THE UNIVERSITY OF CALGARY

FireSmart - ForestWise:

Managing Wildlife and Wildfire Risk

in the

Wildland/Urban Interface

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "FireSmart - ForestWise: Managing Wildlife and Wildfire Risk in the Wildland/Urban Interface" submitted by Alan Lawrence Westhaver in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

Preventing the occurrence of wildfires that threaten homes and communities is a growing priority in Canada. To reduce risk, a consistent set of standards for managing forest fuel has been adopted. However, these largely disregard concerns for wildlife and wildlife habitat. Managing fuels appropriately in the wildland/urban interface necessitates that knowledge of potential impacts and the requirements of wildlife be considered. This research combined literature evaluation with experimental manipulations to develop ecologically based approaches for managing fuel in ways that optimize conditions for wildlife, within constraints of current risk management standards. This research was conducted during a 30-month prototype project covering more than 200 hectares of forest surrounding the community of Jasper, Alberta. The study concludes that fuel management for the purpose of reducing wildfire risk can be compatible with wildlife conservation and presents a series of species-specific mitigations, guidelines, and best practices suited to communities or individual homes.

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DEDICATION

To my Father, Larry Westhaver, for the inspiration and your example.

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Areas where homes, businesses, industrial, agricultural or recreational developments and other structures are mingled with flammable natural vegetation are called the *wildland/urban interface* (or interface). In most cases, the wildland/urban interface occurs on forested lands, but severe interface situations also occur in rural and agricultural settings dominated by grassland, shrub, or mixed vegetation. The boundary between wildland fuels and structures may be abrupt, or vegetation and buildings may be intermixed (Davis 1987).

Interface fire events are highly complex events that involve wildland and structural fuels, and respective fire behavior. Complexity stems from the magnitude of values at risk, simultaneous ignition of multiple structures, degree of hazard to the public and fire fighters due to smoke, flames and evacuation, and their cost as measured in human lives, suppression funds, and recovery costs (Partners in Protection 2003). Interface fires spread rapidly, and swiftly escalate from minor incidents to the civic disasters that overwhelm even the best-resourced firefighting agencies (Cohen 2000a). Unique, multi-disciplinary solutions are required if catastrophic interface fires are to be prevented in the future (Partners in Protection 2003, O'Neill 1987).

1.1.1 Status of the Wildland/Urban Interface Problem in Canada

A review of recent fire seasons revealed that vulnerability of people, property, and forests have reached unprecedented levels, and are expected to continue increasing. In the past ten years more than 250 communities and 700,000 Canadians have been threatened directly by wildfires (Natural Resources Canada 2005). Since 1980 there have been more than 900 documented cases of structure losses to interface fires (P. Bothwell, unpublished data). In and adjacent to Alberta's provincial forests 321 communities are vulnerable to wildfire, as are many more in other forested jurisdictions (DeSorcy 2001). Similar conditions exist in the lower 48 United States where 9.3% of the land base, and more than 60% of some states, is wildland/urban interface (Dwyer et al. 2003). Statistics on interface fires are not routinely kept by Canadian agencies (T. Johnston, pers. comm.). However, virtually every province and territory has experienced major interface fires. Examples include the Lost Creek, Granum, and Chisholm fires in Alberta; the Turtle Lake and La Ronge fires in Saskatchewan; the Kelowna, Penticton, Barrier, and Salmon Arm fires in British Columbia; fires near Burwash, Whitehorse, Fort Norman, and Norman Wells in the north; the Timmins and Beardmore fires in Ontario; Shelborne County, NS and Badger NF.

Detailed information gathered by the province of British Columbia gives further insight (Table 1-1). When compared to a 10-year average, recent fire seasons, including 2003, showed significant upward trends in several indicators relevant to interface fire (P. Fuglem, pers.comm.). Over one hundred of the 2,517 wildfires that occurred in British Columbia in 2003 struck wildland/urban interface areas. Fifteen of these were major incidents that, when combined, resulted in evacuation of over 50,000 people and destruction of 334 homes and businesses.

Table 1–1: Interface fire occurrence in British Columbia (Fuglem 2004)

CATEGORY	10-YEAR AVERAGE	PREVIOUS RECORD	2003
Total Number of Wildfires	2,002	4,088 (1994)	2,517
Total Area Burned (all wildfires)	25,300	235,000 (1985)	266,000
Number of Interface Fires	5	15 (1998)	>100
Number of Homes Destroyed	4	18 (1998)	334
People Evacuated	n/a	7,000 (1998)	50,000
Interface Suppression Costs ($)	54 million	153 million (1998)	500 million

Current trends in population distribution have potential to exacerbate the existing interface problem. First, the number and aerial extent of rural or country residential developments is rapidly increasing (Duryea and Vince 2005), and is compounding the current wildland/urban interface situation. For example, in the United States 880,000 hectares of wildland were alienated by urban sprawl each year between 1997 and 2001. Furthermore, over 45% of this has occurred on forested lands (U.S. Department of Agriculture, Natural Resources Conservation Service 2003). This trend is also reflected in Alberta where country residential development is the main cause of agricultural land conversion. This process reaches a peak in the foothills adjacent to Calgary where the population has risen 81% between 1986 and 1996. In addition to a growing population, more than 25% of the rural quarter-sections now have ten or more structures in the Municipal District of Foothills, (Duke et al. 2003). Second, as the density of settlement in country residential areas rise, it follows that there will be increased risk of human caused ignitions, and an increasing number of wildfires that involve structures or homes. As a final consideration, there is emerging consensus that greenhouse gas emissions will continue to cause considerable warming in northern latitudes, resulting in an increase in the frequency, extent and severity of wildfires in western and central Canada (Flannigan et al. 1998, Flannigan et al. 2003). These convergent issues reinforce the need for effective programs to protect communities from wildfire.

1.2 Financial Impacts of Wildland/Urban Interface Fires.

Unlike a residential fire that typically involves one home and partial loss, wildland/urban interface fires can result in dozens, or hundreds, of completely destroyed homes (Cohen, 2000b). In comparison to remote wildland fires, wildland/urban interface fires are notoriously expensive. Aside from expected suppression costs, additional expenses result from evacuation and relocation of people, heroic efforts to defend threatened homes and structures, facility and infrastructure replacement costs, and community health and recovery costs. The

2003 wildfire season in British Columbia and the Rocky Mountains established the most recent fiscal records for interface losses and firefighting costs. For example, the Okanagan Mountain fire at Kelowna, BC resulted in the loss of over 200 homes, evacuation of 45,000 residents, and cost $700 million (Filmon 2004).

A comparison of two similar fires that occurred simultaneously during 2003 in the front ranges of Alberta's Rocky Mountains illustrates the high cost of suppressing interface fires, relative to wildfires with fewer values at risk. The 22,000 hectare Lost Creek fire adjacent to settled areas in the Crowsnest Pass, Alberta required evacuation of almost 2000 residents (Mc Gee et al. 2005), specialized community protection efforts, and cost approximately $25 million (S. Walkinshaw, pers.comm.). In comparison, the 27,000 hectare Syncline wildfire burning in a remote portion of Jasper National Park, with fewer interface complexities, cost less than $4.3 million (D. Smith, pers. comm.). Wildland/urban interface fires can also impact local or regional forest industries. For example, the 2001 Chisholm fire in Alberta destroyed of 4.5 million cubic metres of merchantable timber and burned over 6,300 hectares of replanted cutblocks (DeSorcy 2001).

1.3 Social Impacts of Wildland/Urban Interface Fires.

Between 1980 and 2004, 367 wildfire-related evacuations involving almost 160,000 individuals, and more than 850,000 evacuee days (P. Bothwell, unpublished data occurred in Canada. Although poorly studied to date (T. Mc Gee, pers. comm.), interface fires have long-lasting and significant social impacts on affected residents and communities. Families are displaced from homes, and jobs and businesses disrupted. Secondary health problems arise due to stress or smoke and respiratory effects. There are some indications that the secondary costs associated with large interface fires (e.g., declines in regional economic activity, property value, and recreation, and job absenteeism) may even exceed the enormous cost of suppressing them (Graham 2003). During severe fire seasons northern settlements are sometimes subject to repeated evacuations as fires ebb and flow with the weather (B. Mottus, pers. comm.).

Interface fires also cause social impacts through loss of human lives and livelihoods. For example, during 2003 three Canadian pilots lost their lives fighting interface fires in British Columbia (Filmon 2004) and 22 civilian lives were lost in California (Winter et al. 2004). In October 1991 the Oakland Hills interface fire in California claimed 25 lives, injured 150, and incinerated 2,249 homes in less than seven hours (National Fire Protection Association 2005).

1.4 Factors Regulating Wildfire Intensity and Behavior.

Wildfire behaviour is the basis for fuel modification standards, and understanding it is essential to avoid violating the intent and effectiveness of those standards. At any given point, fire intensity is the rate of heat released in the flaming front of a wildfire, per unit length. The weight of fuel per square metre is a critical factor in determining fire intensity (Byram 1959). At the broader landscape level, wildfire behavior is regulated by interacting elements of the fire environment: topography, weather, and fuel (Forestry Canada Fire Danger Group 1992). Topographic factors include attributes such as slope, aspect, elevation, and other terrain features. Weather factors encompass temperature, humidity, wind speed and direction, and longer-term climatic patterns and phenomenon (Johnson and Wowchuk 1993, Van Wagner 1977). Fuel characteristics are the third regulating element, and are discussed further in section 1.6.

Interactions between topography, weather, and fuel can produce three types of wildland fire in wildland/urban interface areas (Partners in Protection 2003). Ground fire smolders slowly in compacted fuels below the surface (e.g., roots, organic soils, and rotting logs) but rarely presents a threat to structures. Surface fire burns more quickly with open flames that consume loose above-ground fuels (e.g., leaves, grass, needles, downed wood, forbs, shrubs and young trees).

They do not involve the forest canopy, can present a direct threat to structures or homes, but are usually within the capability of fire fighters to control. Crown fires result when flames spread rapidly through the forest canopy, usually in conjunction with surface fire (Canadian Committee on Forest Fire Management 1994). Aside from generating flames that can impinge directly upon structures, crown fires present additional concerns in the wildland/urban interface. Torching of individual trees or small groups of trees lofts burning embers to nearby fuels and accelerates heating of surface fuels and adjacent surface fire spread rates. As well, energy released from active crown fires often creates a convection column that results in massive long-range (i.e., more than one kilometer) transport of embers. Intense crown fires regularly exceed agency fire suppression capabilities (Van Wagner 1977, Canadian Forest Service 1968).

