatic factors. The stand origin modelling technique was used to study historical fire distribution patterns and determine the fire regime departure. It was calculated that the departure from the mean fire cycle is greater than 200% for coniferous and grasslands vegetation and 189% for the deciduous forests. The critical level of fire regime departure throughout the Cypress Hills is threatening the ecological integrity of these fire-driven ecosystems. Fire-dependent ecosystems in the park, some that include rare plant species/communities, may benefit by moving towards a more natural fire regime. Monitoring and adaptive management tools are important because the effects of disturbance and management options are variable.

A wildfire threat assessment was also undertaken for Cypress Hills Provincial Park. The mature and over-mature age of both deciduous and coniferous forest fuels is associated with significant surface fuel loading and continuous grass cover, which in turn increases the fire behaviour potential. Under the right fire weather conditions, the increased fuel load will create larger and more intense blazes that put the public and neighbouring stakeholders at risk. Extreme fire conditions may burn the entire park within 11 hours. Further, it is expected that the burning severity will be beyond observed historical levels in terms of consumption of soil organic matter, percent canopy removal, and extent of burned area. This could negatively impact the recovery and future viability of some plant communities.

The integrated fire and forest management strategy proposed includes fine-scale fuel reduction programs including FireSmart priorities, grazing and firewood salvage. Recommended broad-scale fuel reduction interventions include pro-active fuelbreaks and containment lines based on the concept of Landscape Management Units (LMUs) introduced in the *Cypress Hills Interprovincial Park-Alberta Management Plan* (2009). Contingency fuelbreaks and suppression containment lines such as sprinkler lines and feller-buncher tree removal are also proposed. Prescribed fire may also be a later possibility once fuel reduction programs are in place. Mitigating catastrophic fire events from a public safety and community protection standpoint requires wildfire operations strategies that include pre-attack planning, initial attack planning, and planning for sustained fire suppression action. Overall, fire management strategies such as mitigation of catastrophic fire risk and prescribed fire contribute to forest health protection through maintenance of natural disturbance processes through which park ecosystems evolved. Wildfire emergency planning, interagency communication, and ecosystem monitoring remain important.

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ABBREVIATIONS

ASRD	Alberta Sustainable Resource Development
ATPRC	Alberta Tourism, Parks, Recreation and Culture
AVI	Alberta Vegetation Inventory
BUI	Buildup Index
CFFBPS	Canadian Forest Fire Behaviour Prediction System
CRRDRS	Canadian Forest Fire Danger Rating System
DC	Drought Code
DMC	Duff Moisture Code
FBP	Fire Behaviour Prediction
FFMC	Fire Fuel Moisture Code
FWI	Fire Weather Index
GCM	Global Climate Model
HFI	Head Fire Intensity
ICS	Incident Command System
IFFMS	Integrated Fire and Forest Management Strategy
ISI	Initial Spread Index
LCC	Land Cover Classification
LMU	Landscape Management Unit
MFRI	Mean Fire Return Interval
MPB	Mountain Pine Beetle
SFMS	Spatial Fire Management System
SSI	Stand Susceptibility Index
TPR	Tourism, Parks and Recreation
WUI	Wildland Urban Interface

GLOSSARY OF TERMS

Many definitions borrowed from Merrill and Alexander (2007).

Aspect Direction toward which a slope faces.

Backfiring A form of indirect attack where extensive fire is set along the inner edge of a control line or natural barrier, usually some distance from the wildfire and taking advantage of indrafts, to consume fuels in the path of the fire and thereby halt or retard the progress of the fire front.

Burning Out (Burnout) A fire suppression operation where fire is set along the inside edge of a control line or natural barrier to consume unburned fuel between the line and the fire perimeter, thereby reinforcing the existing line and speeding up the control effort. Generally limited, small-scale routine operation as opposed to backfiring.

Canadian Forest Fire Danger Rating System (CFFDRS) The national system of rating fire danger in Canada. The CFFDRS includes all guides to the evaluation of fire danger and the prediction of fire behaviour such as the Canadian Forest Fire weather Index (FWI) System and Canadian Forest Fire Behaviour Prediction (FBP) System.

Canadian Forest Fire Weather Index (FWI) System A subsystem of the Canadian Forest Fire Danger Rating System. The components of the FWI System provide numerical ratings of relative fire potential in a standard fuel type (i.e. a mature pine stand) on level terrain, based solely on consecutive observations of four fire weather elements measured daily at noon (1200 hours local standard time or 1300 hours daylight saving time) at a suitable fire weather station; the elements are dry bulb temperature, relative humidity, wind speed, and precipitation. The system provides a uniform method of rating fire danger across Canada.

Catastrophic Fire An unplanned or unwanted natural or human-caused wildland fire that exhibits extreme fire behavior and is usually associated with public safety emergencies and property and natural resource damage.

Crown Fire (Crowning) The movement of fire through the crowns of trees or shrubs more or less independently of the surface fire.

Detection The act or system of discovering and locating fires.

Dry Lightning Storm Thunderstorm in which negligible precipitation reaches the ground. Also called a dry storm. Fire ignitions are most often the results of dry lightning storms.

Fire Behavior: The manner in which a fire reacts to the influences of fuel, weather and topography.

Fire Behaviour Prediction (FBP) System: A subsystem of the Canadian Forest Fire Danger Rating System. It provides quantitative outputs of selected fire behaviour characteristics (i.e., rate of fire spread, frontal intensity) for certain major Canadian fuel types and topographic situations. The system depends partly on the Canadian Forest Fire Weather Index System (FWI) components as inputs.

Fire History The study and/or compilation of evidence (e.g., historical documents, fire reports, fire scars, tree growth rings, charcoal deposits) that records the occurrence and effects of past wildfires for an area. Fire history data is used to document the historical fire regime of a region.

Fire Regime The kind of fire activity or pattern of fires that generally characterize a given area. A number of elements define a regime, such as:

> **Fire Frequency** The average number of fires that occur per unit time (usually per year or decade) for a given region. The information often needs to be normalized for a set number of hectares so that different regions can be evenly compared.
>
> **Fire Size / Burn Area**: The range and average fire size encountered during a given period of time.
>
> **Fire Cause**: The assignment of a wildfire to a category according to the causative agent responsible for starting the fire. Fire cause classes are: lightning, recreation, resident, forest industry, other industry, railroads, incendiary, unknown and miscellaneous.
>
> **Fire Season**: The period of the year during which fires are likely to start. Information on fire frequency, cause and burn area are analyzed on a monthly basis. The fire season is also documented based on the seasonal flammability of fuel types: spring, summer and fall. The seasonal flammability assessment of fuel types falls more under the realm of fire behaviour.
>
> **Mean Fire Return Interval**: The average number of years between the occurrence of fires in a given region (point location, watershed, topographic elements).
>
> **Fire Cycle**: The number of years required to burn over an area equal to the entire area of interest. During one cycle, some areas may burn more than once, while others may not burn at all. This parameter is one of the most useful in terms of fire and forest management. The inverse of the fire cycle is equal to the yearly rate of forest disturbance (average number of ha burned each year). This value varies on both a temporal and spatial scale.
>
> **Weighted Mean Stand Age:** The average age of the forest based on the proportion of each age-class on the landscape. This parameter helps us to

understand if a forest is predominantly young, mature or old. This value is more meaningful when making comparisons between smaller regions such as watersheds or topographic elements.

Fire Type: Categories of wildfires which include: ground fire, surface fire, intermittent and active crown fires. Note that ground fires cannot be detected and are usually not part of fire history studies, and that historical surface fires cannot be mapped from aerial photography due to the light intensity of these fires.

Fire Intensity / Severity: The intensity is the rate of heat energy released per unit time per unit length of fire front. This parameter is estimated from flame size and is used to describe fire behaviour during an active fire. For a fire regime study, where historical fires are assessed, severity of fire is the most common element to be quantified. The proportion of forest crown removal and post-fire regeneration lapse time are indices from which a fire can be qualified as a low, moderate or high severity fire. Most stand replacing fires that burn for an extended period of time are mixed severity fires.

Fire Scar: An injury or wound on a tree caused by the heat of fire flames. Fire scars are visible on cross-sections and are used to date fire events. When the wood is sound enough, it is possible to determine at what period of the growing season the fire occurred. Orientation of fire scars can also tell in which direction the fire was spreading (the direction of spread is opposite to the direction from which the scar is facing).

Fire Weather Index (FWI): A numerical rating of fire intensity that combines ISI and BUI. It is suitable as a general index of fire danger throughout the forested areas of Canada. The FWI System consists of six components. The first three are fuel moisture codes that follow daily changes in the moisture contents of three classes of forest fuel; higher values represent lower moisture contents and hence greater flammability. The final three components are fire behaviour indexes representing rate of spread, amount of available fuel, and fire intensity; their values increase as fire weather severity worsens. The six standard codes and indexes of the FWI System are:

Fine Fuel Moisture Code (FFMC): A numerical rating of the moisture content of litter and other cured fine fuels. This code indicates the relative ease of ignition and flammability of fine fuel.

Duff Moisture Code (DMC): A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code indicates fuel consumption in moderate duff layers and medium-sized woody material.

Drought Code (DC): A numerical rating of the average moisture content of deep, compact, organic layers. This code indicates seasonal drought effects on forest fuels, and the amount of smouldering in deep duff layers and large logs.

Initial Spread Index (ISI): A numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on rate of spread but excludes the influence of variable quantities of fuel.
Buildup Index (BUI): A numerical rating of the total amount of fuel available for combustion that combines DMC and DC.

Fire Weather Index (FWI): A numerical rating of fire intensity that combines ISI and BUI. It is suitable as a general index of fire danger throughout the forested areas of Canada.

Fire Weather: Weather conditions that influence fire ignition, behavior and suppression.

Fuel: Combustible material. Includes vegetation, such as grass, leaves, ground litter, plants, shrubs and trees that feed a fire.

Fuel Type: An identifiable association of fuel elements of a distinctive plant species, form, size, arrangement, or other characteristics that will cause a predictable rate of fire spread or difficulty of control under specified weather conditions.

Fuelbreak: An existing barrier or change in fuel type (to one that is less flammable than that surrounding it), or a wide strip of land on which the native vegetation has been modified or cleared that act as a buffer to fire spread so that fires burning into them can be more readily controlled. Often selected or constructed to protect a high value area from fire. May serve as a control line from which to carry out suppression operations.

Large Fire: A fire burning with a size and intensity such that its behavior is determined by interaction between its own convection column and weather conditions above the surface. Alberta Fire Protection classifies large size fires as those being larger than 200 ha (Class E fires).

Patch: In the context of this study, a patch is referred to as a portion of forest of homogeneous age, which would be surrounded by forests (other patches) of different ages.

Remnant: Scattered individual trees, a clump of trees, or a patch of variable size, that did not burn during the last fire episode. Remnants are thus older aged trees than their surrounding neighbors.

Spot Fire: A fire ignited outside the perimeter of the main fire by flying sparks or embers.

Stand Replacing Fire: A high intensity fire that mainly traveled through the canopy of trees and killed over 75% of the trees in a stand.

1.0 INTRODUCTION

The Cypress Hills have a unique geological and cultural history that many Albertans only appreciate through a visit to the area, and perhaps an introduction to the outstanding local literature during their travel experience. One of the less obvious features to visitors is the pervasive historical role of wildfire that has maintained the ecological integrity of the Cypress Hills for over 10,000 years. An international wildfire historian captures the significance of the role of fire in Canadian landscapes:

Cypress Hills Provincial Park will be used in this document to refer to the provincial park found in Alberta. Any reference to Saskatchewan's park will be noted as Cypress Hills Provincial Park (Saskatchewan) or Saskatchewan's Cypress Hills Provincial Park. The Interprovincial Park will be referred to as Cypress Hills Interprovincial Park (CHIP).

> *"Fire is a defining element in Canadian land and life. With few exceptions, Canada's forests and prairies have evolved with fire. Its peoples have exploited fire and sought to protect themselves from its excesses, and since Confederation, the country has devised various institutions to connect fire and society." (Pyne 2007)*

Early in the past century, it was already recognized that the Cypress Hills region should receive special recognition in its resource management strategies. In the report of the district inspector of forest reserves for 1918 (Department of the Interior 1919), E.H. Finlayson states the following remarks:

> *"In the Cypress Hills forest reserve in southeastern Alberta, and extending into southwestern Saskatchewan, we have perhaps one of the most unique forest areas on the continent. Formerly well timbered, it also has suffered greatly as a result of fires, the last extensive fire occurring in 1886. It is important from the standpoint of timber supply, situated as it is in a country otherwise destitute of forest products; and it is of primary importance in the protection of stream-flow, being the headwaters of numerous streams which traverse the irrigated district. On this reserve it will be necessary to resort to artificial regeneration, although to a considerable extent natural restocking will be of great help in establishing the forest cover. The reserve has for many years been intensively used for timber-cutting and hay. Latterly, however, it is being patronized a very great deal for grazing. From the standpoint of technical forest management the Cypress Hills offers opportunities for scientific investigative and administration work perhaps unequalled on the continent."*

The Federal Government and the Cypress Hills Stockmen Association both recognized the importance and uniqueness of the Cypress Hills, and from 1910 to 1930 established and maintained formal grazing leases. Resource management authority was passed to the Provincial Government in 1930 through the Transfer of Resources Act and many of the modern regulations and policies reflect the early management philosophy. In 1951 the Cypress Hills Provincial Park was established and included all lands held in the original Dominion Forest Reserve; however, a master plan for Cypress Hills Provincial Park was not signed off until 1981. A Forest Management Plan was published in 1987, followed by Cypress Hills Provincial Park Management Plans in 1955, 1999, and 2000. The latter three were not signed off; however, a Draft Park Management Plan prepared in 2007 has been through public review and is expected to be approved in 2009. Although fire protection has been a priority for the Cypress Hills since 1906, a formal fire management plan was not included in previous plans. However, the new Park Management Plan clearly identified the need for an integrated fire and vegetation management strategy, which provided momentum for the current project.

This report addresses the evolution of wildfire as a historic and fundamental agent of forest and grassland renewal and evaluates the current wildfire threat to both human and ecological values. It is a contribution to connecting wildfire and society in one of the most appreciated protected areas in Canada, while facing the challenge of balancing public safety with ecological integrity on a fire prone, protected landbase. In the Cypress Hills, this balance has been recognized since the 1800s (Figure 1.1).

Figure 1.1. Aboriginal lifestyle promoted the role of fire as an agent of grassland and forest renewal.

The greater Cypress Hills landscape is predisposed to large, high and mixed intensity fires based on the observed trend in the East Slopes of Alberta where there is a similar forest age class distribution and fire history (Barrett 1996, Rogeau 2004, 2005, Rogeau and Gilbride 1994). The 1988 Yellowstone fires and the 2003 Lost Creek fire in the

Crowsnest region are the harbinger of future fire events in both the Alberta East Slopes and the Cypress Hills where a century of fire exclusion prevails.

Recent wildfire trends in North America have illustrated a significant increase in the potential for catastrophic fires based on weather anomalies and fuel load modification as a result of the lengthening of intervals between fire episodes due to fire suppression. Today's fire behavioural components (weather and fuel) are providing the environment for more intense and more severe wildfires, which are in the process of modifying fire regime conditions beyond their range of natural variability. The characteristics of fire seasons in the United States were analyzed for a 34-year period (1970-2004) and the conclusions are as follows (Tymstra, pers. comm.):

- Large size fire activity has increased significantly since the 1980s;
- Duration of large fires has increased;
- Fire seasons have lengthened by 78 days through warmer springs, longer summer dry seasons, and reduced winter precipitation followed by early snowmelt;
- The greatest increase in wildfire frequency has been in the Rocky Mountains and Foothills regions; and,
- Areas of contiguous forest fuels resulting from fire exclusion have contributed to the increase in large fires.

In Alberta, the progression of fire severity increase is illustrated in Figure 1.2, where it can be seen that the infrequent historic spikes in the 1970s and 1980s have been replaced with increased, consecutive spikes since 1998.

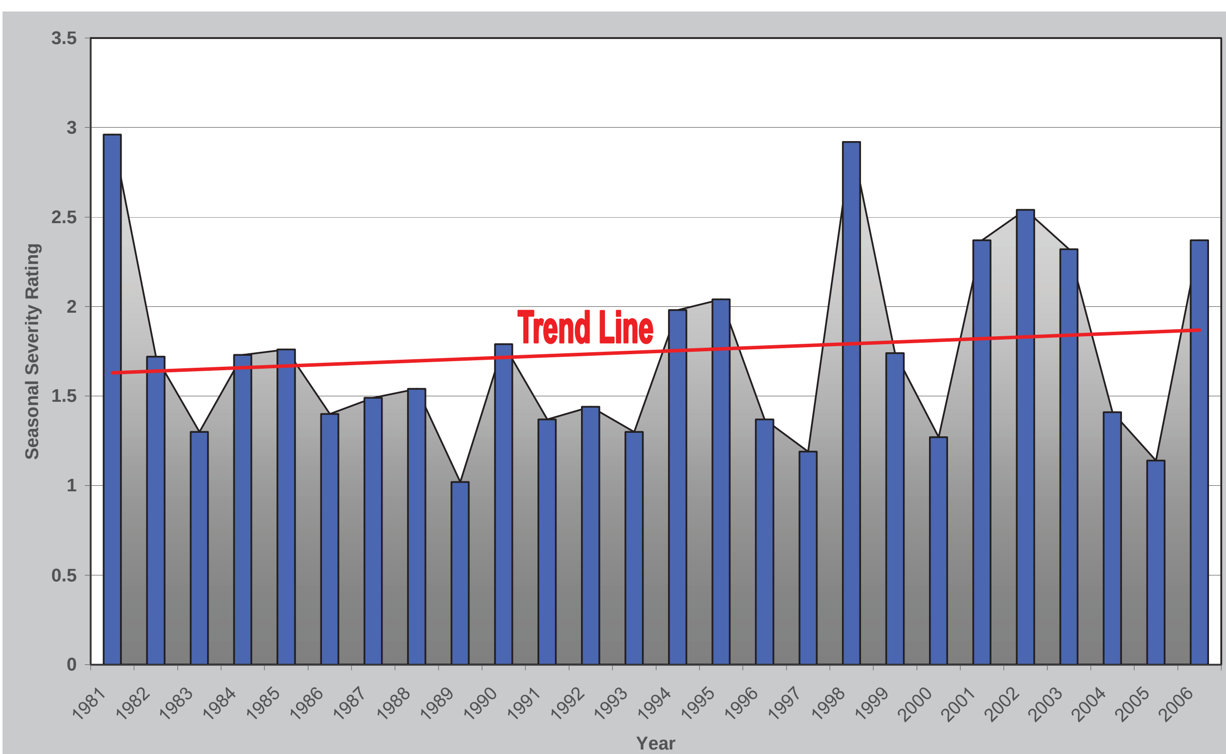


Figure 1.2. Seasonal fire severity rating in Alberta from 1980-2006.

The contents of this document include:

- **Section 2.0** describes specific values and objectives in relation to fire and forest management in Cypress Hills Interprovincial Park-Alberta;
- **Section 3.0** presents an extensive description of the biophysical setting;
- **Section 4.0** summarizes anthropogenic disturbances recorded in the park;
- **Sections 5.0**, **6.0** and **7.0** provide thorough descriptions of forest health, fire regime, fire weather and wildfire threat, respectively;
- **Section 8.0** presents the legislation and policy framework;
- **Section 9.0** provides landscape assessment and integrated management strategies based on the objectives described in Section 2.0;
- **Section 10.0** relates specifically to emergency planning and communication;
- **Section 11.0** provides conclusions and recommendations.
- Appendices include technical details on fire modelling and assessment methods.

2.0 VALUES AND OBJECTIVES

As a provincial park, Cypress Hills is subject to a set of mandated values including preservation of natural heritage and support of outdoor recreation, heritage tourism and natural heritage appreciation in ways that are compatible with environmental protection. Fire and forest management will take place in consideration of the following priorities: (1) public safety, (2) protection of infrastructure, and (3) park ecology.

The *Cypress Hills Interprovincial Park-Alberta Management Plan* (2009) identifies two primary objectives with respect to fire management in the park and two primary objectives pertaining to forests, woodlands and shrub habitats. These objectives are stated as follows:

Fire management:

1. Establish the role of fire in the park.
2. Reduce the threat of a catastrophic fire.

Forests, woodlands and shrub habitats:

1. Manage forests for ecologically and age diverse communities that are representative of the Cypress Hills environment.
2. Protect the gene pool integrity of the Cypress Hills forests.

These objectives are inherently linked. Reducing the threat of a catastrophic fire also protects forest gene pool integrity, by, for example, maintaining soil seed banks and soil organic material, and promoting tree survival and reproduction. Establishing the role of fire in the park also aids in understanding and managing for natural disturbance regimes that maintain ecologically and age diverse forest communities.

Additionally, numerous associated objectives described under other topics of the *Management Plan* must be considered in terms of fire and forest management. The protection of park ecological integrity and landscape values is critical, as well as maintaining public safety through FireSmart and forest health initiatives.

2.1 ECOLOGICAL INTEGRITY AND PROTECTION OF LANDSCAPE VALUES

Ecological integrity refers to the ability of an ecosystem to withstand or recover from natural or human disturbances while the ecological characteristics of the ecosystem (e.g., composition, structure, function and processes) are within its natural range of variability (NRV) (Parrish et al. 2003). One of the ways to protect ecological integrity is to ensure conservation of biodiversity at a community, species and genetic level.

A description of an ecological system with high ecological integrity was defined by Quigley et al. (2001):

> *A mosaic of system components that is resilient to natural disturbances, supports native and desired non-native species, consists of a well-connected mosaic of terrestrial and aquatic habitats, has ecosystem functions and processes present and operating effectively, and generally exhibits high levels of terrestrial and aquatic integrity.*

As a unique landform within the Canadian prairies, the Cypress Hills have a distinctive ecology and management history as well as a number of associated landscape values.

Cypress Hills Provincial Park contains a wide variety of habitats within a relatively small (205 km^2) area, adding considerable value to regional biodiversity. Besides providing important fescue and mixedgrass habitat on the plateau and lower slopes of the park, the Cypress Hills includes extensive and diverse forest habitats. As such, the Hills represent a forest 'island' in a sea of grassland. Many of the plant and animal communities present in the park are unique in the prairies: some species are not found in any other location in the province while others are found in the Rocky Mountains 300 km to the west. These species are referred to as relict cordilleran (montane) species and are thought to have spread eastward from the mountains after glaciation. They have survived within the Cypress Hills as the plains became too warm and dry to support montane communities. Small forest remnants similar to the Cypress Hills are found isolated throughout the Great Plains (e.g., in Montana's Sweetgrass Hills to the south), and are an important part of continental biodiversity. The Cypress Hills remain a refuge for montane species and other species and ecosystems at the edge of their natural ranges.

The viewscapes of Cypress Hills Provincial Park are another key landscape value. Points of higher elevation in the park provide views of the park's forested slopes, lakes, and the surrounding prairies. The unique location and physiography of the park also provides night sky viewing at a quality unparalleled in southern Alberta. The Cypress Hills are designated as a Dark Sky Preserve by the Royal Astronomical Society of Canada (RASC), one of few areas in the country for observing celestial bodies without interference from artificial lighting. The Cypress Hills also have considerable recreational value in terms of the natural amenities they offer (varied and scenic terrain for hiking and camping; lakes for swimming and boating; hills for skiing).

The geological history of the Cypress Hills has resulted in unique formations and sites where pre-glacial soils and bedrock can be observed. Human occupation of the area for over 8000 years has also left many archaeological and cultural sites of interest. Because of the rarity of sites showing pre-glacial development as well as sites showing extended records of continuous human occupation, the integrity of these archaeological sites should be conserved. Ranching has also been a part of the Cypress Hills culture since European occupation of the area, and continues today through formalized stock associations.

Establishing the role of fire in Cypress Hills Provincial Park is an important objective in terms of promoting ecological integrity and landscape values. Identifying appropriate fire regimes as natural disturbance processes for park forests and ecosystems can highlight areas of departure from a natural regime and aid in forest management (e.g., slowing forest encroachment, controlling insect and pathogen outbreaks, improving biodiversity, reducing fuel loading and level of fire hazard). Protecting the gene pool integrity of the Cypress Hills forests is also a primary objective supporting these values.

Objectives for protecting ecological integrity and landscape values through fire and forest management are outlined below in Table 2.1.

2.2 COMMUNITY PROTECTION / FIRESMART

A Canadian milestone of recent fire management improvements was the publication of a nationally recognized manual titled *FireSmart – Protecting your Community from Wildfire* (Partners in Protection 2003). This document was developed by Partners in Protection, an Alberta-based syndicate of fire management professionals representing national, provincial and municipal associations and government departments responsible for emergency services and forest and land-use planning. The manual introduces the three FireSmart Zones illustrated in Figure 2.1 and describes mitigations and solutions directed to community safety in fire prone environments.

Canadians generally live, work or recreate in forested areas but rarely have been affected on a personal level by wildfire. However, the economic and social impact of wildfire across Canada is accelerating, particularly in the wildland/urban interface zone. The FireSmart manual raises the awareness of the issues and has initiated many projects addressing the annual wildfire threat at the community level. The optimum investment prior to a fire event in Cypress Hills Park is an aggressive FireSmart program that addresses the Wildland Urban Interface (WUI) zone for Elkwater, as well as the isolated values at risk throughout and adjacent to the Park. Cypress Hills Provincial Park managers have implemented a Wildland Urban Interface Plan beginning with an independent study in 1997. The project in collaboration with Alberta Sustainable Resource Development experts has expanded from the Elkwater townsite to include campgrounds and other Park facilities, as well as private and lease developments within and adjacent to the Park. Objectives for community protection through fire and forest management are outlined in Table 2.2.

Table 2.1. Primary and associated objectives for ecological integrity and protection of landscape values.

<table>
<tr><th>Value</th><th>Objective</th><th>Management Plan Reference</th></tr>
<tr><td colspan="3">Primary Objective</td></tr>
<tr><td>Ecological Integrity</td><td>1. Establish the role of fire in the park.

Strategies / Actions

Develop an integrated wildfire and vegetation management plan for the park (incorporated into the CHIP Vegetation Management Strategy), including:

full sensitivity to public safety concerns and the protection of park infrastructure and adjacent property
appropriate fire regime for ecosystems (e.g., fescue grassland conservation, aspen regeneration) including frequency, seasonality and intensity. Any action taken will aim at mimicking the NDT (Natural Disturbance Type)
appropriate post-fire rest interval and reclamation procedures for any burn site, natural or prescribed
fireguards and fire access trails in strategic locations

Prescribed fires may be considered a vegetation management tool when the circumstances are appropriate (e.g., to slow forest encroachment, control insect and pathogen infestations, improve biodiversity, control invasive plants, reduce fuel load and the level of fire hazard)

prescribed fire plan developed in advance of any prescribed burn
prescribed burns will be conducted with extreme caution and using established protocol standards
ensure pre- and post-burn vegetation monitoring
recommendations for prescribed burns will be made at the park level in consultation with public and stakeholder groups

2. Protect the gene pool integrity of the Cypress Hills forests.

Strategies / Actions

Preserve the genetic integrity in the park (i.e., not introducing foreign genetics to the locally unique populations)
Encourage research on the genetic makeup of the plant and tree species in the park

assess genetically unique attributes in the park (e.g., lodgepole pine, orchids, hawthorn)

Ensure that reclamation and planting within the park utilizes seeds and seedlings that are endemic to the park

collect tree seed for genetic conservation protection and for use in forest rehabilitation programs

</td><td>2.7.6 Fire Management – Obj. 1</td></tr>
</table>

Value	Objective	*Management Plan* Reference
Associated Objectives		
Ecosystem Diversity	1. Conserve the extent, health and native biodiversity of fescue grasslands.	2.6.2 Flora – Obj. 3
	2. Maintain wildlife habitat for species of concern; protect or enhance habitat for species at risk.	2.6.2 Flora – Obj. 4
	3. Protect the integrity of riparian and wetland ecosystems.	2.6.2 Flora – Obj. 5
	4. Protect rare ecological communities and plant species of significance or special concern.	2.6.2 Flora – Obj. 6
Species Diversity	5. Protect the diversity and abundance of fauna and their habitat within the Cypress Hills.	2.5.7 Fauna – Obj. 1
	6. Create positive human wildlife interactions.	2.5.7 Fauna – Obj. 2
Visual Integrity and Aesthetics	7. Maintain and protect the natural visual integrity within the park.	2.2.4 Natural and Cultural Landscape Values – Obj. 1
Geological and Historical Value	8. Protect unique geological and geomorphological resources.	2.1.1 Geology, Landforms and Soils – Obj. 1
	9. Protect the park's cultural, historic and prehistoric resources for the purposes of scientific study and visitor education and enjoyment.	2.3.2 Cultural Heritage – Obj. 1
Recreational Opportunities	10. To provide trail-based facilities and services that complement the natural setting of the park and have an acceptable environmental impact.	5.1.5 Recreation – Obj. 11

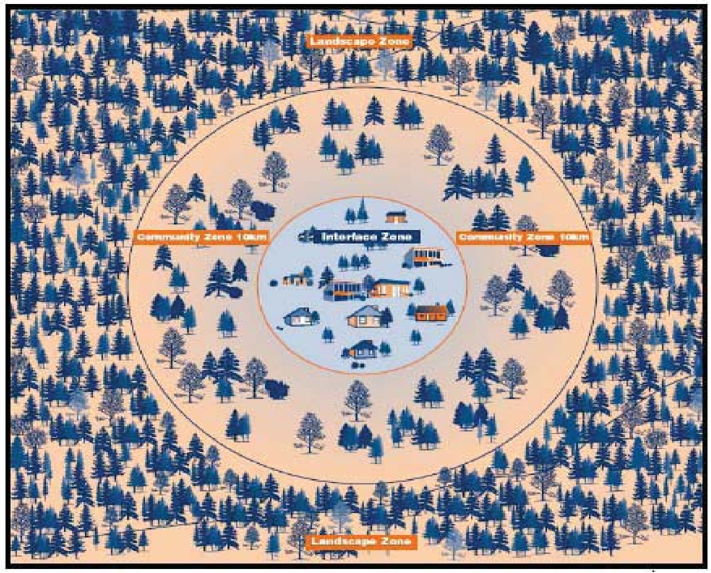


Figure 2.1. FireSmart zones as described in the FireSmart manual.

Table 2.2. Primary and associated objectives for community protection.

Value	Objective	***Management Plan* Reference**
Primary Objective		
Community Protection	1. Reduce the threat of a catastrophic fire.	2.7.6 Fire Management – Obj. 2
	Strategies / Actions	
	• Assess the need for vegetation management zones throughout the park	
	• Develop a fire protection plan for each zone in the park	
	• Ensure that the CHIP Vegetation Management Strategy takes into account fuel loading in the park	
Associated Objectives		
Community Protection	1. Reduce the threat of structural and wildfire destroying property and facilities in the park.	3.1.3 Park Facilities and Infrastructure – Obj. 6
Public Safety	2. Allow the public to experience a full range of park opportunities in a safe and enjoyable manner.	5.2.8 Public Safety – Obj. 2
	3. Ensure an emergency response plan is reviewed and updated for Cypress Hills Provincial Park.	5.2.8 Public Safety – Obj. 4

2.3 FOREST HEALTH MAINTENANCE

Forest health is a specific component of ecological integrity in Cypress Hills Provincial Park. Forest health is defined as a condition in which multiple resources and ecological values (including biodiversity) are sustained over the long term (OSU 1995). Maintaining a healthy forest requires a natural range of disturbance; a diversity of age classes and ecological niches; pest, pathogen and invasive species outbreaks contained within reasonable limits; and maintaining the quality of all forest components including air, soil, water and vegetation. Objectives for maintaining forest health through fire and forest management are outlined below (Table 2.3).

Table 2.3. Primary and associated objectives for maintaining forest health.

Value	Objective	*Management Plan* Reference
Primary Objectives		
Forest Health	1. Manage forests for ecologically and age diverse communities that are representative of the Cypress Hills environment.	2.6.2 Flora – Obj. 1
	Strategies / Actions	
	• Monitor forest health: o identify and maintain forest management practices that encourage, mimic and/or emulate natural processes o investigate environmental factors (e.g., diseases, insects) and park management activities that may be a threat • Utilize and/or develop management practices that are consistent with intergovernmental protocols • Encourage research to define the Natural Range of Variation (NRV) in the park as well as natural disturbance processes and observed forest growth patterns unique to the Cypress Hills • Promote research opportunities to help the park identify best park forest management practices • Manage for a mosaic of local ecosystem elements that is consistent with the NRV • Follow direction of CHIP Vegetation Management Strategy	
Associated Objectives		
Forest Health	1. Manage invasive species, insect and pathogen infestations according to Alberta Parks policies, legislation and Best Practices.	2.7.6 Vegetation Management – Obj.5
	2. To reclaim/restore disturbed sites to as natural a condition as possible.	2.7.6 Vegetation Management – Obj. 6
	3. Mitigate significant impacts on park watersheds through effective land and water management practices.	2.4.3 Water Resources – Obj. 4
	4. Develop an adaptive management/ research and/ or monitoring framework that positively supports park natural resource strategies and staff's abilities to enhance park natural resource qualities in Cypress Hills Provincial Park.	2.10.1 Research, Monitoring and Adaptive Management – Obj. 1

3.0 BIOPHYSICAL DESCRIPTION

Cypress Hills Provincial Park is distinct in its terrain and vegetation from the surrounding prairie. A high plateau that remained above the glaciers while the surrounding prairies were eroded during glaciation, the Cypress Hills persist now as an island of montane forest slopes and high fescue plateau above the mixed grassland. The geological history of the area has led to a unique climate and ecology.

3.1 LOCATION / ACCESS

Cypress Hills Provincial Park is located in southeastern Alberta adjacent to the Saskatchewan border, covering an area of approximately 205 km^2. The widest distance between the park's eastern and western boundaries is 30 km, while the north and south boundaries are separated by 10 km. The park is connected to Saskatchewan's Cypress Hills Provincial Park (West Block) to the east. Together, the two parks form Cypress Hills Interprovincial Park. The Canada-United States border is located approximately 75 km to the south.

The major access route into Cypress Hills Provincial Park is Highway 41 (Buffalo Trail), which crosses the park from north to south. The Trans-Canada Highway 1 provides access to Highway 41. These routes are both paved highways. A number of smaller routes offer access into the park: Highway 514, Bull Trail, Graburn Road, Eagle Butte Road and Willow Creek Road/Golf Course Road. Only one of these (Highway 514) is currently considered an all-weather road. Highway 514 (Jackpot Road) skirts the north side of the park west of Highway 41. These roads are maintained by Cypress County. Roads connecting to both the West Block and the Centre Block of Cypress Hills Provincial Park-Saskatchewan are Battle Creek Road (often called the Interprovincial Park Road), Fort Walsh Road, and Gap Road. The former two are located in the West Block, while Gap Road is located in the Regional Municipality of Maple Creek, Saskatchewan (Map 3.1).

A cottage community, the Elkwater Townsite, is situated within Cypress Hills Provincial Park. The townsite is located on Highway 41, on the southern shore of Elkwater Lake. The nearest city to the park is Medicine Hat, Alberta, located approximately 70 km from the Elkwater Townsite. The city of Calgary is approximately 375 km from the park along the Trans-Canada Highway. Smaller Alberta communities found in the area of the park include Irvine, Dunmore, Walsh and Manyberries. Wild Horse is the Canadian port of entry at the Canada-United States border. Saskatchewan communities in the vicinity of the park include Eastend and Maple Creek, located approximately 100 km from Elkwater, as well as the Centre Block of Cypress Hills Interprovincial Park and the cabin community of Loch Leven.

A significant proportion of native rangelands surround the park, especially to the south. There is also a considerable amount of high-potential agricultural land (Class 3 or better) in the park vicinity (Map 3.2).

3.2 CLIMATE

The raised plateau that represents the Cypress Hills reaches up to 600 m above the surrounding prairies, creating climatic differences between the upper and lower elevations of the park. The upper elevations of the Hills are considered to be part of the Montane Subregion, which experiences relatively mild seasons compared to other areas of the province (Natural Regions Committee 2006). Most precipitation occurs in the summer in this Natural Subregion, and there are frequent Chinook winds in the winter (Natural Regions Committee 2006). The mean annual temperature of the Montane Subregion is 2.3°C (13.9°C in the warmest month and -10°C in the coldest month; Natural Regions Committee 2006).

The lower elevations of Cypress Hills Provincial Park experience a climate more like that of the Mixedgrass Subregion. Precipitation typically peaks in June, and a moisture deficit of approximately 100 mm often occurs near the end of the growing season (Coleman 1968 in ARC 2001, Natural Regions Committee 2006). The mean annual temperature for the Mixedgrass Subregion is 4.4°C, with a mean temperature of 17.6°C in the warmest month and -10.2°C in the coldest month (Natural Regions Committee 2006). However, the Cypress Hills grasslands tend to be cooler and moister than in other areas of the Mixedgrass Subregion (Adams et al. 2005, Natural Regions Committee 2006) as a result of slightly lower evaporation rates and deeper snow accumulation.

Winds in the park are predominantly from the western quadrant and velocities commonly exceed 20 km/h during the fire season. Wind roses in Section 7.0 are provided for weather stations in both CHIP-Alberta and CHIP-Saskatchewan, and illustrate wind directions and velocities by spring, summer and fall seasons. Figure 3.1 is a summary of the fire season wind data from the CHIP-Alberta weather station for the years 1999 to 2007.

Precipitation in Cypress Hills Provincial Park is greater than in the surrounding prairies due to the orographic effect of the Hills, but is still tempered by the rain shadow of the Rocky Mountains. The average annual precipitation in the park over a twelve-year period is estimated at approximately 500-550 mm, compared to 330 mm in Medicine

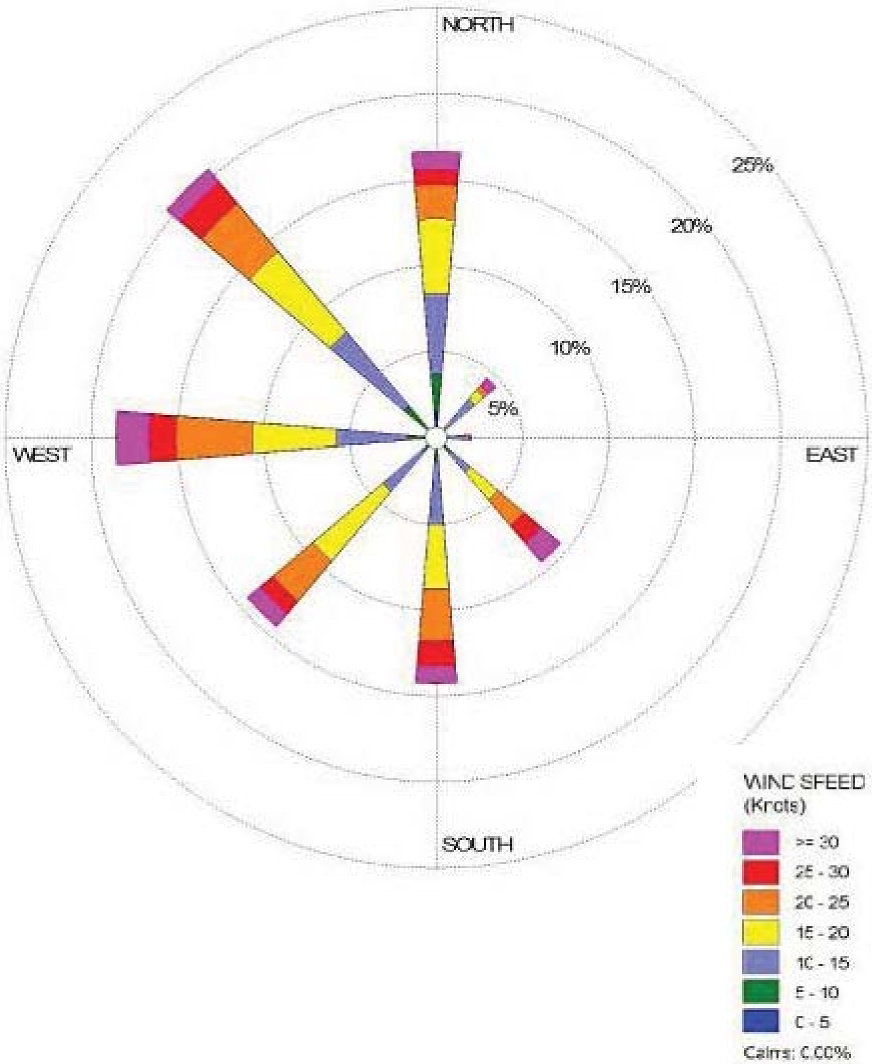


Figure 3.1. Wind speed (km/h) and direction in Cypress Hills Provincial Park through spring, summer and fall (1999-2007 Environment Canada data).

Hat (Environment Canada 2004). Summer precipitation typically comes in the form of local thunderstorms, with peaks occurring in June and September. Mean annual precipitation is higher within the Montane Subregion (589 mm/year) than within the Mixedgrass Subregion (394 mm/year; Natural Regions Committee 2006).

Historic records and environmental evidence show the occurrence of ten one-year droughts and five three-year droughts (defined as periods of precipitation in the lowest 10th and 20th percentiles) in the historical climate record between 1700 and 2000 (Sauchyn et al. 2003).

Average annual precipitation in Cypress Hills Provincial Park is 531 mm (1982-2003 average). The most precipitation typically falls in June (Figure 3.2).

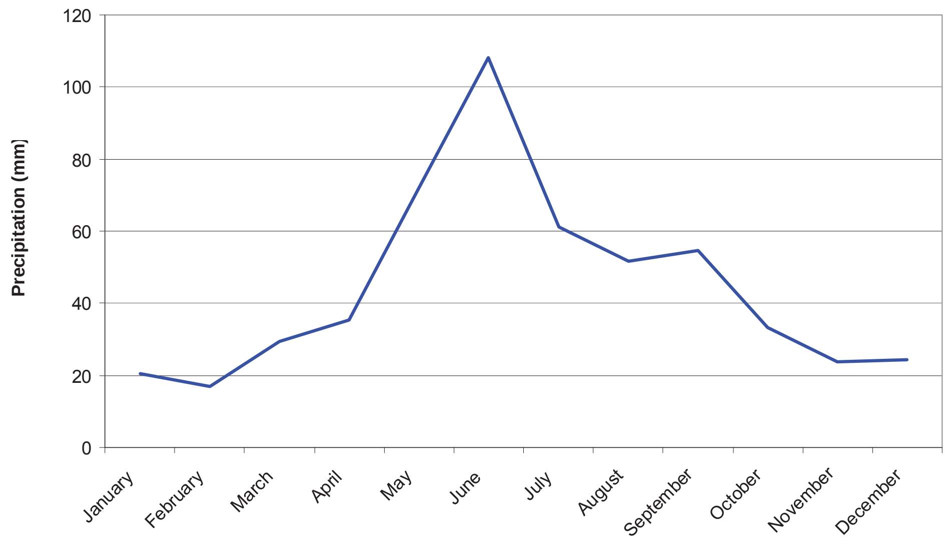


Figure 3.2. Average monthly precipitation in Cypress Hills (1982-2003).

Global Climate Models (GCMs) have been used to try to predict the effects climate change will have on the Cypress Hills. Predicted outcomes vary widely: some show small temperature increases while others show much higher summer temperatures with milder winters and less moisture. Statistically significant warming of 0.9°C has already occurred from the late 1800s to the 1980s (Lemmen et al. 1998, Henderson et al. 2002). Many models show increased incidence of extreme weather events.

In Alberta, temperatures are predicted to rise between 3-5°C from the 1961-1990 baseline by the 2050s, with minimum temperatures increasing more than the maximum. This is significant in terms of park ecosystems, as boreal forest can shift northward with an average warming of 1°C, while the southern boundary transitions into grassland (IPCC Working Group II 1996).

Moisture availability is expected to decline 100 mm by the 2020s, 210 mm by the 2050s and 320 mm by the 2080s (Henderson et al. 2002). The largest decreases in precipitation are likely to occur during the summer months, with greater moisture stress during these times.

For an island forest ecosystem, the potential rise in temperature, coupled with increased moisture stress, could mean significant risks to the forest. In this case, forest encroachment onto grasslands would no longer be the issue. This scenario also has implications for fire management in terms of increasing the length of the fire season and increasing the occurrence of severe fire weather. However, research on the potential impacts on higher elevations have not been well documented, as weather and climatic differences exist between the Hills and the surrounding prairies (Henderson et al. 2002).

3.3 NATURAL REGIONS / SUBREGIONS

Alberta's system of Natural Regions and Subregions recognizes the variety of diverse terrain across the province based on climatic and physiographic patterns, evidenced by patterns of plant communities and soil patterns (Natural Regions Committee 2006). Natural Regions and Natural Subregions are the broadest levels of ecologically-based landscape classification in the province (Table 3.1).

Table 3.1. Natural Regions and Subregions of Alberta (from Natural Regions Committee 2006).

Natural Region	Natural Subregion
Rocky Mountain	Alpine Subalpine Montane
Foothills	Upper Foothills Lower Foothills
Grassland	Dry Mixedgrass Mixedgrass Northern Fescue Foothills Fescue
Parkland	Foothills Parkland Central Parkland Peace River Parkland
Boreal Forest	Dry Mixedwood Central Mixedwood Lower Boreal Highlands Upper Boreal Highlands Athabasca Plain Peace-Athabasca Delta Northern Mixedwood Boreal Subarctic
Canadian Shield	Kazan Upland

Cypress Hills Provincial Park falls into two Natural Regions/Subregions: the Rocky Mountain Natural Region (Montane Subregion) at higher elevations and the Grasslands Natural Region (Mixedgrass Subregion) at lower elevations near the park borders. The majority of the land within the park boundary (98.9%) is in the former subregion.

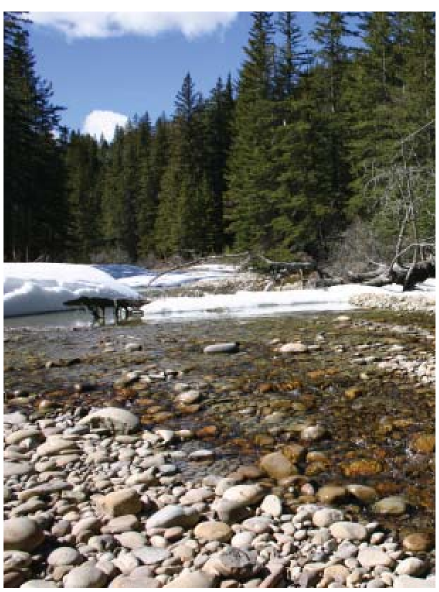
The Montane Subregion belongs to the Cordilleran Ecoclimatic Province. Summers are cool, and winters are mild due to frequent Chinook winds. Major typical soil types include black to dark gray chernozems, brunisols and luvisols. The Mixedgrass Subregion exhibits a continental climate as part of the Grassland Ecoclimatic Province. Major soils of this subregion are dark brown chernozems and wetland gleysols.

3.4 GEOLOGY / LANDFORMS

The Cypress Hills were formed by the deposition of sedimentary layers followed by differential erosion of the surrounding areas during glaciation, creating a raised landform on the plains. It is thought that the location of the Cypress Hills, mid-way between the South Saskatchewan and Milk River drainage systems, spared the area from the stronger of the erosional forces (Saskatchewan Museum of Natural History nd.). The Cypress Hills plateau is currently raised 600 m above the surrounding prairie. This upland area was never glaciated.

The highest peak of the Cypress Hills, Head of the Mountain, is located at its western end at an elevation of 1466 m. The north and the west of the plateau are marked by steep escarpments, which were formed by meltwater channels during glaciation, while gentle slopes are found to the south and east (Map 3.3). Exposures of Cypress Hills conglomerate are visible along the northern and western escarpments. Several fossils have been found within the Cypress Hills conglomerate (Saskatchewan Museum of Natural History nd.). The retreat of the glaciers also caused the deposition of debris along the northern edge of the hills, forming the present hummocky terrain (Beaty 1975). Winds from the north that occurred at this time also deposited a layer of loess sediment on the plateau above the conglomerate to a depth of 30 cm to 2.5 m in some locations.

3.5 HYDROGRAPHY



The Cypress Hills are a major regional water source in terms of both attracting a higher amount of precipitation and as a groundwater recharge zone for the region.

The Cypress Hills tend to be highly absorbent for soil moisture due to the high porosity and permeability of the Cypress Hills conglomerate. Soil moisture percolates through the hills and is released slowly through several springs along the slopes of the plateau. This process is responsible for the presence of several lush forests and vegetation communities associated with sprgins, as well as contributing to important regional groundwater resources.

Springs and seeps lead into a number of permanent, intermittent and ephemeral streams throughout the park. Spring flows are highest following snowmelt in the spring, and are also subject to drought later in the summer. All streams experienced reduced flows after June. The larger, permanent streams are found on the east side of the park and include Battle Creek, Graburn Creek and Nine Mile Creek. These streams all have large, well-incised drainages. Other creeks in the park include Willow, Storm, Ski Hill, Mitchell, Ross and McAlpine Creeks.

There are three major water bodies within the park: Elkwater Lake, Reesor Lake and Spruce Coulee Reservoir. Elkwater Lake is 231 ha in size and is the only natural lake, although water levels are currently controlled at the outlet. Reesor Lake and Spruce Coulee are smaller reservoirs of 51 ha and 21 ha, respectively. Alberta Environment maintains the dams at all three lakes. Elkwater Lake is drained to the north by Ross Creek, Reesor Lake provides storage for Battle Creek, and Spruce Coulee Reservoir is drained by McAlpine Creek (Map 3.4).

The Cypress Hills create a divide between two major Alberta watersheds: the South Saskatchewan River to the north and the Milk River to the south, which drains into the Missouri River system. Ross Creek and McAlpine Creek drain into the former system. Water allocation and licensing within the park are based on the Battle Creek, Ross Creek, MacKay, McAlpine, Boxelder, Lodge Middle and Bulls Head Basins. The primary water use within the park is domestic agriculture by local farms and ranches, and permits for Traditional Agricultural Use were issued by Alberta Environment in 1999. Permitting allows Alberta Environment and the park to inventory and plan for annual uses. Water withdrawals for agriculture occur on all three lakes, with an agricultural water co-op connected to Elkwater Lake by pipeline. Cattle stock water for use within the park is also withdrawn from creeks, ponds, sloughs, beaver ponds and dugouts. Some water sources in the park are additionally diverted for domestic, agricultural and recreational uses including water pipeline dispositions, dams and wells serving local ranches, a golf course south of the park, and other facilities. Any water development requires appropriate permits and licenses from Alberta Environment. Most surface water licenses, including the Ross Creek/Elkwater Lake basin, have been fully allocated and there are several moratoria on future water licenses in other basins of the park.

Wetlands within the park are few, although cattail and bulrush marshes exist along the lake margins. Other wetlands are present on some north-facing slopes near springs and streams. There are several intermittent ponds on the plateau with little emergent vegetation.

3.6 SOILS

Soils in the Cypress Hills are distinct from the soils in the surrounding prairie. Relict, preglacial soils known as paleosols exist in the Hills, sometimes covered by more recent soil deposits. Glacial till is found only at the edges of the Hills, while windblown loess is found over the conglomerate on the Cypress Hills plateau. There are four major soil types found in the Cypress Hills: forest soils (brunisols and luvisols), grassland soils (chernozems), wetland soils (gleysols and terric humisols) and thin regosols on steep, eroding slopes (e.g., northern escarpments) and floodplains.

In some areas of the Cypress Hills, chernozoms exist under stands of aspen, spruce and lodgepole pine. This may be due to a shifting boundary between forest and

grassland, whereby trees overtake soils formed under grassland conditions, but the soils have not yet been modified by forest processes. However, the majority of park forests are supported by orthic and dark grey luvisols on medium to finer-textured tills located in valleys and on moderately steep slopes (<30%; ARC 2001). The older forests in the park are located on grey luvisols (Map 3.5).

Slumping, the slow, downward movement of soil and rock material due to gravity, occurs in various locations across the Cypress Hills where bentonite clay and similar soil types are found. After heavy rain or snowmelt, soil layers can become saturated and unstable and give way underneath the soil layers above. The Police Point Slump is the most famous slump site, where 1.5 million m^3 of earth shifted in 1967.

3.7 VEGETATION / FLORA

Cypress Hills Provincial Park contains a diversity of vegetation representative of both the Montane and Mixedgrass Natural Subregions, with some unique species and variations present. There are over 729 species of flowering plants and 28 fern and fern ally species.

There are six major vegetation communities in the park: lodgepole pine forest; white spruce forest; aspen forest; fescue grassland; mixedgrass prairie; and wetland communities. Representative flora of the major vegetation communities are given in Table 3.2. Rough fescue communities dominate the plateau area, while forests of white spruce are found along valley bottoms and north-facing slopes. Lodgepole pine forests are located in the transitional zone between grassland and spruce forests as well as on some south-facing slopes. Aspen groves are located along the border of the pine forest on the plateau, on north-facing slopes at lower elevations, and on some protected south-facing slopes. Balsam poplar can be found near water and small stands of white birch are located east of the Elkwater Lake lowlands. Mixedgrass prairie vegetation dominates at lower elevations on park slopes (Map 3.6).

Forest cover types in Cypress Hills Provincial Park include trembling aspen, balsam poplar, lodgepole pine and white spruce. The relative areas occupied by each within the park boundary are given in Table 3.3.

The current dominant forest cover type is lodgepole pine, followed by white spruce and aspen. Balsam poplar occupies only a very small area of forest canopy cover.

The total area of forest has increased by approximately 450 ha from 1945 to 1992, with most of this increase attributed to lodgepole pine and white spruce. Forest areas where aspen and balsam poplar were dominant decreased by 50% over this time period (EcoLeaders 2004). This appears to indicate that the forest structure in the Cypress Hills is moving towards a white spruce climax community with an associated decline in aspen forests.

Table 3.2. Representative species and characteristics of the major vegetation communities in Cypress Hills Provincial Park (adapted from Saskatchewan Museum of Natural History nd., ARC 2001, Strauss 2001, EcoLeaders 2004, C. Lockerbie pers. comm.).

Vegetation Community	Representative Species	Ecological Characteristics
Lodgepole pine forest	lodgepole pine (*Pinus contorta*) pinesap (*Monotropa hypopithys*) pine drops (*Pterospora andromeda*)	open, sparse understorey
White spruce forest	white spruce (*Picea glauca*; a potential hybrid with Engelman spruce) bunchberry (*Cornus canadensis*) stiff clubmoss (*Lycopodium annotinum*)	rich understorey of mosses, grasses and herbs climax community
Aspen forest	trembling aspen (*Populus tremuloides*) balsam poplar (*Populus balsamifera*) pincherry (*Prunus pensylvanica*) northern gooseberry (*Ribes oxyacanthoides*) western Canada violet (*Viola canadensis*)	can be in pure or mixed stands often has thick understorey vegetation reproduces through suckers and seed
Fescue grassland	foothills rough fescue (*Festuca campestris*) timber oatgrass (*Danthonia intermedia*) bluebunch fescue (*Festuca idahoensis*) awned wheatgrass (*Agropyron subsecundum*) june grass (*Koeleria cristata*) silvery lupine (*Lupinus argenteus*) three-flowered avens (*Geum triflorum*) wild strawberry (*Fragaria virginiana*) northern bedstraw (*Galium boreale*) common yarrow (*Achillea millefolium*) shrubby cinquefoil (*Potentilla fruticosa*)	climax community, located on plateau
Mixedgrass prairie	western porcupine grass (*Stipa curtiseta*) spear grass (*Stipa comata*) blue grama (*Bouteloua gracilis*) june grass (*Koeleria cristata*) northern wheat grass (*Agropyron dasystachyum*) green needlegrass (*Stipa viridula*) early yellow locoweed (*Oxytropsis sericea*) golden bean (*Thermopsis rhombifolia*) wild bergamot (*Monarda fistulosa*) pasture sage (*Artemisia frigida*)	dominant grassland community on lower plateau and drier slopes
Wetlands	willow (*Salix* spp.) balsam poplar (*Populus balsamifera*) white spruce (*Picea glauca*) bog sedge (*Carex simulata*) common cattail (*Typha latifolia*) common duckweed (*Lemna minor*) common wood rush (*Luzula multiflora*) dewey sedge (*Carex deweyana*) giant bur-reed (*Sparganium eurycarpum*) great bulrush (*Scirpus acutus*) water foxtail (*Alopecurus aequalis*) water sedge (*Carex aquatilis*)	stream banks often consist of wooded vegetation with hydrophilic understorey ponds and marshes often covered by wetland sedges and grasses

Table 3.3. Vegetation composition in Cypress Hills Provincial Park.

Vegetation Cover	Area (ha)	Percent of Total Forested Area	Percent of Total Park Area
Total forest cover	11 555	100	59
Trembling aspen	2042	18	10
Balsam poplar	20	0.17	0.10
Lodgepole pine	5385	47	27
White spruce	4086	35	21
Native grassland cover	7626	-	39
Shrubs	291	-	1

Note: the other 1% land cover is made up of anthropogenic uses.

Forest heath surveys were conducted in the past decade, and it was found that 95% of sampled aspen stands were over-mature and in a state of decline or decadence. In over-mature stands of aspen and lodgepole pine, little regeneration occurs especially within stand interior. Fuel loading occurs as significant amounts of blowdown and dieback remain on the forest floor.

Several rare plants and ecological communities are found within the park, including over 16 species of orchid found in association with the moist, Montane forest.

Rare vascular plant species on the Alberta Natural Heritage Information Centre (ANHIC)'s tracking and watch lists occur in seven generalized habitats (Table 3.4; Map 3.7).

Some of these species (e.g., rockstar) depend on fire to reproduce and rejuvenate their habitat. Lodgepole pine forests and their associated species (pinesap, Douglas hawthorn) are also fire-dependent and establish readily when mineral soils are exposed in forest openings (Peterson and Peterson 1991, Bradley and Ernst 2000). Aspen reproduction is stimulated by fire by vigorous suckering, unless the fire is too intense and damages the root systems or entire canopy structure (Peterson and Peterson 1991, Strauss 2001). Shading or grazing discourages aspen regeneration (Peterson and Peterson 1991). Other species not fire-adapted are those associated with riparian areas and gravely, sparsely-vegetated ridge tops. The role of fire in maintaining hawthorn thickets and associated plant species is little known (Bradley and Ernst 2000).

Rare ecological communities of the Montane Natural Subregion of Cypress Hills Provincial Park include the Foothills fescue (*Festuca campestris*) – western porcupine grass (*Stipa curtiseta*) community and the shrubby cinquefoil (*Potentilla fruticosa*) / Foothills fescue – intermediate oatgrass (*Danthonia intermedia*) community. The latter ecological community is probably the most significant, since this is the typical vegetation type found within the plateau grasslands. The Cypress Hills plateau is the only area in the province where this community is found.

Table 3.4. Select rare species of vascular plants, general habitats and locations.

Habitat	Species	No. of Locations in Park	General Location(s)
Lodgepole pine forest	pinesap	6	plateau
	pine drops	n/a	n/a
Open woodlands / mesic meadows	rockstar	4	southeastern corner of park
	Mingan moonwort	1	eastern edge of park
Hawthorn thickets / aspen woodland	Back's sedge / Rocky Mountain sedge	1	east of Reesor Lake
	waterpod	2	east of Reesor Lake and along Battle Creek
	Douglas hawthorne	1	South of Elkwater
	smooth sweet cicely	2	east of Reesor Lake and along Battle Creek (south-facing slopes)
Riparian hydric / subhydric areas	spike redtop	4	plateau
	broad-scaled sedge	2	central plateau / Willow Creek area
	yellow monkey flower	12	associated with cobble-bed springs / streams across park
	Hooker's sedge	3	upper Battle Creek valley and near Spring Creek
	pasture sedge	2	upper Battle Creek valley
Moist depressions / drainages	hoary goosefoot	1	southwestern corner of park
	flowering quillwort	2	headwaters of Battle Creek (on plateau)
	early buttercup	7	eastern valleys (associated with gravel and cobbles)
	Eaton's aster	1	spruce forest east of Elkwater Lake
Dry gravel / cobbles / shallow soils on roads / ridgetops /	small Cryptanthe	1	southwest corner of park
	dwarf fleabane	1	east of Reesor Lake
drainages	biscuit root	12	plateau and eastern portion of park
	low yellow evening-primrose	1	Spring Creek Ranger Station / Murray Hill
	narrow-petaled stonecrop	1	Elkwater
Grazed fescue prairie	one-spike oatgrass	1	plateau

3.8 WILDLIFE / FAUNA

Due to the diversity of vegetation communities and habitats present in Cypress Hills Provincial Park, the faunal community is equally rich. Over 217 bird species, 38 mammals, five reptile and four amphibian species have been recorded in the Cypress Hills. The forest and shrub communities host many unique and relict cordilleran species, while grasslands provide habitat for several species at risk.

Of the 217 birds recorded in the Cypress Hills, the greatest number rely on wetland habitat and forest ecosystems, including forest edges and forest-shrub ecotones (Dickinson 2000). Several species rely on tall shrub habitat, while the remainder are grassland species (Dickinson 2000). Thirty-two species surveyed were montane species with disjunct populations. Rare birds found sighted in the park include great blue heron (*Ardea herodias*) and black tern (*Chlidonias nigra*) in the Spruce Coulee and Elkwater Lake marshes; brown creeper (*Certhia americana*) in mixed forest; and Sprague's pipit (*Anthus spragueii*) found on the plateau (Baresco and Reynolds 2000). There is also a unique sub-population of red cross-bill (*Loxia curvirostra*) that evolved thicker beaks in response to the thicker cones of the Cypress Hills lodgepole pine (Benkman et al. 2003). The park is also used by many migratory species on the Central Flyway.

Historically, bison, grizzly bear and grey wolf inhabited the Cypress Hills. However, many large mammals have been eliminated from the park since the late 1800s due to commercial and subsistence hunting and trapping. Until recently, there have only been two or three reports of wolf sightings. Elk (*Cervus elaphus*) and moose (*Alces alces*) have been successfully reintroduced to the park, and cougar (*Felix concolor*) appear to have established a stable population over the last five years. The most noticeable mammals in the park currently are the ungulates: moose, elk, white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemiouns*). Thirteen small mammal species on Alberta's Tracking and Watch Lists are found in the Cypress Hills, including seven species of bat, sagebrush vole (*Lagurus curtatus*), prairie shrew (*Sorex haydeni*), Richardson's ground squirrel (*Citellus richardsonii*), American badger (*Taxidea taxus*), bobcat (*Lynx rufus*) and swift fox (*Vulpes velox*; Dickinson 2000).

Reptiles and amphibians found in Cypress Hills Provincial Park include red-sided garter snake (*Thamnophis sirtalis*), bullsnake, western plains garter snake (*Thamnophis radix haydeni*), wandering garter snake, painted turtle (*Chrysemys picta*), wood frog, northern leopard frog (*Rana pipiens*), tiger salamander (*Ambystoma tigrinum*) and boreal chorus frog (*Pseudacris maculata*).

Fish are stocked in the reservoirs of Cypress Hills, including rainbow trout (*Oncorhynchus mykiss*) and eastern brook trout (*Salvelinus fontinalis*). Northern pike (*Esox lucius*) and yellow perch (*Perca flauescens*) are found in Elkwater Lake, although yellow perch were introduced in the mid-1900s. Battle Creek contains both rainbow and brook trout, and Graburn Creek contains brook trout. Several non-game species are also found in the various aquatic ecosystems (O'Neil and Patalas 1992).

The Hills also represent a biodiversity hotspot for butterflies and dragonflies: it is estimated that there are approximately 103 butterfly species in the Cypress Hills, over half the known species of Alberta and Saskatchewan. Some of these butterflies represent unique sub-species, such as Hutchin's checkerspot (*Euphydryas editha hutchinsi*) and the related species *Euphydryas bernadetta*.

There are also a wide variety of forest invertebrates found in the Cypress Hills. Insects inhabiting coniferous forests include white spotted sawyer beetle, yellow headed spruce sawfly, mountain pine beetle, spruce bark beetle, carpenter ants, adelgid galls on spruce, ambrosia beetle, turpentine beetle, lodgepole pine beetle, Ips bark beetle, spruce budworm (possibly a western and eastern hybrid), and root collar weevil, among others. Insects associated with deciduous trees in the Cypress Hills include leafminers, defoliating caterpillars, aphids, aphid galls, poplar borers and others.

Non-sensitive locations of tracked vertebrates and invertebrates are shown in Map 3.8.

3.9 HISTORICAL / CULTURAL RESOURCES

The Cypress Hills have a rich history of human use and settlement spanning over 8000 years. First Nations use of the area for intermittent camping and hunting was followed by the arrival of Europeans and the fur trade. The Métis settlement and the establishment of North West Mounted Police outposts added to the history of the area, as did the ranching of the park and surrounding lands which continues today. There are 65 historical resource sites identified to date within Cypress Hills Provincial Park.

The most famous prehistoric site within the park is the Stampede Site (DjOn-26), where centuries of use by many different native and European groups have left their marks. There are also two early North West Mounted Police Posts that represent the historic period: one on the south shore of Elkwater Lake and another on the southeast slope of Battle Creek near the Alberta-Saskatchewan border.

The Cypress Hills have a rich cultural history of ranching that continues today through the work of three stock associations (Battle Creek, Fox and Medicine Lodge), established in 1919.

3.9.1 Visual Resources

Current cultural resources include the rich park viewscapes. The park's forested hills are very rare in southeastern Alberta and they contrast dramatically with the surrounding prairie. A high level of variety is present in the landscape due to the range of soil and vegetation types, the topographic variation, and bodies of water. In some areas such as the landscape around Reesor Lake, all of these elements are present and the scenic quality is very high.

Extensive contiguous forest stands are found in some Landscape Management Units (LMUs; see Section 3.11) such as Willow Creek, while rough fescue grasslands dominate the Plateau LMU. However, a mix of forest patches with grassland is characteristic of the park's rolling hills and creek valleys. Variety and contrast are typically high in these areas, for example when two or more forest types are visible from a single viewpoint. The mix of aspen with lodgepole pine and white spruce is especially evident in the fall when the range of colours is visually appealing.

3.9.1.1 VISIBILITY OF FORESTED AREAS FROM MAJOR PAVED ROADS AND ESTABLISHED VIEWPOINTS

Areas of high visibility from major paved roads and from established viewpoints are identified in Maps 3.9 and 3.10.

East Valleys

In general these forested valleys are not visible from paved travel routes. The exception is Battle Creek Valley, the south slope of which is highly visible from Reesor Lake Road, including the established viewpoint.

Reesor Hills

The steep, southeast facing slopes north of Reesor Lake Road are visible in the foreground from the road. Visible forests are predominantly aspen, mixed with stands of white spruce.

Ross Creek Headwaters

South of the Elkwater Townsite, the north-facing ridges, forested predominantly with lodgepole pine, are visible from Murray Hill Road. The valleys have generally low or no visibility from this route. A forested valley is visible to the northwest from the established viewpoint at Horseshoe Canyon. The mixed forests between the Ski Hill and the town site are highly visible from Highway 41. Further east, in the area north of Reesor Lake Road, there is low to moderate visibility of the northwest-facing forested slopes.

Murray Hill / Willow Creek

Portions of the continuous lodgepole pine forests covering the south-facing slope are visible from Murray Hill Road. Views range from the foreground into the middleground. The view is down the slope from the road and the overall visibility is low. Aspen forests near the park's south border are also visible in the middleground.

West Fire Tower

The forested slope is not visible from paved roads, however a portion is visible from the Head of the Mountain viewpoint.

Spruce Coulee

The mixed forests of aspen, lodgepole pine and spruce on the north-facing slope south of Reesor Lake Road are highly visible from the road and the established viewpoint. The high scenic quality, prolonged and expansive view, and large number of potential viewers combine to make this one of the most visually sensitive forest areas in the park.

3.9.1.2 EXISTING SCENIC INTEGRITY

The overall level of scenic integrity or intactness of the park's valued natural landscape character is high. There are, however, some disturbances as a result of cultural influence. Various kinds of natural disturbances are also visible or are often observed from park roadsides. They include blowdown, ice and snow loading, dwarf mistletoe and canker infestations.

Major anthropogenic constructions among the natural landscapes include:

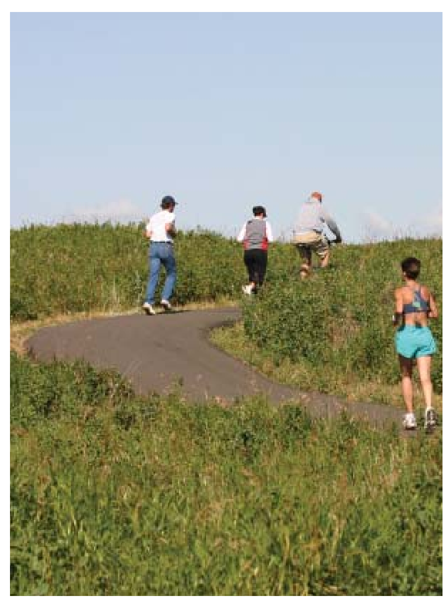
- Hidden Valley Ski Area - clearings contrast with natural forest canopy
- Elkwater Town Site

Lesser anthropogenic constructions among the natural landscapes include:

- Roads
- Campgrounds
- Control or hazard treatments along roads
- Overhead utility lines in the Elkwater Facility Zone
- Small harvesting sites on Ferguson Hill from dwarf mistletoe treatments prescribed by the 1987-92 forest management plan.
- Some historic harvesting prior to 1951 is also evident (see Section 4.1).

3.10 RECREATION

The unique topography, lakes, and forested landscapes of Cypress Hills Provincial Park are highly valued as they offer a wider diversity of opportunities compared to other parts of southern Alberta. A variety of outdoor recreation resources, facilities, and services are available in Cypress Hills Provincial Park on a year-round basis. Year-round facilities and services accommodate camping, hiking, swimming, fishing and biking in the warmer months, while fixed-roof accommodations, restaurants, a downhill ski facility, and groomed cross-country ski trails encourage visitation in the cooler months of fall and winter. The majority of facilities for more intensive recreational activities are found in the Elkwater area. The remaining park areas provide a setting for less intensive, nature-oriented outdoor recreation.



There is an extensive multi-use trail network in Cypress Hills Provincial Park that provides opportunities for hiking, mountain biking and cross-country skiing. Horseback riding is also permitted, with the issuance of a permit. The trails link the areas of Elkwater and Beaver Creek (Beaver Creek Trail System), Spring Creek (Spring Creek Trail System), Reesor Lake and Spruce Coulee (Spruce Coulee and Trans-Canada Trail System). The Trans-Canada Trail links Elkwater Townsite to the Alberta-Saskatchewan border (Map 3.11).

Water sports are permitted on all three lakes within Cypress Hill Provincial Park, with motorized watercraft restricted to Elkwater Lake. In the winter, Hidden Valley ski area is popular for its downhill skiing and snowboarding opportunities. The ski hill is located within the park on Highway 41 just south of Elkwater Lake.

3.11 LANDSCAPE MANAGEMENT UNITS

The Cypress Hills Interprovincial Park-Alberta Park Management Plan (2007) divides the park conceptually into ecologically-based landscape management units (LMUs) based on similar geology, hydrology, soils and vegetation to ensure sound ecological management of the park. There are twelve LMUs identified within the park, each with slightly different management objectives (Table 3.5; Map 3.12).

Land use zones are also applied more specifically to areas within each LMU. Land use zones in Alberta's parks and protected areas reflect the need for specific geographical areas within a park to be classified based on preservation requirements, heritage appreciation, outdoor recreation or heritage tourism activities. There are five land use zones currently applied to Cypress Hills Provincial Park.

Preservation Zone is designated in areas where the preservation of natural values and ecological processes precedes all other uses.

Natural Environment Zone permits low-density recreation, education and interpretation consistent with protection and heritage appreciation. This area can include domestic grazing as an ongoing management regime.

Historical/Cultural Zone recognizes and preserves land or features with significant historical or archaeological value, often stabilized and/ or restored.

Visitor Services and Facility Zone supports day use and overnight accommodation in provincial parks and provincial recreation areas.

Table 3.5. Landscape Management Unit descriptions and general management objectives.

Landscape Management Unit		Areas Included	General Management Objectives
LMU 1	Elkwater	Townsite, Townsite campgrounds, Elkwater Lake and wetlands	To provide facilities, services and recreational opportunities to visitors in a manner that is environmentally sound, universally accessible and that promotes park messages and good stewardship. To prepare a Townsite Development Plan that will provide a clear vision for the future and encourage sustainable urban use.
LMU 2	North Shore	grasslands to the north of Elkwater Lake	To maintain the scenic quality of the area as low-development grassland habitats. To provide access and a sense of entry to the park.

LMU 3	Ski Hill	Hidden Valley Ski Hill area	To provide intensive outdoor recreation to park visitors in a manner that exemplifies ecologically sensitive design and operations. To present park messages and interpretive opportunities as part of the Provincial Park experience.
LMU 4	West End	escarpments at the far western end of the park	To maintain the unique undeveloped scenic and ecological resources of the area and to interpret those resources to the public. To provide low-intensity, rustic recreation experiences within the park while maintaining landscape and ecological integrity with particular emphasis on protecting important wildlife habitats and viewing opportunities.
LMU 5	West Fire Tower	portion of forested slopes along the southwestern end of Murray Hill Road	To maintain wildland forest habitats without development of visitor facilities.
LMU 6	Willow Creek	forested watershed of Willow Creek and Spring Creek draining south into the Lodge-Battle Creeks Watershed from the southwest of the park	To manage for forest health and ecological integrity while maintaining year-round trail-based recreation and heritage appreciation.
LMU 7	Murray Hill	western escarpments on grassland chernozem soils along Murray Hill Road, west of Highway 41	To protect scenic quality, recreation and heritage appreciation opportunities with particular attention to the geological history of the Cypress Hills landform and the resultant variety of vegetation. To provide a scenic roadway corridor that will provide motorists with a variety of viewscapes.
LMU 8	Ross Creek Headwaters	forested watersheds of Beaver and Mitchell Creeks north of Murray Hill and south of Elkwater in the Seven Persons Creek Watershed and east as far as Bull Trail	To manage for forest health and ecological integrity while maintaining accessible trail-based recreation and appreciation of park natural and cultural heritage.
LMU 9	Plateau	upland fescue grassland plateau in the centre and southeast of the park	To sustain the health and ecological integrity of the native fescue grasslands. To ensure or enhance high scenic quality along the corridor by reducing the impact of development.
LMU 10	Spruce Coulee	Spruce Coulee Reservoir and Reesor Lake and the north slopes of the park north of Reesor Road approximately following the major watershed divide and east as far as the Reesor Hill	To provide secluded, nature-based recreation experiences while maintaining landscape and ecological integrity. To interpret the unique ecological features of the area to visitors with particular emphasis on wetlands, orchids and avian habitats.
LMU 11	Reesor Hills	northeastern slopes east of Reesor Lake	To provide low intensity recreation experiences within the park while maintaining landscape and ecological integrity with particular emphasis on protecting important wildlife habitats, geology and heritage and scenic resources.
LMU 12	East Valleys	forested watershed of Battle Creek, Storm Creek and Nine Mile Creek in the east of the park	To protect and enhance ecological and scenic integrity of park creeks, riparian areas and forests. Strictly limit all development of trails and facilities to low-impact wilderness/backcountry opportunities.

Access Zone includes major transportation routes and areas that offer access to outdoor recreation opportunities including parking lots, small picnic facilities and staging areas.

Forest management is of particular concern to the Ski Hill (LMU 3), West Fire Tower (LMU 5), Willow Creek (LMU 6), Ross Creek Headwaters (LMU 8), Spruce Coulee (LMU 10) and East Valleys (LMU 12), as forest cover extends over more than half the area of these LMUs. Elkwater (LMU 1) is also affected by forest management measures due to the concentration of people, facilities and infrastructure within this area.

The North Shore (LMU 2) is the only LMU without forest cover. Aspen and white spruce are found across all other LMUs. Lodgepole pine is located across the park except for the far western slopes (LMU 4) and Elkwater (LMU 1). Ross Creek Headwaters (LMU 8), Spruce Coulee (LMU 10) and East Valleys (LMU 12) contain the highest forest diversity, including balsam poplar among its tree cover (Figure 3.3-3.4).

IMPLICATIONS

1. Cypress Hills Provincial Parkcontains many natural and cultural values that contribute to a unique ecology in the province and a diversity of attractions for park visitors.

2. There is potential for greater severe fire weather as a result of decreased moisture in the park, which may contribute to an increased risk of catastrophic fires. Such fires have the potential for damaging park ecosystems and endangering public safety.

3. Fire-dependent ecosystems in the park, some that include rare plant species / communities, may benefit by moving towards a more natural fire regime.

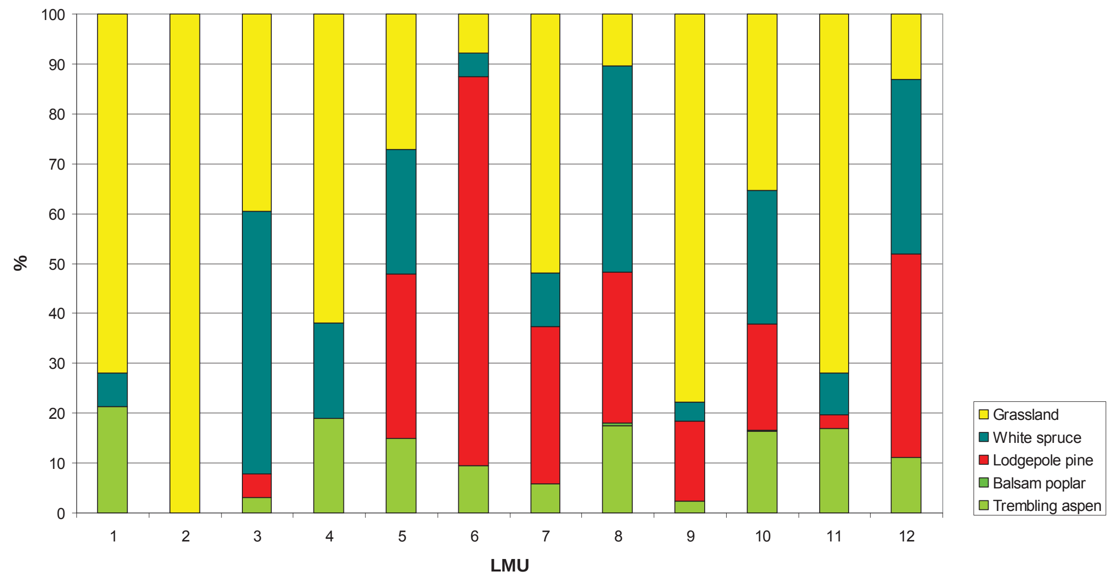


Figure 3.3. Percentage vegetation distribution by landscape management unit (LMU).

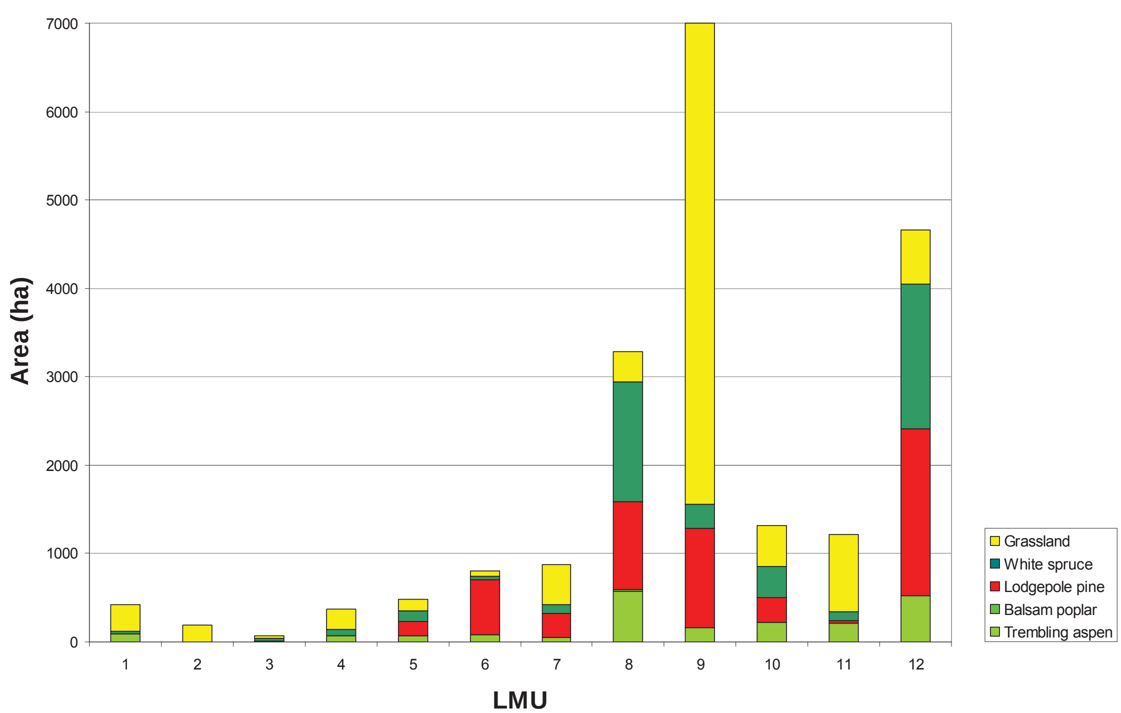


Figure 3.4. Area of vegetation distribution by landscape management unit (LMU).

4.0 EVALUATING EURO-CANADIAN INFLUENCE ON THE VEGETATION

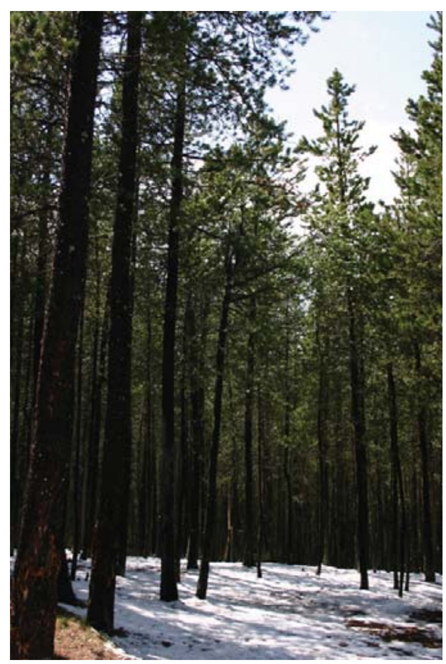
The establishment of the North-West Mounted Police post at Fort Walsh in 1874 contributed to the opening up of the Cypress Hills. Homesteads were established in and around the Cypress Hills, and agricultural activities were already taking place in the late 1870s and early 1880s. By 1916, 2319 people, distributed over 625 farms (ranches), inhabited the Hills (Scace 1972). The settlements of the Cypress Hills, as well as the establishment of the Cypress Hills Forest Reserve in 1906, which brought forest and vegetation management policies, impacted the natural grasslands and forests of the region. Below is a summary of the disturbances that were associated with anthropogenic activities. If a greater level of detail is required, it is recommended to read the thorough report produced by Scace (1972).

4.1 TIMBER CUTTING

The only source of wood for the construction of homes and farm infrastructure was found in the Hills. As a result, a large amount of timber was cut. In 1883, the first small sawmill was established, and from 1900 to 1912, the Rutherford Sawmill was in operation.

After the creation of the Dominion Forest Reserve in 1906, regulations under the Forestry Act were put in place to limit timber extraction to burnt timber or fallen timber as a result of the numerous fires from the 1880s. Cutting permits were issued by forest rangers. The Annual Forestry Reports from the Department of the Interior, between 1909 and 1930, show that at least 300 permits were issued every year, with a peak of 643 permits in 1922.

To provide an idea of the type of timber that was sought, in 1909 a timber berth was surveyed by A. Knechtel. According to Alberta stamping regulations, all timber greater than 10” in diameter at breast height (4.5’ above the ground) was marked for removal. An interesting description made by Mr. Knechtel (Department of the Interior 1911) was that the amount of debris on the ground, likely as a result of the recent fires, made travelling difficult. He reports that only 250 trees per day could be stamped, in comparison with the average of 300 to 500 trees/day that could be stamped in other regions.



Harvesting continued until 1951. Thereafter, the only timber cut was for the removal of infested trees, hazard trees, road clearing, or other park related activities. Salvage harvesting, post and pole harvesting, and thinning occurred in a variety of sites, although these are not well documented.

4.2 GRAZING AND HAYING

At first, in 1908, grazing was not allowed on forest reserves because of the fear of damaging timber production. In 1913, new grazing regulations were passed, which allowed for judicious grazing of grassland portions of forest reserves. It was recognized that cattle and horses could mimic the effect of buffalo grazing and thus, reduce the fire hazard. At first, many ranchers did not bother to apply for grazing permits so the records kept are suspected not to be representative of the actual grazing amount. Better record keeping appears to start around 1918, where anywhere from approximately 6000 to 10 000 heads of cattle and horses grazed the Cypress Hills Forest Reserves.

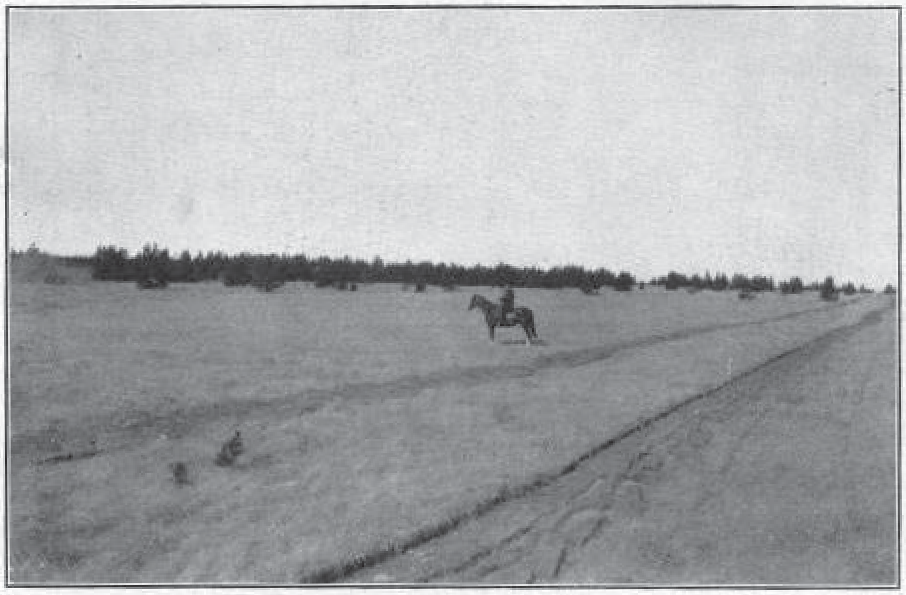
The number of permits issued for haying largely depended on the summer drought conditions in the lower lands. For example, in 1908, the hay crop on the higher elevations of the Cypress Hills, which receives more moisture, saved the situation of many ranchers that had practically no crop as a result of dry conditions (Department of the Interior 1910). Some of the annual reports from the Department of the Interior show that anywhere from 407 to 7037 tons of hay were cut in a season.

4.3 FIRE SUPPRESSION

Soon after the establishment of the forest reserve in 1906, measures were taken to reduce the fire hazard and protect this oasis of timber amid the prairies. In 1909, nine miles of a double 4' wide (i.e., 8') fire guard was ploughed along the reserve boundary. In 1911, the guard was increased to 19 miles (Figure 4.1).

The regular patrols by forest rangers (Figure 4.2), in combination with animal grazing and ploughed guards, significantly reduced the amount of burnt area on the reserved. As per the fire history by Strauss (2001), only a few spot fires were reported and other larger blazes were aggressively fought by local ranchers.

Photo by A. Knechtel, 1909



Fire Guard around Cypress Hill Forest Reserve.

Figure 4.1. Example of a ploughed fire guard around the Cypress Hills Forest Reserve in 1909.

Forest Ranger interviewing Campers, Cypress Hills Reserve Alberta.

Figure 4.2. Forest ranger patrolling the forest reserve in 1908.

IMPLICATIONS

1. Since the 1870s, Euro-Canadian influence has altered natural processes that were at work in the Cypress Hills.

2. Prolonged fire suppression has increased the fuel load and arrangement in the forested areas.

3. Fire suppression in the grasslands coupled with limited managed grazing has favoured encroachment from shrub and forested species. This increases the fuel load and augments the risk for greater fire intensities on the outskirts of forested stands. Shrub and forest encroachment is less likely to occur where grazing is actively managed.

4. Rank grass is created when grazing pressure is not evenly distributed throughout the grassland areas, thus increasing fuel and fire hazards.

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5.0 EVALUATING FOREST HEALTH

Forest health is determined by the condition of multiple resources and ecological values in the park over the long term.

Ecosystems are made up of biotic factors, such as living organisms (plants, animals, micro-organisms) that interact by way of different processes (e.g., natural disturbances, nutrient flows, food webs, succession) with the physical environment (abiotic factors). Sustaining these processes ensures that the integrity of the ecosystem is preserved (Dickinson et al. 1992).

There are many factors that shift the balance of ecosystem processes. Agents of change may include animal or insect pests, pathogens, invasive species, grazing, fire and climatic events. Wildfire and insect outbreaks are the two major disturbance factors dominating forest dynamics in Alberta. Where ecological processes are altered by these agents to the point where a critical threshold is reached, forest health may be affected.

Forest health management in the Cypress Hills focuses on maintaining ecological processes within their range of natural variability. The major agents of change in the park and their impacts on forest health are discussed.

5.1 EFFECTS OF PESTS AND PATHOGENS

A degree of pest and pathogen predation is natural and even desirable, as a removal mechanism for less vigorous trees and for creating canopy gaps which allow for species regeneration. However, if pests or pathogens reach epidemic proportions (e.g., in the case of exotic or invasive pests) there are concerns for forest health.

Forests in an over-mature condition, such as those in the Cypress Hills, are particularly susceptible to pest and pathogen predation. Susceptibility refers to the probability of attack by a pest or pathogen, while vulnerability refers to the probability that a forest stand will suffer mortality as a result of an outbreak (PMRA 2005). The main pests and pathogens of concern to park forests include mountain pine beetle, dwarf mistletoe spruce budworm, and Hypoxylon canker of aspen. Other pests and pathogens that may increase as the forest ages include spruce sawfly, spruce bark beetle, root collar weevil, cankers, and root and trunk rot.

5.1.1 Mountain Pine Beetle

Mountain pine beetle (*Dendroctenus ponderosae*; MPB) is a bark beetle native to western North America with its historical distribution reaching east to the Alberta-British Columbia border. While MPB prefer lodgepole pine, they will also use ponderosa pine, whitebark pine, limber pine, western white pine and jack pine. Mature, dense forest stands are preferred targets. The beetle is the only known vector for a blue-stain fungus that clogs tree cells and prevents water and nutrient transportation from the roots to the upper foliage of the tree ("Mountain Pine Beetle" 2003), which eventually causes tree mortality.

Natural controls on MPB outbreaks include cold temperatures, tree health and vigour, and natural predators. Prolonged cold winter temperatures are the primary control on MPB populations. Healthy trees are less attractive to MPB and can often defend themselves by producing defensive resins. Natural predators include woodpeckers and insects, such as Clerid and Cerambycid beetles, that feed on MPB larvae ("Mountain Pine Beetle" 2003). Changing climate conditions that promote survival of larvae over the winter combined with a greater proportion of mature and old-growth forests on the landscape have increased the historical distribution of MPB.

Cypress Hills Provincial Park currently monitors MPB through use of pheromone baits. The most severe years for beetle attacks were 2008 and 2006 (Table 5.1). Despite the high number of MPB attacks found in 2006, most attacks that year appeared unsuccessful as the galleries made by the beetle were short (<10 cm long). Eggs were only found on two trees with galleries between 20 and 35 cm in length. However, adult beetles appeared healthy and active during the fall in spite of cool, wet and snowy weather. Most attacks were observed along the southeast boundary of Cypress Hills Provincial Park, along Graburn, Storm and Nine Mile Creeks. Currently, there does not appear to be a MPB epidemic despite the jump in beetle attacks in 2008.

Table 5.1 Mountain pine beetle bait summary.

Data	Year								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of plots	8	54	54	23	25	18	18	18	18
Percent of bait sites with attacks (%)	21	22	7	29	7	24	29	26	33
Avg. number of attacks per plot	2.5	2.8	0.6	2.3	0.3	1.6	21.0	13.6	111.1
Total number of trees attacked		56	13	22	4	14	29	25	70

Other pine beetles that colonize pine trees in the wake of MPB include pine engraver beetles (*Ips* spp.), red turpentine beetle (*Dendroctenus valens*) and lodgepole pine beetle (*Dendroctenus murryanae*) (Forest Health Survey 2004). These beetles were observed in Cypress Hills Provincial Park during MPB monitoring.

Susceptibility to MPB according to the provincial Mountain Pine Beetle Stand Susceptibility Index (MPB SSI) is shown in Map 5.1. The SSI is a measure of a stand's capacity to produce beetles in the case that it is attacked, as well as an indicator of the potential loss in stand basal area or volume that could occur. The index determines the susceptibility of stand as a whole, and not the susceptibility of the pine itself to attack.

5.1.2 Dwarf Mistletoe

Dwarf mistletoe (*Arceuthobium americanum*) is a parasitic plant that may affect pine trees of all ages, although it tends to spread from mature overstorey trees to younger trees. Warmer winter temperatures are encouraging the spread of dwarf mistletoe, as its seed survival can be impaired by prolonged cold weather.

Dwarf mistletoe is endemic to pine forests, and is a natural part of the forest balance. There are a number of organisms that use the dwarf mistletoe as host, including species of fungi and insects (Knutson 1978). Examples include the fungi *Wallrothiella arceuthobii*, *Cylindrocarpon gillii*, and *Colletotrichum gloeosporioides* which are important in limiting the spread of dwarf mistletoe. Management typically consists of monitoring species levels and catching it before reaching epidemic problem proportions.

In a warming climate, the plant may increase in number due to higher overwintering success rates. In addition, fungi that feed on dwarf mistletoe do not grow over a temperature of 22˚C and prefer wet weather. This important feedback may warrant increased monitoring attention to dwarf mistletoe if climate change produces generally warmer climatic conditions in the Cypress Hills.

There is a link between fuel management and dwarf mistletoe, such that forest thinning and/or burn treatments reduces mistletoe severity leading to a trend in reduced spread and intensification over time (Hessburg et al. 2008).

Currently, the park is not managing dwarf mistletoe.

5.1.3 Spruce Budworm

Spruce budworm (*Choristoneura fumiferana*) is an indigenous tree defoliator that targets spruce, fir and tamarack of all ages across the province. In Alberta, its preferred host is white spruce. Loss of growth, top kill, and tree mortality as a result of defoliation are the primary damages caused by spruce budworm. While pure stands of overmature spruce are usually the source of budworm attacks, the larvae also target spruce in mixed wood stands (SRD 2002). Outbreaks tend to come in waves, lasting from 5-15 years (Fleming and Candau 1998) to 7-28 years occurring once every 20-40 years (SRD 2002). Spread of spruce budworm is facilitated by the moth life cycle stage where they can emigrate over long distances. Thus, any management strategy must take large areas into account. Migrating moths prefer to land and lay eggs on mature trees (SRD 2002). While outbreaks are natural occurrences, they may be facilitated by practices such as fire control, insect control, harvesting and reforestation (PMRA 2005).