Models and observations of experimental fires are used to predict wildfire behavior, including the onset of crown fire (Cruz et al. 2002), a crucial threshold that must be avoided in the wildland/urban interface. Generally, crown fires are ignited when heat from surface fire below dries and heats the canopy fuels above to the point of ignition (Van Wagner 1977); this is known as the critical surface fire intensity. Given conditions of constant weather and topography, the major variables involved in crown fire initiation are the height of canopy fuels above the ground (i.e., the fuel strata gap), fuel bed characteristics such as fuel continuity and crown bulk density (i.e., canopy weight for a given volume), surface fuel consumption, moisture content of the fuels, and forward rate of fire spread (Scott and Reinhardt 2001, Cruz et al. 2002, Graham et al. 2004, Van Wagner 1977). Regulating these variables is the basis of fuel management in the wildland/urban interface.

1.4.1 Mechanisms of Structural Ignition

Until recently, how homes catch fire has been poorly understood. For any form of combustion to take place adequate amounts of fuel, heat, and oxygen must be present. In the case of an interface fire, both homes and vegetation provide the available fuel. A wildland fire cannot spread to a structure unless these requirements for combustion are met, and a mechanism for fire spread is present. There are two mechanisms for fire spread and ignition of structures in the wildland/urban interface.

In the first mechanism, the total heat transferred by radiation and convection from nearby flames (Cohen 2000a) can ignite a structure. In this case total heat is a function of distance from flames and time of exposure. Reducing home ignitability requires that the fuel and heat components be sufficiently mitigated to prevent ignition (Cohen 2000a). In these cases, the characteristics of a home or structure in relation to its immediate surroundings (i.e., vegetation and other structures within 30 – 60 metres called the "home ignition zone") largely determine the ignition or survival of that structure during a wildfire event (Cohen 2000a).

In the second mechanism, homes can be ignited by embers transported by the convection from an intense, but distant wildfire. Data from the 2002 Hayman fire in Colorado showed that nearly equal numbers of homes ignited from firebrands as from direct exposure to flames (Cohen and Stratton 2003). Similar results were obtained from the Cerro Grande fire at Los Alamos (Cohen 2000b), and from empirical evidence from other investigations (De Sorcy 2001). In this scenario burning embers (e.g., loose bark, cones, or pieces of wood weighing up to several kilograms) are lofted thousand metres into the air by the up-drafting column of smoke and heat that develops over crown fires. These are carried on prevailing winds up to two or more kilometers ahead of the main fire front, then dropped to deluge structures and communities with firebrands. Ember densities may exceed 12 per square metre (Partners in Protection 2003). Under dry conditions, nearly 100% of these embers can ignite new fires among flammable fuels in forest or urban environments (Forestry Canada Fire Danger Group 1992).

1.5 Vegetation Trends Affecting the Wildland/Urban Interface.

Wildland fire managers and researchers in western Canada have observed disturbing changes in the structure (i.e., increased density) of forests that have a history of frequent disturbance by fire, an upsurge in the intensity of wildfires in these locations, and increasing resistance to suppression efforts (D. Quintilio, pers. comm.). Particularly in fire regimes that evolved with frequent, low intensity burning, decades of management practices aimed at exclusion of fire have resulted in high accumulations of combustible fuels relative to conditions prior to 1900 (Graham et al. 2004). Historic regimes of frequent fire served to set back regeneration of fire-intolerant plants, maintain an open forest structure of fire-tolerant species, reduce the activity of forest insects and disease, and create open or early seral habitats for many species of wildlife (Graham et al. 2004). As the vegetation characteristics of these ecosystems change with exclusion of fire, there is increasing fire hazard with time since disturbance across large areas of the American West (USDA Forest Service 2005). Covington and Moore (1994) described how once frequent low-intensity surface fires served to clean the forest floor of fine fuels and kill regenerating conifers. Mutch (1994) outlined that a lengthy period of fire exclusion resulted in widespread increases in stand density and crown fire potential.

Altered fire regimes throughout the Pacific Northwest led to concerns regarding the structure and composition of forests. These conditions are now referred to as forest "in-growth" (i.e., when the density of young trees greatly increases in the understory of open forest stands), and "forest encroachment" (i.e., when trees colonize open areas or take over grasslands) (Risbrudt 1995). In the Rocky Mountain Trench of British Columbia, an estimated 30 km^2 of open forest and grassland is being converted each year by these processes (Kootenay National Park 2002). From a fire perspective, these conditions result in increased fuel loads, increased horizontal and vertical continuity of fuel (e.g., significant increases in mid-level "ladder" fuels that help lift fire into the crowns), and enhanced probability of crown fire due to increased canopy volume and continuity (Daigle 1996, Graham et al. 2004, Scott and Reinhardt 2001).

In response to the problems of encroachment and in-growth, the Government of British Columbia developed management guidelines for restoration of fire-maintained ecosystems (Gayton 1997). Restoration projects to return forests to their natural range of variability (in terms of structure, composition, and density) are now commonplace in the western States (Moore et al. 2003). The issue of fuel accumulation was raised again following the catastrophic fire season of 2003 in British Columbia:

> "It is clear that a successful record of fire suppression has led to a fuel buildup in the forests of British Columbia. The fuel buildup means that there will be more significant and severe wildfires, and there will be more interface fires, unless action is taken." Firestorm 2003 – Provincial Review (Filmon 2004)

The concept of "fire regime condition classes" is gaining widespread use as a system for modeling landscape dynamics and describing the degree of departure from historical or natural range of variability (Hardy et al. 2001) caused by modern fire exclusion practices. In this model, " highly impacted forests" are described as follows:

> "Vegetation composition, structure, and fuels have high departure from the natural regime and predispose the system to high risk of loss of key ecosystem components. Wildland fires are highly uncharacteristic compared to the natural fire regime behaviors, severity and patterns. Disturbance agents, native species habitats, and hydrologic functions are substantially outside the natural (historic) range of variability" (Hann and Strohm 2002).

Many of the fire-adapted ecosystems most severely impacted by abnormal fuel accumulations are also those dryer, low elevation areas most attractive to recreational development and country-residential living (i.e., the wildland/urban interface). For example, the Rocky Mountain Trench has experienced a period of unprecedented increase in human density during the past 50 years while simultaneously losing large areas of grassland and open forest to encroachment and in-growth (Filmon 2004). Although the impact of fire exclusion is now felt most acutely in low severity fire regimes, it is logical that these effects will become apparent in mixed and high severity fire regimes in the future.

1.6 Managing Wildland Fuels to Reduce Wildfire Risk in the Interface

The linkage between wildland fuels and risk of wildfire losses in the interface is well established. Examination of Byram's equation for fireline intensity (1959) reveals that fuel is the only variable that humans can manage to reduce the energy released by fire. Countryman (1974) concluded that the most effective strategy for reducing the potential for wildfire conflagrations in the interface is to create fuel situations that will reduce the energy output of fires to a point where conventional firefighting methods can be effective and thereby limit their size. Graham et al. (2004) arrived at a similar conclusion after a comprehensive analysis of the scientific basis for changing forest structure to modify wildfire behavior and severity. Further support for treatments to abate fuel hazards were provided by Martinson and Omi (2003) following observation of wildfire behavior in treated and untreated fuels. Landscape scale fire simulation modeling conducted by Hirsch et al. (2004) concluded that fuel treatments could have a considerable impact on reducing fire size. To paraphrase, fuel management is a central issue in wildfire protection in the wildland/urban interface.

The ignition, development, and spread of fire in the wildland/urban interface are affected by several key characteristics of the local fuel complex (Canadian Forest Service 1968). These characteristics include the total fuel load; the size distribution of fuels; the horizontal and vertical arrangement (continuity) of fuels; the moisture content of fuels; the chemical make-up of fuels; and the "canopy base height" of fuels (i.e., the lowest height above the ground at which there is sufficient canopy fuel to propagate fire vertically through the canopy (Scott and Reinhardt 2001, Cruz et al. 2002). Each of these fuel characteristics can be manipulated by residents or fire agencies engaged in fire prevention programs – and each is associated with important aspects of wildlife habitat quality.

1.6.1 Current Fuel Management Standards

Current Canadian standards for fuel management in the wildland/urban interface were developed by the non-profit organization known as "Partners in Protection™" and published as part of the comprehensive manual called *FireSmart*®: *Protecting Your Community from Wildfire,* in 1999. When the second edition was printed in 2003, virtually every Canadian wildfire agency, hundreds of municipalities, and several American states had adopted this prevention-based manual leading to national acceptance (B. Mottus, pers. comm.). The FireSmart manual sets out specific standards for managing all types of forest fuels in accord with defined interface priority zones. The standards are preventive in nature, and intended to be implemented in advance of a wildfire event by individual homeowners on their properties or by agencies working at larger scales to protect entire communities. The purpose of these fuel management standards is to limit wildfire intensity, ease fire suppression efforts, and prevent structural ignitions (Partners in Protection 2003).

FireSmart standards are based on published and internationally accepted codes developed by the National Fire Protection Association, that is *NFPA 1144 Standard for Protection of Life and Property from Wildfire* (NFPA 2002). At that time, NFPA standards for thinning the forest canopy were untested in Canada's northern forests, and Partners in Protection felt that NFPA standards "should be viewed as minimum guidelines". To remedy the situation, more rigorous fuel standards for crown fire hazard reduction, developed previously by the Canadian Forest Service (Hirsch 1991), were incorporated along with the NFPA code into the FireSmart standards.

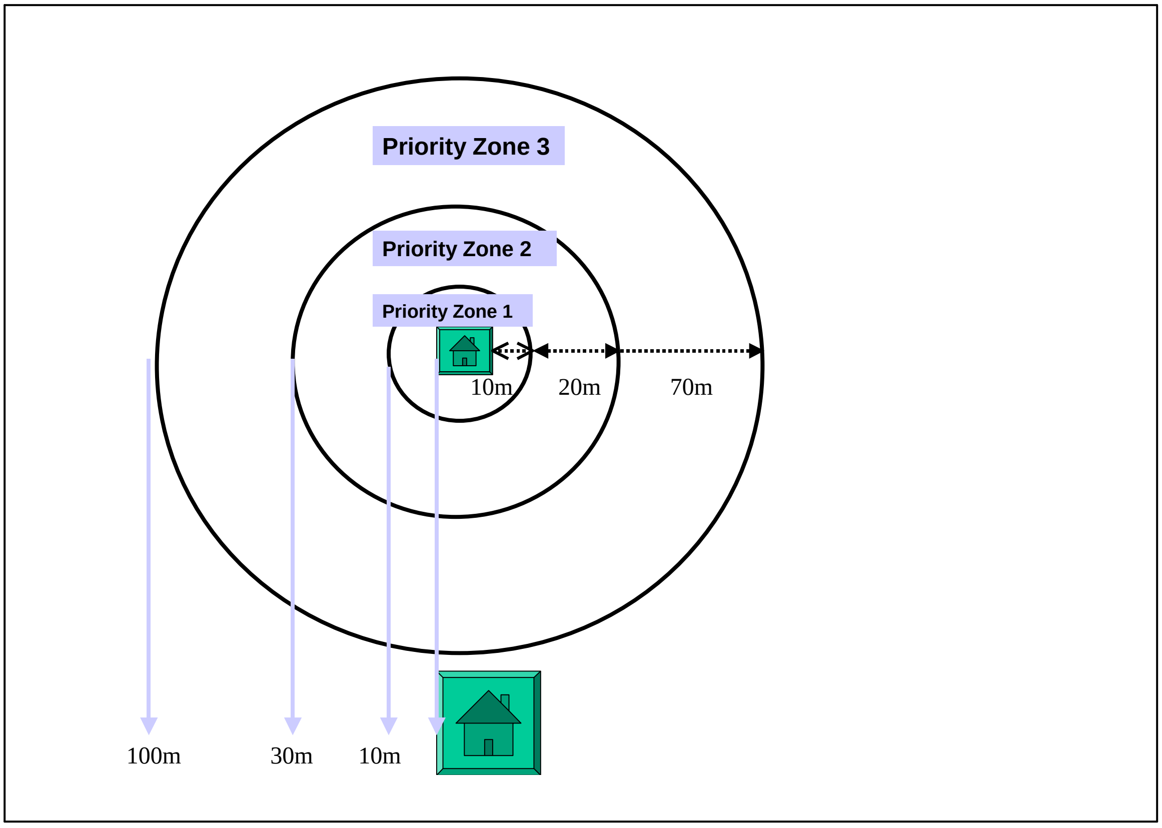
1.6.2 General Strategies for Fuel Management in the Interface

FireSmart fuel management standards fall within one of four general strategies (i.e., are removing, reducing, isolating, or converting fuels). Each strategy is designed to create less flammable conditions and alter characteristics of fuel bed strata that predispose an area to intense surface fire behavior, or initiation and propagation of crown fire.

Removing fuels denotes elimination of a given type of fuel from a specific priority zone. It is the most stringent strategy and most commonly applied in Priority Zone 1. Removal of fuel achieves appropriate physical separation to prevent building surfaces from reaching combustion thresholds due to convection and radiant heat, and eliminates combustion potential. Reducing fuels means to decrease the amount of a given type of fuel from a priority zone. This strategy is applied in all priority zones, and to most types of fuel. Reduction of fuel limits heat production, decreases fire spread potential, and simplifies fire control efforts. Isolating fuels means to create a gap between a particular fuel source and the fuels nearby, such that ignition of the isolated fuel would be inconsequential to its surroundings. The size of the isolated fuel patch and the gap vary with the character of the remaining fuels. Converting fuels means to alter a given fuel complex from highly flammable combinations of vegetation to mixtures that burn with less intensity. Generally this means a shift to deciduous plant species with higher moisture content and/or lower fuel volume, which are more resistant to fire.

Fuel management strategies are spatially explicit. That is, fuel is more aggressively treated as distance to a structure decreases. The concept of “interface priority zones” was established by Partners in Protection (2003) to convey this principal, and is used throughout this study. There are three concentric interface priority zones. Priority Zone 1 extends from the structure outwards for 10 metres, Priority Zone 2 continues from 10 – 30 metres from the structure, and Priority Zone 3 from 30 – 100 metres or more from the structure. With respect to groups of structures or communities, Priority Zone 3 may be several hundred metres in width. The diameter and shape of the zones vary with slope, aspect, and local weather patterns.

Figure 1-1. FireSmart fuel management priority zones within the wildland/urban interface (Partners in Protection 2003).



1.7 Public Response and Perception of Fuel Management.

The Auditor General for British Columbia observed (2001) that only 3% of communities in the province had undertaken significant levels of risk mitigation in the wildland/urban interface, and that very little was being done in 55% of communities where wildfire risk levels were rated moderate to high. Only 11% of communities had undertaken fuel reduction programs of <u>any</u> significance. Independent reviews following two large interface fires in Alberta (DeSorcy 2001) and British Columbia (Filmon 2004) both pointed to lack of pre-fire preparation as a contributing factor, and to the need for accelerated programs of fuel management. Overall, fire protection agencies are meeting with limited success in convincing individuals or communities within the interface to voluntarily manipulate or modify the forest structure on and around private property. This information is corroborated by dozens of informal interviews conducted by the author with fire protection officers in western Canada and United States. These conversations indicate that, despite substantial efforts by agency personnel, progress at implementing preventative fuel management solutions has been slow, and is often frustrating.

In light of the serious consequences of a major interface fire, the lack of action by residents and communities to manage interface fuels more aggressively is surprising. Several reasons for this lack of action have been documented (Mc Gee et al. 2005, Winter et al. 2004, McCaffrey 2004a, Boura 1996) and include: residents perceive wildfire risk to be lower than it actually is; lack of knowledge or understanding about risk reduction measures; a willingness to accept the risk of wildfire losses; constraints on the ability to implement solutions (e.g., ability, funds, or time); skepticism about the effectiveness of risk reduction measures; lack of trust in public agencies responsible for fuel management and; conflicts between risk reduction measures and other resource values or needs (e.g., wildlife, conservation, aesthetics) held by residents.

The latter reason is central to the purpose of this research. Regarding the inter-relatedness of fire hazard and environmental values, Boura (1996) stated that management practices designed to reduce fire hazard in Australia also reduced environmental qualities, caused considerable potential for conflict of interest, and resulted in bitter social divisions within local communities. For many residents and property owners, it is often difficult to reconcile standard (i.e., FireSmart®) fuel reduction methods with the personal importance they place on aesthetic values, wildlife viewing opportunities, and the "natural" forest environment they live in. In many cases, the public fears that direct impacts of standard fuel reduction practices will harm wildlife or reduce their opportunity to view wildlife. A study in Arizona (Winter et al. 2004) reported that local citizens opposed forest thinning "because they moved here for the forest". Residents make it clear that not everyone is comfortable with the concept of cutting trees down, and some residents openly protest such actions as being destructive. Graham (2003) listed five landscape values that influence the acceptability of fuel management activities (i.e., privacy, wildlife viewing, recreation, aesthetics, and ideas of naturalness). Citizens are also concerned about secondary environmental impacts, like soil erosion or stream pollution, which could result from manual and mechanical fuel treatments. In some cases, these concerns have grown into active opposition of "FireSmart" programs (R. Arthur, pers. comm.). Residents and business people who are concerned about adverse impacts of fuel management activities on wildlife, wildlife habitat, and their own enjoyment of the forest environment have been frequently encountered by the author during informal interviews, or while conducting interface hazard assessments and stakeholder meetings. In short, many individual residents and private landowners offer these worries as reasons <u>not</u> to implement recommended hazard reduction measures.

Because of this conflict between values, interface residents feel pressured to make trade-offs between wildfire risk reduction measures and the genuine environmental values they hold (Brenkert et al. 2005). Similarly, when values compete, managers responsible for public safety feel burdened when they must make an "all-or-nothing" decision regarding fuel management (Boura 1996). Consequently, it is easy for conflicts to arise between fire managers advocating manipulation of vegetation, and conservationists who view these actions as destructive. Brown (2002) summarized these, and other concerns regarding the impacts of forest thinning in a paper commissioned by the Defenders of Wildlife.

This controversy highlights deficiencies in the current operational approach to community and residential wildfire protection. A better understanding of how fuel reduction treatments affect forest communities is essential for effective management of habitat for wildlife (Kotliar et al. 2002).

1.8 Governmental Response to the Wildland/Urban Interface Issue.

Action by major Canadian wildfire agencies and coordinating bodies reflects the growing concern for the interface problem. In 2001, the Canadian Forest Service described the wildland/urban interface situation as an "emerging issue" (Natural Resources Canada 2001). In 2005, the Canadian Interagency Forest Fire Centre verified that the interface situation is a "rising priority" with Canadian wildfire agencies across mountain, foothills, and boreal landscapes (T. Johnston, pers. comm.). As a result of their collective concerns, the Canadian Council of Forest Ministers signed the "Canadian Wildland Fire Strategy Declaration" in October 2005. The declaration stressed the need to address the growing threat that wildfires pose to human life, private and public property, and Canada's vital forest sector. The strategy includes a commitment to launch a "Canadian FireSmart Initiative", an undertaking to enhance preparedness and to "develop guidelines for homes and communities and the appropriate management of forest fuels in high-risk areas to create safer communities and healthier forest ecosystems" (Canadian Intergovernmental Conference Secretariat 2006).

1.9 Deficiencies in Current Fuel Management Standards.

A set of standards known collectively as "FireSmart®" have been developed to reduce the risk of wildfire losses in the wildland/urban interface (Partners in Protection 2003). These have been adopted by virtually all wildland fire agencies, and many municipal and volunteer fire departments. At the core of these prevention-based standards are guidelines for manipulating forest vegetation through actions to remove, reduce, convert, or isolate fuels so that resultant fire intensity is decreased.

However, a review of current standards for fuel management reveals a preoccupation on the physical characteristics of the fuel. They largely disregard other resource values such as wildlife, wildlife habitat, biodiversity, cultural, and aesthetic qualities. Instead, the forest is primarily viewed as a fuel complex. For example, less than one page of the one hundred and eighty page manual addresses wildlife concerns. Similarly, few procedures for limiting the secondary environmental impacts associated with major fuel manipulation projects have been published.

As documented in 1.7, lack of consideration for natural resource values is a serious shortcoming that often hampers well-intentioned programs of wildfire prevention and risk reduction. Conversely, fuel reduction has the best chance of success if managers provide effective responses to the questions, objections and concerns of residents (Winter et al. 2002, McCaffrey 2004b). Furthermore, Partners in Protection cited lack of knowledge about how wildfire risk can be reduced in the wildland/urban interface, without sacrificing the natural setting or visual attractiveness of an area, as a reason that wildland/urban interface problems continue to grow (2003). As a result of this review, I evaluate that current FireSmart standards for fuel management in the wildland/urban interface are deficient in their consideration of wildlife and wildlife habitat.

1.10 Summary

Reducing the risk of fire losses in the wildland/urban interface is a widespread and growing problem. Despite deficiencies with regards to wildlife, current fuel management standards do provide a sound framework for future improvements. Efforts to find solutions must adopt a more inclusive view of interface ecosystems, but firmly respect the inherent constraints and limitations existing standards necessary for wildfire risk reduction.