There are four variables that control budworm outbreaks: presence of larvae or moths, presence of host trees, natural biocontrols (e.g., predatory birds, parasitoids, fungi, bacteria, viruses, protozoa), and favourable weather conditions. Vulnerability of stands to spruce budworm depends on stand age, composition, site conditions and severity of the outbreak. Old stands on poor-quality soils are the most vulnerable. White spruce is intermediate in vulnerability of tree hosts (after balsam fir), and black spruce is the least vulnerable (PMRA 2005).

Spruce budworm outbreaks are related to fuel supply and fire risk. The defoliation caused by spruce budworm opens up the forest canopy, allowing understory vegetation to proliferate. This young, green canopy effectively decreases fire spread by separating dry surface fuel from crown fuel (Stocks 1987, Fleming and Candau 1998). After an outbreak greater than five years, however, the amount of dead material that accumulates on the ground overwhelms the effect of the new vegetation and the potential for fire increases again. Greater tree mortality adds to fuel loads and leads to more frequent and intense fires. Conversely, fire suppression alters forest conditions in a way that tends to lead to higher-intensity spruce budworm outbreaks (Heppner and Turner 2006).

The response of spruce budworm activity to climate change, like that of dwarf mistletoe, may be unpredictable. However, under drier and warmer conditions, spruce budworm thrives more than many of its natural enemies (Fleming and Candau 1998). Increased host tree stress can increase mortality rates in the forest, adding to the fuel load.

In 2004, spruce budworm was identified in the spruce trees in the Elkwater Townsite while signs of budworm including silk webbing and defoliation were found in six trap locations across the park. In 2006, mild spring weather may have contributed to a large increase in infestation in the southwest of Cypress Hills Provincial Park from Elkwater east to Reesor Lake and Battle Creek and south to Storm coulee. In facility areas where spruce is dominant, spruce budworm is a major concern.

Map 5.2 shows locations of spruce budworm infestation. Approximately 1900 ha of park trees are infested, an estimated 52% of these severely infested and the other 48% heavily infested.

Most management programs in Alberta focus on detection, monitoring and, if necessary, control. Young budworm larvae can be surveyed in the fall to monitor population chances and predict the severity of defoliation for the next year. The need for control areas may also be determined. Control can take the form of silvicultural treatments (e.g., thinning to increase tree vigour).

5.1.4 Other Pests and Pathogens

Yellow-headed spruce sawfly (*Pikonema alaskensis*) is monitored in Cypress Hills Provincial Park. Infestations spread dramatically in 2001 and occurred in ornamental white spruce trees throughout Elkwater Townsite (Forest Health Survey 2002). Sawfly attacks naturally regenerating white spruce around the Elkwater Townsite and on the plateau near the Townsite. However, few serious problems have yet been recorded.

Spruce bark beetle (*Dendroctonus Rufipennis*) activity occurs in the park, but to date there are no widespread infestations.

Root collar weevil (*Hylobius radicis Buchanan*) is also monitored in Cypress Hills Provincial Park, and has been found in naturally regenerating pine stands in areas of the park. Some expansion of root collar weevil areas occurred in 2001.

Other tree diseases of mature forests include root and trunk rot. One of the main problems in aspen stands, especially in the Townsite area, is hypoxylon canker (*Hypoxylon mammatum (Wahl.) J.H. Miller*). Decay and fungal infection are also common.

5.2 INVASIVE SPECIES

Problem invasive plants (noxious weeds) in the Cypress Hills include Canada thistle (*Cirsium arvense*), ox-eye daisy (*Chrysanthemum leucanthemum*), tall buttercup (*Ranunculus acris*) and toadflax (*Linaria vulgaris*). The fescue grasslands are also seriously invaded by timothy (*Phleum pratense*) and smooth brome (*Bromus inermis*), two examples of invasive agronomics. Invasive species occur primarily along disturbed areas of the park such as roads and resource trails. In many fields, invasive non-native grasses such as Kentucky bluegrass (*Poa pratensis)* and Canada bluegrass (*Poa compressa*) are prevalent.

Invasive species tend to fare poorly in mature forests with a closed canopy and high litter buildup such as those under fire suppression policies, which effectively shade out most pioneer-type invasive plants that require high light levels and diminish likely sites for seed establishment (Keeley 2006). Seed sources for invasive plants are also reduced in dense forest environments. However, the threat of a catastrophic fire present in such a forest greatly increases the chance that the site will be re-colonized by exotic or invasive species. Where the natural fire regime has been altered, gaps created by high-intensity crown fire become sinks for alien species invasion, which change the fuel structure of the forest and also delay natural and artificial tree regeneration (Keeley et al. 2003, Brooks et al. 2004).

When forest fuel load is reduced, either through prescribed burning or mechanical thinning, physical disturbances are created that may introduce invasive species to the area (Keeley 2006). Opening the canopy and thinning the understorey also often creates ecological conditions that promote the establishment of invasive species. Post-burn grazing can increase the transport of invasive species to the disturbed area. Forest patches adjacent to open areas are more susceptible to invasive species than forests surrounded by closed canopy woods (Charbonneau and Fahrig 2004). To reduce the risk of invasive species introductions, all recommendations for implementing activities that reduce fire hazards and forest pests will include invasive species monitoring and management.

5.3 GRAZING

Grazing plays a role in forest and grassland processes, especially at the forest-grassland interface. A grazing regime has long been a part of the Cypress Hills ecosystems, including grazing by native ungulates such as elk and bison (prior to 1880). Domestic livestock grazing began with the arrival of Europeans, and by 1900 domestic cattle and horses were grazed year-round on the plateau. Currently, cattle are grazed in the park from June 1 to October 15 and are managed by three stock associations.

Cattle and ungulates such as elk all graze in the park. In late fall and winter, elk tend to graze on grasses on exposed grassland in the park, usually on south- or west-facing slopes. In summer, while cattle graze on the plateau grasslands, elk browse on forbs and sedges in the forests or near forest edges (Hull 2002). Grazing on young aspen shoots is common, and may prevent aspen regeneration. However, grazing in the park decreases the amount of fine fuels and thatch, with the potential of reducing wildfire threats. The contribution of domestic cattle grazing to reducing the cured grass flammability in the spring and fall is addressed further in Section 9.0.

Domestic grazing also occurs within some open forest stands. Grazing has the potential to impact forest health through alterations in plant composition and quality, nutrient cycling and soil quality. Overgrazing of domestic livestock may cause elimination of the palatable understorey, increase in invasive species establishment, soil compaction and exposure, reduced water infiltration, and reduced aspen regeneration (Fitzgerald and Bailey 1984, Jorgenson and Foster 2008). For managing grazing in forests and forest edges, monitoring is recommended. Jorgenson and Foster (2008) recommend focusing on key species (one to three plants) in key areas. Examples of useful key species include those that typically decrease under grazing pressure, including aspen, ricegrass, creamcoloured vetchling, peavine and saskatoon (Jorgenson and Foster 2008; Table 5.2).

5.4 EFFECTS OF FIRE ON ECOSYSTEMS

In the Cypress Hills, forest and grassland succession has evolved through centuries of low and high intensity fire events, and conversely decades of fire exclusion. Fire

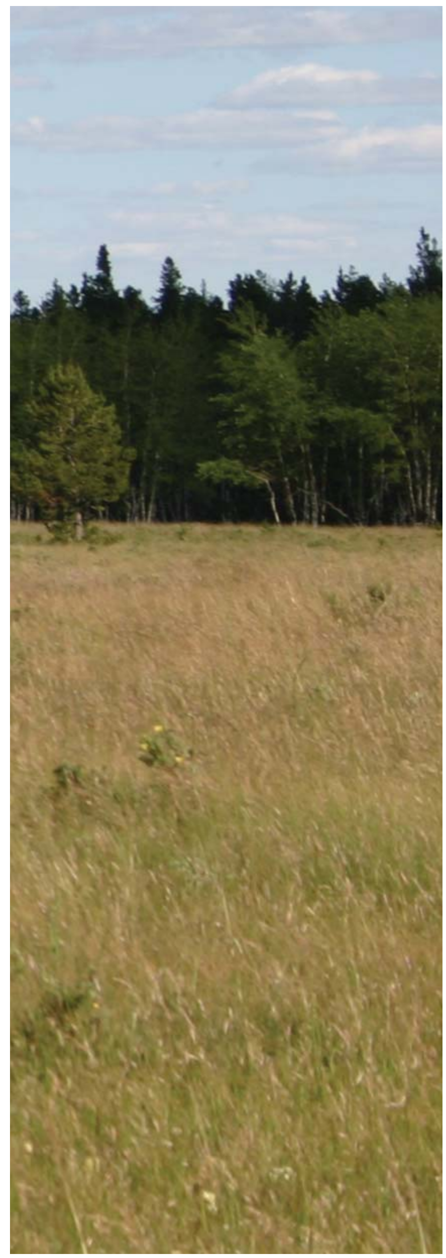
Table 5.2 Response of forest understory plants to grazing (from Jorgenson and Foster 2008).

	Decreasers	Increasers	Invaders
Grasses	fringed brome	hairy wildrye	rough hairgrass
	needlegrasses	sheep fescue	Kentucky bluegrass
	slender wheatgrass	northern ricegrass	smooth bromegrass
	awned wheatgrass		
	aspen ricegrass		
Forbs	peavine	dewberry	Canada thistle
	vetch	baneberry	sow thistle
	showy aster	bunchberry	dandelion
	sarsaparilla	pussy toes	absinthe
	fireweed	yarrow	
Shrubs	saskatoon	bearberry	
	aspen sapling	alder	
	red-osier dogwood	balsam poplar saplings	
	chokecherry	snowberry	
	hazelnut	twining honeysuckle	

exclusion has significant ecological and public safety issues, yet catastrophic wildfire events at high or extreme fire danger rating levels are unacceptable. The long term role of prescribed fire that addresses both issues is described in Section 9.0.

The impact of fire on forest ecosystems is variable, depending on the fire intensity, season, and history of previous fire at the site (BRS 2003). Other ecological factors include the seed bank or reproductive capacity of the site, the post-fire climatic conditions, and post-fire grazing, predation and other disturbances. For example, a high-intensity fire can greatly reduce / eliminate natural regeneration by destroying the seed bank and altering soil properties, leading to proliferation of non-native invasive species. On the other hand, low-intensity and patchy fire can promote the regeneration of some native species and improve habitat by creating structural diversity in the ecosystem and promoting nutrient cycling. Forest ecosystems are typically adapted to a particular fire regime (frequency, intensity, distribution and season). Section 6.0 describes the fire regime including the historic and future role of fire.

The role of fire in the Cypress Hills is also variable depending on the ecological community the fire affects. The park contains a range of communities that have different levels of fire dependency to ensure their long-term renewal. Riparian area communities tend to be fire-independent, while species that have fire-related adaptations such as the lodgepole pine and aspen, are fire-dependent communities. Plant communities that are maintained by regular fire activity are negatively impacted under a decreased fire frequency (e.g., grasslands). For example, fires limit the encroachment of shrubs and trees onto grasslands and eliminate invasive species that are not fire resistant. Due to the lack of fire, shrubby cinquefoil is becoming prominent on the plateau grasslands of the park. Fescue grasslands in the park are well adapted to spring and fall burning,



growing back quickly and showing little change in species richness, diversity, or exotic species invasion (ARC 2001).

5.5 CLIMATIC EVENTS

The small size of the park makes it susceptible to major climatic events and other external pressures. Many of the trees located in the park are at their ecological limit, but persist in the hills due to the higher elevation and moisture content.

Global climate change may also have an effect on the park forests. Southern forest boundaries can transition into grasslands with an average warming of 1°C, and predicted temperature increases range from 3-5°C by 2050 (IPCC Working Group II 1996). This is a long-term process; however, shorter term effects of climate change may be noticeable earlier. For example, it is thought that the initial effects of climate change will be to increase tree rate of growth through increased temperature and CO_2, followed by changes to disturbance regimes including fire, drought, and pests and pathogens. Summer moisture availability could also decline significantly by the 2050s, leading to moisture stress in forested environments (Henderson et al. 2002). Periods of drought have occurred in the recent history of the park.

Regional climate can also have a large impact on park ecosystems. A milder winter may increase predation by MPB and similar pests, while high winds and summer drought may increase fire risk and spread.

5.6 FOREST AND GRASSLAND SUCCESSION

Forest succession is one process that has been altered over the past century. There have been three major compositional changes in the Cypress Hills forests over the last 50 years: the successional movement towards white spruce dominance, the aging and reduction in new growth of aspen stands, and the expansion of lodgepole pine and white spruce onto the fescue grasslands (ARC 2001).

5.6.1 Dominance of White Spruce

Successional changes in forest composition have led to an increase in pine and spruce at the expense of aspen and mixedwood stands (ARC 2001). In the park, a lack of fire activity over the past century has favoured species such as white spruce, which requires undamaged seed sources to propagate, over fire-adapted lodgepole pine. The dominance of white spruce across the park and in the forest understory illustrates this shift in vegetative composition.

5.6.2 Degeneration of Aspen Stands

Aspen tends to be a climax or long-term dominant species in many western forests. Stands are often associated with a rich forb understory and have high associated biodiversity. The primary means of reproduction for aspen is by suckering from the parent root systems, which is often initiated by surface disturbances such as low-intensity fire.

Aspen decline and aspen die-off are two distinct issues that affect forest stands across western North America, and Cypress Hills is no exception. Aspen decline refers to successional changes whereby aspen grow old and are gradually replaced by other species, often conifers. Aspen die-off refers to sudden mortality of mature trees with no new sprouting occurring, indicating that the lateral roots are likely also dead. This can happen as a result of disease or pest attack, or can also occur if high-intensity fire damages subsurface roots.

Many stands of aspen across the park are in a late successional stage, with limited regeneration. The understory of many stands is dominated by white spruce, a shade-tolerant species. Advancing conifers tend to shade out aspen stands, while young regenerating shoots of aspen are often stressed by livestock and ungulate browsing. Ongoing research on aspen restoration is currently a priority across western North America. Some ecological effects of aspen takeover by spruce and other conifers include greater water usage, less undergrowth vegetation, and changes in biodiversity.

Dieback, the death of aspen roots, may be initiated by many different causes including cankers or poplar borers, or it is also hypothesized that animal browsing and a reduction in fire activity may have an impact. Typical treatments include prescribed fire or use of enclosures. However, burning followed by browsing on young shoots is detrimental to aspen growth and regeneration.

Periods of drought have been found to increase suckering. An increase in fire activity is also expected to promote aspen suckering, as long as the fire is not so intense that it harms the roots. If post-fire grazing and browsing are minimized this is expected to promote the growth of young shoots.

5.6.3 Forest Encroachment and Grassland Health

The health of the forests is also related to grassland health in Cypress Hills Provincial Park. Forest encroachment onto the fescue prairie has been the subject of recent research in the Cypress Hills and affects the overall biodiversity of the park (ARC 2001). It is estimated that approximately 450 ha of native grassland have been lost to forest encroachment in the past 50 years (ARC 2001). Although it is likely that the forest-grassland boundary has varied in the past with climatic changes, the current rate of forest encroachment appears high (ARC 2001).

There are several factors that affect the balance of competition at the forest and grassland interface:

i. reduced grazing by bison
ii. wildfire elimination
iii. increased N deposition (from fossil fuel burning in nearby cities)
iv. water availability
v. light competition
vi. presence/absence of ectomycorrhizae.

While many studies suggest that periodic fire and grazing activity curbs forest encroachment, some studies argue that grazing and fire may promote the establishment of woody vegetation by suppressing grass and creating establishment sites for shrubs. Water availability may be a better determinant variable, as grasses have a competitive advantage over trees in moisture-stressed environments. Competition in this case tends to occur primarily below-ground (Wilson 1998). There are a series of models available that explain the relationship at the grass-tree interface (Wilson 1998), but several factors may be at play in the Cypress Hills.

IMPLICATIONS

1. The uniform, mature age structure of the Cypress Hills forests increases susceptibility to pests and pathogens.

2. Any kind of fire and forest management, including passive management, can result in invasive species issues. Therefore, all management activities and wildfire events must account for the costs of monitoring and managing invasive species.

3. Effects of fire on forest ecosystems depend on many associated factors including fire intensity, season and previous fire history as well as post-fire disturbances and climatic factors.

4. Forest biodiversity and a strong genetic base promote adaptability to unpredictable climatic events.

5. Forests are in an advanced and over-mature successional stage, which has implications for forest and grassland health in the park. Monitoring and adaptive management tools are important to consider because the effects of disturbance and management options are variable.

6.0 ESTABLISHING THE HISTORIC AND FUTURE ROLE OF FIRE

Since the last glaciation the wildland fire regime of the Cypress Hills has evolved and has been shaped in response to a variety of natural factors, including traditional land use by aboriginal people. More recently however, beginning in the middle of the 1800s, many changes to the land use of the Cypress Hills occurred. Bison disappeared, the grizzly bear was extirpated, traditional land use reduced, forest harvesting was initiated, and lands were opened to settlements and cattle grazing. In the last century, both lightning and anthropogenic fires have been suppressed effectively, which has allowed for a significant aging of the forests and important fuel build-up. All in all, many variables that contributed directly or indirectly to the balance of standing and down fuel (live and dead), which in turn affect risks of fire ignition and fire behaviour, were modified. These changes altered many components of the fire regime, such as fire intensity, burn severity, fire frequency, fire size, burn patterns and the spatial distribution of fires on the land.

This Section summarizes the leading natural and anthropogenic disturbance factors that have contributed to changing the natural fire regime of the Cypress Hills. Particularly, efforts were put towards documenting today's fire regime from existing fire records for comparison with the historical, or natural, fire regime. Determining the natural fire regime is a more challenging task, as we have very limited data to draw from for that period. An attempt was made to re-create the natural fire regime through fire growth simulations using STANDOR (Rogeau et al. 1996), a custom-built computer program designed specifically to create stand origin maps, age-class distributions, and burn area outputs, which in turn allows one to calculate the fire cycle, or the annual rate of burning.

6.1 RECENT FIRE REGIME

The assessment of the recent fire regime targets a relatively short period of time between 1969 and 2007. It corresponds to the period during which the Forest Protection Branch of Alberta Sustainable Resource Development has collected fire records.

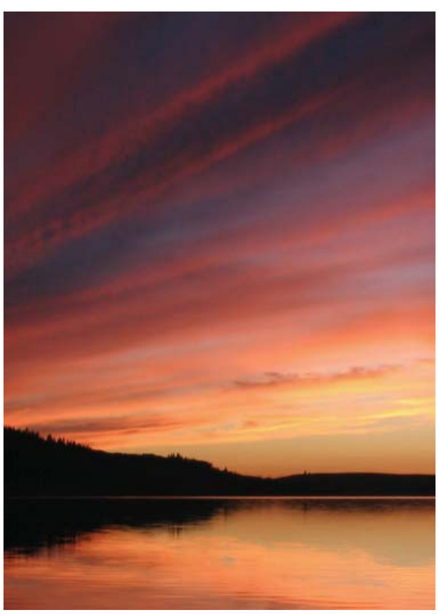
From this data set, and literature review, a number of fire regime parameters were evaluated:

- fire occurrence by year and decade
- fire cause
- fire size distribution
- burn area and fire cycle
- seasonal distribution of fires
- spatial distribution of fire by cause
- spatial distribution of lightning strikes and relationship to lightning-caused fires
- spatial probabilities of ignition from lightning
- spatial probabilities of ignition from both lightning and anthropogenic sources

Details on the analyses may be found in Appendix A. The information gained from these analyses makes it possible to understand some aspects of the natural fire regime and serve as base entry parameters for the fire growth simulation exercise found in Section 6.2.

6.1.1 Fire Frequency

Over a recent 39-year period (1969-2007) in which fire suppression was active, a total of 63 fires were recorded in the Elkwater Block of Cypress Hills. However, for the purpose of these analyses, one fire from 1991 had to be dropped from the data set due to poor recording of its location. The data show similar yearly fire frequencies over the long term (0 to 7 fires), but significant fluctuations in fire frequencies by decade. Some of these differences could be attributed to changes in policies with regards to fire suppression and / or fire recording, better fire detection tools, and differences in land use, which can contribute to additional sources of fire starts (i.e., land clearing projects, brush pile burning from stand thinning, or removal of diseased and insect infested trees).



6.1.2 Fire Cause

Within the Elkwater Block, the leading cause of fire is from anthropogenic sources. It accounts for close to 86.5% of all fire starts in the Cypress Hills. Recreational land users are the greatest source of ignition among these, accounting for 60% of all fire starts. Lightning fire account for 11.3% of fire ignitions, but can account for more than 20% of ignitions during dry and warm periods.

6.1.3 Fire Size Distribution

Unfortunately, due to fire suppression efforts, the fire occurrence database provides a biased perception of the potential for fire size or burn area on this landscape. In recent years, the two largest fires were 20 ha (1969) and 120 ha (1992), both from anthropogenic sources. The remaining fires were almost all less than 1 ha in size. The only other documented fire size was the 1934 Willow Creek fire, which totaled an area burned of approximately 607 ha.

6.1.4 Burn Area and Fire Cycle

As established in the above section, no significant burn area has taken place in the recent past. In the last 39 years, a total of 146.7 ha of land have burned in the Elkwater Block. Under this current rate of burning, which is an average of 3.76 ha/yr, it would take 3,040 years to burn an area equivalent in size to the forested area (11,432 ha). When the natural fire regime was simulated with a fire growth model (Section 6.2), a range of fire cycle values was obtained which was considerably less than 3,040 years (see Section 6.2.2.2). Departure from the natural fire cycle is addressed in Section 6.3.

6.1.5 Monthly Distribution of Fires

The assessment of fire distribution on a monthly basis for the Cypress Hills Region (combined Alberta and Saskatchewan fire records) shows the bulk of lightning-caused fires occur during the months of June and August. Despite the limited number of fires to assess, it is interesting to observe that no lightning-caused fires occurred in July. July is the second wettest month after June, and many lightning storms are followed by rain showers (personal observations by Les Weekes, park forest officer). Another interesting pattern observed by park officer Weekes is that many lightning storms occur later in the evening or overnight, at a time when relative humidity is greater. This could explain why so few lightning-caused fires are recorded within the Park area.

The Saskatchewan fire records were provided by the Ministry of Environment. The data set covers a period between 1981 and 2007. This database covers the Cypress Hills region, but does not include park fires.

Some lightning fires that occurred in May and early June likely ignited cured fuels, before the leaf-out period. August, which receives less precipitation, coupled with rising fire weather indices, would be more prone to lightning fire ignitions. While lightning storms are concentrated in the summer months, the Cypress Hills have recorded lightning-caused fires as early as April and as late as November. By comparison, anthropogenic fires can occur year round, but are most frequent in July and August.

The seasonal distribution of area burned could not be calculated due to the very few fires that have burned beyond 1 ha. The largest fire (120 ha, Saskatchewan data set) burned during the month of March, which is outside of the standard fire season period (mid-April to late September). Early season fires in this region are not necessarily uncommon, due to open grasslands that are wind blown and do not retain snow or moisture for a long period of time. Cured grasses in a wild state (ungrazed or uncut) can carry fire quite rapidly in this ecosystem.

6.1.6 Spatial Distribution of Fires

The spatial distribution of fires from anthropogenic and natural (lightning-initiated) sources for Cypress Hills is described below and detailed in Appendix A. Appendix A also describes the probability of ignition from lightning and probability of all ignitions that were modelled on the landscape.

Strictly from an ignition point of view, very high fire risk was found to prevail on the plateau and around the Elkwater community. Any ignitions on the plateau when grasslands are cured could rapidly develop into important blazes as a result of prevailing southwesterly winds, which would quickly move a grassfire into forested areas.

6.1.6.1 ANTHROPOGENIC FIRES

The most important cluster of anthropogenic fires within the Elkwater Block is along the south shore of Elkwater Lake, which corresponds to park campgrounds and facilities, and the community of Elkwater. Another focal point for fires is along Hwy 41 and the former waste landfill, which is no longer considered a threat for fire ignitions. Areas near larger lakes like the Spruce Coulee Reservoir and Reesor Lake are areas that attract recreational land users and hence show an elevated risk of fire. On the Saskatchewan side, no human-caused fires were recorded within the park boundaries, which suggest that this data set does not include West Block fires. The cluster of anthropogenic fires identified east of Highway 21 should not be a threat to the Elkwater and West Blocks of Cypress Hills. The winds during very high and extreme fire hazard conditions rarely blow from the east (<3% of the time), and the band of lakes and numerous roads should keep any fires under control coming from that direction.

6.1.6.2 LIGHTNING FIRES

The spatial distribution of anthropogenic fires is rather predictable based on the documented sources of fire origin. Lightning-caused fires are not as predictable, but are rarely distributed in a random fashion. An assessment of the spatial distribution of lightning-caused fires in relation to the distribution of lightning strikes, elevation, aspect and fuel type, was undertaken.

In the Elkwater Block region, more than half of the lightning fires started on the plateau at the headwaters of Battle, Graburn, and Nine Mile Creeks. Any ignitions in that area during an extreme fire hazard, coupled with strong dominant southwesterly winds, could move a blaze quickly into these forested watersheds and into the West Block of Cypress Hills. The other lightning fires, which were ignited along the western edge of the park along Road 514, near Reesor Lake and in the lower portion of the Battle Creek watershed, were not as concerning for loss of timber as, under the prevailing southwesterly winds, these potential blazes would have moved away from the park. Under low to moderate winds, fuel breaks such as roads and the numerous ponds in this sector, would be of great assistance to fire fighters in limiting the spread of fire.

Based on the normalized counts of fire occurrence, it can be observed that there is a tendency for fires to occur above 1400 m. The cooler and flat aspects also seem to attract more lightning fires. Lastly, although the normalized values indicate that spruce forests are just as likely to see lightning fires as grasslands, there seems to be greater chances of lightning fire starts across the plateau grasslands due to the easy ignition of dry grasses and thatch.

6.2 HISTORIC FIRE REGIME

Very little evidence is left of the natural fire regime of the Cypress Hills. Most forested stands burned in the 1880s, and salvaging of burnt timber or harvesting of live trees have been taking place since the settlement period of the 1870s, up until 1951 (Dickinson et al. 1992) (Figure 6.1). Below is a summary of what we know of historical fires and timber conditions.

Figure 6.1. Late 1880s - Alberta East Slopes.

The first Europeans to set foot in the Cypress Hills were from two separate government exploration expeditions: the 1853 American Exploring Expedition and the 1857-1859 British Exploring Expedition (Scace 1972). John Palliser, from the British expedition, had heard many reports of the wonderful timber covering these hills. However, by 1859, when Palliser explored the hills for part of July and August, what he found were sizable tracts of burnt timber, although he also reported that many valuable pines remained. The drought severity study by Sauchyn and Skinner (2001) for the Cypress Hills identified the 1850s and 1860s as a cluster of drought years. Hence, it is not surprising that Palliser contemplated a land that had recently been affected by fire.

In 1871 the first European trading post was established in the West Block, which resulted in many accidental fires by settlers while acquiring wood.

Frederick Snow, a Dominion Land Surveyor, surveyed timber in Sec.9, R.3, Tp.8, W4M on June 24, 1884. He described the area as being covered with burnt timber and windfall, but in many places with a regeneration of small pine 5 to 8 cm in diameter. The stand was so dense that it was almost impossible to set a survey line (Dickinson et al. 1992). Based on personal observations of thick, post-fire-regeneration growth following fire in a dry, montane environment, this stand would have been 15 to 25 years of age (i.e., the result of a fire dating from circa 1859 to 1869).

The Report of the Director of Forestry from 1919 (Department of the Interior 1920) mentions that the last extensive fire in the Cypress Hills occurred in 1886. However, it is believed, as per the fire frequency and archive research by Strauss (2001), that this fire was misreported as 1886 when in actual fact it occurred on October 1, 1885. Strauss (2001) reports that an excerpt from the diary of Mrs. McIllree, wife of John (Jack) McIllree, commander of the NWMP post at the time, can leave no doubt as to the exact date. This extensive burn was the result of a grass fire that started in Manyberries, Alberta (roughly 40 km away). It reached the Cypress Hills as a result of strong southwesterly winds. The fire was ignited during an extremely dry period. Precipitation records from the Maple Creek, Saskatchewan weather station indicate that the most recent rainfall, 7 mm, occurred on August 26 through 28. No precipitation was recorded in September and the next precipitation recorded, which was so low that it would not have had a significant effect on a fire of that magnitude, was 1.5 mm of rain on October 16, and then 4.8 mm of rain on October 26. No precipitation fell in November and it was not until December 7-9 that the area accumulated 9 cm of snow, which would have put the fire out for the winter. While the story goes that the entire park burned, Sauchyn (2000) reports that it affected only the western part of the Hills, and the fire history study undertaken by Strauss (2001) located relict fire scarred trees in both the Elkwater and West Blocks. One of which, a double fire scarred tree, was 249 years of age (just south of Elkwater). On that specific sampling site, the mean fire return interval was estimated at 83 years. In another location, in the Graburn watershed, a mean fire return interval of 38 years was established as a result of a number of spot fires recorded. This is an indication of the spatial variability of the fire distribution on this landscape. A 1909 photograph taken along Graburn Creek clearly shows that this portion of the forest escaped fires from the 1880s (Figure 6.2).

The fire frequency study by Strauss (2001) also reports that the North West Mounted Police recorded the worst fire ever in the Maple Creek District, which destroyed what remained of old Fort Walsh. This spring fire was ignited somewhere between the Sweetgrass Hills and the Cypress Hills.

Strauss (2001) found fire scar data in the Cypress Hills that matched documented fire events for the years of 1885, 1889, 1893, 1919 and 1934. These years also coincided with known periods of drought as reflected in the many fires recorded from fire history studies in both the mountains and foothills of southern Alberta.

Since the advent of fire suppression, which started in 1909, only two wildfires grew larger than 200 ha (Class E or 'large' size fire). Both fires were fought extensively with many hundreds of fire fighters. The 1919 Graburn Creek fire burned 434 ha, and the August 7, 1934 Willow Creek fire burned 607 ha after 9 days of burning (Figure 6.3).

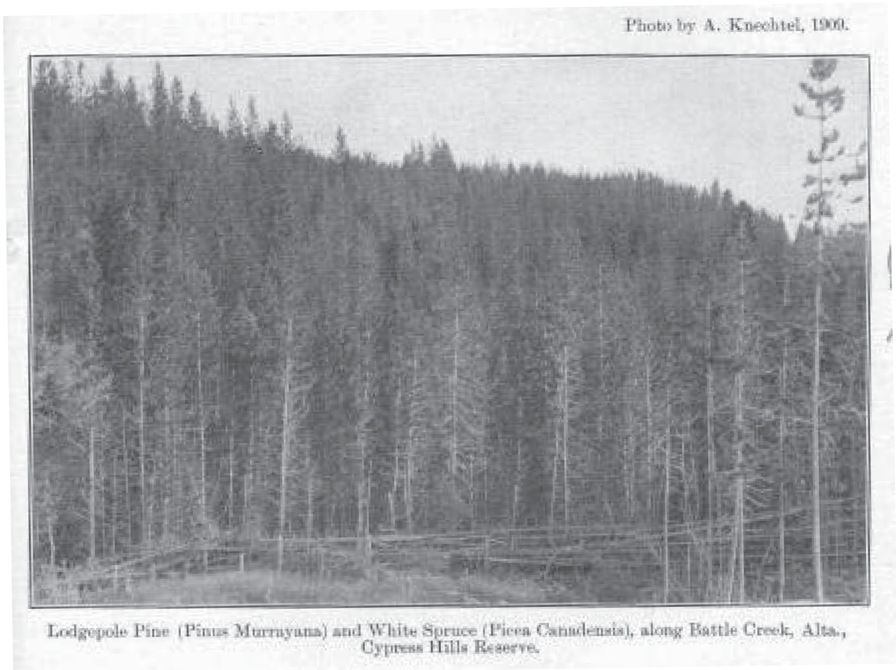


Figure 6.2. Forested stand along Battle Creek that survived the 1880s fires.

The later fire was ignited by a sawmill operation. It is believed, from evidence found on three fire-scarred trees, that a small fire burned from the grasslands into the Graburn Creek watershed in 1949 (Strauss 2001).

Figure 6.3. Smoke column from the 1934 Willow Creek fire.

The Dominion of Canada Annual Forestry Reports noted two fires in 1911, and in 1912 reported three fires on the Saskatchewan side and three fires on the Alberta side. The larger fires, which burned a total of 6370 ha of grassland, were reported in the following locations: township 8, range 24, west of the 3rd meridian; township 7, range 1, west of the 4th meridian; and township 7, range 8, west of the 4th meridian.

Some burning did occur again in 1917, but no detail was given in the forestry report (Department of the Interior 1913, 1914, 1919). Note that the annual forestry reports were normally printed two years after the reported fire season.

A study using proxy-climate data from tree rings sampled in four regions including the Cypress Hills and the Sweet Grass Hills (north-central Montana) identified a number of old growth trees. In the Cypress Hills, 114 trees were cored, the oldest tree found dating only as far back as 1843. However, cores extracted from logs of historical buildings built by early settlers in the 1870s used timber that was 200 years of age (1670s). In the Sweet Grass Hills, more precisely in the West Butte, which is within kilometres of Alberta, a 331 year old lodgepole pine, a 448 year old whitebark pine, a 401 year old jack pine and a 521 year old Douglas-fir were sampled (Sauchyn 2000). The Sweet Grass Hills are reminiscent of the Cypress Hills, but may have been less affected by settlement and their associated fires. Between the proxy-climate, fire history study, and accounts from the first explorers, it has been shown that it is possible for some trees in the Cypress Hills to reach at least 200 to 250 years of age. Withholding the effect of settlers and sawmill operations, it could be possible for the Cypress Hills to hold a small extent of older forests. Due to the narrowness and small extent of the overall forested areas in the Cypress Hills, it is very unlikely that the entire forested cover could reach an old growth stage due to frequent grassland fires that have the opportunity to ignite the forested area from all sides. Thus, it should not be the mandate of Cypress Hills Interprovincial Park to create an extensive cover of old growth forest.

The occurrence of significantly older aged forests in an environment that is fire prone due to its flash fuels and recurrent dry periods can be explained by a number of factors. The thousands of buffalo and other ungulates that roamed the grasslands would have kept the length of grasses, fescues and bushes short, as a result of grazing. The traditional land use by aboriginal people, even if nomadic, would have also kept the understory of forests clear by gathering dead woody debris for camp fires and building shelters. The well-documented use of fire by Natives would have reduced the fuel load in the grasslands, as well as in the treed areas. Frequent, low-intensity burns create open savanna types of forest in such a way that trees can survive several centuries.

Still, very little is known of the natural fire regime of the Cypress Hills. A tool that can lend support to areas with weak historical fire data is a fire growth model. The simulation of landscape fires under a hypothesized range of natural fire frequencies carried out over long periods of time can provide a vision of landscape fire patterns, spatial fire frequencies and fire cycles, and expected stand age distributions. STANDOR, a fire regime simulation model (Rogeau et al. 1996), was applied to the Cypress Hills in order to fulfill this knowledge gap. The following sub-sections describe the model, data layers used, input parameters, and output results. Appendix B describes the technical aspects in greater detail.

6.2.1 Natural Fire Regime Modelling

The stand origin modelling technique used to study fire distribution patterns over the landscape is thought to be a reasonable approach for areas with limited, or lack of, stand age information. As a general rule, fire history data has its own set of limitations which include: an insufficient amount of fire evidence due to the overlap of fires over time; life expectancy of trees sometimes being shorter than the fire return interval; poor quality of tree samples for accurate dating (rotten cores); restricted access; and the inability to sample every single stand due to the time and cost of such research. However, the greatest drawback of the stand origin mapping technique is that we are limited to a single snapshot in time, which amounts to a sample of one, of a landscape that has been shaped for thousands of years by fire. The modelling approach becomes a good complementary technique as it provides a series of stand origin maps and stand age distributions from which basic statistics (average, standard deviation, minimum and maximum) can be drawn. The strongest asset of the STANDOR model, used in this study, is its ability to keep track of the sizes of burned areas before being over-burned or partially re-burned. This feature allows managers to obtain the range of variation in fire size and to calculate the true fire cycle. Another useful feature of the model is that it allows the user to keep stand age information only for areas of interest, such as natural subregions or management subregions. In this case, the model was run regionally, but information was kept only for the Elkwater Block Region. Appendix B details the STANDOR modelling methodology and data layers used.

In summary, three components affect fire behaviour: topography, fuel and weather. The simulated fires were spread across the landscape using a digital elevation model, which was draped with a vegetation layer produced from the Alberta Vegetation Inventory data. Actual fire weather data was used for real-time fire growth modelling. Due to the relevance of fuel type when addressing fire behaviour potential, and planning forest and fire management strategies, a description of the fuel types is presented in Section 7.2. Fire weather is also an important variable that was analysed and presented in its own Section (7.1), outside of the fire simulation context.

6.2.2 Fire Simulation Outputs

The STANDOR model uses formulas from the CFFBS to calculate the rate of fire spread based on a combination of fuel type, slope, wind speed, FFMC (Fine Fuel Moisture Code) and BUI (Build-Up Index).

The fire growth model was tested and calibrated for the Elkwater Block by repeatedly running the model for several decades and / or centuries, until a satisfactory range of age-classes and mean-fire-return-intervals were obtained. Satisfaction was met when the range of age-classes included forests older than 200 years of age, and when the model could produce similar fire-return-intervals as those indicated in the fire history study by Strauss (2001).

Once the calibration and model testing was completed, 5 iterations of 1000 years were run. The time step was set to 5 years and the landscape was not allowed to re-burn during the 5 year interval. To summarize what is detailed in Appendix A, the green-up period was set from June 1 until August 31, and fires were run with BUI values above 60 and above 90 during the spring/fall and summer periods, respectively. The ratio of spring + fall to summer fires was 56% to 44%. Lastly, the fire frequency was set to range from 0 to 4 fires within the 5 year time-step. This fire frequency is very similar to today's, and it was the only frequency in a stand replacing fire regime that could produce stands over 200 years old. Based on historical accounts and findings from studies by both Strauss (2001) and Sauchyn (2000), the Cypress Hills should be able to maintain some older forest stands. Historically, it is quite possible that a greater fire frequency occurred, but with lower fire severity as a result of the reduced fuel load from a combination of repeated burning, grazing, and the collection of down woody debris by land users. Under this scenario, old trees in a savanna type forest can also be sustained.

There are two spatial outputs from STANDOR: a stand origin map and a fire count map (how many times a pixel burned in 1000 years). The fire count map is useful to assess the mean-fire-return-interval (MFRI), and how it varies spatially. It is simply calculated by dividing 1000 by the fire count. As a general rule, the MFRI is shortest where probabilities of ignition are the greatest. Another output of STANDOR are tables that list the age-class distribution from each stand origin map, and individual fire sizes before being overlapped by subsequent burns. The fire size list is used to determine the natural range of variation in fire size, and to sum-up burn areas until they equal the total forested land base, which equals the fire cycle. The spatial distribution of fire is presented in Section 6.2.2.1 while output statistics on fire cycles, MFRIs, fire size distribution and age-class distribution, are presented in subsequent Subsections.

6.2.2.1 SPATIAL FIRE DISTRIBUTION

In this sub-section, a mean stand origin map and a mean fire count map (average of all simulated maps) are presented for the Elkwater Block. While the maps target only the area of interest, fire growth actually took place on a landscape that included the West Block, and was larger by about 10 km along all sides. This allowed for external fires to burn into the study area. The process consisted of an unlimited number of ignitions that were distributed using the probability of ignition map. The program then kept track of the number of ignitions within the Elkwater Block, as well as fires spreading into the Block from the outside. Burn areas were recorded only for the land within Elkwater Block, while the age-class distribution was extracted by cropping out the stand origin information for the targeted area.

While interpreting the spatial distribution of age-classes over the landscape, it is important to be aware of certain model limitations. First, the grasslands were set at 100% curing and there are no modifications to the model that can be made to reflect the effects of grazing. This means that the rate of fire spread in grasslands was in many cases greater than what would have been expected historically when large herds of buffalo were roaming the area. Second, deciduous fuel types are consistently older because during the leaf-out period, the rate of fire spread is severely reduced and the fire will simply stop burning if the rate of spread becomes less than 1 m/min. Third, STANDOR does not have a spotting function. This means that any areas of non-vegetation, as small as it might be (e.g., a pond), created a fire barrier that would stop fire spread in that direction. Last, despite the fact that STANDOR is meant to simulate stand replacing fires, common fire knowledge indicates that the shorter the fire interval, the less time there is for fuel to build-up, and the less severe fires become. Hence, regions under shorter fire return intervals are expected to reflect a mixed severity fire regime where several patches of trees or scattered individuals, would survive. This type of burning maintains open savanna-type forests.

Figure 6.4 displays the mean-fire-return-interval map as a result of 5000 years of burning, and Figures 6.5a-c provide examples of stand origin maps at the end of 1000 years of simulation. A stand origin map is a snapshot in time of the spatial age-class distribution. While the fire regime may not have changed, it can display drastic differences in the age-class distribution depending on the timing of the ‘picture’ taken. If it follows a severe drought, much younger forests will prevail (Figure 6.5a), but if it follows a period of cooler weather or a slightly diminished fire frequency, larger amounts of older aged forests can be maintained. Figure 6.5c is likely reminiscent of what the Palliser expedition observed in the Cypress Hills in 1857-59. It must be said that wide variations in age-class distribution were observed from one stand origin map to the other. This is due to the nature of the study area that is quite small in comparison to the size of some of the fires. The Cypress Hills are also dominated by two distinct fire regimes: a frequent, low intensity burning in the grasslands, which encircles a less frequent, mixed to full intensity burning regime in the forested area.

Fire frequency patterns are normally the result of the probability of ignition and probability of burning maps; however, on this landscape, it is the fuel type that largely dictated the frequency of burning, coupled with the proximity to larger lakes, which are fire spread inhibitors. Zones of shorter fire return intervals are clearly associated with grasslands. The MFRI seems to increase almost linearly as one moves from the grasslands into the forest. The longest fire intervals were found in deciduous forests as a result of the limited burning during the summer months. In reality, it is likely that the fire frequency in aspen stands would be greater, but would be comprised of more low to mixed severity burning during the spring and fall season when the grass is cured and the leaves are off. The differential burning activity associated with the fuel types is the result of the different fire spread equations that were developed for crown fires (stand replacing fires) as part of the Canadian Fire Danger Rating System. Unfortunately, the computer model cannot capture this nuance of understory or partial canopy burning.

6.2.2.2 FIRE CYCLE

The simulated fire cycles represent the number of 5-year periods it took to burn an area equivalent to the size of the vegetated portion of the Elkwater Block, which is 20,812 ha. During a total simulation period of 5,000 years, the fire cycle was reached 123 times. Table 6.1 shows that the mean fire cycle is 39 years, but that it can vary widely due to the small size of the area in relation to the size of some of the larger blazes. Under this fire cycle, historically an average of 534 ha would have burned on a yearly basis, either in grasslands or in forested areas. This is the closest approximation to a simulated 'natural' fire regime.

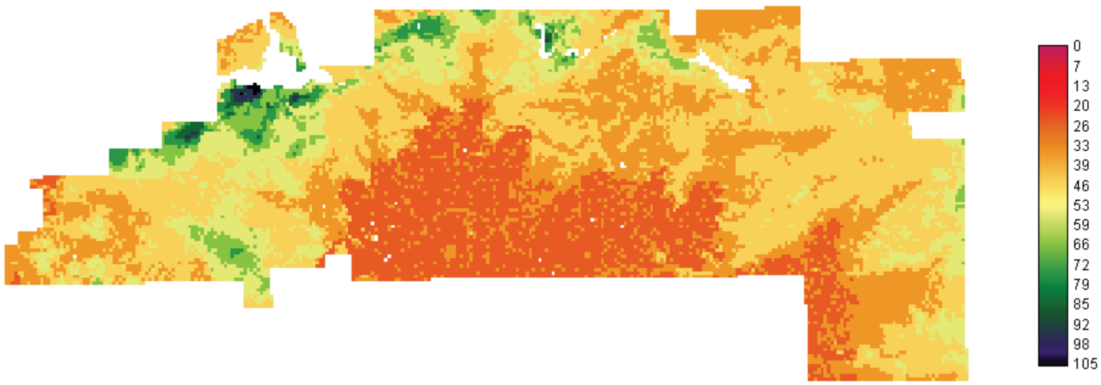


Figure 6.4. Simulated Mean-Fire-Return-Intervals. Elkwater Block, Cypress Hills, AB.

Table 6.1. Fire cycle statistics from the simulation of a natural fire regime in the Cypress Hills of Alberta.

Fire Cycle Statistics	Elkwater Block
Vegetated area (ha)	20 812
Minimum fire cycle (yr)	10
Maximum fire cycle (yr)	110
Mean fire cycle (yr)	39 ± 20
20th percentile (yr)	22
80th percentile (yr)	55
Average annual burn area (ha)	533.64
Average forest disturbance rate/yr	2.56%

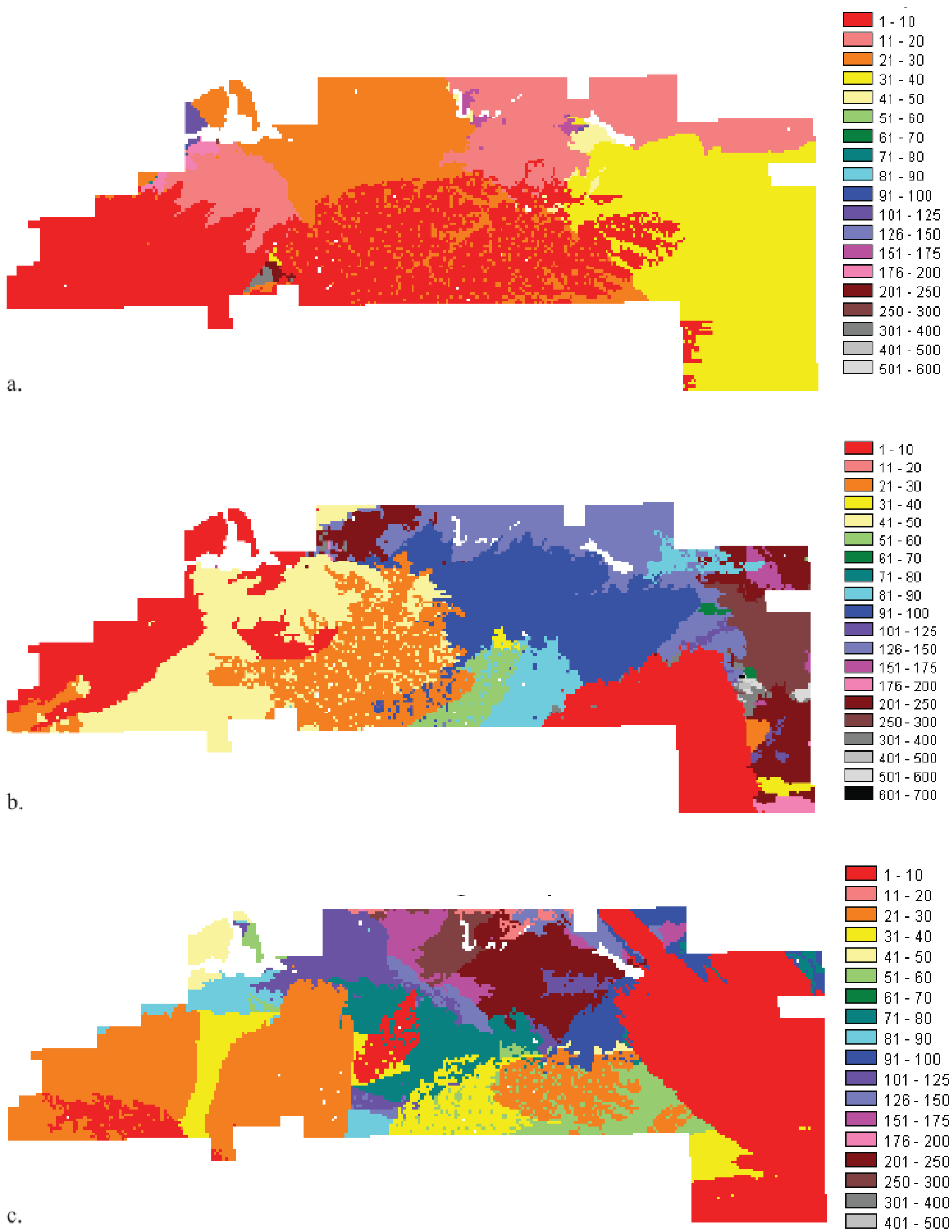


Figure 6.5. Simulated stand origin maps. Elkwater Block, Cypress Hills, AB.