Chapter 2: Study Purpose, Objectives, and Methods.

2.1 Problem Statement

Based on the foregoing problem description, conflicts between fuel modification to reduce wildfire risk and the importance of conserving other resource values, particularly those related to wildlife, must be reconciled if appropriate progress in protecting wildland/urban interface communities from wildfire is to be realized.

The urgent need for increased community wildfire protection, deep concerns of local citizens for protection of the environment, and the mandated priority for ecological restoration within Jasper National Park combined to provide both the motivation and opportunity to integrate this research into a prototype program of intensive forest management in a wildland/urban interface setting. Regardless of the jurisdictional status of the study area (i.e., within a national park) the municipality of Jasper is typical of many Canadian situations, particularly to other communities in the Rocky Mountains and foothills.

2.2 Research Purpose

The purposes of this research are to develop, implement, and recommend practicable, ecologically based approaches for managing vegetation (fuels) at the wildland/urban interface in ways that optimize conditions for wildlife within the constraints of current risk management standards, and to establish a methodology for monitoring the long term effects of these approaches on wildlife habitat and use by wildlife.

2.3 Research Objectives.

To achieve the purpose of this research, specific study objectives were to:

1. Identify the potential effects of standard fuel management treatments on wildlife habitat and selected wildlife species in wildland/urban interface areas.

2. Develop mitigations, guidelines, and practices for managing vegetation of the wildland/urban interface in ways that optimize conditions for wildlife, compatible with current fuel management standards.

3. Recommend methods and equipment for large-scale implementation of ecologically based fuel management practices as determined in a prototype program implemented at Jasper, Alberta.

4. Propose a standardized methodology for quantitatively assessing long-term effects of fuel management treatments on key vegetation/habitat attributes and wildlife utilization, thus enabling follow-up studies in the prototype Jasper study area and other locations.

5. Present conclusions and recommendations regarding ecosystem based approaches for managing forest fuels in the wildland/urban interface.

2.4 Methods.

A combination of techniques including literature review, experimental learning through adaptive management[1] approaches, and deductive analysis were applied to a 350 hectare prototype project of innovative fuel management at Jasper, Alberta to achieve the objectives of this research. Figure 2.1 summarizes this

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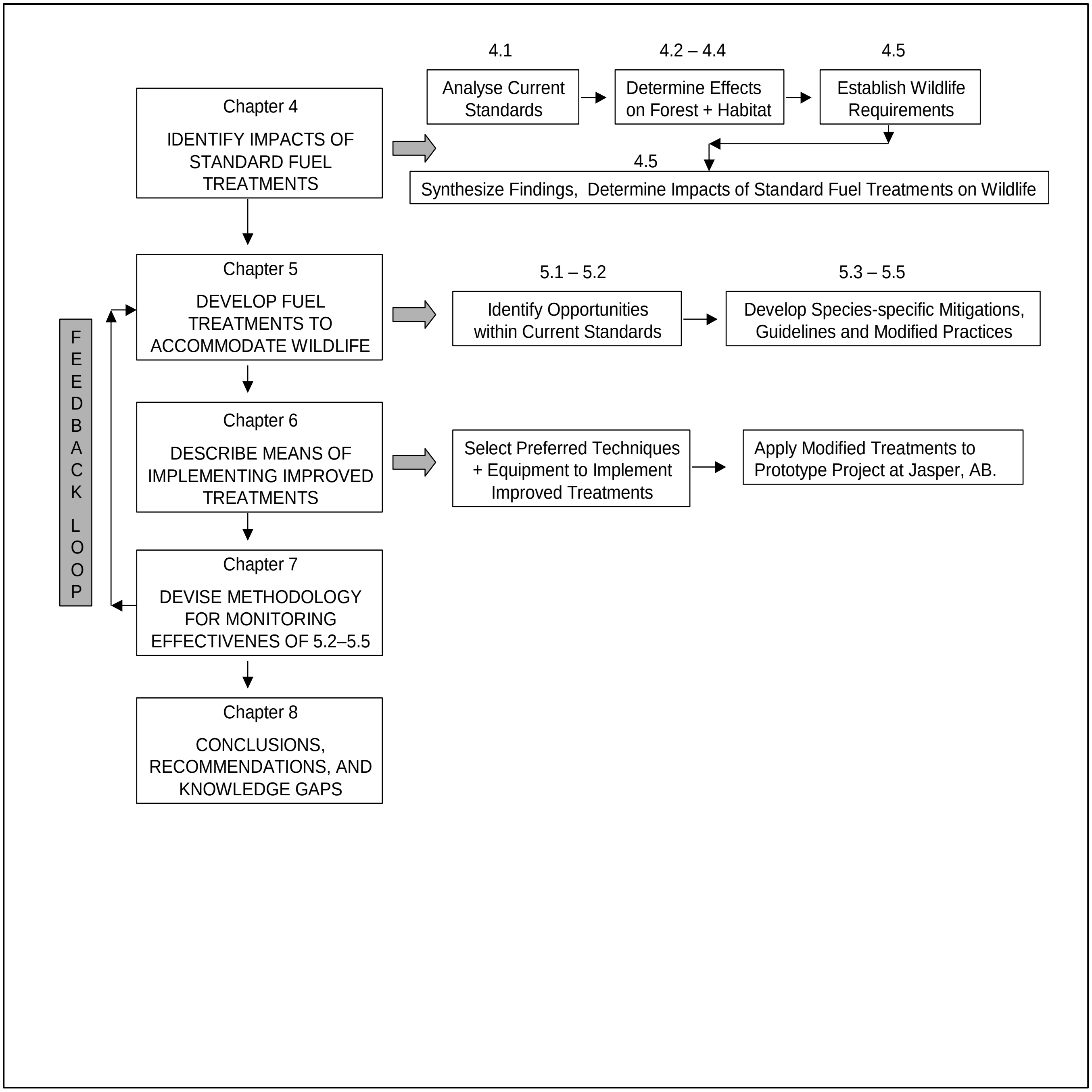
[1] Adaptive management is an approach developed and promoted by C. Walters and C.S. Hollings (1990) to facilitate effective management in the face of uncertainty by ensuring that monitoring results are quickly incorporated into day-to-day operations. In this approach, work or operational projects are conducted as "management experiments" and innovations or improvements continuously added.

approach, and the sequence of analytical steps employed to achieve the purpose of this research.

Figure 2–1: Schematic of research methods.



2.3.1 Identify the potential effects of standard fuel management treatments on wildlife habitat and selected wildlife species common in wildland/urban interface areas.

- Analyse current FireSmart fuel management standards and describe them in relation to fuel bed strata. (section 4.1)
- Review relevant literature and describe the probable effects of standard fuel management activities on abiotic components of forest ecosystems. (section 4.2)
- Review relevant literature to describe probable biological effects of standard fuel management activities on forest strata. (section 4.3)
- Based on review of existing literature, determine the potential effect of standard fuel management activities on selected wildlife habitat types and features. (section 4.4)
- Compile existing information regarding the life requirements of a range of wildlife species common to wildland/urban interface areas and synthesize with findings about the ecological effects of fuel management to determine the potential impacts of fuel management on these species. (section 4.5)

2.3.2 Develop mitigations, guidelines, and practices for managing vegetation of the wildland/urban interface in ways that optimize conditions for wildlife, compatible with current fuel management standards.

- Examine FireSmart fuel management standards as applied to forest strata in the light of current ecological knowledge, to identify opportunities for accommodating wildlife and habitat attributes without compromising objectives for reducing wildfire risk. (section 5.1)
- Examine the potential for achieving objectives for ecological restoration concurrently with objectives for fuel management in the Montane and foothills forests of Alberta. (section 5.2)

- Develop species-specific mitigations to reduce the impact of fuel management activities on wildlife commonly found in the wildland/urban interface.(section 5.3)
- Prepare ecosystem based guidelines that integrate habitat attributes and the needs of wildlife compatible with interface fuel management standards. (section 5.4)
- Prepare guidelines for modified fuel management practices that address other wildlife issues in the wildland/urban interface. (section 5.5)

2.3.3 Describe appropriate techniques and equipment for large scale implementation of ecologically based fuel management practices as determined through a prototype program conducted at Jasper, Alberta.

- Assess and adaptively test prospective approaches for implementing ecologically based fuel management operations through a prototype project at Jasper, Alberta. (section 6.1)
- Recommend preferred techniques and suitable timber harvesting equipment for implementing ecologically based fuel management guidelines on large-scale wildland/urban interface community protection projects. (section 6.2)

2.3.4 Propose a standardized methodology for quantitatively assessing long-term effects of fuel management treatments on key vegetation/habitat attributes and wildlife utilization to enable follow-up studies in the prototype Jasper study area and in other locations.

- Determine key attributes and parameters of forest vegetation and wildlife habitat that are likely to be affected by fuel management actions, and identify species of wildlife whose patterns of utilization may change in response to modified habitat conditions.

- Review scientific literature to identify sampling procedures appropriate for measuring and documenting the response of selected vegetation/wildlife parameters to fuel management treatments.
- Develop and describe sampling methods and combine them into an integrated sampling design based in permanent sampling plots.
- Implement the sampling design and collect baseline data prior to initiation of fuel management activities.

2.3.5 Present conclusions and recommendations regarding ecosystem based approaches for managing fuels based on research findings and results of implementation in the prototype study area.

- Based on the preceding steps, offer conclusions and recommendations for ecologically based approaches for managing forest vegetation of wildland/urban interface areas in ways that optimize conditions for wildlife and minimize impacts to the environment.
- Identify perceived knowledge gaps and future research needs.

2.5 Research Affiliations

This research was encouraged by Parks Canada as one component of a large-scale operational undertaking, called the *FireSmart – ForestWise Communities Project* in Jasper, Alberta. This project was also implemented under the auspices of the Foothills Model Forest[2]. Because of that sponsorship, there was increased emphasis on a scientific approach to the problem above, creating new knowledge, and transfer of information and technology to communities elsewhere in the Foothills Model Forest and across Canada.

[2] The Foothills Model Forest is a unique partnership dedicated to providing practical solutions for stewardship and sustainability on Alberta forest lands through a solid, credible, recognized program of science, technology, demonstration, and outreach. The Foothills Model Forest is located in west-central Alberta, and covers roughly 2.75 million hectare (27,500 square kilometres). The model forest includes Jasper National Park, the Willmore Wilderness Park, and the forest management area of Hinton Wood Products, a Division of West Fraser Mills Ltd.

As the operational project and research evolved, interest by other agencies such as Public Safety and Emergency Preparedness Canada, industry, and neighboring municipalities increased. Regular interactions occurred with innovative contractors, forest industry experts, experienced forest and park managers, fire protection officers, and ecologists from the Canadian Forest Service, Alberta Sustainable Resource Development, British Columbia, the Yukon, Australia, and many other jurisdictions. All of these interests shared the quest for improved fuel management practices and forest conservation, and it was through these associations that the mechanisms of adaptive management were able to function effectively.

CHAPTER 3: Study Area Description

The level of wildfire risk in the municipality of Jasper, Alberta is substantial, but not atypical of the situation of wildland/urban interface communities across Canada; that risk is the product of local conditions. This chapter describes pre-treatment conditions within the study area, including the ecological, social, and risk settings relevant to the problem being addressed by this research.

3.1 Ecological Setting of the Study Area

This study is located within a heavily forested area of Jasper National Park near the confluence of the Athabasca, Miette, and Maligne rivers (Figure 3 -1). It is centered around two major developments, the town of Jasper itself and a nearby cottage subdivision at Lake Edith. The study area is comprised of approximately 350 hectares of mostly coniferous forest that extends outwards from the perimeter of these urban developments.

In the biophysical sense, the project is located within the low-lying "Montane" Ecoregion (Holland and Coen 1982) that occurs between the elevations of 1000 and 1350 metres. Despite its small size (i.e., less than 7% of the park's total land mass), Holroyd and Van Tighem (1983) report that the Montane is the most productive and biologically diverse area within Jasper National Park. It contains much of the park's critical winter range, and other specialized wildlife habitats.

3.1.1 <u>Climate</u>

The Montane Ecoregion is subject to highly variable seasonal and annual precipitation and temperature patterns, typical of the continental macroclimate within the Canadian Rockies (Janz and Storr 1977). Overall, annual precipitation is less than 40cm due to northwest-southeast trending mountain ranges that create a rain shadow effect from westerly winds aloft, and frontal ranges that frequently block upslope precipitation from the east. Mean annual temperature is +3 degrees Celsius; the summer mean is +16 degrees (Janz and Storr 1977).

3.1.2 Landforms and Soils

Landforms and soil types influence erosion potential and also create limitations for types of treatment and equipment that may be used. Landforms within the study area are primarily level glacio-fluvial plains, gently sloped alluvial fans, areas of rolling moraine, and narrow inclusions of inclined, gullied stratified drift (Holland and Coen 1982). The study area is dominated by calcareous brunisolic soils that are well to very well drained. An area of luvisolic soils (i.e. soils with an impervious clay horizon) is located on the "Pyramid Bench" area and locally increases susceptibility of trees to windthrow.

3.1.3 Landscape Classification: Distribution and Abundance of Eco-sites

The biophysical (ecological) land classification system developed by Holland and Coen (1982) provides a means to classify, map, and manage Jasper's landscape. "Ecosites" are the basic unit of classification. Each ecosite reflects a unique combination of climate, landform, soil and vegetation conditions (Holland and Coen 1982), and the relative distribution, abundance, and pattern of ecosites across the landscape reflect the level of native biodiversity.

Dominant ecosites in the study area are Athabasca 1 (55%), Patricia 1 (15%), Norquay 3 (10%), Athabasca 3 (5%), Patricia 3 (5%), Fireside 1 (5%), and Hillsdale 4 (5%). Each contains remnants of open forest and grasslands (Holland and Coen 1982). By virtue of their location in the Montane zone and the paucity of natural disturbance over the last several decades, these ecosites are inherently rare within the park. Analysis (Table 3-1) of the Ecological Land Classification (Biophysical) for Jasper National Park (Holland and Coen 1982) reinforces the relative rarity of these ecosites which underlines their importance to wildlife.

Figure 3-1: Location of FireSmart – ForestWise project areas within Jasper National Park.

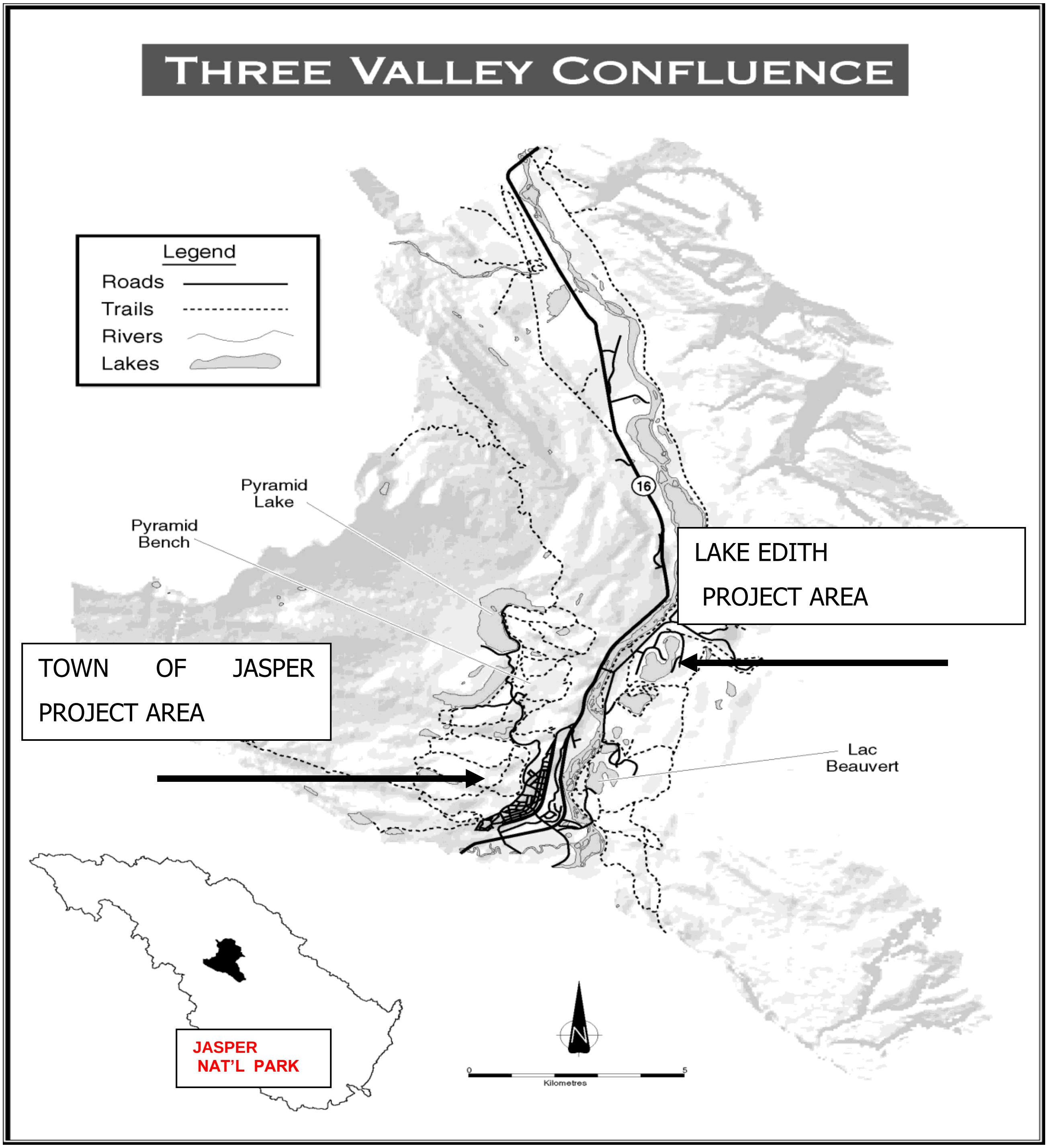


Table 3-1: Frequency, total area, and relative abundance of ecosites within the study area.

ECOSITE	# POLYGONS	TOTAL AREA	% OF JNP
Athabasca 1	56	68.8 km^2	0.63
Athabasca 3	5	5.74 km^2	0.05
Fireside 1	56	24.12 km^2	0.22%
Hillsdale 4	17	8.25 km^2	0.07%
Norquay 3	71	104 km^2	0.95%
Patricia 1	111	148 km^2	1.3%
Patricia 3	47	81 km^2	0.74%

3.1.4 Vegetation

The composition and structure of vegetation are important factors that contribute to wildfire risk, and the habitat value of an area. Both attributes would be altered by activities to reduce fuels or restore vegetation conditions to within historic norms. Vegetation species and communities are fire-adapted and most evolved in a regime of frequent, low-intensity surface fire or mixed-intensity fire (Tande 1979, Andison 2000).

Present vegetation composition of the project area is primarily closed conifer forest (Figure 3-3), with minor remnants of open forest, grassland, and trembling aspen forest. The coniferous forest of the study area is largely composed of mature sub-xeric lodgepole pine, with lesser areas of Douglas fir forest and mixed conifer forest. White spruce and Douglas fir are late-successional species in parts of the study area. White spruce dominates coniferous regeneration in mesic sites, whereas lodgepole pine and Douglas fir regeneration is more common on dryer sites. Dominant vegetation types (VT's) of the project area and their major constituent species are summarized, by ecosite, in Tables 3-2 and 3-3 as per the classification developed by Achuff and Corns (in Holland and Coen 1982).

Table 3-2. Dominant vegetation types of the project area, by ecosite.

ECOSITE	VT1	VT2	VT3	VT4
Athabasca 1	C3	C6	C19	C1
Athabasca 3	H6	C3		
Fireside 1	C6	C19		
Hillsdale 4	H6	C3		
Norquay 3 (south slopes)	O5	C1	L1	
Norquay 3 (north slopes)	C5	C19	C6	C1
Patricia 1	C6	C19	C3	
Patricia 3	C3	C6	C19	C1

Table 3-3: Dominant plant species by vegetation type.

VEG TYPE (VT)	SPECIES 1	SPECIES 2	SPECIES 3
C1	Douglas fir	Hairy wild rye	
C3	Lodgepole pine	Juniper	Bearberry
C5	White spruce	Douglas fir	Feather moss
C6	Lodgepole pine	Buffaloberry	Showy aster
C19	Lodgepole pine	Buffaloberry	Twinflower
05	Douglas fir	Juniper	Bearberry
L1	Shrub cinquefoil	Bearberry	North. bedstraw
H6	Junegrass	Pasture sage	Wild blue flax
H7	Wheatgrass	Pasture sage	

In terms of forest structure, the tables above show a present day dominance of closed forest (C) vegetation types over low shrub-herb (L) and herb-dwarf shrub (H) types. Open forest types such as O5 (e.g., open Douglas fir) do occur, but mostly in shrinking patches too small to be mapped at the 1:50,000 scale. Much of the Douglas fir forest and substantial portions of lodgepole pine forest in the study area are now characterized by a dominant canopy of widely spaced, large diameter veterans (many aged 200 – 300 years) interspersed with an intermediate or suppressed understory of dense, smaller diameter lodgepole pine and Douglas fir (Figure 3-5). Random tree coring indicates that the dense tree understory is generally younger than 75 years and has originated since the advent of fire suppression policies within the park. Aspen forests are present but now include significant proportions of conifer; the term "mixedwood" forest is more descriptive of current conditions. Aspen clones in Jasper are not successfully regenerating and are considered to be in decline, but this issue is complicated by the heavy year-round browsing of elk (White 2001, Bartos and Campbell 1998, Kay 1997, Nietvelt 1999).