6.2.2.3 MEAN FIRE RETURN INTERVAL

The spatial distribution of MFRI values, as shown in Figure 6.3, appeared to be closely associated with fuel type. Table 6.2 presents the area distribution of the range of MFRI encountered in each fuel type. In theory, under a homogeneous fire regime and with probabilities of burning being relatively similar across the landscape, the weighted MFRI should be fairly similar to the weighted mean age, as well as the mean fire cycle. In this case, the average of the weighted MFRI from all fuel types is 43 years, which is close to the 39 year mean fire cycle that was calculated for the entire landscape.

Table 6.2. Percent area distribution by Mean Fire Return Interval (MFRI) for each fuel type found in the Elkwater Block.

Frequency*	MFRI	C1	C2	C3	C7	D1	M1	O1a
48	21	0.00	0.00	0.00	0.00	0.00	0.00	1.12
45	22	0.00	0.16	0.13	0.00	0.00	0.00	3.37
43	23	0.20	0.66	0.15	18.18	0.00	0.00	7.09
42	24	3.36	0.16	0.49	0.00	0.00	0.00	7.67
40	25	0.20	0.08	0.19	0.00	0.00	0.00	3.13
38	26	0.40	0.21	0.58	0.00	0.07	0.00	4.72
37	27	1.19	0.16	0.19	0.00	0.20	0.00	2.13
36	28	1.19	0.04	0.26	0.00	0.17	0.75	2.08
34	29	1.38	0.54	0.68	9.09	0.66	1.50	4.69
33	30	0.59	0.25	0.30	0.00	0.30	0.00	3.25
32	31	0.59	0.58	0.55	18.18	0.20	0.00	2.76
31	32	0.79	0.74	0.90	0.00	0.50	1.50	3.40
30	33	2.17	0.95	0.73	18.18	0.76	1.50	3.66
29	34	0.99	2.22	1.13	9.09	0.80	0.75	3.48
28	36	2.37	2.22	1.60	0.00	1.43	3.76	4.28
27	37	4.15	3.50	3.03	0.00	1.46	3.76	5.86
26	38	4.94	4.74	4.98	0.00	1.82	3.01	7.06
25	40	6.32	5.56	6.13	9.09	3.35	7.52	6.80
24	42	8.50	9.35	7.47	9.09	5.54	11.28	5.98
23	43	11.86	13.51	10.59	0.00	7.13	10.53	5.30
22	45	13.83	11.74	12.26	9.09	8.82	15.04	3.40
21	48	13.24	9.81	10.49	0.00	10.58	9.02	2.56
20	50	8.10	11.66	10.87	0.00	10.31	6.02	1.78
19	53	3.56	8.74	10.40	0.00	9.45	5.26	1.29
18	56	2.37	5.52	6.54	0.00	8.82	12.03	0.94
17	59	1.38	2.97	4.32	0.00	7.13	3.76	0.62
16	62	2.17	1.94	3.20	0.00	5.74	2.26	0.51
15	67	2.96	1.40	1.41	0.00	5.21	0.75	0.47
14	71	0.59	0.33	0.30	0.00	4.54	0.00	0.26
13	77	0.59	0.25	0.08	0.00	2.39	0.00	0.18
12	83	0.00	0.00	0.06	0.00	1.59	0.00	0.10
11	91	0.00	0.00	0.00	0.00	0.46	0.00	0.03
10	100	0.00	0.00	0.00	0.00	0.43	0.00	0.03
9	111	0.00	0.00	0.00	0.00	0.13	0.00	0.00
8	125	0.00	0.00	0.00	0.00	0.03	0.00	0.00
6	167	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wgt MFRI	44.06	45.79	46.56	33.09	52.44	45.79	34.51

* Number of times a 1 ha pixel burned over a 1000 year period.

6.2.2.4 FIRE SIZE

All fires that burned during the 5000 year period of fire simulations were recorded in a file. Due to the small size of the study area, many fires were cropped at the boundary of the Elkwater Block. Many fires were in fact much larger than the largest recorded fire in the file. This important data set of 2001 fires provides ample information to derive reliable fire size distribution statistics (Table 6.3).

Table 6.3. Fire size distribution statistics from a simluated natural fire regime in the Elkwater Block of Cypress Hills, AB.

Size Class (ha)	Frequency	% Frequency
<1	35	1.75
2 to 10	188	9.40
11 to 100	456	22.79
101 to 200	187	9.35
201 to 500	280	13.99
501 to 1000	193	9.65
1001 to 2000	244	12.19
2001 to 5000	263	13.14
5001 to 10 0000	131	6.55
>10 000	24	1.20
Fire Size Statistics		
Minimum	1	
Maximum	15 439	
Average	1308	
Standard deviation	2183	
5th percentile	4	
10th percentile	9	
15th percentile	18	
20th percentile	31	
25th percentile	51	
50th percentile	307.1	
75th percentile	1582.3	
80th percentile	2125.5	
85th percentile	2812.6	
90th percentile	4033.9	
95th percentile	6087.3	

The bulk of fires ranged in size between 2 and 5000 ha, which is a very wide range in comparison with other study areas of the Foothills, Rocky Mountain and Boreal Natural Regions where STANDOR was applied. Many fires were found in the relatively small size-class of 11 to 100 ha, but this is largely an outcome of the disturbances being cropped at the study boundary. The maximum area that was disturbed by a single fire was 15 439 ha. Disturbances greater than 10 000 ha in size would only occur 1.2 times every 100 years. It goes to show that extremely large fires can occur, but on such low frequency that in reality these may not be observed in one's lifetime. Note that the smallest fire size was 1 ha, which corresponds to the pixel resolution.

6.2.2.5 AGE CLASS

A 5-year age-class distribution was extracted from each simulated stand origin map. For ease of display, age-classes were re-grouped into 10-year intervals up to 100 years, and into wider classes as stand ages increased. Individual age-class distributions are presented in Table 6.4, along with the mean age-class distribution and its associated standard deviation.

With an average fire cycle established at 39 years, the weighted mean forest age tends to be around 49 years. Under this fire regime, 62% of the landscape will be less than 30 years of age on average. Because this distribution includes grasslands, which cannot really be aged, this distribution is seen more as theoretical. The age-class distributions were re-evaluated for forested areas only and these results are presented in Table 6.5.

Table 6.4. Simulated age-class distributions in percent area values for the Elkwater Block. Weighted mean stand origin ages are presented in bold.

Age-class	Sim1	Sim2	Sim3	Sim4	Sim5	Mean	Std
1 - 10	9.96	36.53	34.97	22.20	29.38	26.61	9.72
11 - 20	62.61	17.05	6.05	0.00	0.65	17.27	23.48
21 - 30	1.31	17.84	32.92	13.63	24.14	17.97	10.56
31 - 40	0.96	26.19	2.09	0.62	8.18	7.61	9.69
41 - 50	0.38	0.79	13.26	15.87	1.45	6.35	6.77
51 - 60	8.20	0.00	5.28	2.16	4.50	4.03	2.79
61 - 70	3.73	0.00	0.06	0.22	0.00	0.80	1.47
71 - 80	2.62	0.01	1.19	0.00	6.62	2.09	2.46
81 - 90	9.26	0.00	0.00	4.65	2.69	3.32	3.45
91 - 100	0.97	0.01	1	16.59	3.57	4.43	6.20
101 - 125	0.00	0.35	3.19	0.58	5.62	1.95	2.16
126 - 150	0.00	0.00	0.00	10.61	2.29	2.58	4.11
151 - 175	0.01	0.41	0	0.68	2.58	0.74	0.95
176 - 200	0.00	0.44	0.00	0.56	0.02	0.20	0.24
201 - 250	0.00	0.18	0.00	6.83	6.45	2.69	3.23
251 - 300	0.00	0.01	0	3.86	1.87	1.15	1.53
301 - 400	0.00	0.18	0	0.61	0.00	0.16	0.23
401 - 500	0.00	0.00	0.00	0.08	0.00	0.02	0.03
501 - 600	0.00	0.00	0	0.24	0.00	0.05	0.10
601 - 700	0.00	0.00	0	0.01	0.00	0.00	0.00
Wgt age	**33.43**	**26.54**	**31.19**	**88.65**	**65.02**	**48.97**	**24.05**

Table 6.5. Simulated age-class distributions in percent area values for the forested areas of the Elkwater Block. Weighted mean stand origin ages are presented in bold.

Age-class	Sim1	Sim2	Sim3	Sim4	Sim5	Mean	Std
1 - 10	7.83	29.86	23.62	19.91	31.63	22.57	8.49
11 - 20	61.66	17.19	3.94	0.00	0.19	16.60	23.39
21 - 30	0.34	19.35	44.35	5.21	24.23	18.70	15.54
31 - 40	0.67	30.64	3.09	0.81	5.05	8.05	11.41
41 - 50	0.53	1.16	13.48	22.43	0.35	7.59	8.93
51 - 60	9.62	0.00	6.3	0.19	3.59	3.94	3.67
61 - 70	4.70	0.00	0.00	0.12	0.00	0.97	1.87
71 - 80	3.53	0.02	0.98	0.00	5.06	1.92	2.03
81 - 90	9.45	0.00	0	1.68	2.81	2.79	3.50
91 - 100	1.66	0.01	1.09	21.52	4.03	5.66	8.04
101 - 125	0.00	0.04	3.16	0.53	6.76	2.10	2.60
126 - 150	0.00	0.00	0	10.62	1.83	2.49	4.13
151 - 175	0.01	0.58	0.00	0.26	3.38	0.85	1.28
176 - 200	0.00	0.62	0	0.87	0.01	0.30	0.37
201 - 250	0.00	0.26	0	8.16	8.42	3.37	4.02
251 - 300	0.00	0.00	0	6.16	2.64	1.76	2.42
301 - 400	0.00	0.27	0	1.00	0.00	0.25	0.39
401 - 500	0.00	0.00	0	0.09	0.00	0.02	0.04
501 - 600	0.00	0.00	0	0.43	0.00	0.09	0.17
601 - 700	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wgt age	**35.81**	**29.15**	**34.03**	**103.02**	**71.54**	**54.71**	**28.48**

6.3 FIRE REGIME DEPARTURE

Since the advent of aggressive fire suppression, most fire prone ecosystems are running a burn debt with a burn deficit added annually following each fire season that sees little burnt area. A method called the Burn Deficit Calculation (BDC) was originally developed in 2000 for Banff National Park, so that the park could identify regions that are most in need of restoration, and keep track of its prescribed burn plans (Rogeau et al. 2004). In 2007, this method was applied to a test area of Kananaskis Country (Rogeau 2007) to compare the process and result outputs with the Fire Regime Condition Classification method, which has been applied across the US. For the information currently available in many regions of Alberta, the BDC method was the preferred method. More recently, this same method has been adopted to determine fire regime departure conditions for the National Parks of Canada, along with other measures of departure from a range of fire regime parameters (Rogeau 2008). The logic of this approach is that a greater burn deficit or burn debt for an area implies a greater departure, in both vegetation condition and fire severity, from historical conditions. This affects the ecological integrity of the area.

The vision of Alberta Parks is to protect and preserve, in perpetuity, landscapes, natural features and processes representative of the environmental diversity of the province. Regulations that are in place help to ensure that this environmental diversity is preserved for future generations (Alberta Parks web site). However, the prolonged removal of fire in the historically fire prone region of the Cypress Hills could, in the long-term, deteriorate the ecological integrity of this unique ecosystem. To verify the percent departure of the fire regime of Cypress Hills, the Burn Deficit Calculation was applied to three vegetation communities that were shown to have distinctive mean fire return intervals and fire cycles, utilizing 5000 years of natural fire regime simulations (Section 6.2). These vegetation communities, referred to as Fire Vegetation Groups (FVG), include:

1) coniferous and mixedwood forests;
2) deciduous forests; and,
3) grasslands combined with open forest types.

The sub-sections below describe the BDC method in greater detail, present the calculation table, and translate the burn debt into a percent departure value based on pre-defined threshold values as adopted by Parks Canada (Rogeau 2008).

6.3.1 Burn Deficit Calculation

The Burn Deficit Calculation (BDC) method uses the fire cycle as one of the measures to determine the degree of departure from natural fire regime conditions. The fire cycle is defined as the number of years required to burn an area equivalent in size to the study area. It is implied that some portions of land may burn more than once, while others may not burn at all during one cycle (Merrill and Alexander 2007). The fire cycle captures fire regime parameters for both the frequency and area burned, while the inverse of the fire cycle is equivalent to the annual burn rate (Johnson and Gutsell 1994).

Period of reference: period of natural fire regime conditions.

Monitoring period: period since the onset of fire suppression up to the present time.

In summary, this method consists of identifying the historical rate of burning (number of ha/yr) based on a map showing fire cycle values during the period of reference. In the case of the Cypress Hills, the mean-fire-return-interval map produced from 5000 years of natural fire simulations will be used as a surrogate. The rate of burning is then multiplied by the length of the monitoring period (MP) to determine the number of hectares that were expected, in theory, to burn during that time. Subsequently, this total amount of expected burned area is subtracted from the number of hectares that actually burned from wildfires and prescribed fires during the MP. The result is the burn debt (it is possible to have a burn surplus). For each subsequent year from the start of this exercise, a burn deficit or surplus will be added and will either increase or decrease the burn debt. The burn debt value, in area burned, is the surrogate measure for the departure from natural rates of burning. For example, a burn debt (burn deficit) that is greater than the target area will amount to more than one fire cycle being

Table 6.6. Threshold values to determine the degree of fire cycle departure from natural conditions.

Fire Cycle Departure Class	Threshold
1 Low	< 33%
2 Moderate	34 - 67%
3 High	67 - 100%
4 Critical	>100%

skipped and will show a departure greater than 100%. Table 6.6 shows the threshold values used to determine the level of fire cycle departure.

The definition of this method is better described and understood by visualizing the calculation table (Table 6.7). Note that the calculations can be repeated for the upper and lower end of the fire cycle class to obtain a range of variation for the expected burn areas. In a restoration context, more realistic and conservative goals for re-introducing fire can be set by using the upper (U) benchmark of the fire cycle class over the mean (M) benchmark. To monitor the burn status in the future, this operation can be repeated annually, or every 2nd or 5th year. Two calculation tables are thus presented. One uses the mean fire cycle value (Table 6.7), and the other uses the upper benchmark of the fire cycle range (from the standard deviation around the mean) (Table 6.8). The range in fire cycle values was only available for the whole landscape, and not by fire vegetation group. The mean fire cycle for the Elkwater Block was evaluated at 39

Table 6.7. Burn Deficit Calculation table using mean (M) fire cycle values to evaluate the burn status as of year 2008.

Fire Vegetation Group	Fire Cycle (mean)	Area	ha/yr	Monitoring Period	Expected Burn Area	Wildfire	Prescribed Fire	Burn Status 2008	FC Trend	% Departure	Departure Class	FC 1909 to 2007
FVG	FC_M	A (ha)	A/FC	MP 1909	EBA (A/FC)*MP	WD	PB	BS_x (WD+PB)-EBA	FC_2008 (D/100)* FC)+FC	D (BS/A)*100	D class	FC_MP (MP*A)/(WD+PB)
1. Coniferous & mixed	45	8401.34	186.70	99	18,482.95	710.76	0.00	-17,772.19	140.19	-211.54	4	1,170.20
2. Deciduous	52	3019.65	58.07	99	5,748.95	39.96	0.00	-5,708.99	150.31	-189.06	4	7,481.12
3. Grassland & open forest	35	9063.75	258.96	99	25,637.46	6,660.44	0.00	-18,977.02	108.28	-209.37	4	134.72

Table 6.8. Burn Deficit Calculation table using upper range (U) fire cycle values to evaluate the burn status as of year 2008.

Fire Vegetation Group	Fire Cycle (upper)	Area	ha/yr	Monitoring Period	Expected Burn Area	Wildfire	Prescribed Fire	Burn Status 2008	FC Trend	% Departure	Departure Class	FC 1909 to 2007
FVG	FC_U	A (ha)	A/FC	MP 1909	EBA (A/FC)*MP	WD	PB	BS_x (WD+PB)-EBA	FC_2008 (D/100)* FC)+FC	D (BS/A)*100	D class	FC_MP (MP*A)/(WD+PB)
1. Coniferous & mixed	65	8401.34	129.25	99	12,795.89	710.76	0.00	-12,085.13	158.50	-143.85	4	1,170.20
2. Deciduous	72	3019.65	41.94	99	4,152.02	39.96	0.00	-4,112.06	170.05	-136.18	4	7,481.12
3. Grassland & open forest	55	9063.75	164.80	99	16,314.75	6,660.44	0.00	-9,654.31	113.58	-106.52	4	134.72

years ± 20 years (Section 6.2.2.2). It is likely that the upper bracket of each FVG's fire cycle would also be about 20 years greater than the mean fire cycle.

The burn status for each Fire Vegetation Group and fire cycle departure (D) up to year x is calculated using these formulas:

$$BSMx = [(A/FCM) \times (MP)] - WD - PB$$
$$D = (BS / A) \times 100$$

Based on the degree of departure, the fire cycle trend at year x is calculated as follow:

$$FC\_year\ X = (D / 100 \times FC) + FC$$

The last column presents the fire cycle based solely on the burn rate recorded during the Monitoring Period. While this fire cycle value is not part of the departure evaluation, it serves as an indication of long-term fire cycle departure if a similar burn rate were to be maintained for a long period of time.

When using the mean fire cycle values (Table 6.7), it can be observed that the burn debt accumulated since 1909 is such that for most of the region, more than two fire cycles have been skipped. This translates into a fire regime departure greater than 200% for the coniferous and grasslands vegetation, and a departure of 189% for the deciduous forests. Overall, the entire Elkwater Block is rated with a critical departure class of 4. Even by using the upper range of the fire cycle values (Table 6.8), which increases the fire cycle length by 20 years, all fire vegetation groups remain in the critical fire regime departure category. However, by using the longer fire cycle values, the percent fire cycle departure is less than 200% and varies between 107% and 144% depending on the Fire Vegetation Group.

The fire cycle trend shows where the fire cycle is since the start of fire suppression. In comparison, the fire cycle calculated strictly based on the burning recorded between 1909 and 2007 shows that by maintaining this tendency for a long period of time, fire cycles will reach well over 1000 years. For an ecosystem that has been shaped by fire for thousands of years, such a level of departure is detrimental to the overall health and integrity of the communities living in this ecosystem. While the occurrence of fire is a threat to the public, the complete removal of fire threatens the ecological integrity of the ecosystem, and ultimately creates conditions that favour very large, dangerous fires that are difficult to control. The increase in fuel load as a result of fire suppression has several implications. Some of these may be offset by the strategic use of mechanical tools, either in combination with prescribed fire or alone (see Section 9.0 for recommended management strategies).

IMPLICATIONS

1. The critical level of fire regime departure throughout the Cypress Hills is threatening the ecological integrity of these fire-driven ecosystems.

2. Under the right fire weather conditions, the increased fuel load resulting from the prolonged removal of fire will create larger and more intense blazes that will put the public and neighbouring stakeholders at risk. Further, it is expected that the burning severity, in terms of consumption level of organic soil matter, percent of canopy removal, and extent of burning will be beyond levels observed historically and could negatively impact the recovery and future viability of some of the plant communities.

7.0 ESTABLISHING THE BURNING ENVIRONMENT

The Cypress Hills extend 600 m above the surrounding prairie and the plateau area ascends westward from an elevation of 1310 m in the east to 1466 m at Head of the Mountain. Abrupt, steep escarpments are found to the north and west, while the plateau slopes gradually downward to the plains in the south and east. The land base of Cypress Hills Provincial Park-Alberta includes 11,700 ha of forests, 8,000 ha of fescue grasslands and 300 ha of surface water. The higher elevation Cypress Hills forest is dominated by lodgepole pine stands that regenerated following the extensive 1885 fire. White spruce occurs in mixed and pure stands in the northern portions of the park and in most of the creek bottoms, while aspen is found in mixed and pure stands throughout the park. The fescue grasslands are associated with the higher elevations (i.e., the plateau), with minor distribution along creek bottoms and bench lands.

The Cypress Hills is associated with the rain shadow effect of the Rocky Mountains located 200 km to the west, which influences the persistence of drought cycles. Historic records and environmental evidence document the occurrence of ten one-year droughts and five three-year droughts (defined as periods of precipitation in the lowest 10th and 20th percentiles) in the historical climate record between 1700 and 2000 (Sauchyn et al. 2003).

The variable topography, associated with aging and flammable forests and annual severe fire weather, contribute to a unique wildfire threat given the distance to Cypress Hills from the closest provincial airtanker base. An SRD wildfire threat assessment is included in this report as a component of advanced fire management planning, that recognizes the complexity of protecting life and community property throughout the fire season. At the landscape level, a wildfire threat assessment provides a spatial analysis of the factors contributing to catastrophic fire events and is useful for introducing risk management interventions. To complement the generalized wildfire threat analysis a fire growth model was incorporated to demonstrate the impact of simulated catastrophic fire events. Historical fire weather, described in Section 7.1, and Fire Behaviour Prediction (FBP) fuel types, presented in Section 7.2, served as input for both the wildfire threat assessment and the fire growth modelling exercise included in this Section of the report.

7.1 HISTORICAL WEATHER ANALYSIS

Fire Weather Index components and weather data from three recording stations, in and adjacent to Cypress Hills Provincial Park, were used for the following analyses. An Alberta station at Pole Haven, south of Pincher Creek, provided a perspective from the closest forested land base to CHIP, and the local Alberta and Saskatchewan Cypress Hills stations provided on-site data. Both Alberta stations included fire weather data from 1999 to 2007, while the Saskatchewan station offered data between 1998 and 2007.

7.1.1 Fire Weather and Fire Weather Index

The summary tables in this section stratify weather and Fire Weather Index (FWI) components from 1300 h observations by season and 70th, 80th and 90th percentile levels. This stratification is helpful to assess potential fire behaviour throughout the fire season. As expected in southern Alberta, extended hot drying cycles are common and FWI values reflect this for all three stations. The weather data suggests that the area common to the three stations experiences similar climate and that a fire hazard can develop from the foothills of Alberta through to the Saskatchewan border concurrently.

Table 7.1. Weather and FWI components at the 70th, 80th and 90th percentile levels for Poll Haven, Alberta.

Poll Haven (C3) Spring Weather 1999-2007

Percentile	Temp(^{o}C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	13	40	87	18	111	8	25	12	22
80th	15	35	88	24	125	10	30	16	26
90th	17	30	90	33	153	13	40	22	30
Max	25	N/A	94	56	201	43	56	37	61

Poll Haven (C3) Summer Weather 1999-2007

Percentile	Temp(^{o}C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	21	37	90	56	289	10	73	25	18
80th	22	32	91	75	347	12	93	32	21
90th	24	26	93	98	424	16	121	41	25
Max	29	N/A	96	204	636	35	218	73	55

Poll Haven (C3) Fall Weather 1999-2007

Percentile	Temp(^{o}C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	17	37	89	43	476	8	69	18	20
80th	20	31	91	58	532	11	91	28	23
90th	22	25	92	100	572	16	133	38	27
Max	29	N/A	97	178	673	44	210	71	47

*** Relative Humidity values are reversed. For example, the 90th percentile means that in 10% of the observations the RH will be lower than shown in the table**

Table 7.2. Weather and FWI components at the 70th, 80th and 90th percentile levels for Cypress Hills, Alberta.

Cypress Hills (C5) Spring Weather 1999-2007

Percentile	Temp(°C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	14	38	87	21	128	8	29	13	23
80th	16	35	89	25	144	10	33	16	26
90th	18	29	90	30	296	13	40	22	33
Max	23	N/A	93	51	366	35	75	44	44

Cypress Hills (C5) Summer Weather 1999-2007

Percentile	Temp(°C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	21	40	89	46	309	9	64	20	18
80th	23	35	90	65	368	11	87	27	20
90th	25	29	92	84	440	13	111	36	24
Max	31	N/A	97	188	587	27	196	65	30

Cypress Hills (C5) Fall Weather 1999-2007

Percentile	Temp(°C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	17	38	88	75	523	7	108	24	21
80th	19	31	91	83	555	12	119	34	23
90th	23	25	93	92	572	14	128	42	26
Max	27	N/A	96	114	615	62	152	111	37

*** Relative Humidity values are reversed. For example, the 90th percentile means that in 10% of the observations the RH will be lower than shown in the table**

Table 7.3. Weather and FWI components at the 70th, 80th and 90th percentile levels for Cypress Hills, Saskatchewan.

Cypress Hills (Saskatchewan) Spring Weather 1998-2007

Percentile	Temp(°C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	14	38	88	30	300	7	43	15	20
80th	16	35	89	40	365	9	58	20	22
90th	18	29	90	52	422	13	74	26	26
Max	24	N/A	94	84	532	27	113	53	37

Cypress Hills (Saskatchewan) Summer Weather 1998-2007

Percentile	Temp(°C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windpseed
70th	22	42	88	43	349	7	64	18	17
80th	23	37	90	64	416	9	89	25	19
90th	25	30	92	90	481	13	116	34	22
Max	33	N/A	97	230	740	38	259	68	40

Cypress Hills (Saskatchewan) Fall Weather 1998-2007

Percentile	Temp(°C)	RH (%)	FFMC	DMC	DC	ISI	BUI	FWI	Windspeed
70th	17	40	88	53	485	7	83	19	19
80th	19	36	90	63	536	9	92	27	20
90th	22	29	92	76	571	12	107	35	22
Max	28	N/A	95	131	645	29	205	69	30

*** Relative Humidity values are reversed. For example, the 90th percentile means that in 10% of the observations the RH will be lower than shown in the table**

7.1.2 Wind

Wind data from two on-site weather stations were stratified by season and velocity from 1300 h observations. Again, there are very similar values for direction and velocity between the stations and the seasonal trends are also similar at each station. In general, the prevailing wind is from the westerly quadrant in the Cypress Hills. In the spring season, south winds are stronger and more prevalent on the Saskatchewan side, and this trend persists through the fall. Southwest winds are also common at both stations with the exception of the fall season on the Saskatchewan side.

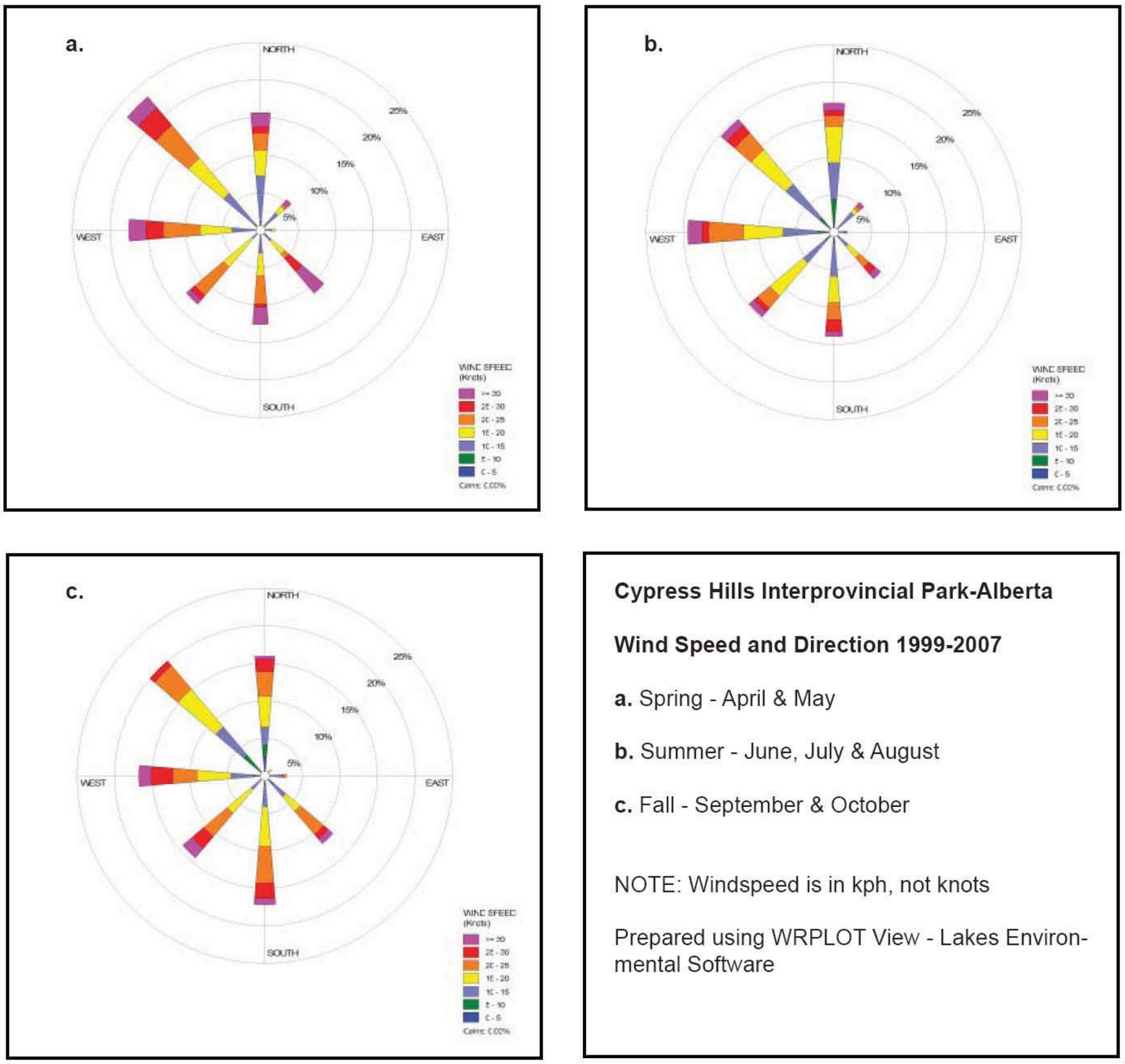


Figure 7.1. Wind data from Cypress Hills Interprovincial Park-Alberta, 1999-2007.

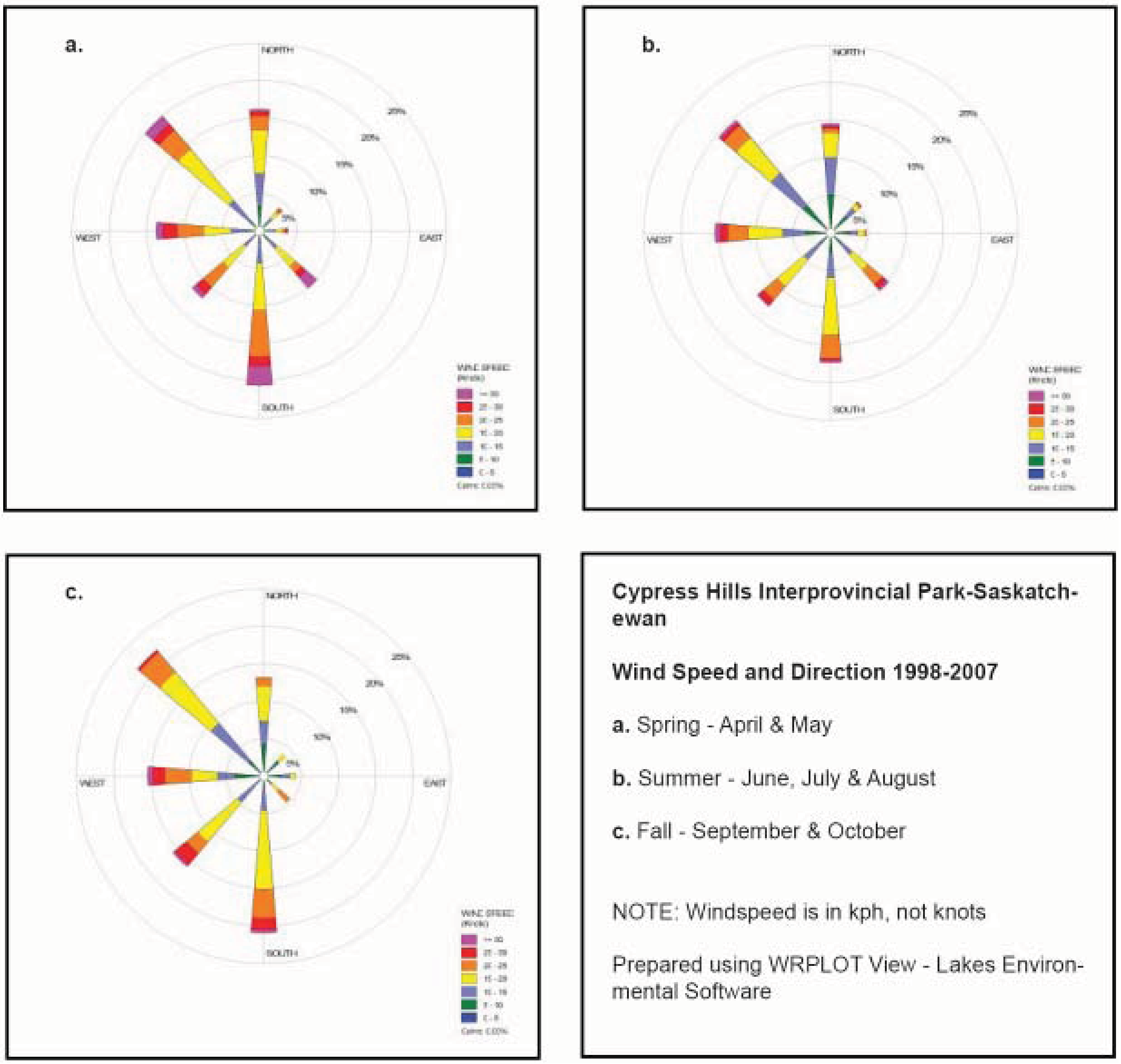


Figure 7.2. Wind data from Cypress Hills Interprovincial Park-Saskatchewan, 1998-2007.

7.2 FBP FUEL TYPE

These Fire Behaviour Prediction (FBP) fuel types are a combination of vegetation species and their associated physical characteristics that contribute to fire behaviour under defined burning conditions. Several fuel type categories can be found in the Cypress Hills. A series of photographs, below, present examples of fuel composition typically found in the park (photos by Stew Walkinshaw and Dennis Quintilio).

Native Prairie Grasslands-01b

Native prairie grasslands are present throughout the Park. When the grass is cured (e.g., during spring and fall) it can contribute to rapid fire spread under appropriate wind velocity and fuel moisture conditions. In contrast, from June 1 to September 1, grasslands are typically greened up, the fire risk is low, and a non-fuel code can be applied. However, for the Prometheus model simulation runs based on August 2006 conditions, grasslands were considered 75% cured based on field observations (Section 7.4).

Cultivated Land-NF

Cultivated agricultural land was considered a non-fuel (NF) type for the fire growth simulations using Prometheus (Section 7.4), because fire spread would typically be limited, other than during the spring and fall drought periods.

Mature Pine-C3

Extensive stands of mature pine are common throughout the Park, particularly on the Plateau. This fuel type originated following the 1885, 1919 and 1934 fires and, at present, ladder fuels and concentrations of surface woody material create the potential for a high intensity crown fire.

Deciduous-D1

Deciduous fuels are scattered throughout the Park and support surface fire in spring and fall. Mid-summer fires under green-up conditions are infrequent.

Boreal Spruce-C2

Spruce fuels are found mainly in the moisture creek draws of Cypress Hills. C2 fuel types have the potential to develop intense crown fires due to abundant ladder fuels and surface woody debris.

Mixedwood-M1

Mixedwood stands, which are comprised of a mixture of deciduous and coniferous fuel types, are infrequent in Cypress Hills Park. The stands' composition represent a mixture of spruce and aspen with a crown fire potential that is low to moderate.

Open Pine – C7

This fuel type is dominated by open lodgepole pine and white spruce with abundant 01a grass fuels. C7 fuel types present moderate to high risk fire potential, depending on stand density and amount of cured grass and surface fuels.

7.3 WILDFIRE THREAT ASSESSMENT

The five components of the SRD Wildfire Threat Assessment Model (WTA) are (1) Fire behaviour potential, (2) Headfire intensity, (3) Fire occurrence risk, (4) Values at risk and, (5) Suppression capability. These components are discussed individually in greater detail in Appendix C. In the case of the Cypress Hills Provincial Park wildfire threat analysis, the extensive grassland fuel was initially considered a non-fuel throughout the spring, summer and fall, as the annual grazing program was assumed to decrease the flammability of the grass during these periods. Through consultation with SRD and TPRC staff, this assumption has been changed to include the grasslands as the 01b fuel type for the spring and fall periods. The fuel grid change is now corrected in the provincial WTA to reflect the flammable condition of the grasslands once they are cured. The grass is still considered non-fuel from June 1 to September 1 because of green-up. The duration of the summer season predominates in Cypress Hills, so it is useful to include a wildfire threat analysis for the summer months.

Figure 7.3 illustrates the generalized Wildfire Threat Rating that incorporates the four assessment components with the very high rating emphasizing primarily the areas of the most significant summer fire behaviour potential and proximity to values at risk. This rating has been considered in the Section 9.0 discussion of integrating fire and forest management strategies; however, the fire growth modelling results using a cured grass assumption suggest a more serious fire behaviour potential in late summer and early fall.

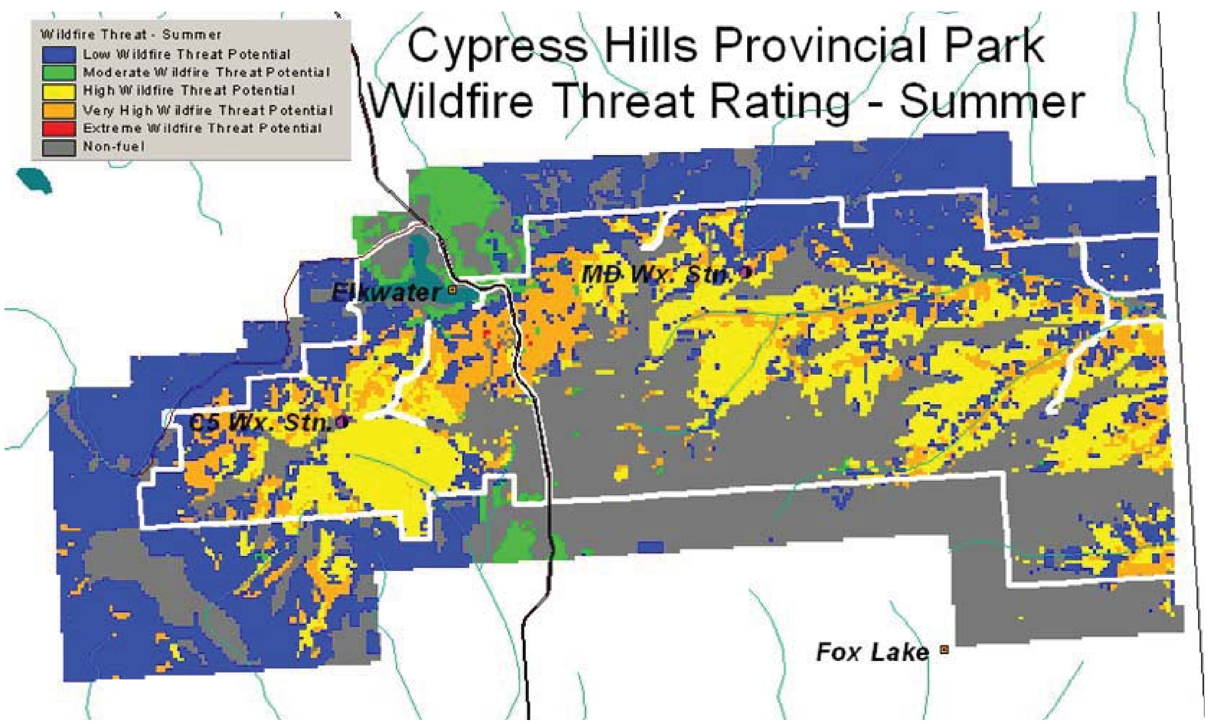


Figure 7.3. Wildfire Threat Rating for the summer season.

7.4 FIRE GROWTH MODEL SCENARIOS

A fire growth model is introduced in this report to evaluate the extent of catastrophic fire events using 90th percentile weather data under cured grass assumptions.

7.4.1 Introduction

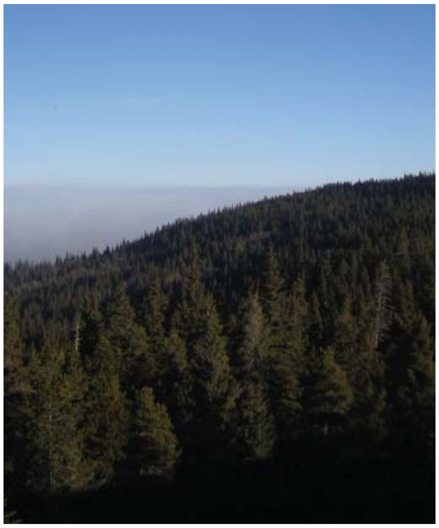
Catastrophic fires are generally a function of extreme weather, over-mature forest fuel types and topography combinations that contribute to rapid fire spread. Cypress Hills Interprovincial Park has all of the above elements and is prone to fire events across the entire landscape. To view the theoretical impact of large fires in the Park a simulation exercise is included in this report. An innovative Canadian Wildland Fire Growth Model (Prometheus) provides deterministic fire growth simulations using spatial fire behaviour inputs based on fuel types, weather streams and topography. Using current and historic fire behaviour input data for the Cypress Hills, including 90th percentile weather data (Section 7.1), a number of fire growth scenarios are presented. In particular this report has documented the extent and severity of the 1885 fire and following a 120 year interval, current fuel loading and weather trends have combined to suggest the probability of recurring extreme fire behaviour.

7.4.2 Prometheus

The application of the Prometheus model includes: predicting fire growth following unsuccessful initial attack; evaluating the potential threat wildfires could pose to communities, recreational facilities and other values at risk; and assessing the effectiveness of various forest and fire management strategies aimed at reducing the threat of large fires. The model is considered state-of-the art in Canada and uses a sophisticated ellipse and wave propagation equation to map fire growth over space and time. Since only one significant fire has occurred in Cypress Hills since the 1885 event it is helpful to simulate a number of potential free burning fires to evaluate the impact on human safety and values at risk. An understanding of the fire behaviour characteristics of these fires is essential to future fire and forest management strategies. The simulations in this report are based on Cypress Hills weather and fuel conditions in August of 2006. Appendix D includes the three simulations overlayed on the FBP fuel type grid. The authors of this report appreciate the contribution of the Prometheus images by Alberta Sustainable Resource Development.

7.4.3 Fuel Types

At the provincial level, the Alberta Vegetation Inventory (AVI) provides the linkage to the Fire Behaviour Prediction System (FBP) fuel types used for fire growth modeling. In Cypress Hills seven of the FBP fuel types are present and the distribution is illustrated in Appendix B (Figure B.1). In the three simulations, the 01b grass fuel type is assumed to be 75% cured as a result of the extended drought in August of 2006.



7.4.4 Weather Data

Actual hourly weather data on August 14, 2006 were used as model inputs for scenarios one and two, and for scenario three a constant wind speed of 50 km/h is assumed. This particular day was selected to approximate the 90th percentile weather stream calculated from the on-site weather stations from 1999 to 2007.

7.4.5 Topography

The topography of Cypress Hills contrasts significantly with the prairie landscape of southeastern Alberta. An upper elevation plateau rises 600 m above the surrounding prairie grasslands which is interrupted by forested creek draws that are oriented both north/south and east/west. The plateau is exposed to wind events and the forested creek draws have accumulations of surface fuels that contribute to extreme fire behaviour, which, in combination, present complex fire management challenges. During normal fire seasons the topographic variations are a benefit to fire protection efforts; however, during high and extreme fire danger periods, as defined by the 90th percentile weather stream, the topographic features contribute to potential catastrophic fire events.

7.4.6 Fire Growth Scenarios

If the 90th percentile weather occurred approximately ten days per fire season in the next decade, then the following three fire growth scenarios are realistic representations of potential fire impact at the landscape level in Cypress Hills Provincial Park. Scenarios One and Two are average worst case events while Scenario Three is the worst case event, *and although the probability of Scenario Three is low, the adverse consequences are high*. The fire growth simulations support aggressive forest and fire management strategies (Section 9.0) that compartmentalize Landscape Management Units through low impact disturbance interventions to mitigate fire growth during high and extreme danger rating levels, and FireSmart initiatives that protect values at risk. Assuming that the fuelbreak corridors that are recommended in Section 9.0 were in place, the fire size projections in Scenarios One and Two would be significantly reduced. Further assuming that FireSmart recommendations in Section 9 are implemented and emergency wildfire protocols are in place prior to Scenario Three, the threat to life and property will be mitigated.

Scenario One: Ignition in the Grasslands Fuel Type (O1b)

The location of a fire ignition in scenario one is adjacent to and east of Highway 41 near the southern boundary of CHIPP. The model run assumes that Highway 41 is a fire barrier to the west and most subsequent fire growth is north and east of the fire origin. This model run assumes 75% cured stage in the prairie grassland fuel type and as a result the initial forward progress of the fire is significant. On August 14, 2006, the 90th percentile for fire growth potential is exceeded as defined by weather and

FWI components; therefore, this day was selected to test for the impact of extreme fire behaviour. Using the actual weather of August 14, 2006, the southerly winds prevail until 1800 hrs, followed by westerly winds through to 2100 hrs. The fire is theoretically ignited at 1300 hrs and grows to 55 ha in one hour and an unsuccessful initial attack is assumed. Following eight hours of free burning on August 14th, the fire size is 3343 ha (Figure 7.4).

Scenario Two: Ignition in the Pine Fuel Type (C3)

The location of the ignition for scenario two is near Graburn Road, at the southern boundary of CHIPP. The August 14th, 2006 weather approximated the 90th percentile calculations of FWI components and a 75% cured stage in the prairie grassland fuel type is again assumed. The fire is theoretically ignited in the C3 fuel type at 1300hrs and initial attack is assumed unsuccessful as a result of priorities and resource commitments in scenario one. Fire size after one hour is 27 ha and following 8 hours of free burning on August 14th the fire is 2341 ha (Figure 7.4).

Scenario Three: Ignition in the Spruce Fuel Type (C2)

A worst case fire event would include ignition near the western boundary of the park combined with a *sustained* 90th percentile wind throughout the burning period. Scenario Three assumes ignition with a 50 km wind for eight hours in the C2 fuel type and the fire is 123 ha after one hour of free burning and 9592 ha after eight hours of free burning (Figure 7.5).

More detailed maps of the three scenarios overlaid on the FBP fuel types are given in Appendix D.