Hammond (2003) concluded that much of the current structure of Jasper's Montane forest is an artifact of recent fire management practices, rather than reflective of natural processes and the historical range of variation. In the absence of active natural disturbance (i.e., fire) the processes of forest encroachment and in-growth described in section 1.5 are also affecting Jasper's Montane forests and grasslands. AXYS Consulting (2001) expressed concern about loss of landscape heterogeneity in the Athabasca valley that is a result of these processes.

3.1.5 Natural Disturbance Regime and Fire History

Knowledge of disturbance regimes, and the vegetation conditions that arise from them, are at the crux of this research as well as current issues of fire protection and ecological restoration in Jasper. The influence of natural disturbance on vegetation and landscapes of Jasper National Park is well documented, and the fire history of few areas in North America have been studied in more detail than the Athabasca valley (Achuff 1996). Even within the Rocky Mountain parks, the Montane ecoregion of Jasper is notable for its remarkably active fire history. Tande (1979) conducted the most intensive of these studies while others have contributed significantly to that information and its analysis (Andison 2000).

The long-term fire regime of the study area is characterized by frequent low intensity (stand maintaining) surface fires and less frequent high intensity (stand replacing) crown fires. Historically, low intensity, "stand maintaining" fires predominated in grasslands and open canopy Douglas fir and some lodgepole pine stands of Montane valley bottoms and lower slopes. Higher intensity, stand replacing crown fires prevailed in moister continuous pine stands on the valley sides and in upper elevations (Tande 1979), and also influenced valley bottom areas.

A compilation of several dendrological fire history studies conducted in the Rocky Mountains (Achuff et al. 2001) further quantifies the active nature of natural disturbance by fire in Jasper National Park. Park wide, a long-term average annual burn area of nearly 42 square kilometres (4,163 hectares) was calculated. In the Montane, mean historic fire cycles ranged from 50 years for Montane pine and Douglas fir dry forests (i.e. C1, C3, C6, O5 and C19 vegetation types) to 10 years for Montane shrublands and grasslands (i.e. H6, L1 and some C3 vegetation types) within the study area. From these data, it is conservatively calculated that the long-term average annual area burned in the Montane should be about 1,500 hectares, or about 2% of the Montane each year.

Prior to settlement, humans influenced the Montane ecosystems and vegetation of Jasper for over 10,000 years (Heitzmann 2001, White 2001). During this time, aboriginal peoples appear to have ignited the majority of Montane fires and therefore played an evolutionary force in establishing ecosystem patterns and plant composition through deliberate use of fire (Heitzmann 2001, Wierzchowski et al. 2002). Traditional ecological knowledge regarding fire use by Aboriginal peoples provided by Elders of the Foothills Ojibwa (O' Chiese 2003/2004) and by a former Metis resident (Murphy 1980) supports the scientific evidence cited above. However, since the arrival of European man, anthropological use of fire has dramatically declined in the Rocky Mountains (White 2001). Upon park establishment, this trend was amplified by prohibitions against traditional fire use practices (Murphy 1985) and policies that favored fire control (Murphy 1985, White 1985).

These management policies were apparently successful in achieving their intended purposes. Analysis of park fire occurrence records (Kubian unknown date) shows that less than 42 square kilometres has burned in all wildfires since strict fire suppression was instituted about 1930. This is about 1/70th of the expected burn area, based on the historical average annual burned area (Achuff et al. 2001), and represents a considerable deficit in terms of fire effects. Andison (2000) reached a similar conclusion by conducting a "rollback" analysis of stand age distributions in the Montane zone of Jasper. He determined that less than 0.5% of the total Montane area has burned since 1931. This represents a low rate of burning that is historically unprecedented, whereas the natural range of variability for burning is between six and 54% of the Montane forests over a 20-year period. Analysis of all available data from Rocky Mountain fire history studies by Van Wagner (1995) also concluded that the 1930-1995 "fire free" period was unique in the 500-year dendrology fire record. After studying 100+ years of weather data (Wierzchowski et al. 1996) showed that this fire free period is not the result of reduced fire weather conditions.

The impacts of the recent "fire free" period on vegetation are significant. This is especially evident when the relative amounts of older forest from 1930 are compared to those of today. Andison (2000) documents that over the past 65 years the amount of Montane forest older than 100 years has nearly quadrupled from 21% to 78%. The implications of this shift in forest age structure on vegetation (habitat) heterogeneity in the Montane was analysed by Rhemtulla (1999). She documented a loss of 60 percent of grasslands and conversion of more than 70 percent of open forest to closed forest during the fire suppression era between of 1915 and 1995 (see Figures 3-2 and 3-3).

In a similar analysis of vegetation change using large-scale aerial photos, Mitchell (2005) also concluded that large shifts in the patterns and spatial heterogeneity of Montane vegetation occurred between 1949 and 1997. Grassland, forb, and wetland vegetation cover types decreased in total area, proportional representation, and number of patches. The spatial extent and proportion of the study area occupied by grassland vegetation decreased by just over 50% and patch density (i.e., number of patches/100 ha) decreased by 58%. A 30% decrease in patch density was also noted for coniferous forest cover. The spatial extent of sparse and open coniferous canopy closure patches[1] decreased by 64% and 42%, respectively. Conversely, mean patch size of the closed and dense canopy closure classes increased significantly ($p<.001$ and $p=0.02$, $\alpha= 0.05$ respectively), and total area of closed canopy forest increased by 91%. Moreover, a 79% increase was seen in the proportional representation of this class relative to the other canopy classes (Mitchell 2005). Mitchell's analysis (2005) indicates that considerably more uniform and homogeneous Montane landscape exists now. Overall, the analyses by Rhemtulla and Mitchell illustrate a significant structural shift in forest and grassland communities, and a loss of heterogeneity at the landscape level due to changes in the areas fire regime.

As an extension of the same problem, it is suspected that there may be significant deviations in the diversity and composition of understory shrub and herbaceous plants that play roles important habitat functions for interface wildlife. The Three Valley Confluence Recovery Framework (Parks Canada 2002) cited "a near absence of natural disturbance processes in fire adapted and dependent ecosystems" and "subsequent loss of habitat for many species dependent upon early seral stages and open structured "old growth" forests".

Taken as a whole, habitat types dependent upon low intensity, stand maintaining fire, such as open Douglas fir, pine savannah, and grasslands have declined and are in need of active restoration efforts (Parks Canada 2000a) to recover from effects of past management practices that lacked in ecological understanding.

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[1] Coniferous canopy closure classes used by Mitchell were as follows: sparse (6-20%), open (20-40%), closed (40-60%), and dense (>60%).

Fire Management

Despite modernization of park policies to support restoring the role of fire, the presence of high-value urban and commercial developments vulnerable to wildfire continues to dictate fire management actions and natural disturbance processes in the central Athabasca valley and surrounding landscapes. That is, in order to protect the town of Jasper and nearby developments from wildfire, managers continue to designate a large area surrounding urban "values at risk" as fire exclusion zones (Fenton and Wallace 1978, Kubian 1999). This suppression zone extends to portions of three major watersheds, thus depriving fire from an area of approximately 114,000 hectares.

When considered over a longer planning timeframe, the ecological and economic costs of maintaining this fire suppression zone are substantial. In addition, this influence on fire management options is being felt by neighboring jurisdictions. For example, as far west as Mt. Robson Provincial Park in British Columbia where prescribed burns are also curtailed by the Jasper interface situation (W.Van Velzen, pers. comm.), and in Alberta where prescribed fire in Jasper is viewed as a means of retarding the eastward advance of the mountain pine beetle. Simply put, the presence of unprotected human developments in the wildland/urban interface of Jasper National Park continue to block a range of significant resource management initiatives in the greater Yellowhead ecosystem.

Consequently, as outlined in its management plan (Parks Canada 2001) Parks Canada has concluded that the current fire regime and subsequent conditions of forest vegetation are significantly outside the historical ranges of variation and that fire must be actively restored to park lands-but that risks to developed areas must be ameliorated.

3.1.6 Fuel Conditions in the Vicinity of Jasper, Alberta

The recent history of vegetation/fire management in Jasper National Park has resulted in widespread forest in-growth and encroachment in dry, coniferous forests of the Montane Ecoregion. All aspects of the present forest fuel complex make wildland/urban interface forests surrounding the town of Jasper, and nearby developments, exceedingly susceptible to high intensity crown fire, given an ignition. These factors include significant accumulations of fuel that occur in each of the fuel bed strata (fuel load), fuels arrangements with a high degree of vertical and horizontal continuity, the inherently volatile type of fuels and their chemical composition, and the low canopy base height of many stands that promotes the escalation of surface fire into the canopy. The sum of these factors is that extreme fuel hazards exist in the wildland/urban interface forests of Jasper.

The vegetation and forest types described in section 3.1.4 correspond to five of the sixteen distinct fuel types as defined in the Canadian Forest Fire Behavior Prediction System (Hirsch 1996). These are, the mature jack or lodgepole pine type (C-3), immature jack or lodgepole pine type (C-4), ponderosa pine/Douglas fir type (C-7), and boreal mixedwood types (M-1 and M-2). Because these fuel types occur across Canada, there will be applications of research results to other areas of Canada.

With regard to structures in the study area architectural motifs, building materials, and the arrangement of structures in Jasper also create a vulnerable urban fuel complex. Vegetation-to-structure ignitions (both by firebrands and flame impingement), and structure-to-structure ignitions are both highly probable given a wildfire event (G. Van Tighem, pers.comm.).

Figure 3-2: 1915 photo of Athabasca Valley by James Bridgeland.