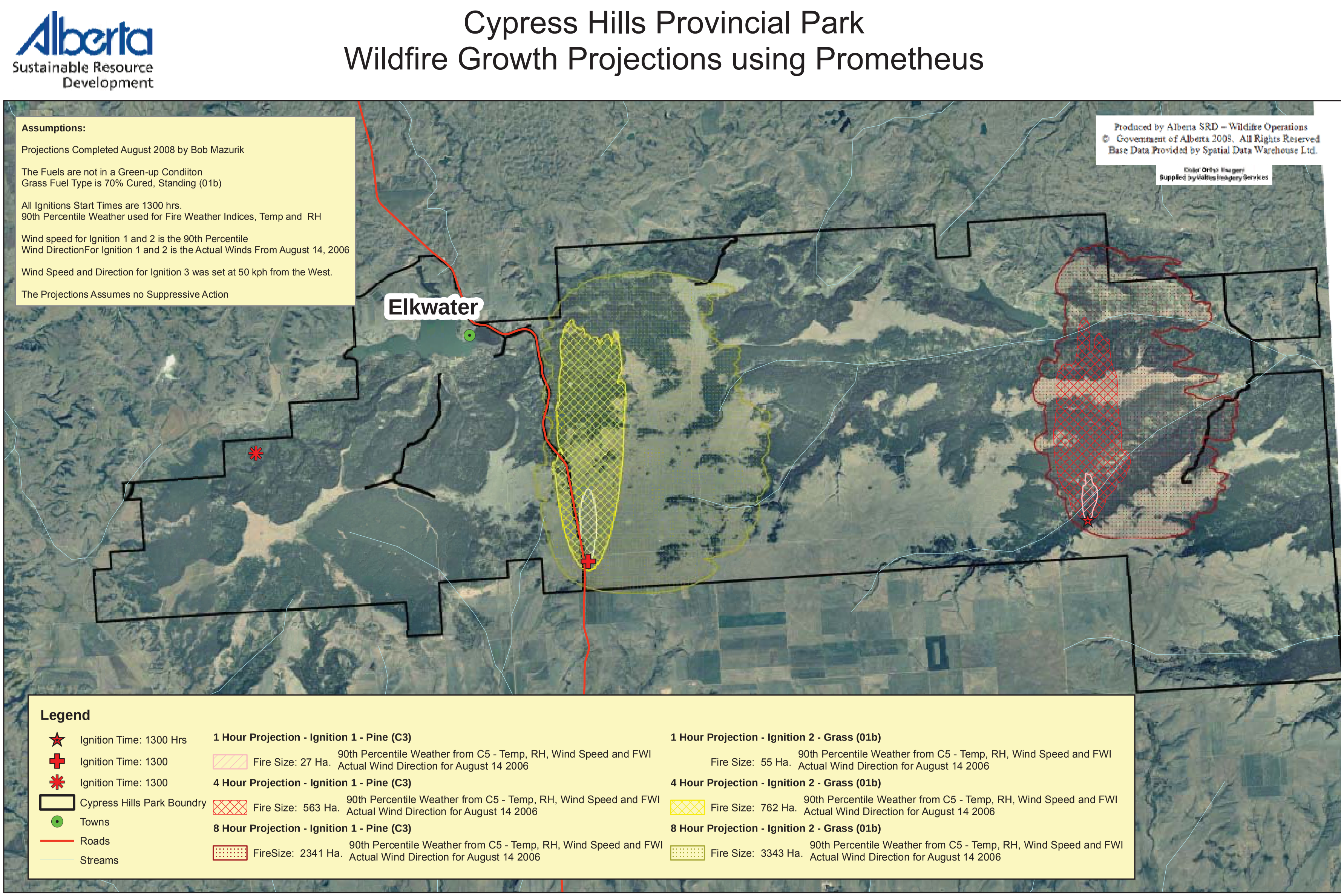


Figure 7.4. Fire growth projection for Scenarios One and Two.

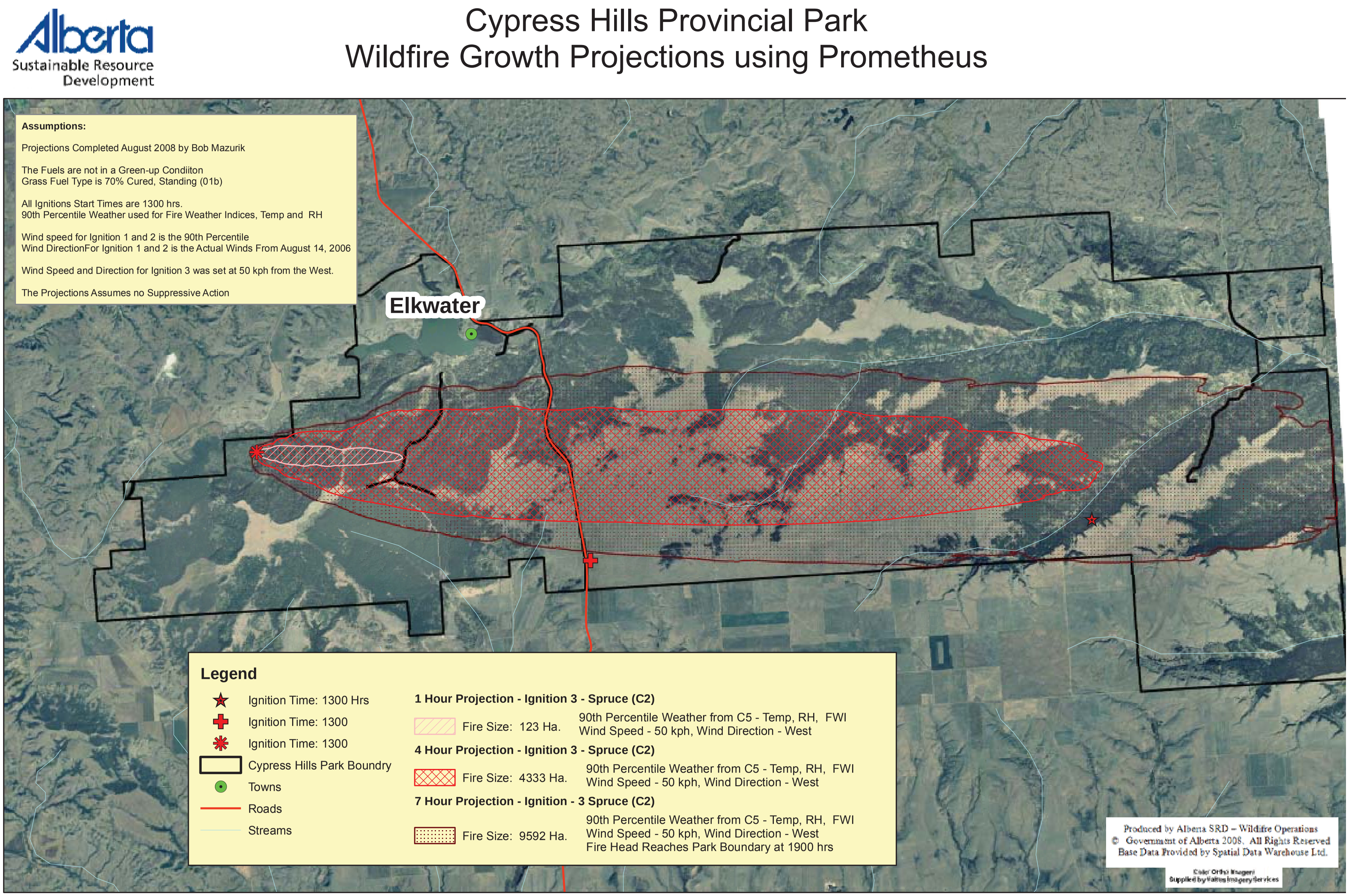


Figure 7.5. Fire growth projection for Scenario Three.

IMPLICATIONS

1. The mature and over-mature age of both deciduous and coniferous forest fuels is associated with significant surface fuel loading and continuous grass cover, which in turn increases the fire behaviour potential.

2. A fire growth simulation with 90th percentile weather data and a constant 50 km/h wind suggests a 50% area burned in Cypress Hills Provincial Park in one day.

8.0 LEGISLATION AND POLICY FRAMEWORK

Cypress Hills Provincial Park is administered by the Alberta Government through the Provincial Parks Act. The Act is administered by Alberta Tourism, Parks and Recreation (TPR), who is responsible for the management, protection, planning and control of the park.

Protection of Cypress Hills Provincial Park from wildfire impact is linked to various provincial legislation, policy and agreements, including:

- Alberta Parks Act
- Forest and Prairie Protection Act
- Municipal Governance Act
- Alberta Environmental Protection – wildfire protection policy, section 6.0
- Parks and Protected Area Policy and Procedure, sections 8.1 to 8.1.9
- Land and Forest Service Wildfire Protection Program Standards
- Cypress Hills Provincial Parks Management Plan
- Fire Agreement with Municipal District of Cypress Hills (County of Cypress)
- Saskatchewan/Alberta Fire Cooperation Agreement
- Cypress Hills Inter-Provincial Park Agreement, August 25, 1989
- Memorandum of Understanding between SRD and TPR, March 19, 2007

Several sections of these acts and pieces of legislation are relevant for fire action outside of the Forest Protection Area. These are described in Table 8.1.

Mutual aid agreements are often completed with overlapping jurisdictions or in areas adjacent to the FPA. Agreements have a number of benefits, including:

- allowing Alberta Sustainable Resource Development (SRD) to identify available resources and manage issues before they become a problem (e.g., personnel, equipment, communications, costing)
- aiding SRD to organize ahead of an incident's occurrence, in conjunction with neighbouring agencies and industry
- providing for wildfire training and cross training exercises.

A Memorandum of Understanding (MOU) was developed in March 2007 by Alberta Sustainable Resource Development (SRD) and TPR regarding common interests in land and resource management on Alberta's public lands. The intention of the MOU was to clarify roles and responsibilities, identify and eliminate areas of jurisdictional overlap and enhance stewardship, departmental resource use and communication. Enhancing public services and safety was the overall objective.

In terms of forest fire prevention, detection, presuppression and suppression, SRD has the lead role. This includes fire permits, public closures and fire reclamation. In Cypress Hills Provincial Park, TPR will be provided with presuppression and suppression assistance by SRD as requested and agreed upon. TPR has the mandate to manage wildfire within the boundaries of Cypress Hills Provincial Park. Guidelines are renewed annually that outline the SRD resources that may be considered for presuppression under different Head Fire Intensity (HFI) scenarios.

Mutual aid Fire Control Plans typically define:

- Administrative procedures (such as operational zones, request and invoicing procedures)
- Prevention and detection information (such as fire permit issuance, fire control orders and bans, cooperative prevention opportunities, detection sharing, prescribed burning and wildfire interface training)
- Presuppression information (such as activities, hazard and resource sharing)
- Wildfire operations (such as manpower, equipment, communications and responsibilities)
- Training and certification opportunities
- Effective dates

They may also include a number of appendices (maps, contacts, etc.).

SRD also has the lead with respect to control of invasive forest insect and disease pest species, including the Mountain Pine Beetle (MPB). TPR will be consulted in the development of and amendments to forest health policy and planning. Since Cypress Hills Provincial Park has an effective detection and survey program, SRD will not carry out additional surveys but will assist CHPP in planning and evaluating the surveys. TPR is responsible for management and control of all invasive plants on its lands.

Table 8.1. Excerpts from legislation relevant to fire action within Cypress Hills Provincial Park.

Legislation	Section	Excerpt
Forest and Prairie Protection Act	7(1)	The council of a municipal district is responsible for fighting and controlling all fires within the boundaries of the municipal district and the costs and expenses shall be paid by the municipal district, subject to its right to recover them under section 9(3).
	9(1)	The Minister may fight a fire within a municipal district or an urban municipality where it appears to the Minister that satisfactory action to control and extinguish the fire is not being taken by that municipality and that the fire might damage public land.
Municipal Governance Act	75(1)	In this section, “forest protection area” means a forest protection area (FPA) designated under the Forest and Prairie Protection Act (Defines FPA).
	75(2)	The council of a municipal district may not pass a bylaw respecting fires that applies to the part of the municipal district in a forest protection area (Passing Bylaws).
	75(3)	Despite subsection (2), the council may pass a bylaw respecting fires, other than forest or running fires, that applies to the part of a hamlet that is within a forest protection area (Passing Bylaws).
	75(4)	Sections 4(2) and (3), 7 and 19(2) of the Forest and Prairie Protection Act do not apply to the council of a municipal district with respect to the part of the municipal district that is within a forest protection area (Exceptions within the FPA).

IMPLICATIONS

1. Testing of emergency procedures between SRD, TPR and the County would be beneficial.

2. SRD’s mutual aid agreements with counties should be negotiated to include Cypress County.

9.0 INTEGRATED FIRE AND FOREST MANAGEMENT STRATEGY

The *Park Management Plan* (2009) for Cypress Hills Interprovincial Park articulates the broad management strategies required to ensure that the Park will be managed for the protection, conservation, and appreciation of the heritage resources of the Cypress Hills ecosystems. Two fire management objectives in the Park Management Plan are proposed as follows: (1) establish the role of fire in the park, and (2) reduce the threat of a catastrophic fire. Additional objectives for forests, woodlands and shrub habitats are: (1) to manage forests for ecologically and age diverse communities that are representative of the Cypress Hills environment, and (2) to protect the gene pool integrity of the Cypress Hills forests.

The Integrated Fire and Forest Management Strategy (IFFMS) has documented the historic and current fire regime of Cypress Hills, which is fundamental to understanding the evolution of forest and grassland vegetation and, more importantly, the management challenges posed by a departure from the historic fire regime.

Section 6.0 of this report suggests that there has recently been a major departure from the pre-1900 fire regime. As a result, forests have aged and densified dramatically throughout the Park. This component of the IFFMS has addressed the first fire management objective, and a science-based understanding of the role of fire in the Park is a cornerstone of addressing the second objective of reducing the threat of a catastrophic wildfire.

Section 7.0 of this report presents three fire growth simulations using the 90th percentile weather data as determined from the local weather station. The combination of the fuels and weather input to the modelling exercise presents potential extreme fire behaviour consequences given a fire ignition and escape at high or extreme fire danger levels.

Section 9.0 now sets out the criteria for integrating fire and forest management solutions including pre-attack planning and fire suppression strategies, fine- and broad-scale fuel management initiatives, and forest management disturbance interventions that contribute to the return of a fire regime of smaller, low intensity fire events that are limited to pre-determined landscape level units. A short- and long-term fuel reduction strategy designed to mitigate catastrophic fire events, accompanied by aggressive wildfire management protocols that in the short-term prevent large fires, is in the interest of public safety and ecological integrity based on the analysis included in this report. Since forest management disturbance interventions require long term timelines, the success of annual fire suppression operations is critical in the short term. A pre-attack plan is recommended for 2009 (9.2.11) to support initial attack and sustained fire suppression activities that are appropriate for the unique values at risk within and adjacent to Cypress Hills Park.

9.1 FOREST MANAGEMENT STRATEGIES

Forest management strategies include a variety of techniques for fine- and broad-scale fuel reduction. These strategies help mitigate the risk of a catastrophic fire that would endanger the public, infrastructure, and forest health and ecological integrity.

9.1.1 Fine-Scale Fuel Reduction

9.1.1.1 FIRESMART PRIORITY

The FireSmart program is well established in Alberta and community projects are individually listed in Appendix E. In addition, a recent example of a YMCA camp saved by a timely fuel management initiative is included in Appendix E, as well as FireSmart aerial photographs of the Canmore corridor.

The FireSmart program is a strategic fuel reduction initiative in the Elkwater Wildland/ Urban Interface, as well as other facility zones in the park and private land with infrastructure close to the park boundary. This program provides the highest return on investment for overall public safety and security and contributes to the success and flexibility of suppression operations. FireSmart project support is critical to enhancing the protection of public and ecological values at risk throughout Cypress Hills Provincial Park. The projects that are ongoing and planned require significant budget allocations and long-term timelines to complete. Experience with low-budget manpower fuel reduction in Cypress Hills Provincial Park concludes that small forest harvesting equipment, as opposed to manpower alone, is necessary to ensure that the immediate life and community forest protection priorities are addressed while intermediate and long term fire and forest management strategies progress. Additional resources to prepare and implement FireSmart activities are essential to protect the infrastructure within and adjacent to the Park.

The FireSmart program is well established in Alberta. Appendix D lists individual community FireSmart projects, as well as a recent example of a YMCA camp saved by a timely fuel management initiative, and FireSmart aerial photographs from the Canmore corridor.

9.1.1.2 GRAZING

From a fire management perspective, grazing is an important fuel reduction initiative that decreases the fire hazard in the grassland fuel type. The enhanced contribution of the three Stock Associations to fuel reduction strategies in pre-identified fuelbreaks should be explored. A range of strategies could be used to influence the timing and distribution of grazing. For example, the use of temporary electric fencing could increase low impact fire barriers that prevent the spread of fire among landscape management units. From a fire behaviour perspective, the abundance and continuous arrangement of matted and standing cured grass throughout the Park is a serious fire spread issue, particularly during fall drought cycles. In the interest of both public visitors and the Stock Associations, strategic grazing areas should be identified for aggressive reduction of the build-up of matted grass, as a catastrophic fire will negatively impact tourism and the ranching industry for many years. In general, focused grazing should be prioritized based on prevailing winds pushing fire ignitions in western grazing areas across the entire Park. In addition, grazing strategies that help isolate the 1934 burn from values at risk to the north and east should also be prioritized.

9.1.1.3 FIREWOOD SALVAGE

The abundance of heavy concentrations of surface woody material throughout the Park contributes to a serious fire hazard, particularly during drought periods. The advanced age of all forest types implies that surface fuel loading will continue to increase. From a fire management perspective, this trend is not in the interest of public safety. Conversely, visitor attendance in the Park and associated demand for firewood is increasing and it seems logical to solve both problems by aggressively salvaging surface fuels and providing firewood to visitors through a cost recovery program. Small-scale firewood operations contracts, such as those being currently run by the Venturers Society of Calgary, could be increased in the Park, particularly in the area of the 1934 burn.

9.1.2 Broad-Scale Fuel Reduction Interventions

Broad-scale forest disturbances are rarely acceptable in Canadian protected areas. However, strategic interventions designed to interrupt the spread of a catastrophic fire event should be considered in the interest of public safety. The analysis of fire behaviour potential in this report is useful to compare wildfire threat and risk versus ecological, heritage, and public safety values. If a catastrophic fire event is certain over the long term and broad-scale fuel reduction can mitigate the incident, a strategic disturbance design should be considered. In Cypress Hills Provincial Park, the commercial value of the forest is marginal and ultimately the cost will be deferred to the provincial budget. From a fire management perspective, it is important to identify and prioritize forest stands that are candidates for disturbance proposals in the public interest. In this report, the areas of proposed stand disturbance or forest stand conversions are recognized in supporting the use of Landscape Management Unit (LMU) boundaries to mitigate fire spread. In general, forest stands that are candidates for priority treatment fall into three categories: (1) all stands originating from the 1934 fire, (2) all stands identified on the Mountain Pine Beetle Susceptibility Severity Index map as High (Map 5.1), and (3) all stands located on the perimeter of LMUs that have high mortality from wind and snow damage or forest health deterioration.

9.1.2.1 PRO-ACTIVE FUELBREAKS AND CONTAINMENT LINES

The *Park Management Plan* for Cypress Hills Interprovincial Park introduces the concept of LMUs. It provides a way to compartmentalize the Park on the basis of ecological objectives, which could include fire management strategies. Figure 9.1 is a map of fuel types in Cypress Hills Park. It illustrates the opportunity to enhance fuelbreak corridors to limit fire growth to LMUs bounded by natural features. By containing future fires within individual LMUs, catastrophic fire events that impact the entire Park can be avoided. This map potentially provides a basis for accepting the historic role of fire in Cypress Hills within the context of public and community safety priorities.

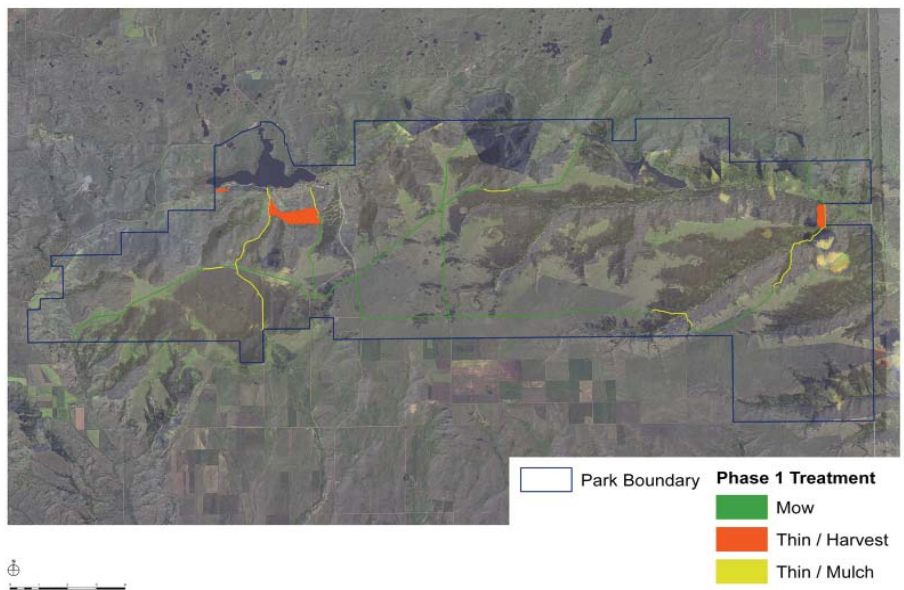


Figure 9.1. Phase 1 Fire Management Treatments.

The analysis in Section 6.0 of this report articulates the departure from the historic fire regime, and ultimately the challenge of accepting future fire disturbance events that contribute to ecological integrity. While a park-wide fire disturbance target may not be acceptable, the use of LMU boundaries designed to contain fire spread could support long-term burn rates of natural fires or prescribed fires. The association of the grassland and forest ecotypes in Cypress Hills creates a formidable fuel continuity mosaic when the grasslands are cured; however, there are opportunities to break the continuity at strategic LMU boundaries. A combination of grazing, mowing and mulching is a low-impact yet effective tactic to limit fire spread and/ or provide backfire or burnout anchor points. Corridor locations to apply this fuelbreak strategy are identified in Figure 9.1.

9.1.2.2 CONTINGENCY FUELBREAKS AND CONTAINMENT LINES

In protected areas in Alberta, the utilization of contingency fuelbreaks and suppression containment lines has recently been proposed. This concept assumes that high impact fire lines are not desirable in a Park setting; however, in the event of an emergency fire situation, pre-identified lines that minimize contravention of protected area objectives could be established in a timely and low impact operation. Tactics that could contribute to this concept include sprinkler lines and feller-buncher tree removal that support indirect attack, rather than bulldozer lines associated with direct attack. These line locations would typically be identified in a pre-attack plan and be approved by SRD fire operations staff. The contingency lines are lower priority relative to the pro-active establishment of LMU boundary fuel breaks, but could substitute for bulldozer lines during an actual fire event.

9.1.3 Prescribed Fire

Merrill and Alexander (2007) define prescribed fire as "any fire deliberately utilized for prescribed burning; usually set by qualified fire management personnel according to a predetermined burning prescription". Murraro (1975) defines prescribed burning as "the knowledgeable application of fire to a specific land area to accomplish predetermined forest management and other land use objectives". Prescribed burning is one of the most universally accepted tools for managing fire-dependent ecosystems, particularly in protected areas such as provincial and national parks. In Alberta, prescribed burn plans are being implemented in Banff, Jasper and Elk Island National Parks, Wilmore Wilderness Provincial Park, and the R11 Forest Management Unit west of Nordegg. Introduction of prescribed burning in Cypress Hills Provincial Park has merit in the context of long term ecological objectives and completion of fire management planning initiatives such as FireSmart and vegetation interventions that mitigate fire spread and limit fire size at the landscape level.

Using Parks Canada as an example for applying adaptive fire management strategies, the Panel on the Ecological Integrity of National Parks (Parks Canada Agency 2000, 2001) recommends that in appropriate parks, fire be restored within an active management framework to 50% of the long-term average of the fire cycle. However, the Fire Management Strategy group (Parks Canada Agency 2005) recognized that attaining 50% of the long-term fire cycle may not be feasible in every national park in the short term. Rather, an overall program goal of 20% of the long-term fire cycle, accounting for both prescribed fires and wildfires, was adopted while acknowledging that individual parks may have a 50% or more restoration goal in their fire management plan. For example, prescribed burning, applied strategically, is an accepted component to the fifty percent target in Jasper National Park. The short fire return intervals documented in the Montane ecoregion of Waterton, Jasper and Banff National Parks, through fire history studies, are believed to be reminiscent of fire regime conditions found in the Cypress Hills (Figure 9.2).

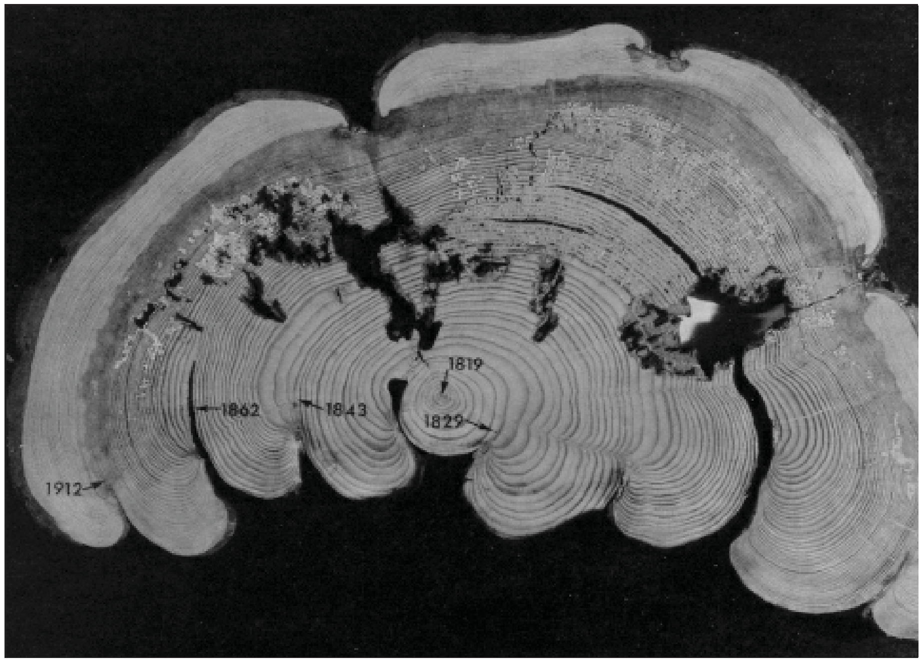


Figure 9.2. Cross-section of a multiple fire-scarred lodgepole pine tree from Jasper National Park documenting fires from 1829, 1843, 1862 and 1912.

9.2 MITIGATION OF CATASTROPHIC FIRE EVENTS

Mitigating catastrophic fire events from a public safety and community protection standpoint requires wildfire operations strategies that include pre-attack planning, initial attack planning, and planning for sustained fire suppression action.

9.2.1 Wildfire Operations Strategies

The concept of advance planning for an eventual wildfire fire event is universally accepted. The basic premise is that small fires are manageable, but large, intense fires involve million dollar expenditures and often require help from Mother Nature to control. Public safety is the primary fire management priority in Alberta, and advance intelligence and emergency protocols are prerequisites for successful fire suppression outcomes. In the event of a catastrophic fire event, a comprehensive Evacuation Plan (June 1, 2005) for Cypress Hills Provincial Park will guide an emergency evacuation. In addition to the emergency protocols established in the Park, a pre-attack plan is recommended to enhance public safety during a wildfire emergency. Pre-attack planning is the link between emergency planning and initial attack operations following fire ignition. This relationship implies that information is up to date and that duty officers at the provincial and local level have access to the current pre-attack plan. In addition, a sophisticated pre-attack plan ensures that fire suppression operations, community values at risk, and emergency communications are aligned. In a provincial park setting, a pre-attack plan is particularly useful to identify opportunities for low-impact fire suppression operations. An important component of a pre-attack plan is a sprinkler layout plan for community values at risk that considers water supply, pump pressures and location, hose and sprinkler specifications, and installation timing and priorities. A preliminary sprinkler system for Cypress Hills Interprovincial Park is included in this report to illustrate the opportunity to quickly protect the west perimeter of Elkwater or other values at risk throughout the Park. Rapid Fire and Rescue Inc. is an Alberta-based fire protection company which has visited Elkwater and prepared a very helpful summary of a high volume pumping and sprinkler system that could be set up in less than three hours (Figures 9.3 and 9.4). The system includes a pump, connectors, sprinklers and hose that would use Elkwater Lake to supply water to 7th avenue properties as an example (Appendix F). Low cost sprinkler systems have saved numerous values at risk under extreme fire behaviour conditions and examples are illustrated in Appendix G.

Figure 9.3. Portable pump (Rapid Fire and Rescue Inc.).

Figure 9.4. Sprinkler deployment (Rapid Fire and Rescue Inc.).

9.2.1.1 PRE-ATTACK PLAN OUTLINE

A suggested outline is included in this report to guide the inter-agency discussions required to integrate fire suppression operations and Cypress Hills Provincial Park emergency planning measures. A pre-attack plan is an important document which contributes directly to protecting life and property in fire prone environments and includes the following subjects:

- Emergency planning contact information
- Detailed Area Description
    - Community location, critical infrastructure and access routes
    - Fire behavior potential
    - FireSmart priorities
    - Indirect attack fuelbreak designs and protocols
    - Comprehensive list and location of all values at risk
    - Hazardous material sites
    - Water supply
- Action Plan
    - Protocols for issuing fire bans and access closures
    - Wildfire evacuation protocols for the public
    - Wildfire evacuation protocols for the emergency responders
    - Wildfire operations protocols –provincial and local
    - Staging areas for firefighting operations
    - Constraints on equipment and tactics
    - Sprinkler layout plan
- Communications
    - Public
    - Interagency
    - Fireline operations
    - Media

9.2.1.2 INITIAL ATTACK

Sustainable Resource Development (SRD)'s fire management performance targets include detecting 90% of fires in five minutes or less and responding with initial attack resources before the fire exceeds 2 ha. These goals require a preparedness level that is appropriate for the fire danger levels that are calculated daily based on observed weather throughout the fire season. The Alberta government has traditionally approved a wildfire protection commitment and budget that supports the performance targets, which is recognized and admired internationally. A sophisticated Spatial Fire Management System (SFMS) in turn pre-positions initial attack resources throughout the province based on hazard and provincial priorities. A Wildfire Working Agreement between SRD and TPR provides guidelines for levels of wildfire pre-suppression that are referenced in the interagency MOU. In the case of Cypress Hills Provincial Park, local resources are adequate for low and moderate danger rating levels; however, SRD backup is required for high and extreme fire danger levels. The working agreement guidelines between SRD and TPR describes initial attack resource levels in relation to Head Fire Intensity (HFI) ranking. At HFI 1 and 2, Parks will use local resources with no SRD support. At HFI 3 and 4 it is recommended that SRD commit a four-person Type 1 crew complete with a truck and initial attack fire equipment. At HFI 5 and 6 one intermediate helicopter will be added to support the Type 1 crew and another eight-person crew with a truck and equipment will be supplied by SRD. In addition, consideration for hiring a water tender will be discussed between the local and Calgary duty officers. Once a fire is detected in Cypress Hills, the standard information regarding size, fire behaviour, location, and values at risk will be reported to the Calgary Fire Centre and a fire number is assigned which commences the initial attack coordination between local and provincial resources. Based on the analysis of Fire Weather Index components in this report a refined working agreement for initial attack is being discussed for the 2009 fire season. The updated agreement will recognize both the significance of the cured grass stage and a threshold Buildup Index that contribute to extreme fire behaviour.

9.2.1.3 SUSTAINED FIRE SUPPRESSION ACTION

Direct Attack

Given the weather and fuel type analysis in this report, it should be assumed that if single or multiple fire ignitions occur during high or extreme danger rating levels, an escaped fire in Cypress Hills is highly probable. If a fire escapes initial attack, either direct or indirect suppression tactics are implemented with direct attack options being preferred in most cases. Direct attack involves aggressive, high impact suppression operations on the fire perimeter that directly limit fire spread and the final size of the fire. In Alberta, the use of bulldozer units for direct attack is standard practice followed by extensive reclamation to re-vegetate fire lines that expose mineral soil. Although the Cypress Hills is a unique and important protected area in the province of Alberta, the protection of life and community property from a potentially catastrophic fire may require aggressive direct attack.

Wildfire managers in Alberta have adopted the Incident Command System (ICS), which is an internationally accepted fire management operations approach with the following components:

- Command
- Planning
- Operations
- Logistics
- Finances

Fire incident levels vary from Type 1 which is the most complex to Type 5 which is the least complex. The ICS standards for Types 1 to 5 incidents are given in Appendix H. A Type 1 or Type 2 incident in Cypress Hills Provincial Park will have serious consequences in terms of ecological integrity as the suppression footprint is extensive if fire lines are established with bulldozer units. As an alternative to standard direct attack operations this report identifies proactive strategies that include LMU fuelbreaks and the use of indirect attack options.

Indirect Attack

The natural vegetation mosaic in Cypress Hills supports indirect attack options that are associated with the LMUs in the *Park Management Plan* (Figure 9.5).

In Section 9.1.2.1 fuelbreak corridors enhancements are presented at the landscape level as opportunities to mitigate fire spread and also limit the suppression footprint without compromising suppression success. A successful burnout and backfire tactic has been developed and used in Alberta for three decades and aerial torches and ignition teams are available throughout the province for both wildfire or prescribed burn assignments (Figure 9.6). If the concept of compartmentalizing the Cypress Hills Provincial Park using LMUs and indirect attack options that could contain fire spread up to 90th percentile weather events is accepted, then both public safety and ecological integrity are prioritized. The prerequisite for approval and success of this strategy is a sophisticated pre-attack plan and timely fire and forest management initiatives that create and maintain fuelbreak corridors.

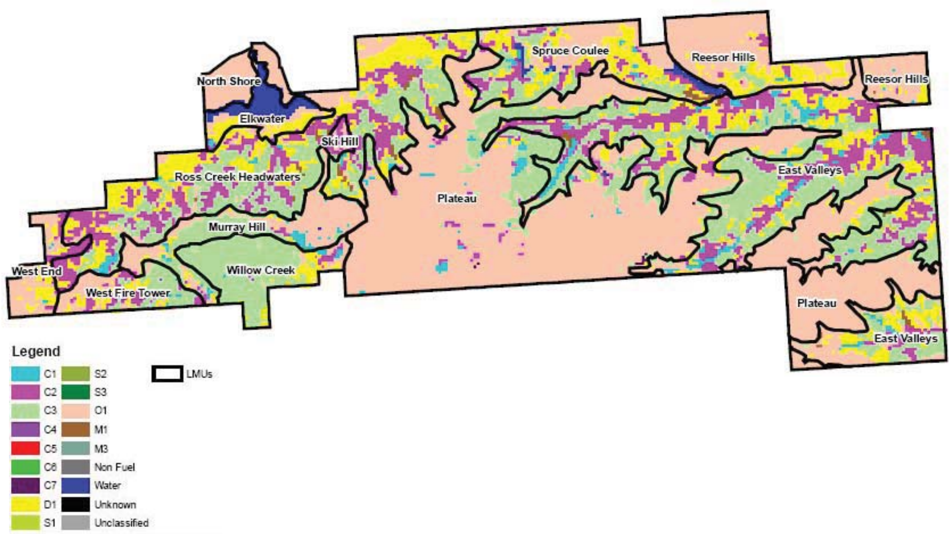


Figure 9.5. Landscape units overlaid on the FBP fuel types as a basis for determining indirect fire suppression strategies.

Figure 9.6. Aerial Ignition Team preparing for the Mt. Nestor prescribed burn, 2007.

9.3 FOREST HEALTH PROTECTION

Protecting forest health means maintaining ecological processes within their range of natural variability so that the ecosystem structure, resources and ecological values persist over the long term. Agents of change such as pests and pathogens, invasive species, grazing, fire, climatic events and forest and grassland succession must be monitored and may be individually managed, where required.

Active management is required in the Cypress Hills environment because of historical factors such as alteration of the natural fire regime and replacement of bison grazing by cattle grazing. The small size of the park and isolation from similar environments also makes it susceptible to agents of change.

Overall, fire management strategies such as mitigation of catastrophic fire risk and prescribed fire contribute to forest health protection through maintenance of natural disturbance processes through which park ecosystems evolved. Compartmentalizing the landscape into 'fire units' allows for a diversification of forest age structure along management lines, as fires may occur in any of these units in any given year, but be arrested at the unit boundary through sustained fire suppression action. The diversity of age classes and ecological niches contributes to forest health and makes the forest less susceptible to the agents of change introduced in Section 5.0. Occasional low-intensity fires also help to maintain species composition and promote nutrient cycling.

At a smaller scale, the condition of forest components such as air, soil, water and vegetation should be maintained or enhanced through management activity. Thus, any fuel breaks or containment lines considered in order to manage fire activity must also be managed for soil conservation / erosion control, water quality and invasive species prevention. Forest health protection may also include the reclamation of disturbed sites, whether by human action (e.g., direct fire suppression) or natural causes (e.g., MPB). An adaptive management and monitoring framework is again important. Monitoring involves determining trends in resources, how factors are increasing or decreasing, and their cause.

More specific strategies for protecting forest health in terms of the agents of change introduced in Section 5.0 are provided in Table 9.1.

As a long-term strategy, restoring a more natural forest age structure through fire management (as decribed in the rest of this Section) would have considerable impact on forest health. However, another agent of change, climate change, will introduce some unpredictable effects to the Cypress Hills forests. Some potential effects of climate change and of implementing fire management recommendations on forest health are given below:

Potential effects of climate change (to monitor):

- increased overwintering success of pest species such as MPB and dwarf mistletoe
- greater success of pests over many of their predators (e.g., fungi) under a warmer and drier climate
- increased moisture stress by trees, leading to increased vulnerability to pests and pathogens
- shifts in ecological communities on the edge of their range (e.g., transition of forest boundaries into grasslands)
- incidence of drought may promote aspen suckering
- slowing or reversal of forest encroachment onto grasslands due to decreased moisture availability

Potential effects of fire management as recommended in this Section (including prescribed burns):

- greater diversity of age classes leading to reduced susceptibility to MPB, dwarf mistletoe, and spruce budworm
- burn treatments and thinning reduce dwarf mistletoe severity
- increased risk of invasive species colonizing disturbed sites
- decrease in dominance of white spruce and increase in lodgepole pine
- potential for increased aspen suckering
- slowing or reversal of forest encroachment onto grasslands

Table 9.1. Strategies and examples of monitoring indicators for forest health protection.

Forest Health Issue	Overall Strategy	Sample Indicators for Monitoring
Pests and pathogens	**Short- to medium-term:** Continue to monitor pest numbers in the park Compare with natural range of variability (if known) Report epidemic outbreaks to Alberta SRD Decrease pest populations where severe defoliation is occurring using approved biological sprays or other best practices Maintain current information on pest management best practices **Long-term:** Return to a more diverse forest age structure (related to fire management and prescribed fire opportunities) to decrease stand susceptibility and vulnerability	Tree condition in sample plots, measured by % defoliation % trees affected by spruce budworm, MPB and other known pests and pathogens over time
Invasive species	**Short- to long-term:** Monitor species regrowth and post-disturbance ecosystem recovery Exclude cattle from post-burn or post-disturbance areas Maintain current information on invasive species best practices	Level of expansion of smooth brome and other invasive species Species diversity measures Presence of expected natural species and forest plant layers / Presence of noxious weeds Thickness of the surface organic layer Signs of accelerated soil erosion / exposed soil
Grazing	**Short- to medium-term** Continue to allow light grazing within and on boundary of forest stands Monitor for decreaser plant species Exclude cattle from post-burn or post-disturbance areas	Increase or decrease in species that typically decrease with increased grazing pressure (e.g., aspen, peavine, saskatoon)
Fire	**Long-term** Consider long-term role of prescribed fire and use of landscape units (see Section 9.1.3)	Areas experiencing natural and prescribed fire
Climate events	**Medium- to long-term** Monitor temperature and moisture trends Consider possibility of maintaining seed banks from local sources	Comparison of temperature and moisture trends with the other indicators
Forest succession	**Medium- to long-term** Monitor effects of grazing, climate and fire at forest boundaries Consider long-term role of prescribed fire for aspen regeneration and lodgepole pine renewal Reduce browsing and post-fire grazing in forested areas	Degree of encroachment / Loss of gain of grasslands compared to forests on a 5-year basis Aspen age-class distribution

9.4 PROTECTION OF ECOLOGICAL INTEGRITY AND LANDSCAPE VALUES

Ecosystems retain their ecological integrity and resilience to disturbances when biodiversity and ecosystem processes are conserved. The fire management strategies described above can help to restore some of the ecosystem processes related to natural fire disturbance regimes in the park. However, when conducting management activities, impacts on biodiversity and ecosystem processes should be minimized. Rare ecological communities and species in particular should be appropriately considered. Rough fescue grasslands are an endangered ecosystem. A number of at-risk wildlife species and rare plant species are also located in the park, primarily within fescue grasslands as well as wetlands. The relict cordilleran forest and associated species are also somewhat unique, since they are isolated from similar ecosystems and larger populations in the Rocky Mountain foothills to the west.

Potential measures for maintaining ecological integrity include a strong knowledge of landscape, stand and community structures, as well as how ecosystem processes function and are maintained. An understanding of human uses within the park and their interactions with the ecosystem is also paramount to sustain ecological integrity (Quigley et al. 2001).

9.4.1 Biodiversity Protection Strategies

Establishing the role of fire in the Cypress Hills is critical to maintaining natural processes within their range of natural variability. This ensures a diversity of niches which increases both community and species diversity. Strategies such as prescribed burning may control the encroachment of spruce, pine and shrubby cinquefoil onto the plateau, as well as spurring aspen regeneration. However, post-fire effects should be monitored and management adapted to site-specific conditions as required.

There are four management objectives related to biodiversity protection:

- conserve health, biodiversity and extent of fescue grasslands;
- protect integrity of wetlands/riparian areas;
- maintain habitat for species of concern and rare ecological communities; and,
- maintain diversity of fauna and habitat.

Maintaining native fescue and associated species in the park's fescue grasslands is critical. This includes limiting the spread of invasive species during forest and fire management operations. Keeping priority areas for mowing and mulching activity along existing roads should help in this respect, as well as promoting the use of landscape compartments to guide forest management. Genetic diversity may be maintained by promoting the use of local, native propagules when restoring a disturbed site.

The use of best practices for erosion control during fuelbreak construction and maintenance, especially near riparian areas, helps protect the integrity of park watersheds and wetlands.

Breeding and nesting times of local species should be considered when any management activity is required, such as forest thinning or focused grazing. By timing activities to avoid critical seasons, nesting success may be promoted.

Vascular plants of concern within priority management areas are shown in Figure 9.7, including broad-scaled sedge, pasture sedge, Douglas hawthorn, early buttercup, yellow monkeyflower, and pinesap. Pinesap and pine drops are both associated with lodgepole pine forests. Broad-scaled sedge, pasture sedge and yellow monkeyflower are found in riparian hydric to subhydric areas, while early buttercup is found in moist depressions and drainages. In addition, the fescue grassland community located on the plateau (shrubby cinquefoil/foothills rough fescue/intermediate oatgrass) is considered a Rare Ecological Community by the Alberta Natural Heritage Information Centre (ANHIC).

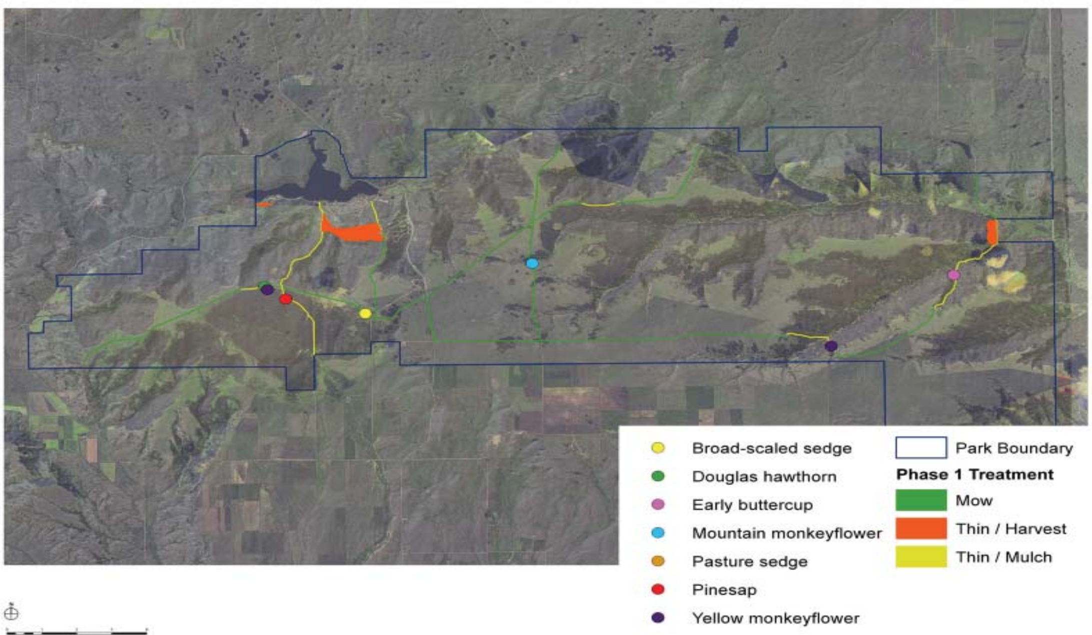


Figure 9.7. Plant species of concern within priority management areas.

In addition, there is a draft park directive requiring an environmental review to be completed when any new development, site upgrading, or site ground disturbances are proposed.

9.4.2 Scenic Protection Strategies

Maintaining and protecting the natural visual integrity of the park is one of the management objectives for Cypress Hills. The impact of forest management activities such as mowing, mulching and thinning on scenic quality may be mitigated through several measures. One strategy, already taken into account in the placement of the mowing/mulching lines, is to use existing disturbances such as road lines. Other strategies include:

- 'Feathering' the edges of mowed and mulched areas (clear vegetation in an uneven pattern to blend with adjacent vegetation);
- Storing construction and other operational materials away from highly visible sections along scenic corridors (see Section 3.9.1);
- Thinning in irregular patches of varying density, rather than keeping an even scatter of retained trees within a unit, causes the unit to resemble a natural opening.

IMPLICATIONS

1. Aggressive fire and forest management strategies, spatial and temporal, are essential to protecting public safety and ecological values.

RECOMMENDATIONS

Forest Management Strategies

Fine-Scale Fuel Reduction – FireSmart

1. Complete the FireSmart program for the Elkwater community, including the three church camps, in 2009.
2. Complete the FireSmart program for the 18 campgrounds and facilities rated as Extreme Hazard by 2012.

Fine-Scale Fuel Reduction – Grazing and Firewood Salvage

1. Introduce grazing designs that support the landscape fuelbreak corridors and are also ecologically appropriate.
2. Enhance firewood salvage operations that support the landscape fuelbreak corridors.

Broad-Scale Fuel Reduction Interventions – Pro-active Fuelbreaks and Containment Lines

1. Adopt the concept of landscape compartmentalization and implement mowing and mulching operations that create corridors designed to mitigate fire spread.
2. Design low impact contingency fuelbreak lines that would be constructed in emergency wildfire operations.

Mitigation of Catastrophic Fire Events

Wildfire Operations Strategy

1. In 2009, develop a pre-attack plan for Cypress Hills Provincial Park that ensures maximum protection for human, community and ecological values in the event of a catastrophic wildfire emergency.
2. Refine the Wildfire Working Agreement to include cured grass and Buildup Index thresholds for HFI levels 5 & 6.
3. Acquire a sprinkler system dedicated to the Elkwater community as support for infrastructure protection.
4. Refine CHIPP policy on fire bans and forest closures.

Forest Health Protection

1. Introduce disturbance events that prioritize forest stands that are health risks (e.g., see Maps 5.1 and 5.2 for MPB and spruce budworm infestations) and that are also adjacent to fuelbreak corridors.
2. Manage the ingress of coniferous regeneration as a contribution to landscape fuelbreak corridors.
3. At the conclusion of implementing IFFMS recommendations, introduce prescribed burning in priority areas to maintain ecological integrity and decrease the probability of a catastrophic fire (2015).
4. Minimize impacts of disturbances on park streams and watersheds through appropriate use of erosion control practices.
5. Monitor regeneration of disturbed sites for native and non-native species using a defined protocol.
6. Build relationships with the scientific community in terms of monitoring, research and best practices.
7. Continue detailed surveys of MPB spread and introduce detailed surveys for spruce budworm infestation.

Protection of Ecological Integrity and Landscape Values

1. Promote a spatially diverse forest age-class structure by utilizing landscape compartments to guide fire management strategies.
2. If revegetation of an area is required, use native and local varieties of seed.
3. Time focused grazing activity along fire breaks to minimize impacts to grassland flora and fauna.
4. Minimize visual impact from park viewpoints and trails.
5. Active monitoring and management of invasive species undertaken when implementing all grassland, forest and fire management activities.

10.0 WILDFIRE EMERGENCY PLANNING AND COMMUNICATION

Wildfire protection for Cypress Hills Provincial Park has been provided through a Memorandum of Understanding with Sustainable Resource Development since 1997. In the agreement the Park is responsible for wildfire protection with support from SRD unless dictated otherwise by provincial wildfire or hazard situations. A Wildfire Working Agreement provides guidelines for levels of wildfire pre-suppression and suppression support agreed to in the MOU. In addition, a Saskatchewan/Alberta Fire Cooperation Agreement allows either province to take suppression action within 20 km of the border. The County of Cypress recently has developed a Mutual Aid Agreement with SRD regarding facilitation of fire control efforts supported by an Annual Mutual Aid Fire Control Plan. Cypress County and CHPP have an agreement for fire protection in Elkwater and a surrounding protection area of approximately 370 000 ha. Within this agreement the Elkwater Volunteer Fire Department provides fire protection and emergency services in the municipal protection area. In 2001, a Cypress Hills Fringe Area Planning Study was initiated by the Cypress County which addressed the risk of wildfire in the County jurisdiction associated with the fire behaviour potential in Cypress Hills Provincial Park. Conversely, the threat of a fire in the County spreading to the Park is a concern particularly when the grasslands are cured and extremely flammable. Given the complexity of coordinating SRD, Inter-provincial, TPR and Cypress County operations during a fire emergency, an interagency mock fire exercise is recommended to validate the independent understanding and protocols in each agency.

IMPLICATIONS

1. Clear communication interagency protocols are key elements to successful wildfire emergency response.

RECOMMENDATIONS

1. Organize a mock wildfire emergency exercise that involves all agencies and serves to demonstrate the complexity and importance of communication.
2. Develop a three or four page brochure describing the wildfire issues for the Information Centre.
3. Encourage SRD to include Cypress and adjacent Counties in their mutual aid agreement.

11.0 CONCLUSION AND RECOMMENDATIONS

The Cypress Hills is a unique and provincially important landscape that attracts a significant number of domestic and international visitors on an annual basis. Heritage, cultural and ecological features all contribute to the visitor experience in Cypress Hills Provincial Park; however, based on the analysis in this report, many of the human and ecological values are at risk from a catastrophic wildfire. Since the 1885 fire that burned through much of the Cypress Hills forests, both frequent low intensity and infrequent high intensity fires have been absent. The exception is the 1934 Willow Creek fire that burned approximately 600 ha. Although the current fire occurrence risk is low, the fire behaviour potential each fire season is high as a result of aging forests, and a one-day extreme fire event could potentially burn more than 50% of the Park. Since the Park is in a remote location relative to the SRD airtanker base locations, which provide the most effective initial attack capability, early fire suppression success is primarily dependent on local resources during high and extreme fire danger levels. Human values, as well as ecological values, are present throughout and adjacent to the Park and, as expected in a prairie environment, the community and recreational infrastructure are closely associated with the unique forested areas. This association of flammable forests and human values is a universal challenge for fire protection agencies and unfortunately many tragic losses are experienced on an annual basis. The fire severity trend prompts the recommendations for aggressive fire and forest management initiatives that address the wildfire risk issues in Cypress Hills Provincial Park described in this report.

The objectives of this Integrated Fire and Forest Management Plan were directed toward documenting the historic and present fire regime, assessing the overall wildfire threat in the Park and presenting recommendations to mitigate a catastrophic fire for the purposes of public safety and the protection of forest health and ecological integrity. Based on the report analysis, aggressive fire and forest management commitments are required to protect both human and ecological values in both the short term and long term in Cypress Hill Provincial Park. Table 11.1 presents a summary of fire and forest management strategies.

The summary of recommendations is grouped by subject areas as presented in the document.

Table 11.1. Summary of the priority, timeframe and cost of forest management and prescribed burn options.

Option	Priority	Timeframe	Implementation Constraints	Unit Cost	Size of Identified Priority Areas	Cost of Implementation in Identified Priority Areas
Mitigation						
Development of pre-attack plan	High	1 year	None	$25,000		
FireSmart						
FireSmart fuel reduction around Elkwater WUI	High	1 to 2 years	Light equipment and hand felling required, slow process. Resident awareness and education required. Cost.	$6000/ha[1]	100 ha	$600,000
FireSmart fuel reduction around isolated infrastructure, campgrounds, church camps	High	3 to 4 years	Light equipment and hand felling required, slow process. Resident awareness and education required. Cost.	$6000/ha[1]	33 ha	$200,000
[1]Note: Operational planning, monitoring and invasive species management adds an additional $1000 to the base unit cost of $5000						
Landscape Fuelbreak Corridors						
Mowing	High	Immediate	Access and regular maintenance required.	$100/ha	23.7 ha	$2370 initial
Mulching / Thinning	High	Immediate	Short term visual impact	$2000/ha	14.8 ha	$29,600
Sprinkler Contingency Lines (Townsite Sprinkler Protection)	High	1 to 2 years				$200,000
Feller Buncher Contingency Lines	Moderate	Mid-term	Long term visual impact, damage to adjacent vegetation	Fire suppression cost		
Grazing Corridors	High	Immediate	Negotiation with stock associations	$1000/km for electric fence systems	~3 km	$3000
Prescribed Burning						
Grassland Hazard Reduction	High	Long term (5 years)	Public resistance	$50/ha	~800 ha	$40,000
Stand Replacement or Conversion	Moderate	Long term (10 years)	Risk of escape	$300/ha	~600 ha	$220,000
Total Priority Zones Cost						$1,319,970 (including sprinkler lines)

Summary of Recommendations

FireSmart Programs (see Section 9.1.1)

Recommendation 1---------Complete the Firesmart program for the Elkwater community, including the three church camps in 2009.

Recommendation 2-----------Complete the FireSmart program for the 18 campgrounds and facilities rated as Extreme Hazard by 2012.

Fine-scale Fuel Management (see Section 9.1.1)

Recommendation 1----------Introduce grazing designs that support the landscape fuelbreak corridors.

Recommendation 2----------Enhance firewood salvage operations that support the landscape fuelbreak corridors.

Landscape Fuelbreak Corridors (see Section 9.1.2)

Recommendation 1----------Adopt the concept of landscape compartmentalization. and implement mowing and mulching operations that create corridors designed to mitigate fire spread.

Recommendation 2----------Design low impact contingency fuelbreak lines that would be constructed in emergency wildfire operations.

Wildfire Operations (see Section 9.2.1)

Recommendation 1----------In 2009, develop a pre-attack plan for Cypress Hills Provincial Park that ensures the maximum protection to human, community and ecological values in the event of a catastrophic wildfire emergency.

Recommendation 2-----------Refine the Wildfire Working Agreement to include cured grass and Buildup Index thresholds for HFI levels 5 & 6.

Recommendation 3----------Acquire a sprinkler system dedicated to the Elkwater community as support for infrastructure protection.

Recommendation 4----------Refine CHIPP policy on fire bans and forest closures.

Forest Health and Succession (see Section 9.3)

Recommendation 1----------Introduce disturbance events that prioritize forest stands that are health risks and that are also adjacent to fuelbreak corridors.

Recommendation 2----------Manage the ingress of coniferous regeneration as a contribution to landscape fuelbreak corridors.

Recommendation 3--------At the conclusion of implementing IFFMS recommendations, introduce prescribed burning to maintain ecological integrity and decrease the probability of a catastrophic fire (2015).

Recommendation 4---------- Minimize impacts of disturbances on park streams and watersheds through appropriate use of erosion control practices.

Recommendation 5----------Monitor regeneration of disturbed sites for native and non-native species using a defined protocol.

Recommendation 6 --------- Build relationships with the scientific community in terms of monitoring, research and best practices.

Recommendation 7---------- Continue detailed surveys of MPB spread and introduce detailed surveys for spruce budworm infestation.

Ecological Integrity and Landscape Values (see Section 9.4)

Recommendation 1-------------Promote a spatially diverse forest age-class structure by utilizing landscape compartments to guide fire management strategies.

Recommendation 2-------------If revegetation of an area is required, use native and local varieties of seed.

Recommendation 3-------------Time focused grazing activity along fire breaks to minimize negative impacts to grassland flora and fauna.

Recommendation 4------------Minimize visual impact from park viewpoints and trails.

Recommendation 5------------Active monitoring and management of invasive species undertaken when implementing all grassland, forest and fire management activities.

Emergency Planning (see Section 10.0)

Recommendation 1------------Organize a mock wildfire emergency exercise that involves all agencies and serves to demonstrate the complexity and importance of communication.

Recommendation 2-------------Develop a three or four page brochure describing the wildfire issues for the Information Centre.

Recommendation 3------------Encourage SRD to include Cypress and adjacent Counties in their mutual aid agreement.

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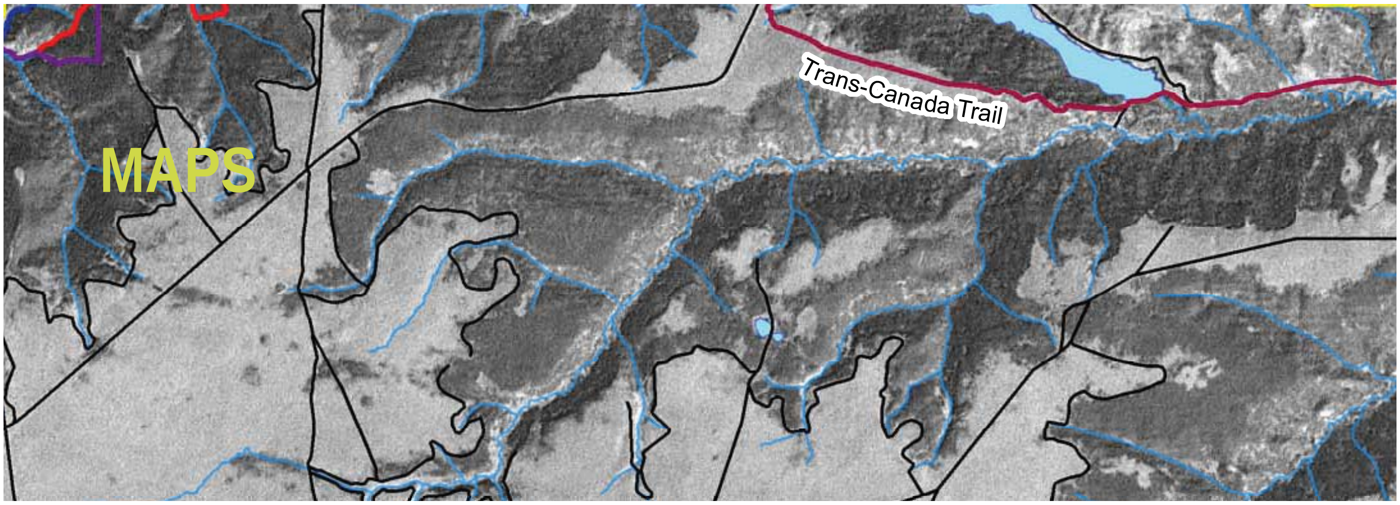
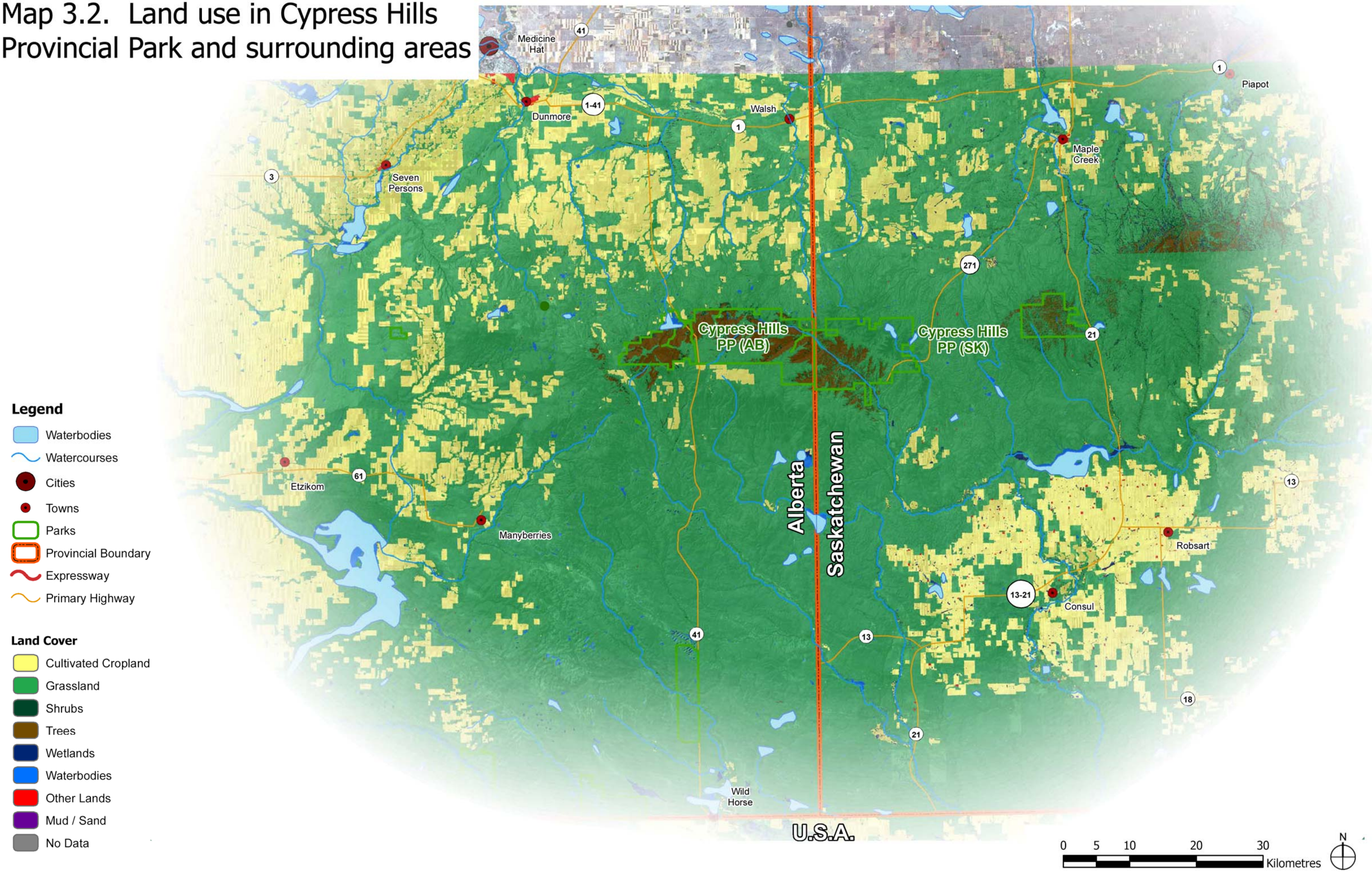
MAPS

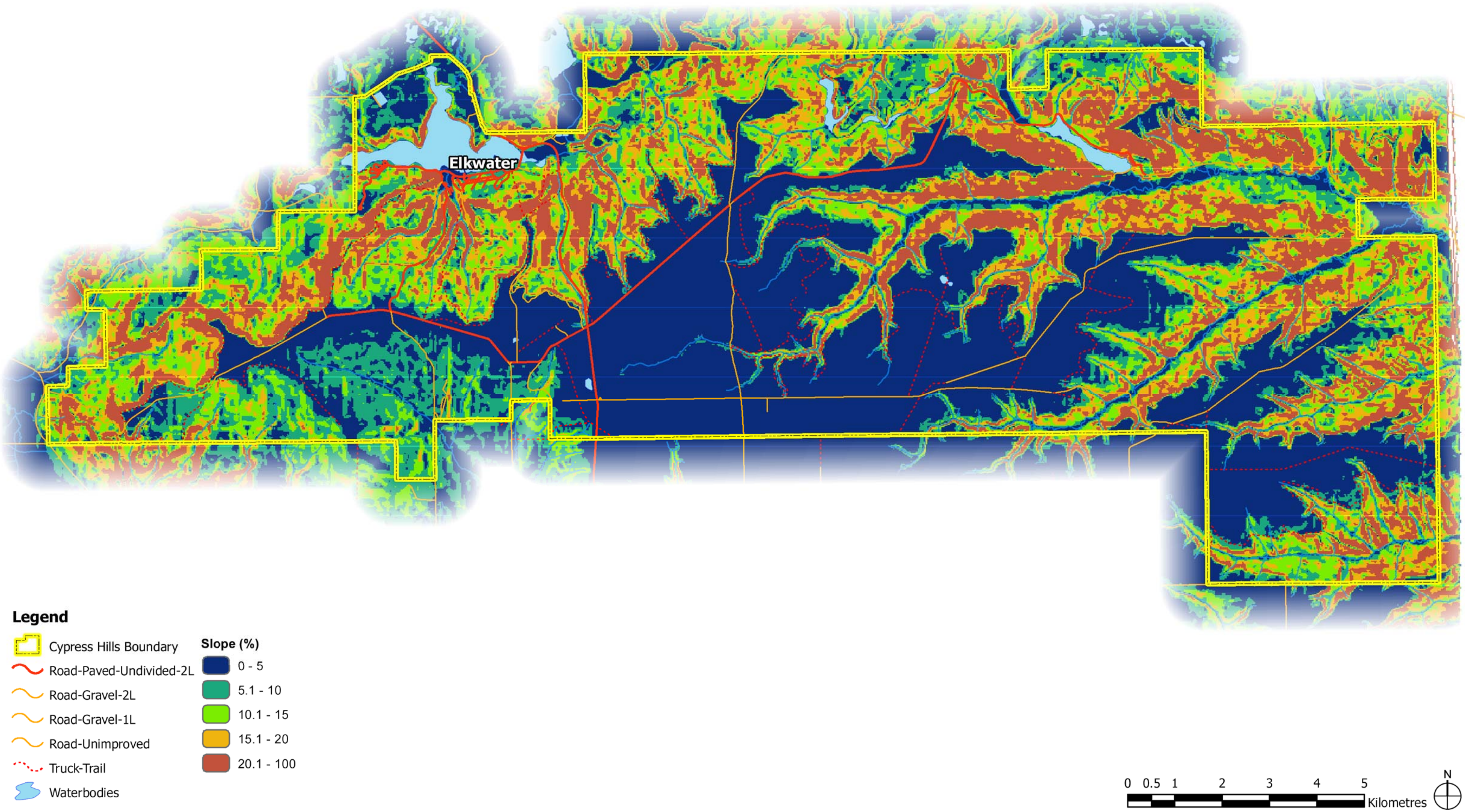


Map 3.1. Cypress Hills Provincial Park: Access Routes

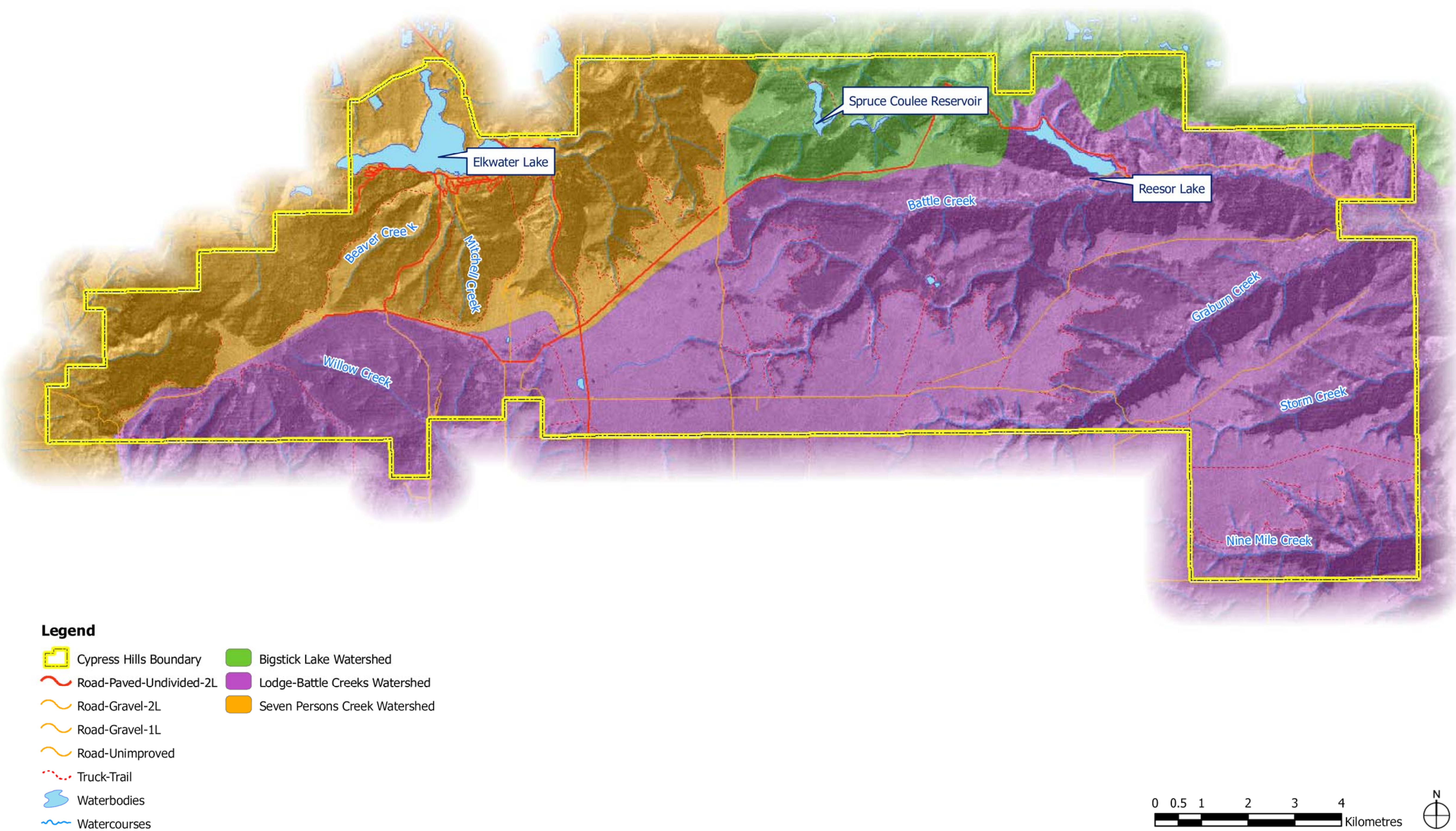
Map 3.2. Land use in Cypress Hills Provincial Park and surrounding areas



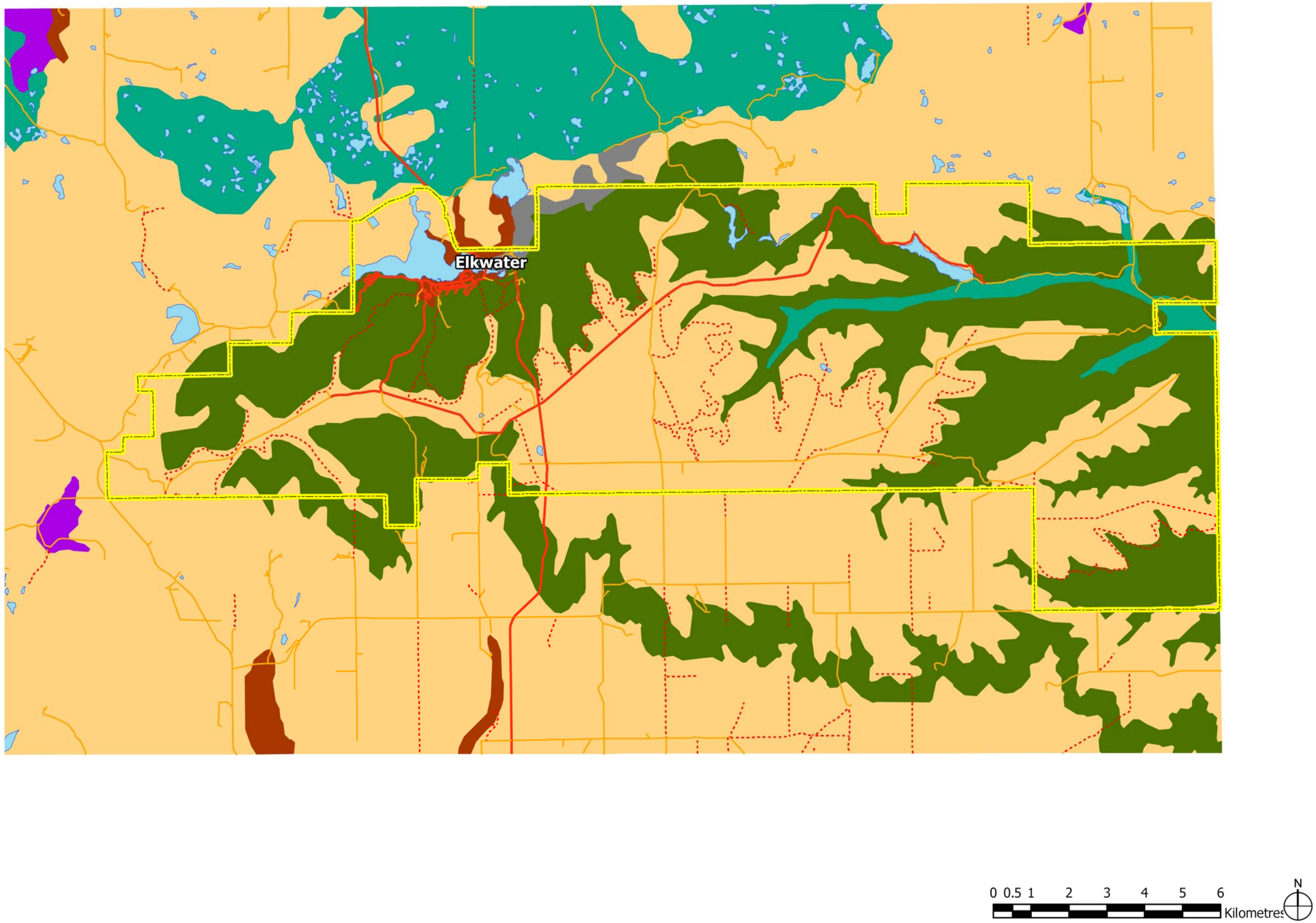
Map 3.3. Cypress Hills Provincial Park: Slopes



Map 3.4. Cypress Hills Provincial Park: Hydrology



Map 3.5. Cypress Hills Provincial Park: Soil Types



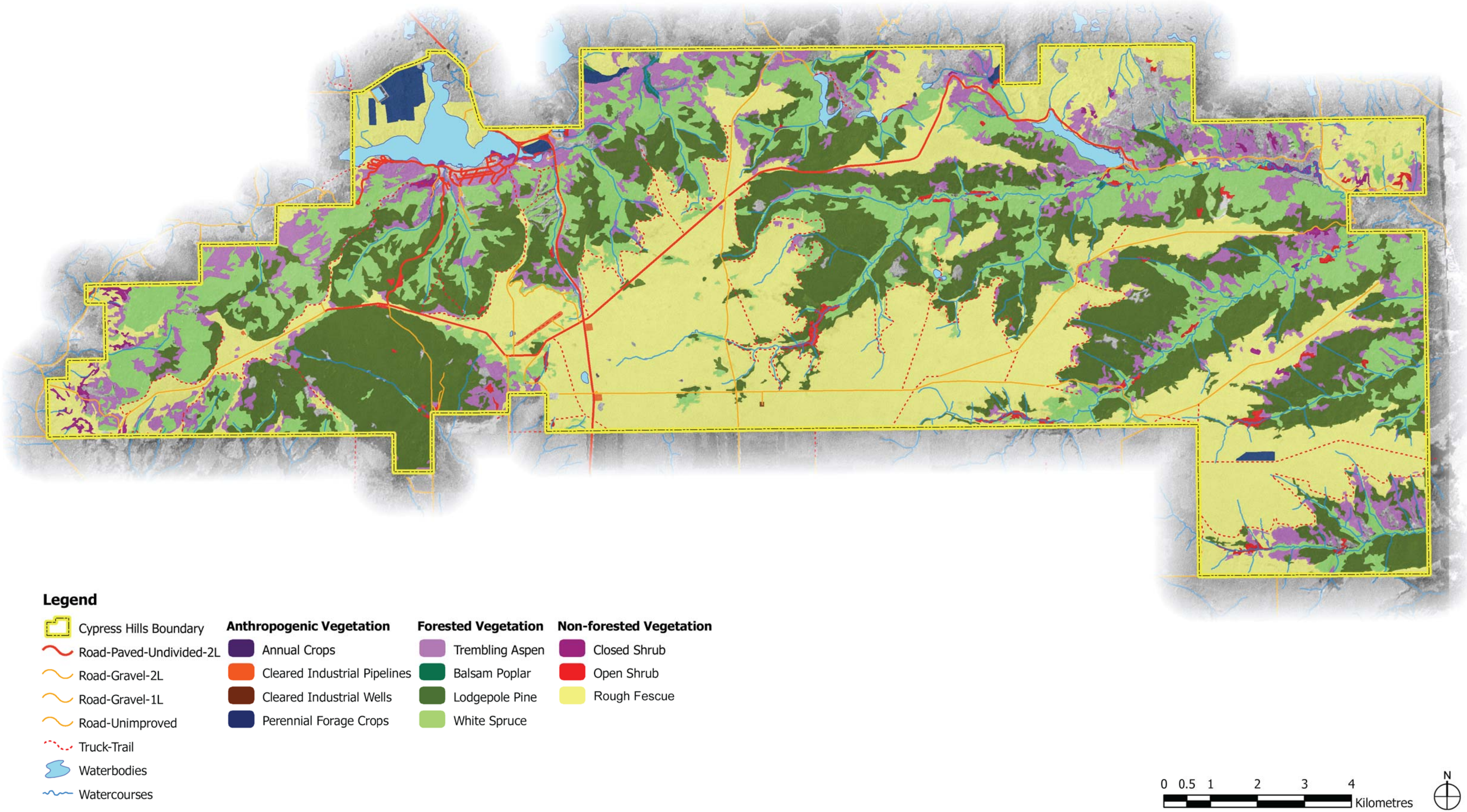
Legend

- Cypress Hills Boundary
- Road-Paved-Undivided-2L
- Road-Gravel-2L
- Road-Gravel-1L
- Road-Unimproved
- Truck-Trail
- Waterbodies

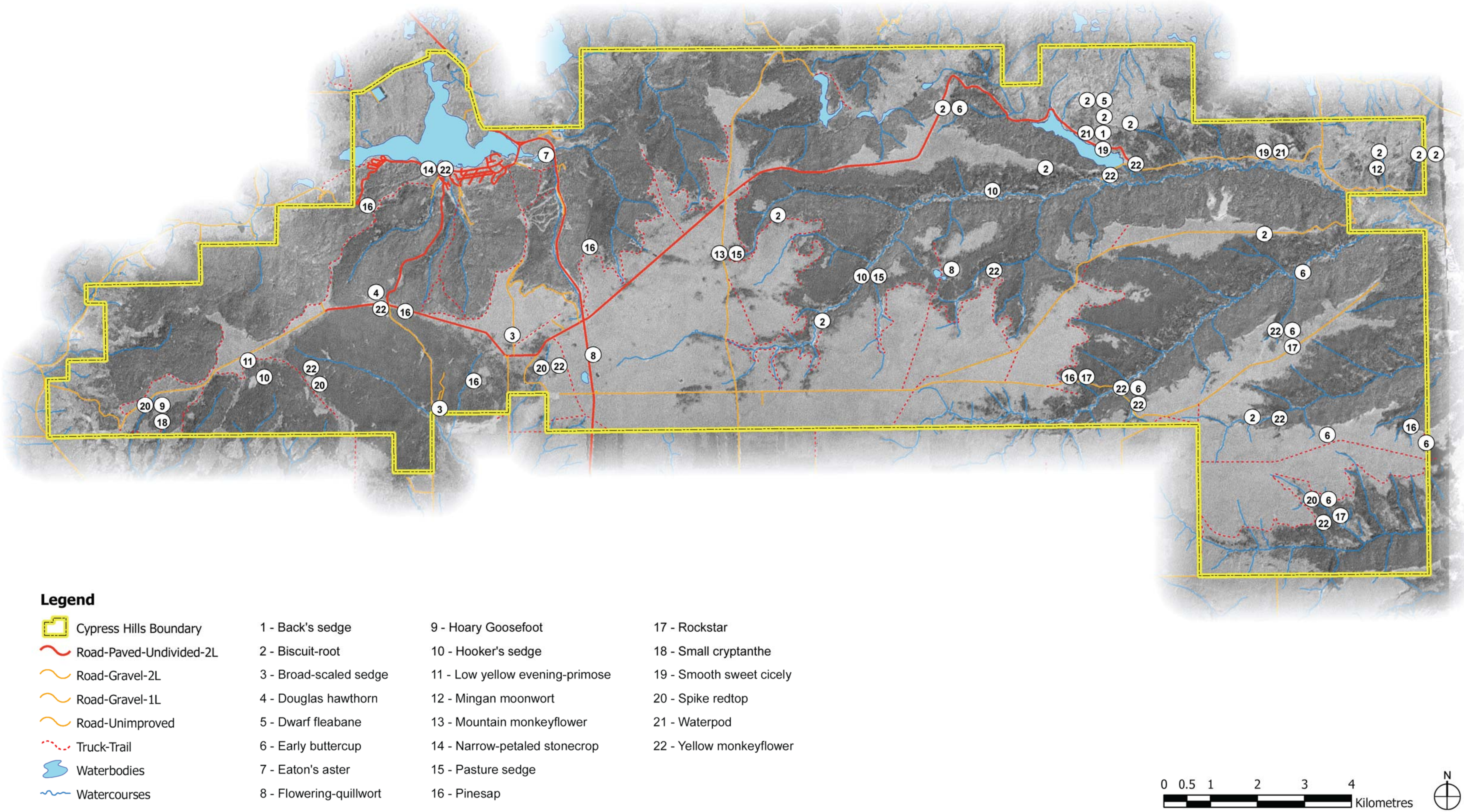
Soils

- Chernozem
- Luvisol
- Gleysol
- Regosol
- Organic
- Solonetzic

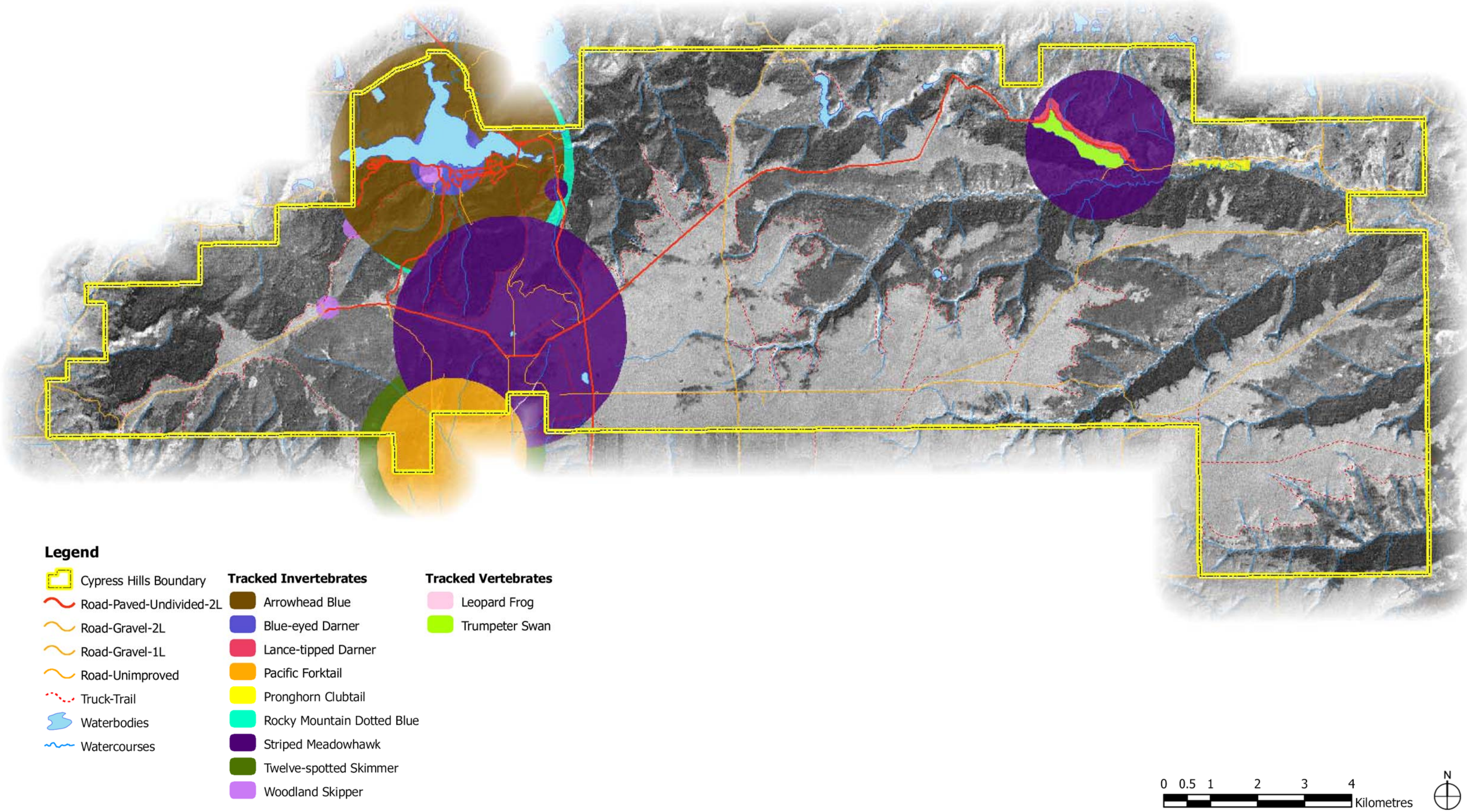
Map 3.6. Cypress Hills Provincial Park: Vegetation Cover



Map 3.7. Cypress Hills Provincial Park: Rare Vascular Plants

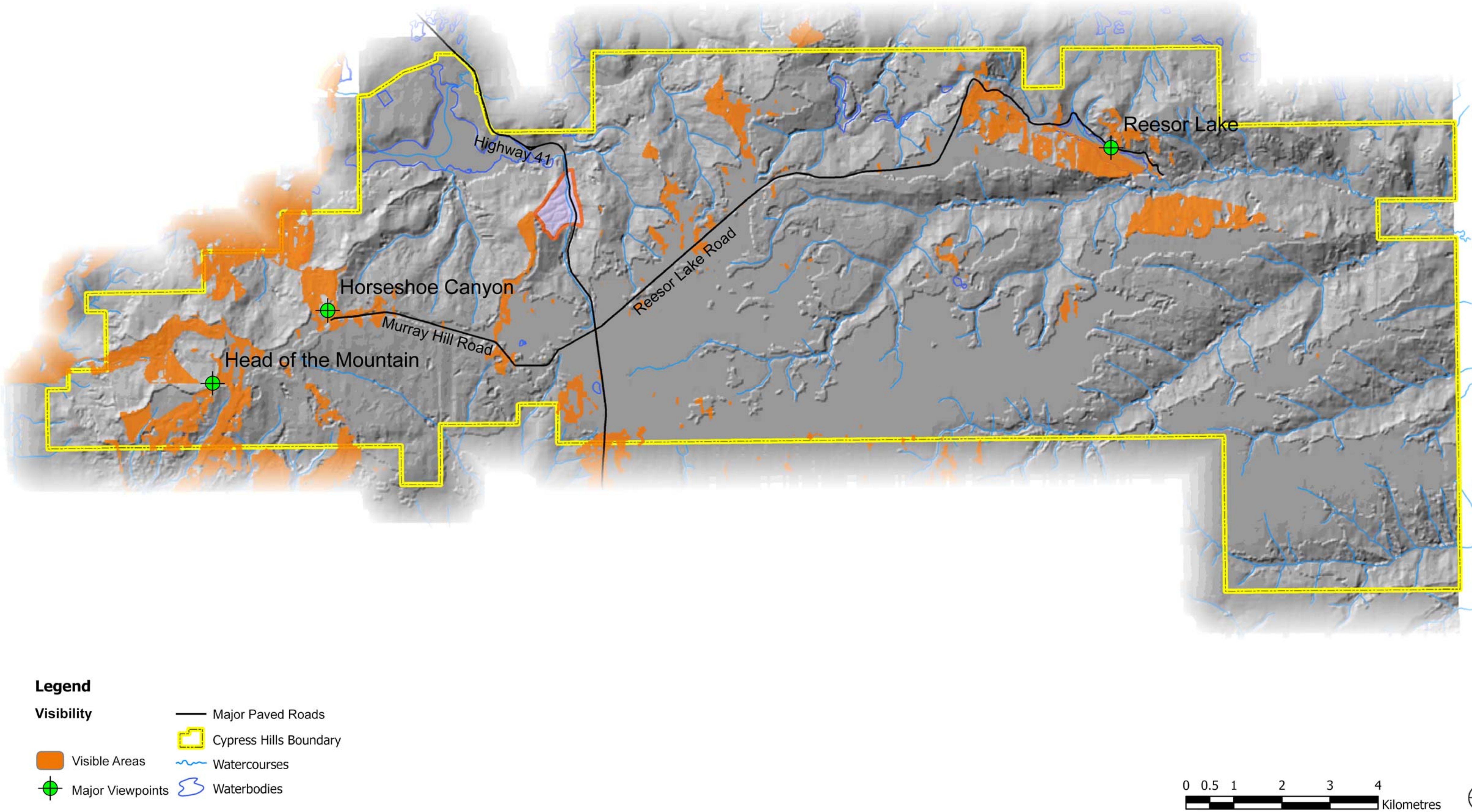


Map 3.8. Cypress Hills Provincial Park: Location of Tracked Vertebrates (Non-Sensitive Locations) and Invertebrates

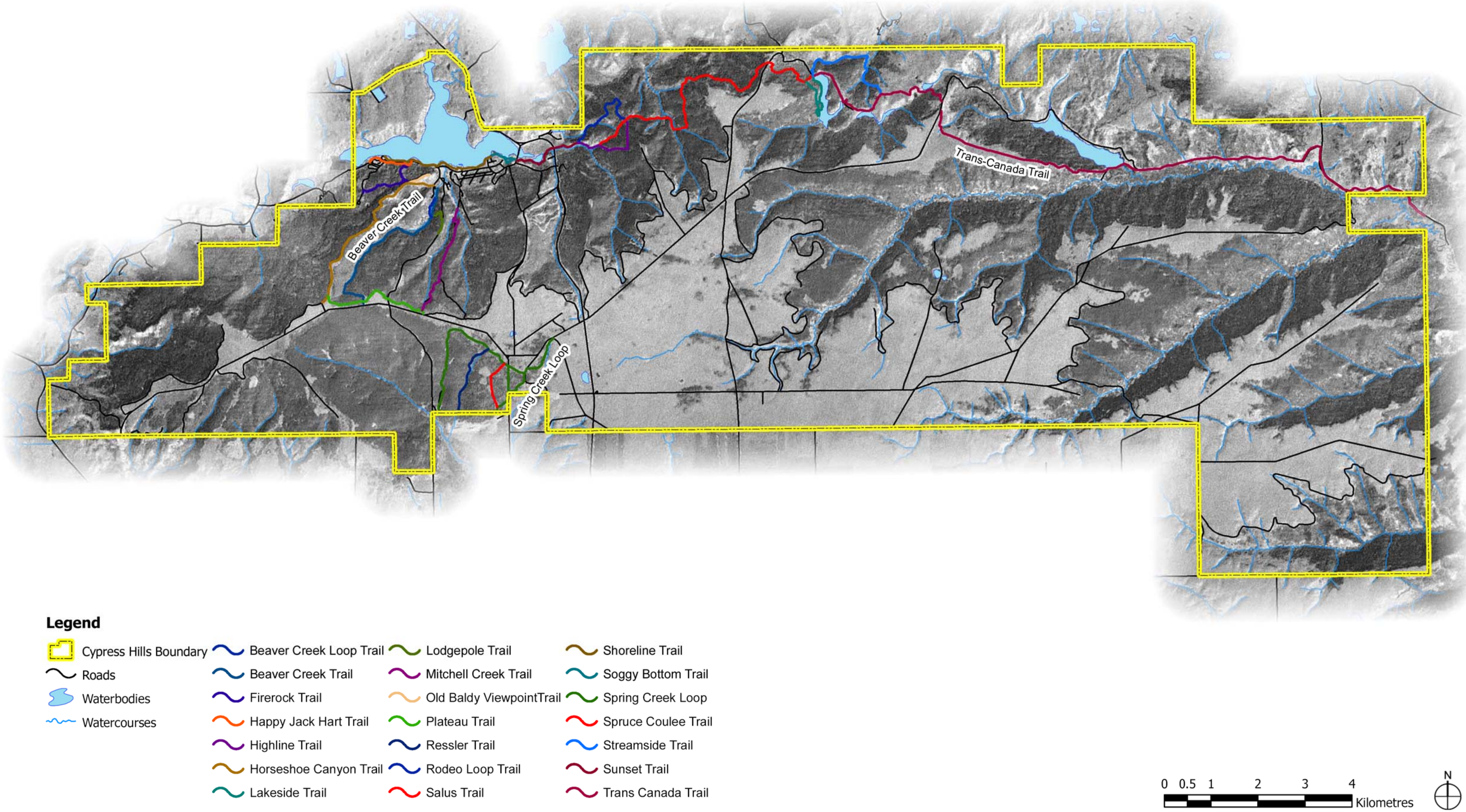


Map 3.9. Cypress Hills Provincial Park: Visibility from Major Paved Roads

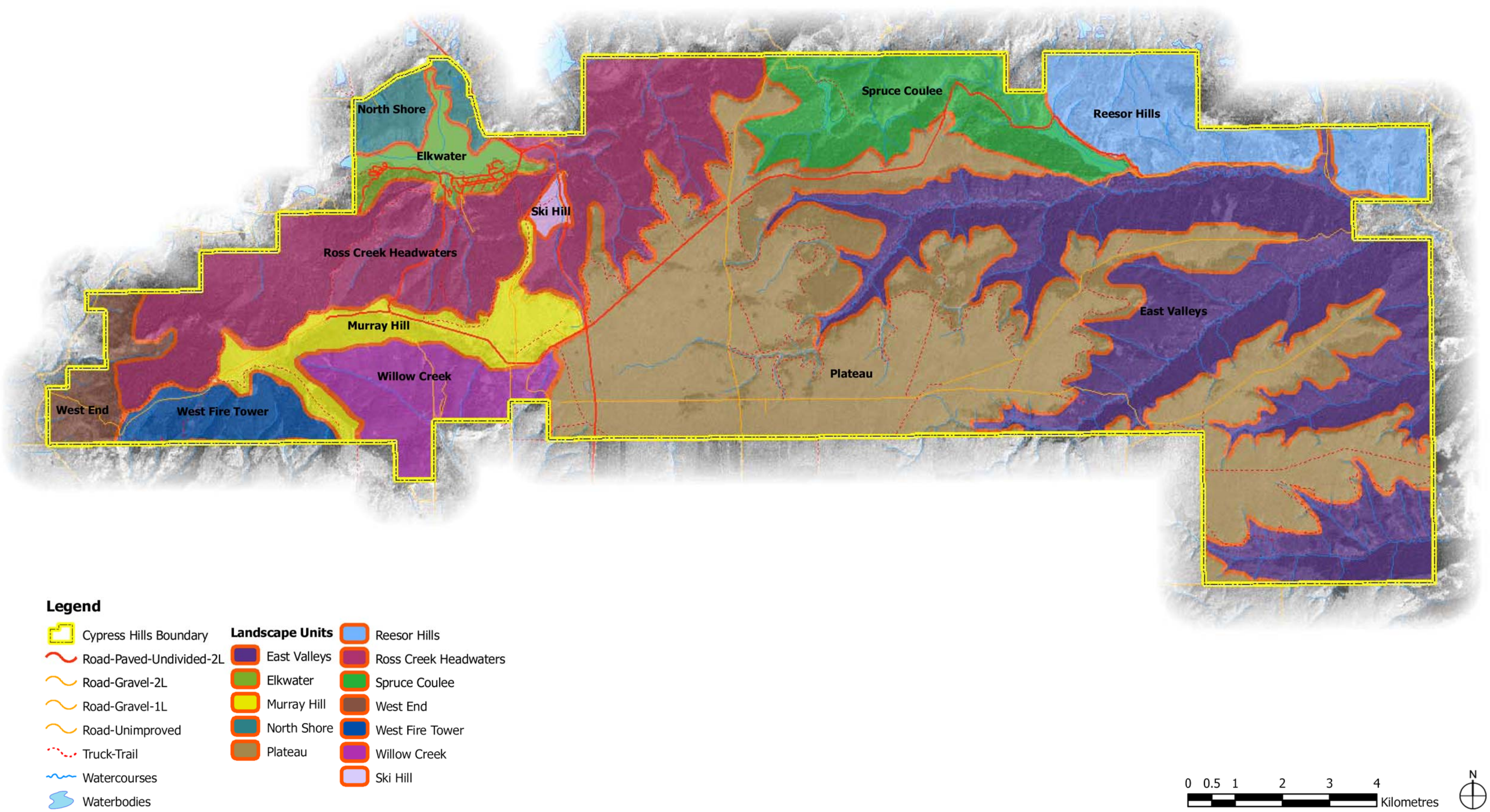
Map 3.10. Cypress Hills Provincial Park: Visibility from Major Viewpoints



Map 3.11. Cypress Hills Provincial Park: Existing Trail Network



Map 3.12. Cypress Hills Provincial Park: Landscape Management Units



APPENDIX A: DETAILS OF ESTABLISHING THE RECENT FIRE REGIME

FIRE FREQUENCY

Table A.1 presents the yearly and decadal fire frequencies starting in 1970. Despite similar yearly fire frequencies over the long-term, which ranged from 0 to 7 fires, there are some significant fluctuations in fire frequencies when the information is assessed by decade. While this table records the number of fires it does not record area burnt (see Section 5.1.3), which is generally small due to fire suppression efforts. The resulting build-up of fuel loads currently observed in the park attests to the risk of one of these fires becoming catastrophic.