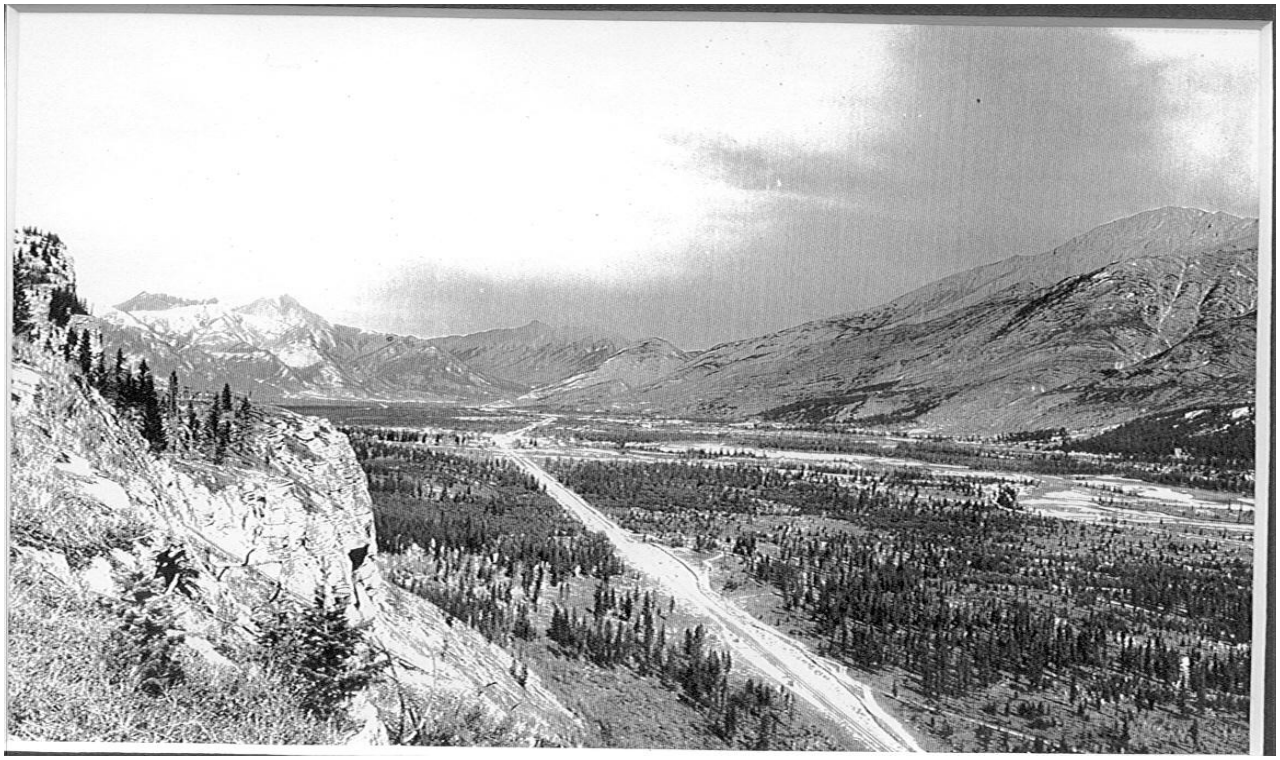


Figure 3-3: 1995 re-take of same scene by J. Rhemtulla (1999).

Figure 3-4: Typical conditions in Douglas fir forest prior to prescribed treatments, Jasper National Park 2005.

Figure 3-5: Conditions representative of the historical range of variation, Jasper National Park demonstration site. (Hammond 2003)

3.1.7 Description of Wildland/Urban Interface Forest Types

The wildland/urban interface zone, which comprises the study area, extends outwards from major developments in the Athabasca valley for distances of over a kilometer. The majority of this area is forested and reflects the diversity of forest types found within the Montane Ecoregion. To facilitate both research and operational aspects of the project, the study area was stratified into discrete physiognomic types by delineation on 1:10,000 color aerial photographs (Geographic Air Survey, 1990) aided by a magnifying table-top stereoscope.

These areas were then verified in the field, and categorized into vegetation types as defined by I.G.W. Corns and P.L. Achuff (Holland and Coen 1982).

Following extensive field reconnaissance, these vegetation types were later aggregated into five somewhat broader forest types. These are: fire-maintained upland (open) pine forests; fire-maintained Douglas fir forest on level terrain; fire-maintained Douglas fir on steep slopes; dense even-aged lodgepole pine originating from stand-replacing fire and; mixed conifer forest. General attributes of these forest types are summarized in Table 3-4, and additional details provided in the stand descriptions that follow.

Fire-maintained Upland (Open) Pine Forests

Photogrammetric analysis revealed these stands to be significantly more open in terms of canopy tree cover and multi-layered in structure, relative to other pine stands. Ground surveys confirmed this, but also determined that this forest type was commonly characterized by evidence of historical low intensity surface fire (e.g. one or more fire scars) or a multi-aged structure indicative of lodgepole pine (*Pinus contorta*) colonization or encroachment over a significant period of time. The presence of large-diameter lodgepole pine with bulky crowns and sweeping live branches near to the forest floor (i.e., bull pine or wolf-trees) are characteristic of this type. Douglas fir (*Pseaudotsuga menziesii*) are establishing in these stands but mature individuals are rare. White spruce (*Picea glauca*) is present up to 10% total cover and remnants of mature trembling aspen (*Populus tremuloides*) are occasional (<5%) elements of these stands. These stands are primarily found in level, dry to mesic sites in valley bottom locations. The density of trees over ten centimetres ranges from 275 to 800 stems per hectare with an average of 500. Diameter at breast (dbh) height ranges from 15 to 40 cm, with an average of 24 cm. The height of dominant trees is 19 – 20 metres. Canopy densities currently range from 45 – 70%. Small openings are rare but do persist in this forest type but many are now occupied by thickets of young conifers.

Table 3-4: General attributes of wildland/urban interface stand types in the Jasper study area. (Westhaver 2005)

	Open Pine	Dense Pine	Douglas fir Level sites	Douglas Fir Steep slope	Mixed Conifer
Species 1[a]	Pl	Pl	Df	Df	Pl
Species 2[b]	Sw<10%	Sw<5%	Pl<20%	Pl<5%	Df<30
Species 3[c]	Df<10%	Df<2%	Sw<5%		Sw,Aw<15
Avg stem density[d] (#/ha)	500	950	800	550	850
Density range (#/ha)[d]	275-800	850-1040	650-900	300-850	650-900
Avg dbh (cm), species 1	24	19	23	28	24
dbh range of species 1	15-40	13-35	10-115	10-125	16-37
Average stand height (m)	20	18	22	22	19
Tree Canopy Cover (%)[e]	45-70	60-85	40-70	25-55	45-70
Regeneration Species/%[f]	Sw,Pl/15	Sw,Fb/20	Df/35	Df/20	Df,Sw/20
Approximate stand age	120+	90-110	200+	200+	90-110

[a] Most common species in tree canopy (Pl= lodgepole pine, Df= Douglas fir, Sw= white spruce, Aw= trembling aspen)
[b] Second most common species in tree strata with estimated % of total stems in stand
[c] Other species in forest canopy with estimated % of total stems in stand
[d] Density of all trees over 10 cm dbh
[e] Estimated total canopy cover of all trees
Species and estimated % cover of most common regeneration <5 m
f Estimated % cover of all coniferous regeneration

Fire-maintained Douglas Fir Forest on Level Terrain

The presence of 50 – 175 widely spaced, large-diameter veteran Douglas fir per hectare is characteristic of this forest type. These are dominant trees that range from 21 – 30 metres in height, are 50 –115 cm in diameter, and may be up to 400+ years old. Many have abundant evidence of past fires. The area between these veterans is now densely populated with multi-aged lodgepole pine and Douglas fir mostly less than 70 years old. The in-growth ranges from 10 to 30 centimetres dbh with heights of up to 20 metres. Total crown cover varies from 40 – 70% in these stands. They occur on dry sites, level to mildly undulating sites in the valley bottom, and on lower glacial terraces. The overall density of trees over ten cm ranges from 650 to 900 stems per hectare. The cover of trees less than 10 cm and advanced conifer regeneration is frequently high with stem densities well over 1000 per hectare. Remnants of grasslands and many smaller openings are found within this forest type. The latter are now largely occupied by young conifer trees and thickets of regeneration. Signature native grassland species such as *Stipa, Koeleria, Artemesia*, and others persist in this forest type.

Fire-maintained Douglas Fir on Steep Slopes

This forest type is similar to its counterpart on level terrain (i.e., both are characterized by dominant large-diameter Douglas fir) but has been separated for reasons of potential fire behavior and access challenges associated with the steep (i.e., 35–60+ percent) slopes where these forests occur. Its distribution is restricted to the steep south-facing scarps that overlook the town of Jasper. These slopes are extremely dry. Overall tree densities and canopy cover is lower than on level terrain. In-growth of trees >10 cm dbh on these slopes is heavily dominated by Douglas fir. Thickets of Douglas fir saplings and regeneration are mostly limited to gullies and north or easterly slope aspects. Small pockets of even-aged lodgepole pine occur within this forest type.

Dense Even-aged Lodgepole Pine Originating from Stand- replacing Fire

These stands are typified by a dense canopy of lodgepole pine with very similar ages, height, and dbh. They appear to correlate with known, stand-replacing wildfire events (Tande 1979). Mean age ranges from 90 to 110+ years. Layers are not evident in most stands, although dead or dying individuals create a sub-dominant tree canopy is some cases. These stands have variable amounts of white spruce and balsam fir (*Abies balsamea*) trees <10 centimetres dbh, and advanced and/or young regeneration of the same species. Mature aspen and Douglas fir are occasional, but comprise < 2% of the total canopy. These stands occur on stony, dry sites and sites with deep soils and more abundant moisture, in valley bottom and lower slope locations. The density of trees over ten cm ranges from 850 to 1040 stems per hectare, with highest densities on mesic sites with less stony soils. Dbh ranges from 13-35 cm, with an average of 19 cm. The height of dominant trees is 17–19 m. Canopy cover currently ranges from 60–85%. Some stands are heavily impacted by dwarf mistletoe (*Arceuthobium sp.*), various rusts, and secondary bark beetles (i.e., *Ips pini*) and contain up to 30% dead standing stems. Recent drought conditions have resulted in many dead trees with needles still attached.

Mixed Conifer Forest

This forest type occurs on mesic, rolling terrain and is characterized by highly variable mixtures of mature lodgepole pine, Douglas fir, and white spruce. Spatially, it dominates bench lands on the lower, undulating slopes of Pyramid Mountain. Canopy cover ranges from 45–75%, is often multi-layered in structure, and is comprised of multiple or all age classes. Large-diameter lodgepole pine with bulky crowns and sweeping live branches near to the forest floor and veteran Douglas fir are rare within this forest type. However, young Douglas fir is well established in these stands with many individuals up to 19 m in height, and 25–40 cm dbh. White spruce is present up to 10% total cover and remnants of mature trembling aspen contribute up to 5% of the total canopy cover. These stands are primarily found on mesic sites. The density of trees over 10 cm ranges from 650 to 900 stems per hectare. Diameter at breast (dbh) height ranges from 16 to 37 cm, with an average of 24 cm. The height of dominant trees is 19 – 20 m. Canopy densities currently range from 45 – 70%.