Table A.1. Yearly and decadal fire statistics for the Elkwater Block of the Cypress Hills Region.

	Elkwater Block, AB
Yearly Statistics	
Minimum	0
Maximum	7
Average	1.59
Standard Deviation	1.63
Decade	
1970's	13
1980's	25
1990's	17
2000's	5
Total	60

FIRE CAUSE

Broken down into categories (Table A.2), recreational land users are by far the greatest source of ignition (60%), followed by industrial / commercial activities other than forestry (26%). In this case, most of these are park management related activities (unpublished data compiled by Les Weekes, park forest officer for the Elkwater Block).

Table A.2. Classification of fire occurrence by cause for the Elkwater Block of Cypress Hills.

Fire Cause	Fire Code	Count	% count
Other industry (park activities)	0	16	3.00 (23.00)
Lightning	1	7	11.29
Resident	2	0	0.00
Forest industry	3	0	0.00
Railroad	4	0	0.00
Prescribed burns	5	0	0.00
Recreation	6	37	59.68
Incendiary	7	1	1.61
Misc. known	8	1	1.61
Unknown	9	0	0.00
All		62	100

Lightning-caused fires by decade have not been consistent (Table A.3). It is believed that these fluctuating patterns are attributed to changes in temperature and moisture regimes associated with the Pacific Decadal Oscillation guided by El Niño. During El Niño years, fire weather conditions are more severe and lead to greater fire activity. As indicated by proxy-climate data from Southern Alberta (Sauchyn and Beaudoin 1998, Sauchyn 2000), the 1990s was a cooler and wetter period and much less area was burned (Rogeau 2004, 2005, Tymstra et al. 2005). In the Cypress Hills, during dry and warm periods, lightning fires can account for more than 20% of the fire ignitions. This is an important fact to know because location of lightning fire starts are not as predictable and most importantly, are not preventable.

Table A.3. Temporal distribution of lightning-caused fires for the Elkwater Block Region of Cypress Hills.

Decade	Lightning Fires	% Lightning Fires
1970's	1	7.69
1980's	3	12.00
1990's	0	0.00
2000's	3	60.00
Total	7	11.67

MONTHLY DISTRIBUTION OF FIRES

Table A.4 shows the assessment of fire distribution on a monthly basis, showing that the bulk of lightning-caused fires occur during the months of June and August.

Table A.4. Monthly distribution of wildland fires in the Cypress Hills Region.

	Lightning Fires		Anthropogenic Fires	
Month	**Count***	**% Count**	**Count**	**% Count**
January	0	0.00	2	2.44
February	0	0	0	0.00
March	0	0.00	1	1.22
April	1	7.69	4	4.88
May	1	7.69	10	12.2
June	4	30.77	7	8.54
July	0	0.00	25	30.49
August	6	46.15	17	20.73
September	0	0.00	9	10.98
October	0	0.00	5	6.1
November	1	7.69	0	0
December	0	0.00	2	2.44
Total	13	100.00	82	100

* one lightning fire had to be discarded from the Saskatchewan side as there was no month, day information.

SPATIAL DISTRIBUTION OF FIRES

Anthropogenic Fires

All fires from anthropogenic sources were recorded spatially by legal section on the Alberta side and by one-square kilometre grid cell on the Saskatchewan side. This resulted in a map showing the density distribution of human-caused fires in the Cypress Hills. Because the data recording period is different between Alberta and Saskatchewan, rather than presenting an actual fire count, the grid cell values represent the yearly probability of fire (Figure A.1).

Lightning Fires

Lightning strike data, obtained from Alberta Sustainable Resource Development - Forest Protection Division, was used to determine if clusters of lightning strikes yield more lighting-caused fires. The data set covered a 17-year period, from 1990 to 2006. During that time, 11,571 strikes were recorded, 1549 of which had a positive polarity.

It is the positive strikes that tend to touch the ground and ignite fuels. The average annual density of positive strikes was recorded for 5 km x 5 km grid cells to better depict broad patterns. It was found that the density of positive strikes ranges from 4 to 41 strikes per year.

With so little lightning fire data (14 for the combined AB and SK data sets), it is meaningless to measure statistically the strength of the relationship between lightning strike density and lightning fire occurrence. Rather, it was simply observed that most lightning fires occurred in density cells ranging between 13 and 21 strikes / year. The highest strike density (> 35) did not attract a greater number of lightning-caused fires. Actually, only one lightning fire occurred in a high density zone of strikes. Figure A.2 shows the lightning-caused fires overlaid onto the lightning strike density map.

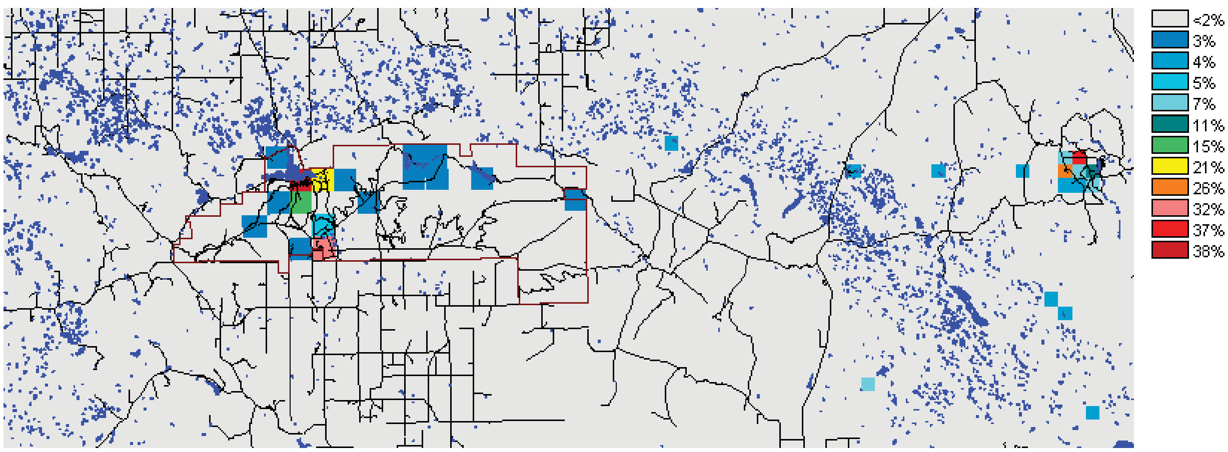


Figure A.1. *Spatial distribution of anthropogenic fires in Cypress Hills Provincial Park. Percent values represent the yearly probability of ignition. Note that the 32% probability of ignition associated with the former landfill is no longer a threat.*

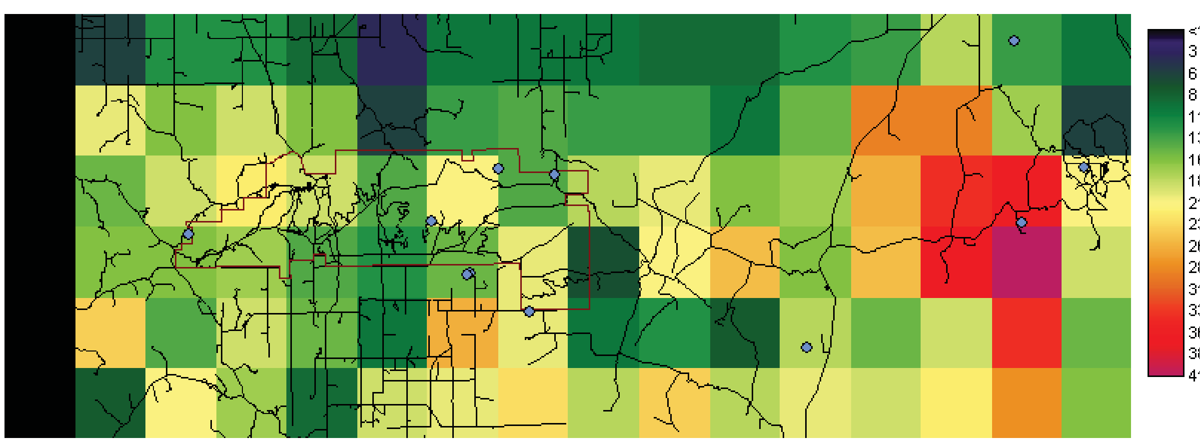


Figure A.2. *Yearly average density of lightning strikes over 5 km x 5 km grid cells. Lightning-caused fires are overlaid onto the map. Strike data: 1990 to 2006. Elkwater Block, AB fire data: 1969 to 2007. Saskatchewan data: 1981 to 2007.*

Aside from the density distribution of lightning strikes, it is interesting to examine what other factors may drive the distribution of lightning-caused fires on the landscape. Terrain and vegetation composition are the two main environmental variables that affect lightning-caused fire distribution. Elevation, aspect, and fuel type classes were assessed individually. Because of the wide variation in land base associated with each variable class, the fire counts were recalculated for a normalized area of 10 000 ha (arbitrarily chosen). This is done to remove any interpretation bias, as larger areas have a greater opportunity to capture a larger number of fires. That said, with only seven fires as a data set, it is not possible to draw too many hard conclusions.

Tables A.5, A.6 and A.7 present the percent of lightning fire occurrences associated with each variable class tested (elevation, aspect, and fuel type).

Table A.5. Percent of lightning-caused fires by elevation class. Elkwater Block. N = normalized area of 10 000 ha.

Elevation (m)	Area (ha)	% area	Lgt Count	% Lgt	N Lgt Count	N % Lgt
< 1100	0.00	0.00	0	0.00	0.00	0.00
1100 - 1199	3,338.38	9.38	1	14.29	3.00	34.31
1200 - 1299	10,433.25	29.33	1	14.29	0.96	10.98
1300 - 1399	11,577.46	32.55	1	14.29	0.86	9.89
1400 - 1499	10,222.84	28.74	4	57.14	3.91	44.82
	35,571.93	100	7	100	8.73	100

Table A.6. Percent of lightning-caused fires by aspect class. Elkwater Block. N = normalized area of 10 000 ha.

Aspect	Area (ha)	% area	Lgt Count	% Lgt	N Lgt Count	N % Lgt
Flat	8,052.78	22.64	3	33.33	3.73	19.80
NE	3,831.41	10.77	2	22.22	5.22	27.75
E	4,350.92	12.23	2	22.22	4.60	24.43
SE	2,865.07	8.05	0	0.00	0.00	0.00
S	3,556.28	10.00	0	0.00	0.00	0.00
SW	2,836.19	7.97	0	0.00	0.00	0.00
W	3,594.91	10.11	0	0.00	0.00	0.00
NW	3,794.69	10.67	2	22.22	5.27	28.02
N	2,689.69	7.56	0	0.00	0.00	0.00
	35,571.93	100	9	100	18.81	100

Table A.7. Percent of lightning-caused fires by Fire Behaviour Prediction fuel type. Elkwater Block. N = normalized area of 10 000 ha.

Fuel Type	Area (ha)	% area	Lgt fires	% Lgt	N Lgt fires	N % Lgt
C1 - spruce lichen woodland	577.34	1.62	0	0.00	0.00	0.00
C2 - boreal spruce	2,771.00	7.79	1	14.29	3.61	56.89
C3 - pine	5,511.44	15.49	0	0.00	0.00	0.00
C7 - open pine	17.92	0.05	0	0.00	0.00	0.00
D1 - aspen	4,260.64	11.98	0	0.00	0.00	0.00
O1a - grass	21,936.80	61.67	6	85.71	2.74	43.11
M1 - mixedwood	148.58	0.42	0	0.00	0.00	0.00
Water	348.20	0.98	0	0.00	0.00	0.00
	35,571.93	100.00	7	100.00	6.34	100.00

Probability of Lightning Ignition

The probability of lightning ignition model takes into account the spatial distribution of lightning-caused fires on the landscape. Results from the lightning strike density distribution, and occurrence of lightning-caused fires by elevation, aspect and fuel type, were used in a GIS weighting and ranking system to estimate probabilities of lightning ignition within the Cypress Hills Region.

While a probability of ignition model was produced for the entire Cypress Hills region, only the fire data set from the Elkwater Block was used to make predictions. Interestingly, the Saskatchewan fire data showed opposite trends in lightning-caused fire distribution, with lightning fires starting mainly on flat and warmer aspects and at elevations less than 1300 m. Again, because there are also very few lighting fires that were recorded on the Saskatchewan side, and that all these lightning fire starts were recorded outside of the park (because the data set did not include park data), it is difficult to determine any trends with confidence. It is suspected that there is an orographic effect at play.

The weighting process consisted of rating, in percentage value, the importance of each variable (GIS layer) used, while the ranking process ranked the variable classes on a scale of 1 to 5, where 5 represents the highest likelihood of getting an ignition. The weighting and ranking of the information was done as follows:

35%	**Density of Lightning Strikes**
	2 - Low density (<11)
	4 - Moderate density (11 - 20)
	4 - High density (21 - 30)
	5 - Very high density (>30)
30%	**Aspect**
	2 - SE-S-SW-W
	5 - NW-N-NE-E-Flat
20%	**Elevation**
	2 - < 1100m
	4 - 1100 to 1200m
	3 - 1200 to 1400m
	5 - > 1400m
15%	**Fuel Type**
	3 - forests
	4 - grasslands

Probability of lightning ignition model:

([strike_density*35] + [lgt_aspect*30] + [lgt_elevation*20] + [lgt_fuel*15]) / 5

This map manipulation process resulted in a range of probabilities of ignition that vary spatially over the landscape from 27 to 82 % (Figure A.3).

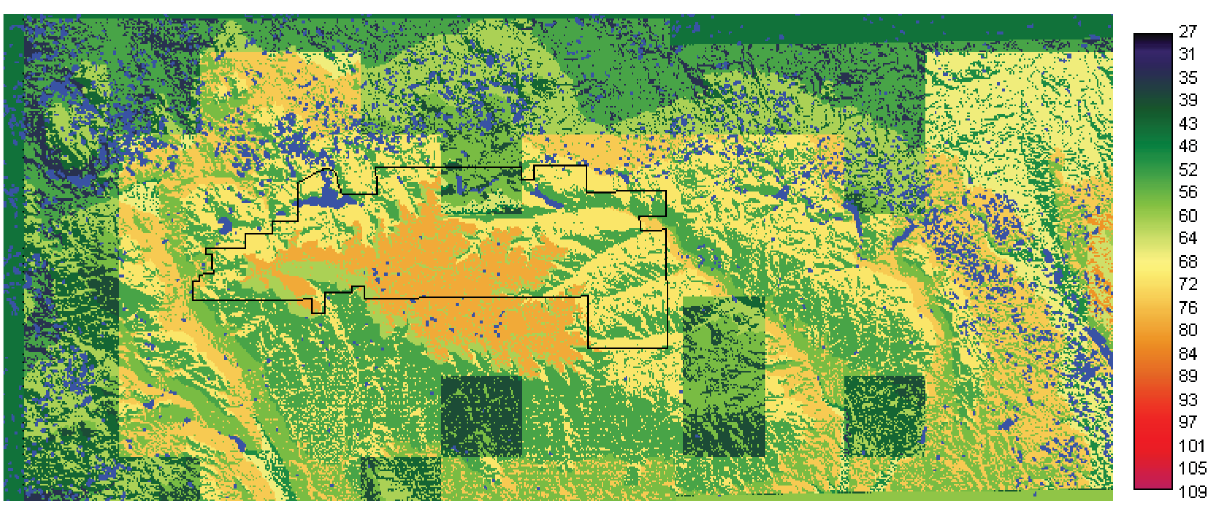


Figure A.3. Probability of lightning fire ignition model for the Cypress Hills region.

Probability of All Ignitions

This model takes into account both sources of ignition: lightning and anthropogenic. Probability statistics are a cumulative process and as such, probabilities of ignition from people were added to those from the probability of lightning ignition model. The percent probability values from anthropogenic fires presented in Figure A.1 were added to the probability values of the lightning ignition model Figure A.3. (Note that the probabilities of ignition that used to be associated with the former landfill have been removed.) The combined sources of ignition map now shows yearly probability values of fire incidence ranging from 28 to 109% (Figure A.4). These percent values must be interpreted as relative risks of fire and should be compared among each other rather than assuming that zones with risks equal or greater than 100% are guaranteed to see a fire each year (which is likely not the case). This probability of ignition map is to be used to determine areas that are more at risk of fire.

To ease the interpretation of these percent values, a fire risk map (Figure A.5) was created by classifying the percent values into five fire risk zones: very low (≤20%), low (21 to 40%), moderate (41 to 60%), high (61 to 80%) and very high (81 to 109%). As shown in Figure A.5, strictly from an ignition stand point of view, very high fire risk prevails on the plateau and around the Elkwater community. Any ignitions on the plateau could rapidly develop into important blazes as a result of prevailing southwesterly winds, which would quickly move a grassfire into forested areas.

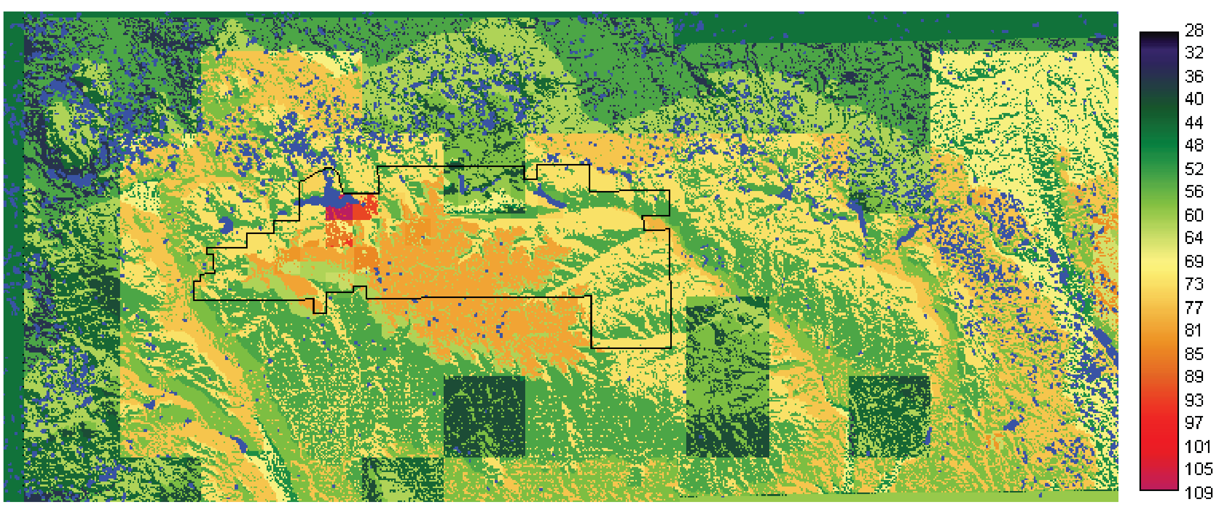


Figure A.4. Probability of ignition model from combined lightning and anthropogenic sources of ignition.

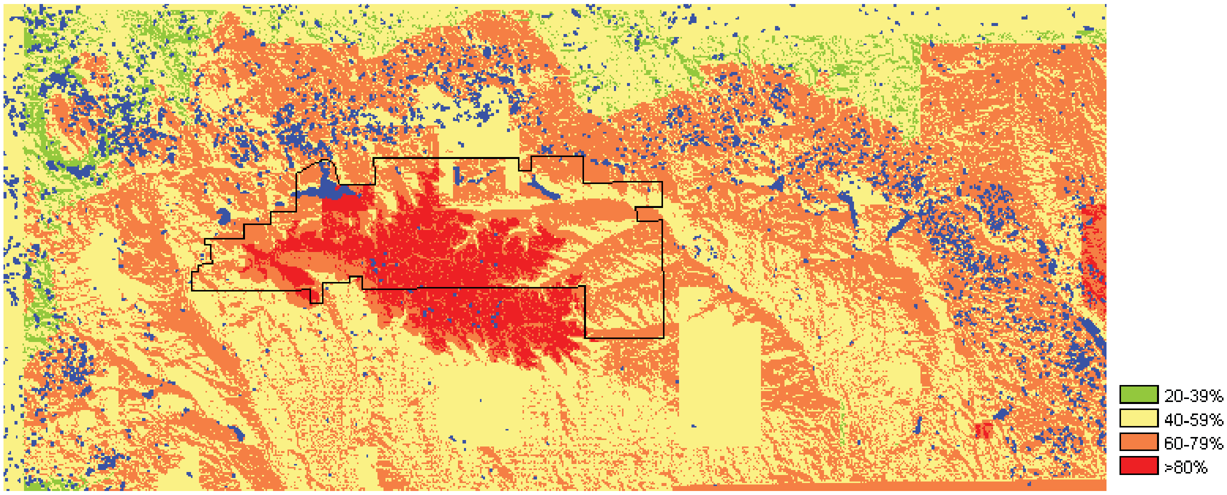


Figure A.5. Wildfire threat zones based strictly on values from the probability of ignition model.

APPENDIX B: STANDOR MODELLING

THE STANDOR MODEL: HOW IT WORKS

STANDOR (Rogeau et al. 1996) is a landscape disturbance model that uses real fire size and frequency statistics typical of an area in order to emulate its long term fire distribution patterns. It distributes fires over the landscape in a randomly 'adjusted' fashion that accounts for the effect of fire regime on fire starts. To do so, a "likelihood of getting an ignition" map must be developed. This map is based on the knowledge of human use, density of lightning strikes and fire occurrence reports specific to the study area.

Fire growth is achieved in two ways depending on the burning season (summer or spring/fall). The first one is based on a fuel map that has no factor limiting fire growth, aside from pixels designated as non fuel which will not support fire spread. In this case, every pixel representing fuel has an equal chance of burning. This burning strategy can be used on flat landscapes, or when fire weather indices are high enough that fire will spread without regard to aspect and elevation. The other way of growing fires on the landscape is based on probability values of fire spread based on topography. In the mountains or in hilly terrain, the spread of spring and fall fires are frequently influenced by topographic components such as elevation and aspect. In early June, for example, fuels located on low and southwest facing slopes in mountainous terrain are often available for burning, while there can still be snow, or cooler and wetter conditions, on north and east facing slopes. This differential drying process of fuels largely controls fire spread in the mountains during the spring and fall months.

STANDOR allows the user to run up to five different fire regimes per simulation, where an unlimited number of simulations can be specified. The length of the simulation (i.e., 200, 500, 1000 years or more), size of study area and length of time-step periods (i.e., 5, 10, 20 years ...) are user specified. The fire regimes to be simulated, which differ by their probability of fire ignition distribution and frequency of fires per time period, are also user specified. Fire size is governed by the fire growth module, which uses equations from the Canadian Forest Fire Behaviour Prediction System, fuel type, fuel availability, slope, number of daily burning hours and maximum number of days fires are allowed to grow. The intervals between fires or the time to the next arrival (of fire) can also be set. For example, a fire may not be allowed to re-burn an area until it has been 20 years since the last disturbance. For each simulation, the model produces a stand origin map and a fire frequency per pixel map. The model also keeps track of the number of fires per time-step period and the burn area associated with each fire. This feature is critical to calculating the simulated fire cycle.

Model Algorithms for Fire Ignition, Spread and Extinction

1. Randomly select the number of fires for the time period (normally a decade). This is defined by the minimum and maximum fire frequency that are user-specified.

2. Verify the likelihood of a randomly selected pixel being affected by fire (using the probability of ignition map). If the random number is smaller or equal to the probability of ignition value, then a fire starts. Repeat step 2 until a pixel can support a fire.

3. Verify the fuel type. If the pixel is categorized as non-fuel, repeat step 2 and 3 until the pixel is coded as fuel.

4. Verify the lapse time since the last fire. If fuel is not yet available for burning, repeat step 2 to 4.

5. Verify in which weather zone the fire will start. Then randomly pick a start date within the appropriate weather zone from the fire weather database. (For Cypress Hills only one weather zone was used.)

   a. If the date of ignition is not during the summer fire season, then the probability of burning (p_burn) map will be chosen to determine fuel availability.
      i. determine the valley orientation for initial fire spread during Day 1. The fire burns equally up and down the valley. (This feature was deactivated for the Cypress Hills.)
      ii. determine the probability of burning of adjacent cells by looking at their fuel type, time-since-last fire and p_burn value. If it is not available for burning, repeat step 2 to 5. The p_burn of adjacent cells is determined by comparing their p_burn value to that of the ignition pixel. If their p_burn value is less than that of the ignition pixel, then the fire doesn't spread in that direction.
      iii. repeat step 5a.ii) until fire weather values are too low to support a fire or until the allowable burning time has expired, or until there is no fuel available to burn.

   b. If the date of ignition chosen falls during the summer months, then no p_burn map is used, which means that there are no burning restrictions.
      i. determine the valley orientation for initial fire spread during Day 1. The fire has a 50/50 chance of spreading in either valley direction. (This feature was deactivated for the Cypress Hills.)
      ii. fire burns until fire weather values are too low to support a fire, or until the allowable burning time has expired, or until there is no fuel available to burn.

6. Repeat step 2 to 5 until the number of fires chosen for the time-step period (step 1) is reached.

The direction of fire spread is difficult to manage due to the fact that weather stations, where the fire weather data is extracted from, can be many kilometres away from the location of burning fires. Further, in mountainous terrain there is the possibility that the wind direction may be different than that of the valley where the weather station is located. By using a valley orientation map for the first day of burning, it over-rules the wind direction input from the fire weather database and makes the spread of fire a bit more realistic.

7. Before starting a new period, verify if the fire regime has changed in order to select the appropriate database for the fire frequency and probability of ignition map.

8. Repeat step 1 to 7 for the length of the simulation divided by the length of the time-step period.

Data Layers

A set of map layers is needed to run the model, as well as information on fire frequencies and distributions that are specific to the study area. The procedure that was used to create some of the map layers has already been described in Section 5.1, along with information on the source and format of the data used. Following is a description of each data layer and information on specific inputs used.

While the output results were retained for the Elkwater Block only, the fire simulation area included the West Block, as well as a buffer zone of approximately 10 km in width from all sides of Cypress Hills Interprovincial Park.

Note that all GIS raster layers that were originally created at a 20 m resolution for this project were converted to 100 m resolution to use with STANDOR. Despite the coarser resolution (1 ha or 100 m2), it is sufficient for forest management planning considering that computer modelling is not a precise science, but rather a supplemental tool to aid in the understanding of fire regime.

FUEL TYPE MAP

The Canadian Forest Fire Behavior Prediction System (CFFBPS) quantifies fuel types that can be used as inputs to fire behaviour predictions (Forestry Canada 1992). These fuel types are a combination of vegetation species and their associated physical characteristics that contribute to fire behaviour under defined burning conditions. A total of seven fuel type categories can be found in the Cypress Hills (Table B.1 and Figure B.1).

The Fire Behaviour Prediction (FBP) fuel data for the Alberta side was derived from the Alberta Vegetation Inventory (AVI), while on the Saskatchewan side it was derived from the Land Cover Classification (LCC) map. The map received from the Saskatchewan Ministry of Environment was in a raster format at 100 m resolution. An important issue was found with the Saskatchwan fuel layer. Perhaps as a result of numerous rasterization processes from coarse scale maps, hardly any coniferous or forested zones were represented for the treed area of the Cypress Hills. The map only presented scattered pixels of trees within the grasslands. To correct the problem, a recent digital orthophoto was used to digitize the perimeter of forested patches (coniferous, deciduous and mixedwoods). The scattered forested pixels from the LCC map, which was more detailed with its fuel typing, was stamped overtop of the newly digitized cover.

Table B.1. Number of hectares and percent coverage by Fire Behaviour Prediction (FBP) fuel type for the Elkwater Block.

FBP Code	FBP Fuel Type	Area (ha)	% Area
1	C1: spruce-lichen woodland	501.99	2.41
2	C2: boreal spruce	2438.59	11.70
3	C3: mature pine	5326.38	25.55
7	C7: open pine forest	11.00	0.05
13	D1: aspen	3019.65	14.49
31	O1a: matted cured grass following spring melt	9052.76	43.43
60	M1: mixedwood 50/50	134.39	0.64
102	water	359.52	1.72
		20 844.27	100.00

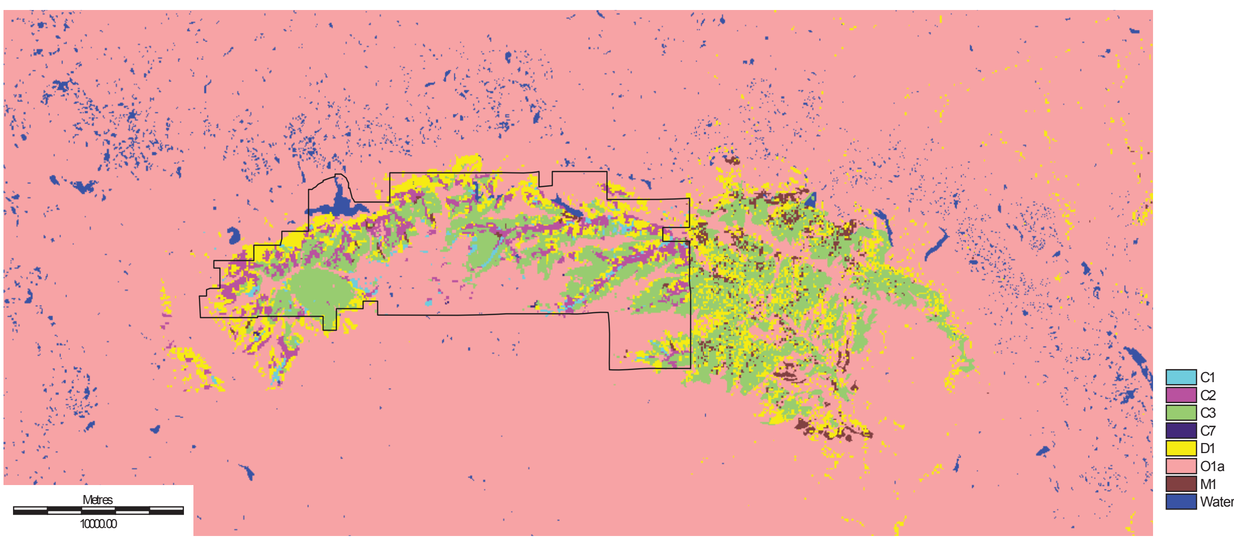


Figure B.1. Fire Behaviour Prediction (FBP) fuel type map for the Cypress Hills region.

ELEVATION MAP

An unclassified 1:20,000 digital elevation model was used as part of a base layer to grow fires on. Elevation values are used by the model to determine terrain slope and calculate the appropriate rate of fire spread. Rate of spread for fires moving down hill is at the same rate as fires burning on flat terrain. The minimum rate of fire spread in the modelling exercise was set at 1 m/min.

WEATHER ZONE MAP

This map is used to outline zones of similar fire weather data. Each zone is linked to a single weather station. This is an important feature for mountain or hilly landscapes, as higher elevations portray higher levels of humidity and cooler temperatures, hence reduced FFMC and BUI values. As a result, ignitions at higher elevations may initially not spread as fast as those at lower elevations.

In the case of the Cypress Hills only one weather zone was used. The study area is too small to see a wide variation in weather patterns and only one weather station is available for the area. Therefore, it was not possible to differentiate between the weather of Elkwater, for example, and the top of the Plateau.

INITIAL STAND AGE MAP

This is the initial stand age layer used to grow fires on. The entire study area was simply given an arbitrary age of 100 years. At the end of the 1000 year period of simulations, anything that did not burn during that time can easily be tracked down by looking for stands that are 1100 years of age (this actually never happened with the Cypress Hills simulations).

PROBABILITY OF IGNITION MAP

The probability of ignition map represents the chance a pixel has of getting an ignition. The model generates a random number from 0 to 100. If the random number is less than the p_ignition value of the pixel, then the fire starts. The probability of lightning ignition map that was created as part of the recent fire regime assessment process in Appendix A (Figure A.3) was used as a base map. Added to this were probabilities of human ignition that are representative of historical human land use from the 1800s.

For this study, we are interested in the natural fire distribution before the strong influence of Europeans on the land. This includes lightning, but also traditional land use by the aboriginal people. It is difficult to estimate where and how many fires would have been set by Natives because there are conflicting reports on the occupation of the territory. When Fort Walsh was established, hundreds of natives were camped nearby. However, it is also said that historically six tribes would fight over the territory and as a result of warfare, the Cypress Hills tended to serve as boundaries between territorial clans, and that the Hills themselves were a neutral territory (Scace 1972). It is not clear if this meant that the area was used less because of the fear of being attacked.

To account for probabilities of ignition as a result of traditional land use, a 15% increase in the probability of ignition was added to the lightning ignition model for buffer zones around or along specific target features. Larger lakes were considered as enticing places for setting camps, and a buffer of 500 m was created around these features. A 100 m buffer zone was also created along today's main travel corridors with the assumption that these would have been similar in the past (Hwy 514, Hwy 41, Eagle Butte Road, Reesor Lake and Battle Creek Road).

Figure B.2 shows the probability of ignition map that was created specifically to model the natural fire regime. With the combination of lightning and anthropogenic sources, probabilities of ignition ranged across the landscape from 27 to 94%.

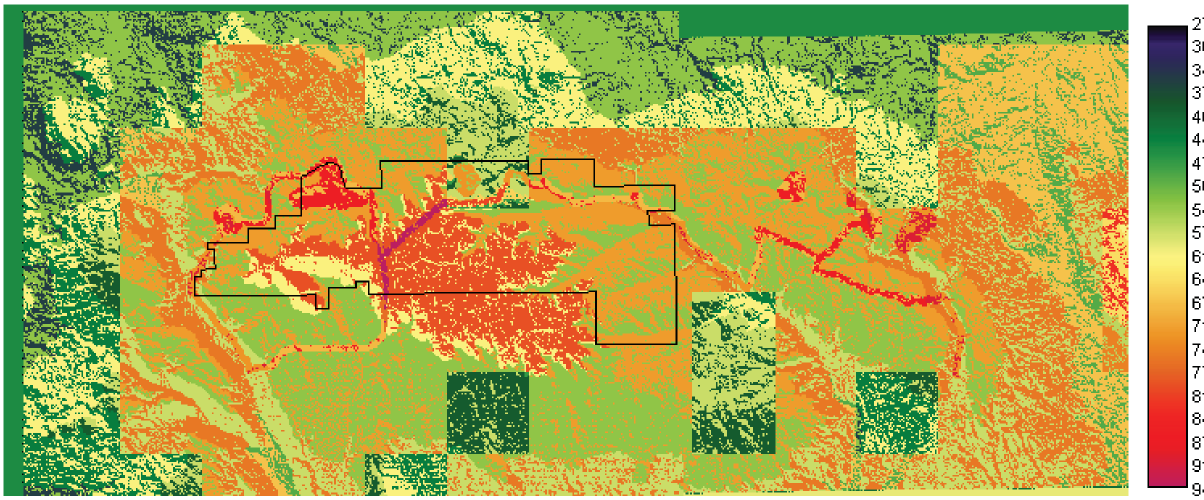


Figure B.2. Probability of ignition model from combined lightning and anthropogenic sources representative of the natural fire regime. Presented in percent probability values.

PROBABILITY OF BURNING MAP

In mountainous and hilly terrain such as the Cypress Hills, probabilities of burning vary spatially according to aspect and elevation. This effect is pronounced during the spring/fall season when north facing slopes and higher elevations can have snow on the ground, or a much higher fuel moisture content, which inhibits the spread of fire. Using a probability of burning model, each pixel is assigned a p_burn value on a scale from 0 to 100. Before spreading into neighbouring pixels, the p_burn value of the pixel is compared to that of the ignition pixel. If the p_burn value of the pixel is less than at ignition time, the fire will not spread in that direction.

The spring/fall season is determined from the fire weather database (see Fire Weather Data below). During the summer period, all pixels are assumed to have the same probability of burning and no p_burn map is used. For all other dates, the fire spread is determined in part by the p_burn map. For example, if a spring fire starts at low elevation and on a south facing slope, that fire will not be allowed to spread higher than a certain elevation or on to north or east facing slopes. But, if that fire starts at a high elevation or on a north facing slope, it would be able to spread anywhere as other p_burn values would be greater than the p_burn value from the ignition pixel.

Probabilities of burning vary with topographic locations (Rogeau et al. 2004). During the spring and fall seasons, the fuel drying process and its availability for burning are largely driven by temperature and sun exposure, which are both captured by aspect and elevation. Normally a GIS weighting and ranking system is developed using only these two variables. In the case of the Cypress Hills, fuel type was also added as being an element with differential probabilities of burning. Due to wind effect and evaporation, grasslands can be clear of snow even on the plateau's higher elevations. This fine fuel can also dry very quickly and be available for burning much more rapidly than forested areas. Classes from the aspect, elevation and fuel type variables were ranked on a scale of 1 to 5, 5 being the highest likelihood of burning. Each variable was also weighted by multiplying the ranked map with a percentage value in terms of its relative influence on fire spread patterns. Results from the grouping, ranking and weighting process are shown in Table 5.9. Each ranked and weighted map was then overlaid and subsequently divided by 5 (the number of ranks) to obtain the p_burn map. These map manipulations can be represented by the following equation:

p_burn = (0.20*[elevation_r] + 0.50*[aspect_r] + 0.30*[fuel_r]) / 5
r = ranked

With this model, probabilities of burning ranged spatially from 16 to 100% (Figure B.3).

Ranks and weights of topographic and fuel type classes used to create the probability of burning map.

Variables	Classes
Elevation (20%)	5: < 1100m 4: 1101 - 1200m 3: 1201 - 1300m 2: 1301 - 1500m
Aspect (50%)	5: SE, S, SW, W 3: Flat 2: NW, N, NE, E
Fuel (30%)	5: grass 4: deciduous and mixedwoods 3: coniferous

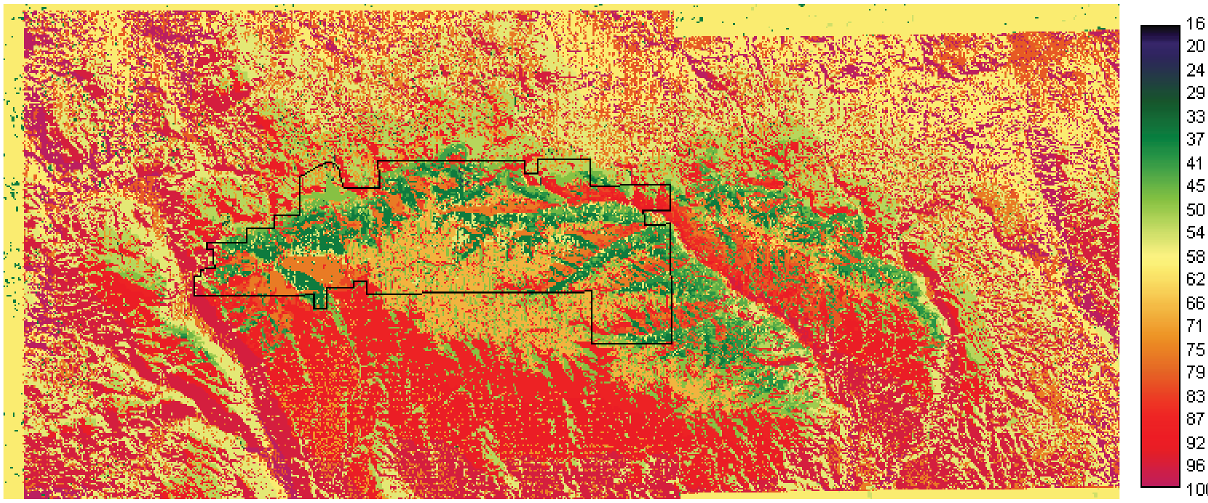


Figure B.3. Probability of burning model based on elevation, aspect and fuel type. Presented in percent probability values.

MASK MAP

This map layer is only utilized if the user is interested in obtaining fire cycle information for a specific area. The mask has a value of one for the area of interest and a value of zero for the remainder of the landscape. For this project, a mask was used to focus on the Elkwater Block. Note that during the fire growth simulations, fires are distributed throughout the landscape, but any information that is not of interest is then discarded.

FIRE WEATHER DATA

Before a fire is allowed to spread on the landscape, the program looks in the fire weather database (Table B.2) to find fire weather data associated with the proper weather zone (based on the weather zone map). It then randomly picks a date and reads the fire weather values for that day. To ensure that we are modelling fire regime conditions that will sustain stand replacing fires, the database contains only the dates where BUI values are greater than the 80th percentile breakpoint value. For the spring and fall season, this corresponds to a BUI value greater than 60, and to a BUI value greater than 90 for the summer season. The summer season, or the green-up period, was set to occur between June 1 and August 31.

The fire simulation model grows fires for as long as there are consecutive days with a BUI value equal to or greater than 60 or 90, depending on the fire season. That said, during the calibration of the fire growth model, it was found that burning fires for several days leads to extremely large, and unrealistically big fires that could burn an entire landscape. To regulate fire sizes, this setting was over-ruled by specifying a maximum number of burning days. Other ways to adjust fire sizes can be by playing with the number of daily burning hours, which are based on the number of daylight hours (Table 5.11), or by modifying the FFMC values. Based on previous projects where STANDOR was applied, it was found that the maximum number of burning days had to be set between 2 and 4 days to match the range of historical fire sizes. Otherwise, the model always burned too hot and fires spread too fast to nearly impossible proportions. As we do not have a fire size data set for the Cypress Hills, the maximum number of burning days was set to three. This calibration appeared to provide a satisfying range of fire sizes. Although this also seems unrealistic when compared to natural fires, we must remember that FBP fire spread equations were developed for very specific conditions, which are not always met in the study area.

One weather station with hourly data since 1994 is available in the Cypress Hills. However, due to data gaps, the database is complete only since 1998. To cover a wider range of fire weather values, the Poll Haven weather station located east of Waterton Lake National Park and near the international boundary, was used to supplement the Cypress Hills weather data set. Both stations have comparable fire weather values.

The two weather station data sets were appended to form a single file containing these attributes:

- year
- month
- day
- wind direction
- wind speed
- FFMC (Fine Fuel Moisture Code)
- BUI (Build-Up Index)
- summer: true or false statement
- number of day light hours (see Table B.3)
- number of daily burning hours (1/3 of the day light hours)
- weather zone code (from the weather zone map).

Table B.2. Fire weather stations used to provide fire weather data for the stand origin modelling sessions.

Station (Code)	Lat., Long.	Elevation (m)	In Operation Since
Cypress Hills, SK	49.6500, -109.5200	1012	1994
Poll Haven, AB (C3)	49.0281, -113.6020	1615	1990

Table B.3. Number of daylight hours (and burning hours) associated with time of year.

Dates	Daylight Hours*	Dates	Daylight Hours
April 1 - 14	13 (4)	Aug. 10 - 24	14 (5)
April 15 - May 5	14 (5)	Aug. 25 - Sept. 9	13 (4)
May 6 - 24	15 (5)	Sept. 10 - 30	12 (4)
May 25 - July 20	16 (5)	October	11 (4)
July 21 - Aug. 9	15 (5)		

*obtained from www.theweathernetwork.com for the Medicine Hat region.

APPENDIX C:
WILDFIRE THREAT ASSESSMENT

The five components of the SRD Wildfire Threat Assessment Model (WTA) are (1) Fire behaviour potential, (2) Headfire intensity, (3) Fire occurrence risk, (4) Values at risk and, (5) Suppression capability.

FIRE BEHAVIOUR POTENTIAL

The Cypress Hills is a unique association of forest and grassland fuels, topography, fire weather and climate, all of which contribute to fire behaviour on a daily basis throughout the annual fire season. The plateau area of Cypress Hills is exposed to significant drying conditions and wind events, while the coulees and draws have accumulations of forest fuels that in combination will contribute to extreme fire behaviour. As the summer season progresses, the fire behaviour potential increases and this trend extends into the early fall. Figure C.1 illustrates the high and extreme fire behaviour potential in the coniferous forest types, specifically the pine on the plateau area and the spruce in the draws that are associated with surface fuels.

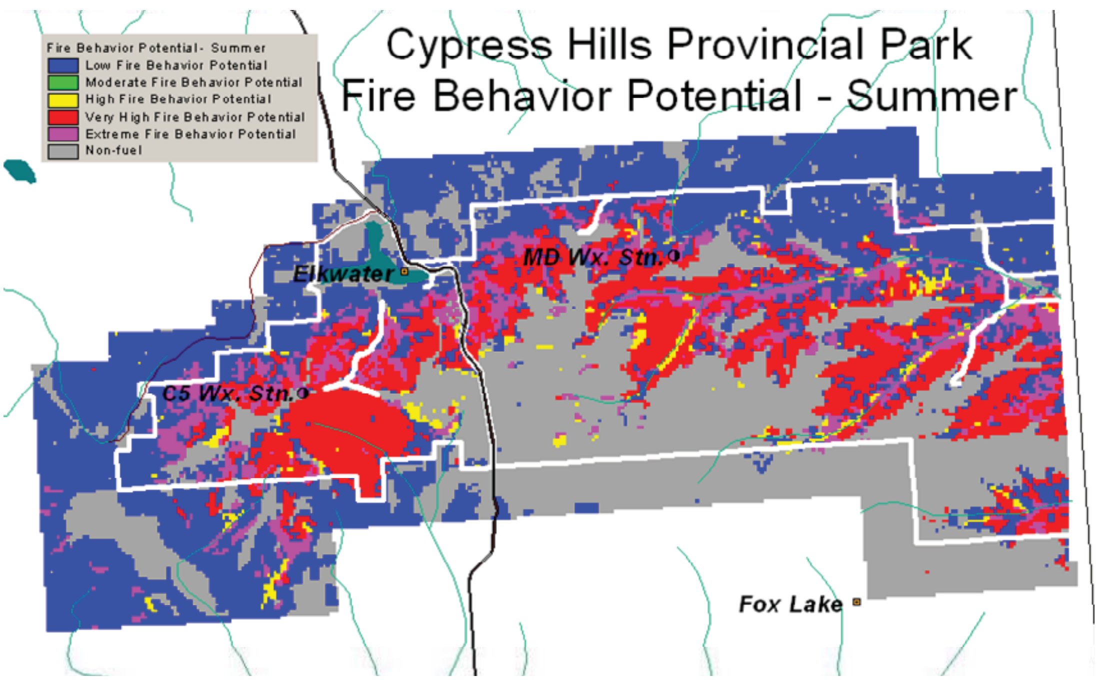


Figure C.1. Fire Behaviour Potential for the summer season.

HEAD FIRE INTENSITY

Head Fire Intensity (HFI) is defined as the rate of energy released per unit of a moving fire front. This expression of fire behaviour is commonly used for operational fire management planning. It is a function of the landscape fuel complex and fire weather as incorporated in the Fine Fuel Moisture Code (FFMC), the Build-up Index (BUI) and the Initial Spread Index (ISI) components of the Canadian Fire Weather Index System. At HFIs of rank five and six, which are the most intense, suppression effectiveness is often limited and priorities revert to public safety. Figure C.2 illustrates the potential for summer HFI ranks of 5 and 6 in the pine and spruce forests.

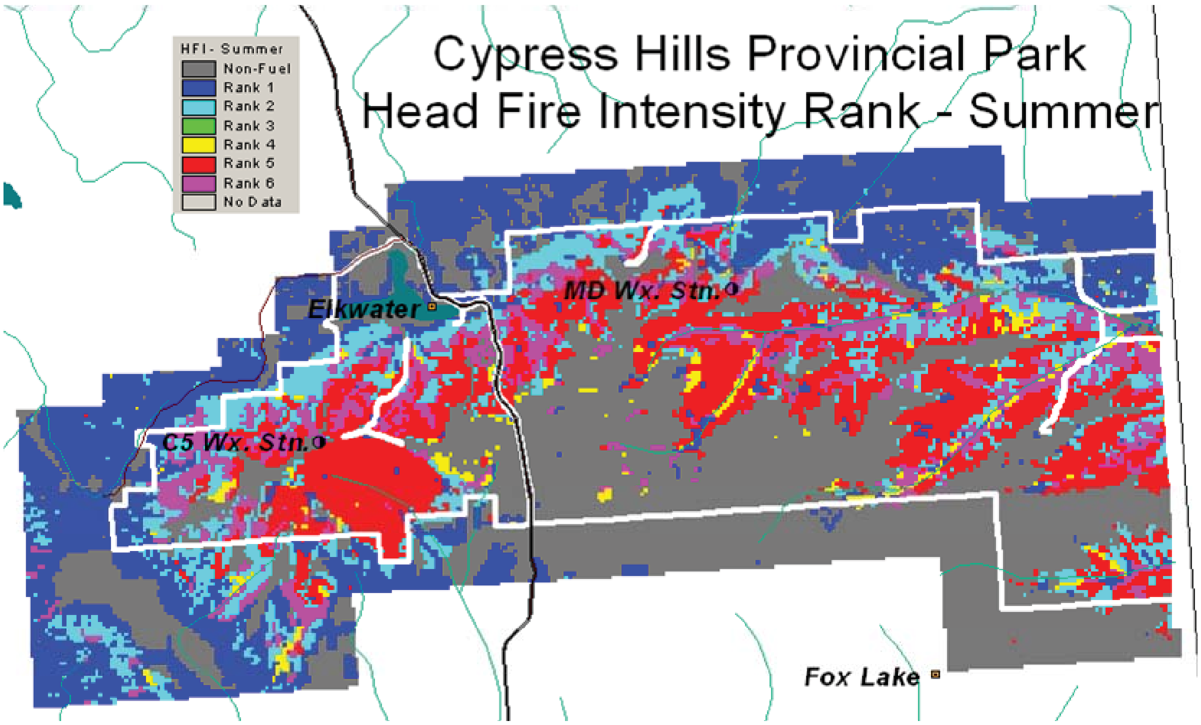


Figure C.2. Head Fire Intensity Rank for the summer season.

FIRE OCCURRENCE RISK

The fire ignition risk in Cypress Hills Provincial Park is strongly correlated with the state of curing in the fescue grasslands throughout the Park. The months of May, early June, late August, September and October are associated with very flammable fine fuels including cured grasslands, which occupy over 8000 ha of the Park. During the summer season, green-up conditions prevail and ignition risk is generally a function of moisture in the dead surface fine fuels in the forested area of the park. An estimate of the overall fire occurrence risk includes assessments of weather and fuel moisture, topography, soil moisture, vegetation phenology, and ignition sources. The output of these assessments is the relative probability of fire occurrence risk, which illustrates the risk for the summer season when the grass fuel is green (Figure C.3). An important additional component of occurrence risk is the spatial distribution of potential ignition sources, which has been described in Section 6.1 and Appendix B. The low to moderate fire occurrence risk throughout the Park due to fire suppression activity has ironically created the high to extreme fire behaviour potential, which has steadily increased with forest age over the last fifty years.

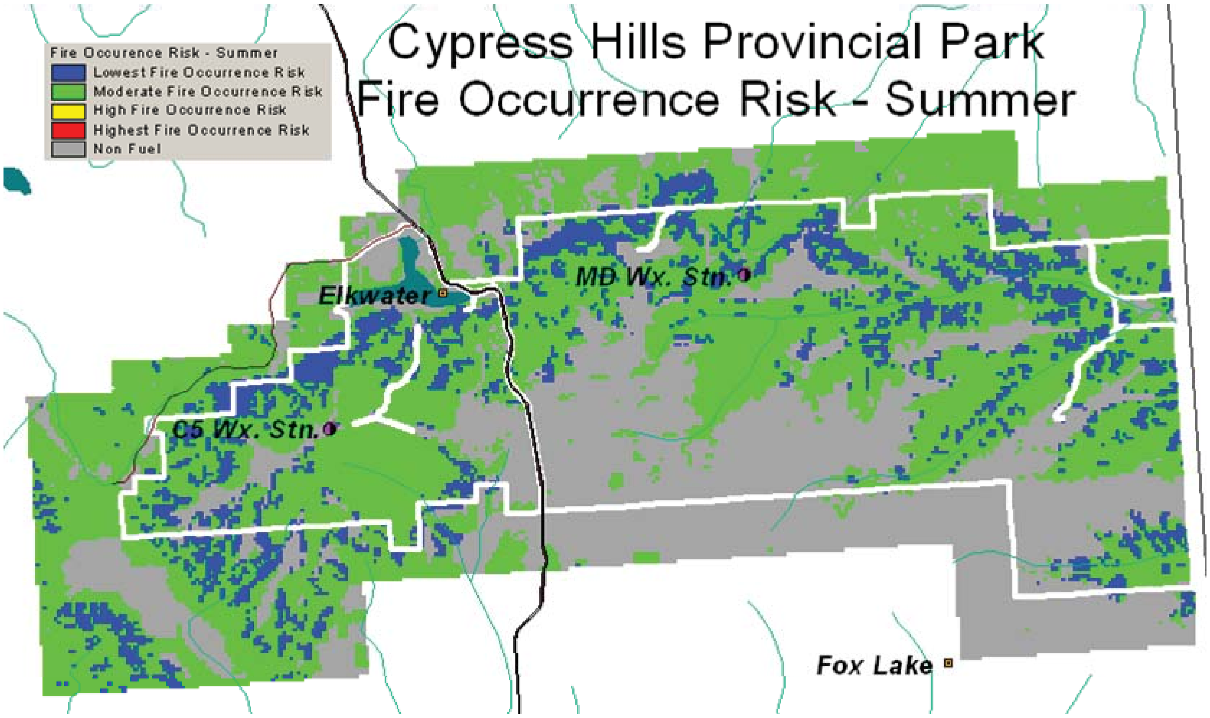


Figure C.3. Fire Occurrence Risk during the summer months.

VALUES AT RISK

Values at Risk in the context of this report include human developed property and ecological systems and processes that are prone to high intensity wildfires. At the provincial level, wildfire protection priorities are ranked as follows: (1) Life (2) Communities (3) Watershed and Soils (4) Natural Resources and (5) Infrastructure. In Cypress Hills Provincial Park the safety of Elkwater residents, local residents adjacent to the Park and annual visitors is the first protection priority. At the landscape level the natural resources, watersheds and soils are important priorities both from wildfire protection and high impact fire suppression tactics.

Human Related Values at Risk

Although Cypress Hills Provincial Park is a relatively small land base there is an extensive community development and many infrastructure values located throughout the Park. Values at risk include the Elkwater town site and other developments embedded in the Park such as campgrounds, church and service club camps, water well facilities, trails and roadways. In addition, private property values within 3 km of the Park boundary are considered at risk during a high intensity wildfire event (Figure C.4).

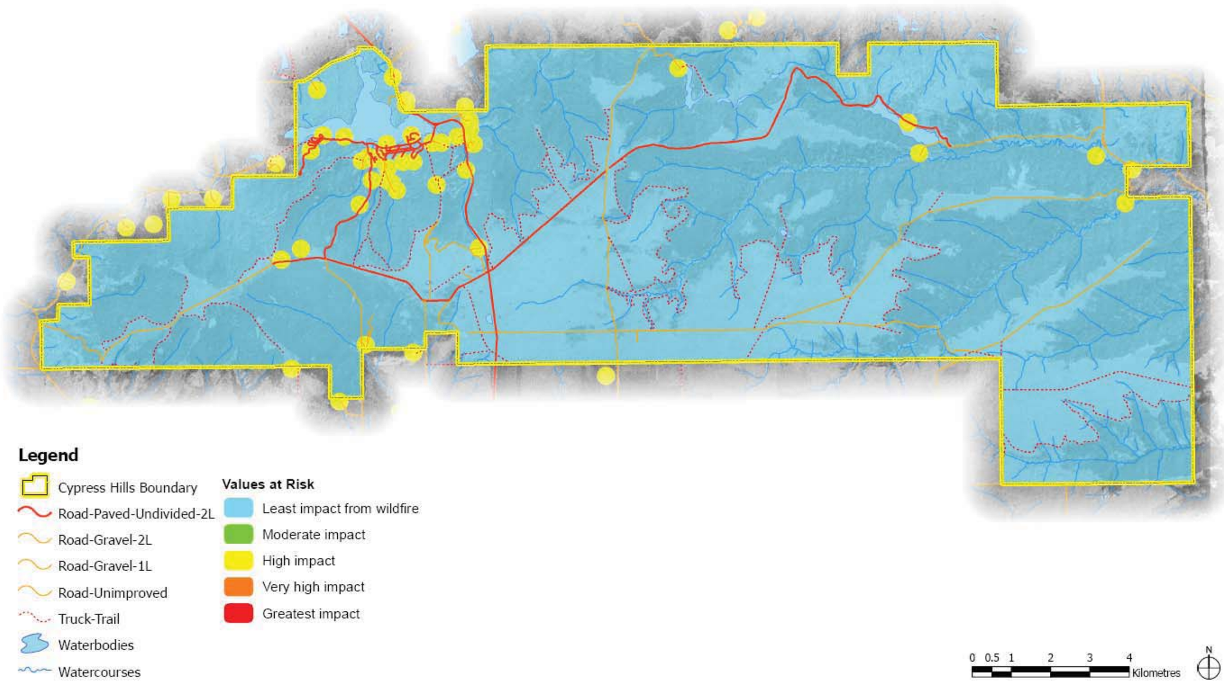


Figure C.4. Human values at risk in Cypress Hills Provincial Park.

Ecological Values at Risk

Wildfire is a historic natural disturbance process in the Cypress Hills, and in fact some forest and grassland plant species are dependent on fire frequency for reproduction and rejuvenation (e.g., aspen, lodgepole pine; see Section 5.0). In Section 6.0 of this report a significant and lengthy departure from the historic fire regime is described in detail. The absence of frequent low intensity fires and occasional large fires in Cypress Hills for over a century has increased the probability of a severe, and consequently catastrophic, fire event. The ecological values that contribute to the integrity of the Park are at risk, given both the fire regime departure (Section 6.3) and current fire behaviour potential and head fire intensity. Ecological values at risk include species / communities at risk (see Map 3.7 and 3.8) which are either sensitive to fire, high-intensity fire, or mechanical disturbance from management activity.

SUPPRESSION CAPABILITY

Cypress Hills is a remote landscape in terms of airtanker initial attack capability during high and extreme fire danger periods in southern Alberta. The closest airtanker base is Pincher Creek, Alberta and realistically a first strike dispatch could result in a 45 minute or more airtanker drop (Figure C.5). Based on the wildfire threat analysis the Cypress Hills is at a disadvantage for airtanker initial attack capability. The significant distance from an airtanker base implies a reliance on locally based initial attack resources during high and extreme fire danger levels. The limited airtanker initial attack capability also emphasizes the importance of strategies for fire bans, park closures and evacuation procedures that are triggered by fire danger levels and single or multiple fire ignitions.

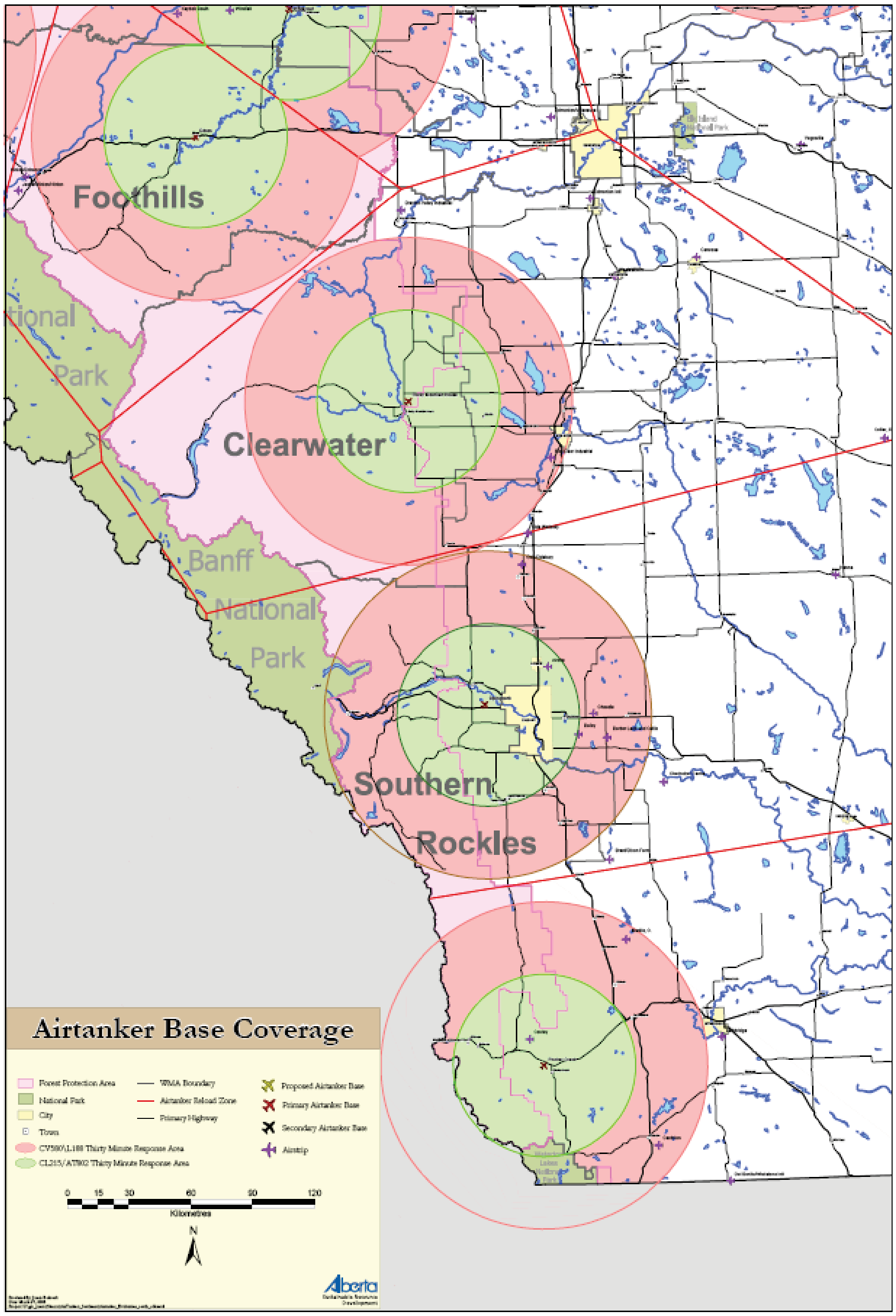


Figure C.5. Thirty minute response time for the Pincher Creek Airtanker Base by aircraft configuration.

APPENDIX D: PROMETHEUS MODELS

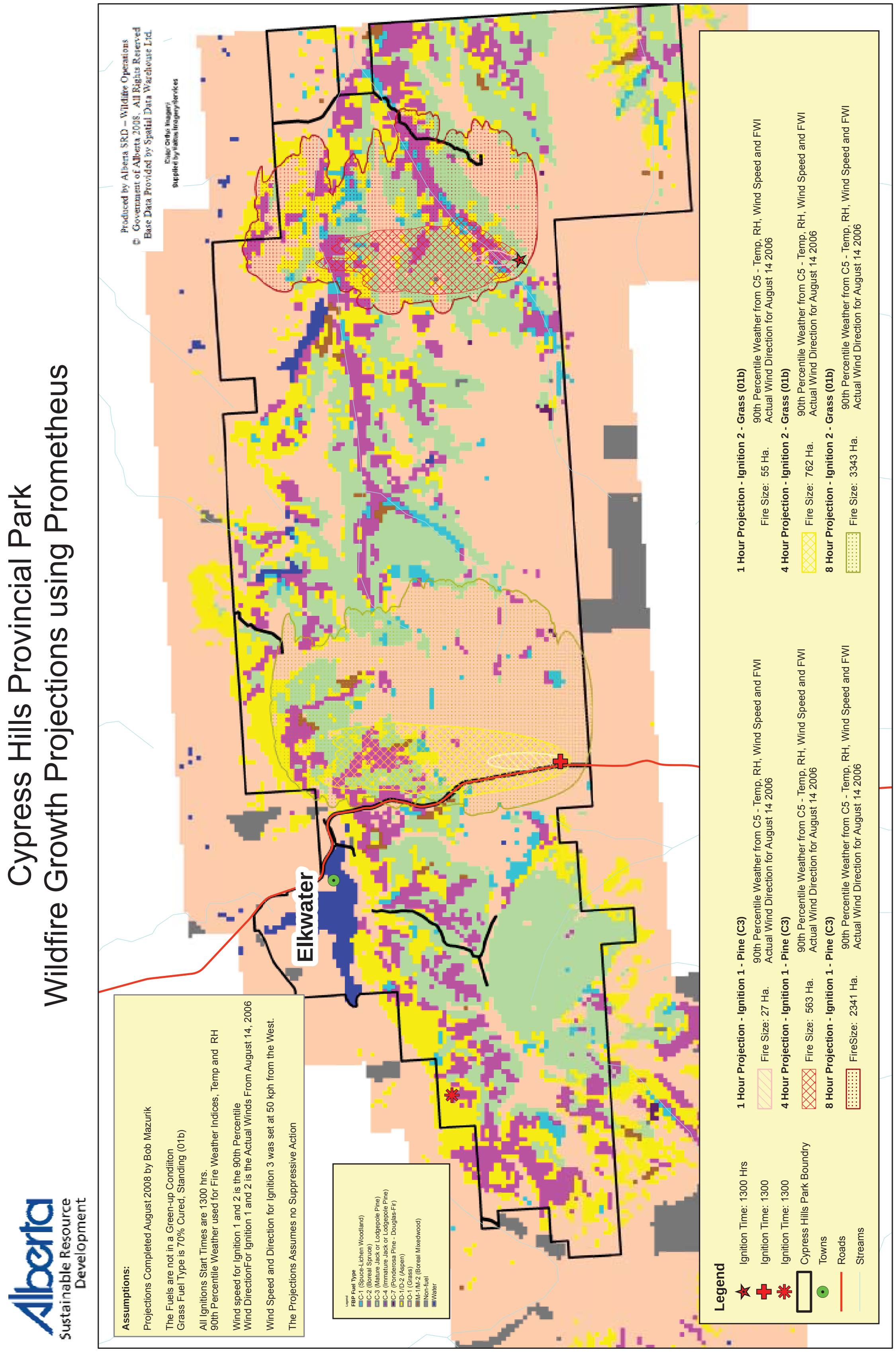


Figure D.1. Fire growth projections over FBP fuel types for Scenarios One and Two.

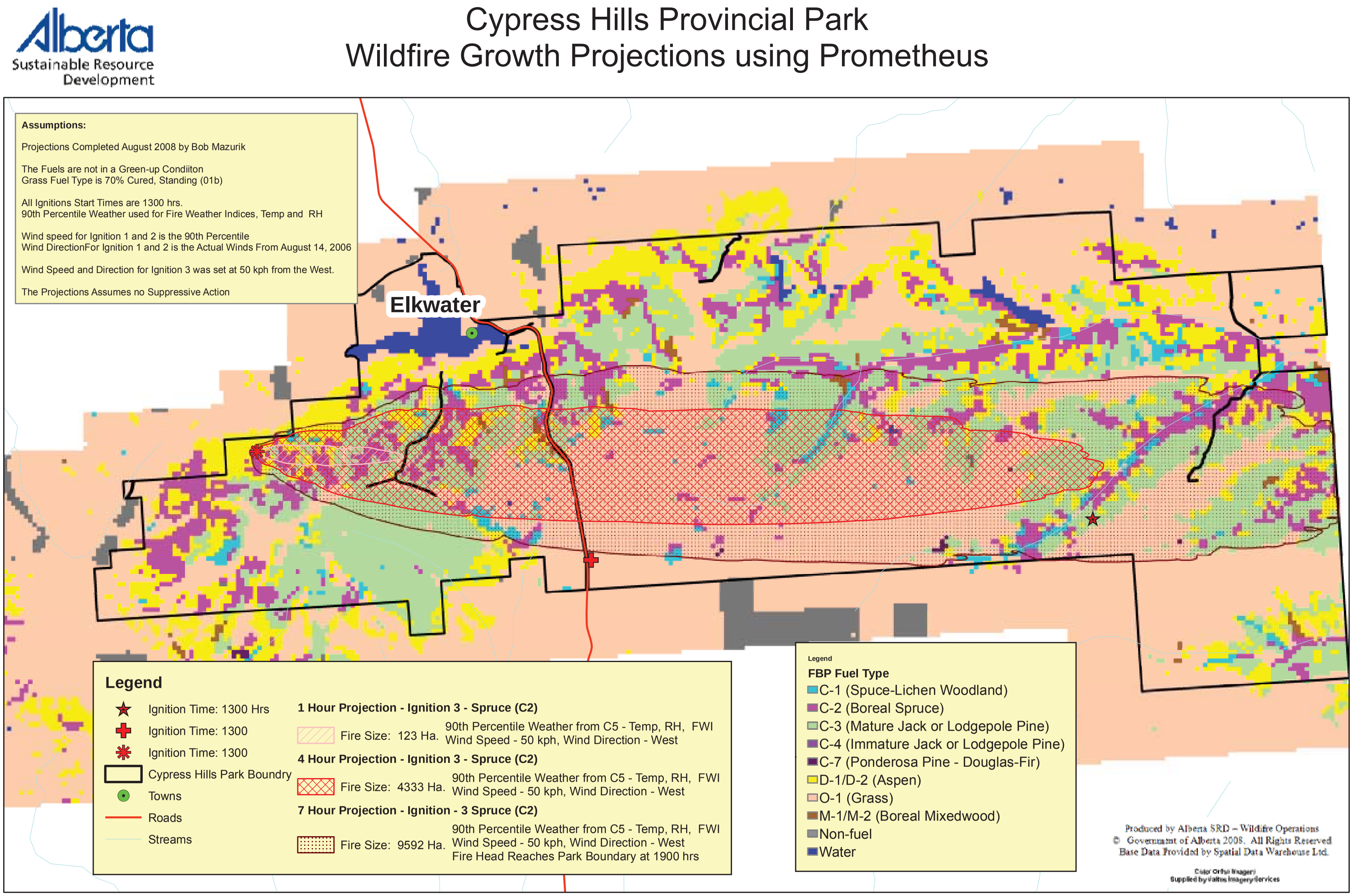


Figure D.2. Fire growth projection over FBP fuel types for Scenario Three.

APPENDIX E: FIRESMART EXAMPLES AND CASE STUDIES

SRD Area	Community	Treatment	Area (ha)
Clearwater	Hamlet of Lodgepole	Debris Mngt	10.38
	Hamlet of Lodgepole	Mulching	8.00
	Hamlet of Lodgepole	Partial Cut Logging	34.35
	Hamlet of Nordegg	Partial Cut Logging	689.79
	Hamlet of Nordegg	Mulching	26.50
	Hamlet of Nordegg	Thinning/Pruning	53.90
	Summer Village of Burnstick Lake	Thinning/Pruning	21.45
	Summer Village of Burnstick Lake	Partial Cut Logging	4.10
Foothills	Coalspur	Logged	4.82
	Town of Hinton	Thinning/Pruning	80.00
	Hamlet of Robb	Hand Pruning	9.83
	Hamlet of Robb	Mulching	25.00
	Hamlet of Robb	Selective Logging	15.98
	Lower Robb Coal Seam	Fire Guard	0.00
	Bryan Creek Fire Guard	Fire Guard	0.00
	Mountain Park Coal Seam	Fire Guard	0.00
	Town of Grande Cache	Thinning/Pruning	95.00
Lac La Biche	Beaver Lake (First Nations)	Pruning	0.30
	Beaver Lake (First Nations)	Thinning/Pruning	2.30
	Beaver Lake (First Nations)	Pruning	0.30
	Beaver Lake Camp	Thinning/Pruning	2.30
	Chisholm Tower	Hand Thinning	0.30
	Hamlet of Calling Lake	Thinning	8.90
	Hamlet of Calling Lake	Fire Guard	1.85
	Hamlet of Calling Lake	Thinning	6.00
	Hamlet of Calling Lake	Fire Guard	9.60

SRD Area	Community	Treatment	Area (ha)
Lac La Biche	Hamlet of Calling Lake	Debris Mngt	9.00
	Hamlet of Calling Lake	Hand Thinning	22.00
	Hamlet of Calling Lake	Fire Guard Maintenance	25.60
	Hamlet of Calling Lake	Fire Guard	21.60
	Hamlet of Calling Lake	Debris Mngt	7.00
	Hamlet of Calling Lake	Hand Thinning	6.00
	Hamlet of Calling Lake	Thinning	18.05
	Hamlet of Calling Lake	FireGaurd	9.60
	Hamlet of Calling Lake	Thinning	35.00
	Hamlet of Calling Lake	Mulching	48.00
	Hamlet of Calling Lake	Debris Mngt	182.37
	Hamlet of Calling Lake	Fire Guard	9.60
	Hamlet of Calling Lake	Mulching	48.00
	Hamlet of Chisholm	Fire Guard	24.00
	Hamlet of Chisholm	Non-draining Borrow Pit	n/a
	Hamlet of Chisholm	Mulching	37.18
	Hamlet of Conklin	Fire Guard	27.60
	Hamlet of Conklin	Hand Thinning	119.02
	Hamlet of Conklin	Mulcher	32.41
	Hamlet of Conklin	Debris Mngt	173.15
	Hamlet of Conklin	Logging	220.00
	Hamlet of Janvier	Fire Guard	1.50
	Hamlet of Janvier	Thinning	30.50
	Hamlet of Janvier	Debris Mngt	14.60
	Heart Lake Tower	Hand Thinning	2.40
	Leismer Base	Hand Thinning	10.00

SRD Area	Community	Treatment	Area (ha)
Lac La Biche	Margueritte Lake	Thinning	1.40
	May Tower	Thinning	0.90
	Pine Ridge	Mulching	4.50
	Pine Ridge	Fuel Reduction	16.00
	Pine Ridge	Debris Mngt	122.00
	Pine Ridge	Maintenance	4.00
	Pine Ridge	Commercial Thinning	48.00
	Pine Ridge	Pruning	7.00
	Rock Island Tower	Hand Thinning	0.10
	Sand River Tower	Thinning	2.00
	Sand River Tower	Debris Mngt	n/a
	Hamlet of Smith	Thinning	53.40
	Hamlet of Smith	Selective Logging	38.90
	Hamlet of Smith	Debris Mngt	38.00
Peace River	Cadotte Lake/Little Buffalo	Thinning/Pruning	37.50
Slave Lake	Drift Pile (First Nations)	Thinning/Pruning	5.00
	Peavine (Metis Settlement)	Thinning/Pruning	5.00
	Hamlet of Grouard	Thinning	30.00
	Hamlet of Grouard	Thinning/Pruning	5.00
	High Prairie Staging Camp	Fuel Reduction	20.00
	Martin River	Fire Guard	5.00
	Mitsue Creek Industrial Park	Fire Guard	1.00
	Peerless Lake (First Nations)	Mulching	6.00
	Peerless Lake (First Nations)	Debris Mngt	4.00
	Peerless Lake (First Nations)	Thand Thinning	17.00
	Hamlet of Red Earth	Hand Thinning	4.00
	Hamlet of Red Earth	Debris Mngt	10.00

SRD Area	Community	Treatment	Area (ha)
Slave Lake	Sandy Lake (First Nations)	Hand Thinning	9.40
	Sandy Lake (First Nations)	Thinning/Pruning	5.00
	Sandy Lake (First Nations)	Debris Mngt	8.00
	Trout Lake (First Nations)	Fire Guard	5.70
	Trout Lake (First Nations)	Hand Thinning	1.00
	Trout Lake (First Nations)	Debris Mngt	21.00
	Trout Lake (First Nations)	Fire Guard	31.70
	Hamlet of Wabasca	Hand Thinning	20.30
Smoky	Nose Creek Settlement	Hand Thinning	5.80
Southern Rockies	Camp Horizon/Elbow Ranger Station	Fuel Removal/Reduction	2.00
	Canmore Nordic Centre	Selective Logging	95.60
	Canmore Nordic Centre	Selective Logging	53.40
	Elbow Ranger Station	Fuel Removal/Reduction	7.00
	Harvie Heights	Logging	3.90
	Harvie Heights	Fuel Removal/Reduction	10.00
	Kananaskis Boundary	Fuel Removal/Reduction	9.50
	Kananaskis ID	Logging	55.30
	Westcastle	Thinning	3.00
Waterways	Hamlet of Anzac	Thinning/Pruning	5.20
	Hamlet of Fort Chipewyan	Fuel Removal/Reduction	19.50
	Hamlet of Fort Mackay	Thinning/Pruning	13.00
	Town of Fort McMurray	Thinning/Pruning	59.50
	MD of Wood Buffalo	Thinning/Pruning	6.71
	Hamlet of Saprae Creek	Fuel Removal/Reduction	8.00
Woodlands	W11 Brush Disposal Contract	Debris Mngt	673.00
	W11 Brush Disposal Contract	Debris Mngt	1006.00
	Horse Creek Compartment	Clear cut	211.00

Firebreak Helps Firefighters Save YMCA Camp and Subdivision

On June 25, 2007, a human-caused fire broke out at the YMCA Snow Mountain Ranch near Winter Park. Although burning conditions were only moderate, the fire grew and spread rapidly, partly due to the dry beetle-killed trees. Recent tree cutting to reduce forest fuels at the ranch and a fast, coordinated response by firefighters kept people and buildings safe.

The Colorado State Forest Service advised ranch managers to protect their cabins from wildfire, and ranch managers did just that. A month prior to the Y Fire, they established a 150- to 200-foot firebreak around several buildings that previously were nestled in a thicket of timber.

"When the fire hit the firebreak, it literally dropped to the ground, and between the weather, a logger who was putting in dozer line, and the rest of our efforts, we were able to get a handle on it," said Ron Cousineau, Colorado State Forest Service firefighter and Granby District forester. "The firebreak did exactly what we wanted it to."

A firebreak at YMCA Snow Mountain Ranch not only protected the YMCA cabins, it also kept the fire from spreading into the neighboring Fairways at Pole Creek subdivision, which has about 100 homes.

Grand County Sheriff and Emergency Medical Services, every fire department in the county, the Colorado State Forest Service, the U.S. Forest Service, and Summit County fire departments all helped with the firefighting efforts.

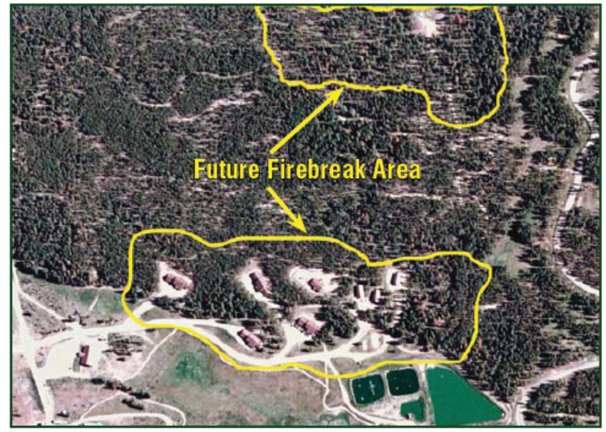
Forest thinning work reduced fire behavior in other parts of the fire.

Firefighters attribute the fire's unusual intensity for the early time of year and moderate weather to beetle-infested trees.

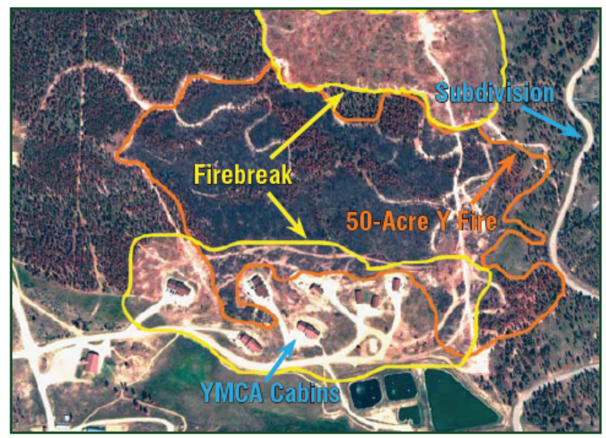
From the *2007 Report on the Health of Colorado's Forests*

www.csfs.colostate.edu

Aerial imagery of the YMCA camp shows the firebreak location (outlined in yellow) and the extent of the Y Fire (outlined in orange). A firebreak is an area where trees and shrubs are removed so that a wildfire drops to the ground, allowing firefighters a better chance to extinguish the fire. Firebreaks can involve a significant amount of work and hazardous fuel removal, but, as seen in the lower image, can be successful in protecting homes from wildfire.



Before the Firebreak and the Y Fire, 2005



After the Firebreak and the Y Fire, 2007

© 2007 QuickBird Satellite Imagery

Courtesy DigitalGlobe, Inc. and NCDC Imaging & Mapping

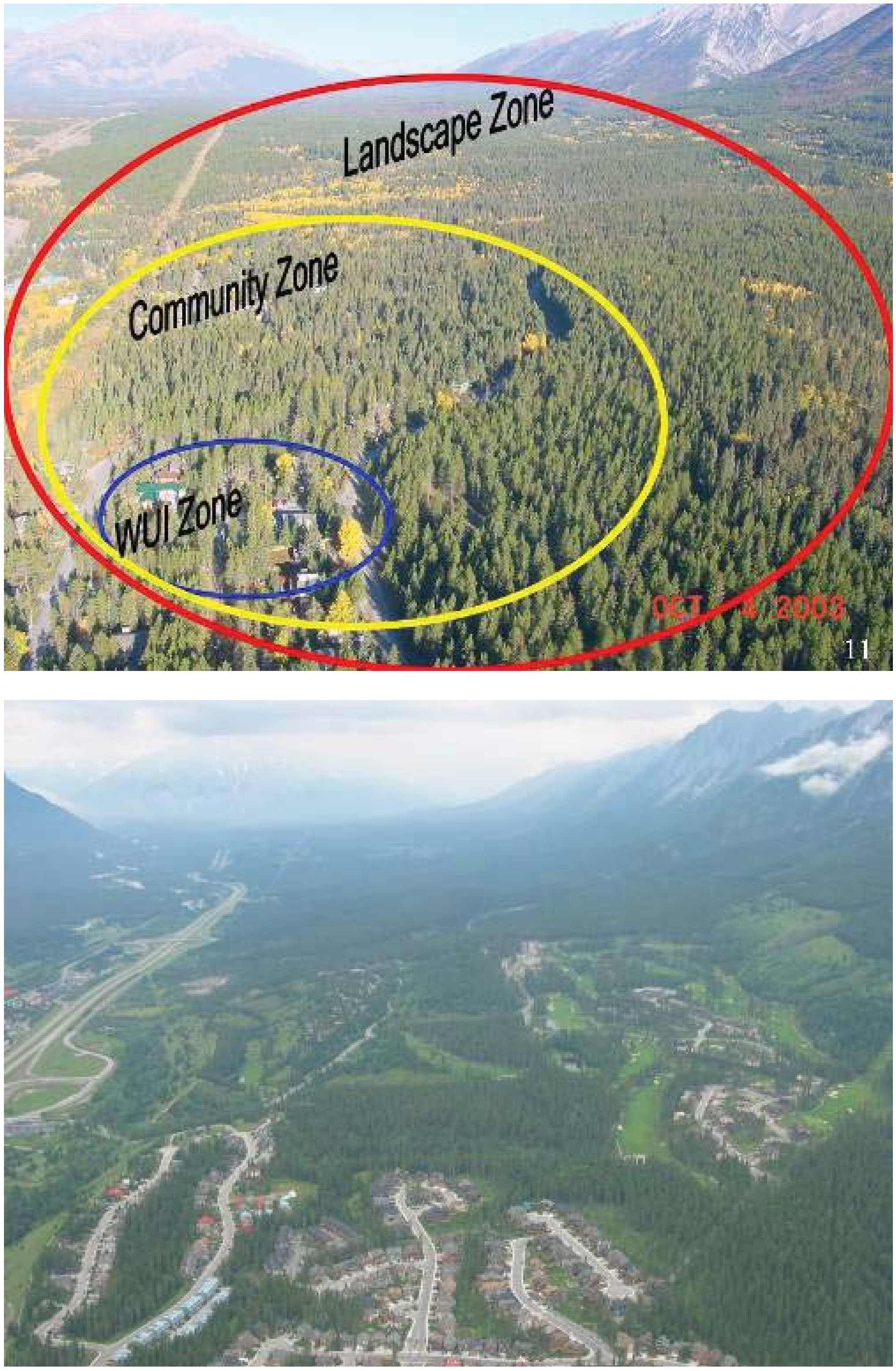


Figure E.1. The Canmore corridor.

APPENDIX F:
SPRINKLER PROPOSAL FOR CYPRESS HILLS PROVINCIAL PARK-ALBERTA

O2 Planning + Design Inc. July 22, 2008

Dennis and Doug and Christina:

Please accept this letter in response to our last meeting and on site assessment of the Cypress Hills community wildland fire protection plan, and your Fire Smart mitigation efforts.

Once again we are pleased to offer any service that may compliment your existing efforts. In this particular circumstance it was nice to see some prior planning by Mr. Ted Bochan. We work for Ted frequently and thus use many of the same tools, strategies and tactics.

After assessing the town site and its proximity to both grassland and forested areas alike, we certainly see a use for a dedicated high volume pumping system as Mr. Bochan has suggested. We own several of these systems ourselves and find them invaluable for moving and placing large volumes of water in a timely, cost effective, and efficient manner. I have speculated a slightly different set up only because we have had some amount of experience in similar communities.

The Cypress Hills Town site has a wonderful proximity to the lakefront on the north edge of town. Obviously this is the resource of choice given a large scale fire threat to the community. Certainly, the logistics of moving volumes of this water through the community, and up slope to where it could be needed come to play.

We try to utilize as much 4 inch or 100mm hose as possible because it is the largest diameter hose that can be handled by fire line staff quickly, and still be able to deliver upwards of one million gallons daily. For this particular site I suggest that 5000 ft. or 1 mile of 4" hose be preloaded onto a trailer in flat lay fashion with outlet fittings intact for fast and easy deployment. We typically install one 2.5 inch or 65mm outlet, valve, and gated wye every 500 feet. This in effect provides the community with a second above ground hydrant system to be used either for sprinklers in a defensive posture, or multiple wildland pumps and or nozzles in an offensive posture separate from the existing community hydrant system. This system also provides an excellent backup system for that existing infrastructure.

65 mm or 2.5 inch hose with B.A.T. thread is common in Alberta and we suggest a min. of 20 lengths or 2 for each outlet and valve assembly. We then convert down again from 65mm hose to 38mm or 1.5 inch forestry hose with sexless couplings. And for this we recommend no less than 50, 100 ft. lengths. or 5000 ft. and a min. of 50 large sprinklers with 1.5 inch flow through tees.

As for pumps we use Agriculture, Industrial, and Municipal fire service pumps depending on the site. In this case we suggest a municipally rated trailer pump with a 2000 GPM. Output and a 200 PSI discharge pressure.

These systems have proven themselves in some very demanding situations, and we are proud to offer our experience from over 30 different Wildland Urban interface events. Science and this experience tells us that if structures are wet they don't burn. We have seen some incredible results with a surprisingly small amount of water per site. The logistics needed behind this effort is where things count.

We break our systems into 2 parts, Delivery, and Distribution. The delivery segment has its challenges set within the volumes and pressures needed to combat the velocity, lift, and friction concerns involved. The Distribution segment must place the resource delivered to site in the place needed on time and in sufficient supply to have the effect needed.

For these concerns we suggest a trial effort to use these tools be made via a mock exercise on your site in a timely and effective manner. Through this any concerns like street crossings and equipment placement can be met and addressed.

RapidFire is proud to offer you the benefit of our systems and experience surrounding these issues. We thank you for your confidence and trust, should you have any questions or concerns you might contact us at your earliest convenience.

Please feel free to contact myself anytime at (403) 341– 3000 or view our website www.rapidfireandrescue.ca

Yours in fire protection:

Troy O'Connor
Pres. RapidFire & Rescue Inc.

Proud to offer our brand of service, through safety, & solutions

APPENDIX G:
EXAMPLES OF VALUES AT RISK PROTECTED BY SPRINKLERS

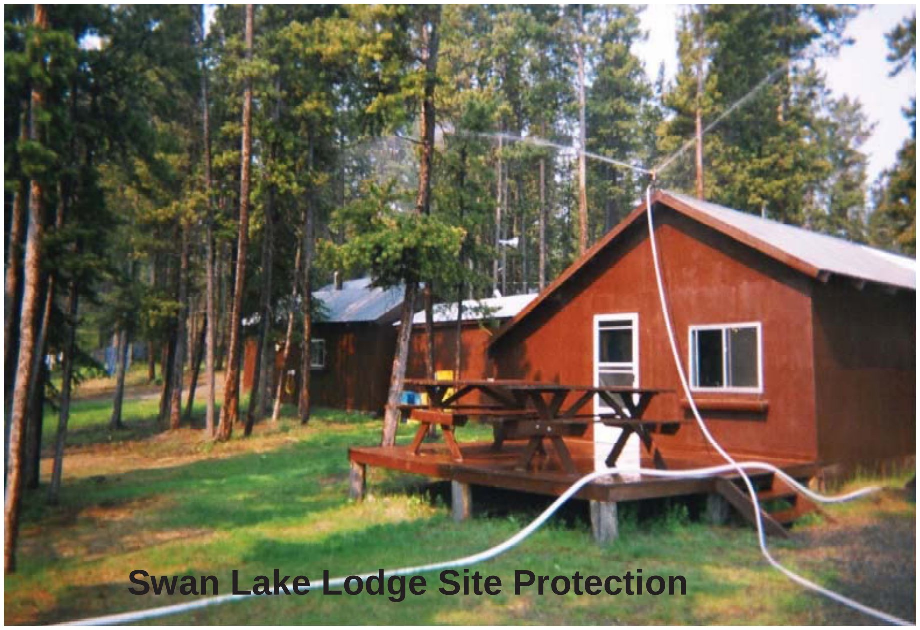


Figure G.1. Sprinklers installed at a Yukon lodge.

Figure G.2. Oil and gas installation in the House River Fire (2002).

Figure G.3. Fishing lodge in interior British Columbia fire (2003).

APPENDIX H:
ICS INCIDENT STANDARDS

The ICS format is the standard as follows:

Type 1 Incident

- More than 75 personnel involved
- Multiple operational periods
- Written incident action plan developed
- Extensive/ complex air operations involving many types and numbers of aircraft
- All command and general staff positions filled with Type 1 qualified people
- Branches activated to address span-of-control needs based on the number of division groups

Type 2 Incident

- 26-75 personnel involved
- Multiple operational periods
- Written incident action plan developed
- Air operations often involving several types and numbers of aircraft
- Most of all command and general staff positions are activated and filled by a Type 2 Incident Management Team
- Logistical support required, such as camps to feed, sleep, and supply fireline personnel

Type 3 Incident

- Several strike teams, possibly organized into divisions or groups
- 9-25 personnel involved
- Based more on number of resources required than on complexity
- More than one operational period likely required
- Incident Commander requires assistance supplied by filling Operations Chief and Planning Chief roles, though no formal Logistics Chief required
- Type 3 incidents are often a transition phase from Type 4-5 to Type 2 incidents

Type 4 or 5 Incident

- Resources vary from a single resource (Type 5) to several single resources (Type 4)
- 1-8 personnel involved, possibly as a single strike team
- Normally limited to one operational period during the containment phase of fire control, through mop up may extend into multiple periods
- Normally does not require a written incident action plan

- Incident Commander (IC4 and IC5) may be an Initial Attack Crew Leader and is responsible for performing all command and general staff functions