3.1.8 Wildlife

Conserving the wildlife and the habitat to sustain them is a core issue for Parks Canada; it is also an important issue to many Canadians who live or recreate in the wildland/urban interface areas (section 1.7). The potential of vegetation (i.e., habitat) to support populations of wildlife is largely dependent upon stand structure (Mysterud and Ostbye 1999).

The most relevant inventory and analysis of wildlife, wildlife habitat, and habitat use in the mountain parks was conducted as part of the ecological (biophysical) land classification program (Holroyd and Van Tighem 1983). That report provides detailed species accounts, distribution information, and knowledge of relationships between wildlife species, ecosites, and vegetation types.

Wildlife/Human Conflicts

Two main categories of conflicts between people and animals are described in Jasper (Parks Canada 2000a). These are aggressive encounters (generally with elk or bears), and direct mortality of wildlife due to collisions with vehicles. Aggressive encounters can occur in circumstances where people have limited control (e.g. surprise encounters) and in circumstances over which there is more control (e.g. purposely approaching wildlife). The Community Action Plan for Elk Management in Jasper National Park (Elk Action Working Group 1999) and the Bear/Human Conflicts Management Plan (Ralf and Bradford 1998) are community-based strategies that have been developed to reduce these types of conflicts. Several forest attributes that affect potential for wildlife/human conflicts will change as a result of vegetation manipulations in the wildland/urban interface, and are relevant to this study. The density of the forest overstory will decrease and, depending on the treatment and methods, understory canopy layers will change. These changes have variable effects on availability of preferred forage and habitat for elk and bears. In the case of more open forest conditions, wildlife and humans are more able to observe and avoid each other.

Grizzly Bear Habitat Effectiveness

The concept of grizzly bear habitat effectiveness is used to model the impact of human use on this sensitive species. Habitat effectiveness is a comparison between the potential of an area to support grizzly bears, and the actual value of the areas as bear habitat, after accounting for the impact of human disturbance

(Parks Canada 2000). The model predicts that current habitat effectiveness for the study area is 61%, but that grizzlies will not use areas as home range if effectiveness dips below 80%. Therefore, Parks Canada's objective for the study area is that it shall retain qualities that allow it to function as a link between areas that are effective grizzly bear habitat. This is an important consideration when developing ecosystem-based fuel management measures.

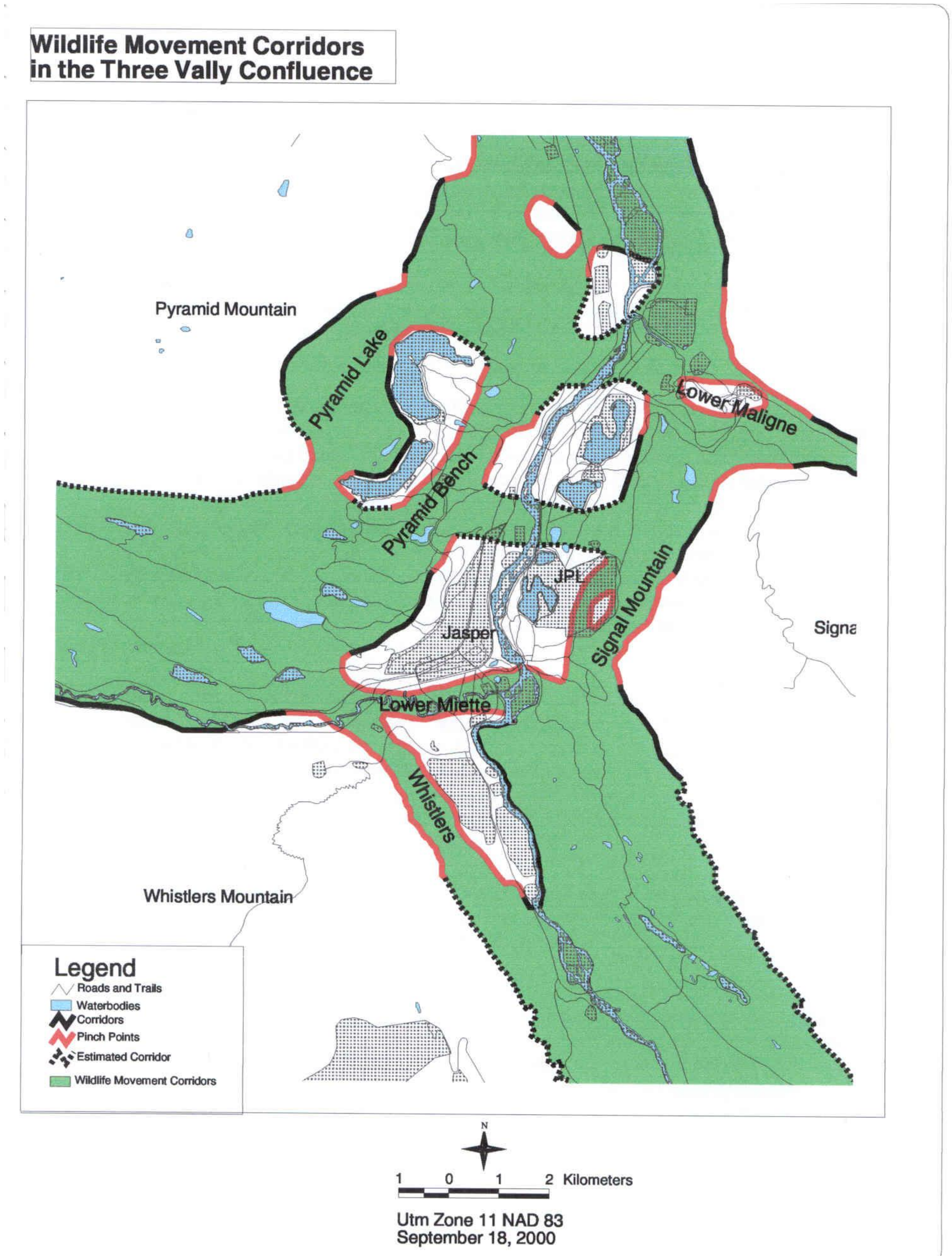
Habitat Connectivity – Wildlife Corridors

It is essential that wildlife, particularly wary carnivores, be able to avoid contact with people so that their movements through the landscape, between patches of important habitat, are not blocked (Parks Canada 2000). Monitoring has shown that several important movement corridors exist adjacent to the wildland/urban interface, and the study area (Mercer and Purves 2000). These are illustrated in Figure 3-6 and include the Lower Miette and Pyramid Bench movement corridors near the town of Jasper, and the Signal Mountain corridor near Lake Edith. The Three Valley Confluence Restoration Framework (Parks Canada 2002) sets out management actions to maintain or improve the effectiveness of these corridors. In addition, fuel management practices must be sensitive to maintaining the movement of wildlife through these corridors.

Listed Wildlife Species

The Committee on the Status of Endangered Wildlife in Canada lists two species known from the study area as species of "special concern". These are the grizzly bear (*Ursus arctos*) and the western toad *(Bufo boreas*). Grizzly bears are known to pass through the project area when traveling to portions of their home range. Occasionally, they are attracted to human food sources, but systematically visit the area during spring elk calving, and to feed on berries in late summer. They are not known to den in the study area. Management actions actively discourage grizzlies from frequenting the area (W. Bradford, pers. comm.). The western toad is Jasper's most common and widespread amphibian but there are no known population centres within the study area (W. Hughson, pers. comm.).

Figure 3-6: Wildlife movement corridors in the Three Valley Confluence, Jasper National Park.



3.2 Socio-economic Setting of the Study Area

Knowledge of the social setting, inclusive of current human use, aesthetic considerations, policies and jurisdictional authorities, and wildfire risk is required in order to properly identify the problem, to achieve the objectives of this research, and to identify appropriate recommendations.

3.2.1 Modern Human Use and Development

The wildland/urban interface area that comprises the study area also receives the vast majority of human development and use that occurs in Jasper National Park (Parks Canada 200a) . The modern era of park development has resulted in dense concentrations of people, property and facilities in locations where they are now threatened by wildfire. The town of Jasper, a community of 4700 permanent residents, has been established as a service node for park visitors and the administrative centre for Parks Canada and Canadian National Railways. The town area commonly hosts an additional 20,000 overnight visitors. Over one million visitors use the developed core of the park each year, replete with modern amenities and services (Parks Canada 2000). As such, Jasper figures heavily in the regional and national tourism industry. The Lake Edith cottage subdivision, established in the 1920's, also forms part of the study area. It includes 54 seasonally occupied homes arrayed along the shores of Lake Edith on individually leased lands. The Lake Edith subdivision is representative of countless other country residential and recreational subdivisions in wildland/urban interface areas across Canada. Firefighting services within the Municipality of Jasper are provided by the Jasper Volunteer Fire Brigade (structural fire protection) and by Parks Canada (wildland fire suppression).

3.2.2 Aesthetics, Natural Setting, and Resident Values in Relation to Wildfire Protection

Parks Canada conducted a series of structured workshops to seek the opinions of Jasper residents with regard to social, economic, environmental, and aesthetic values held within and about the community. Eventually these views were integrated into a "resident vision" for the community of Jasper that has since guided municipal planning efforts (Anderson et al. 1997). Both the vision and values were then subjected to additional stakeholder scrutiny and formalized in the Jasper Community Land Use Plan (Parks Canada 2001a). As a result, it became evident that local citizens and park visitors view native vegetation of the wildland/urban interface as providing many important amenities and services. For example, residents recognized that the community of Jasper possesses a distinct aesthetic character, which is drawn from its natural vegetation and setting. As well, local vegetation was valued for providing visual screening and privacy between residences and commercial accommodations, the industrial area, railways, and the highway corridor (Parks Canada 2001a). As well, vegetation functions as an effective noise buffer from industrial and transportation activities. Residents emphasized that vegetation, wildlife, and wildlife viewing opportunities are basic "quality of life issues", and that these values must be considered when managing the forests that surround the town of Jasper (Anderson et al. 1997).

The local business community has since reinforced the importance of visual qualities afforded by forests surrounding the town in their choice of the local tourism theme: "Jasper – Naturally" (B. Journault, pers. comm.). More recently, the Jasper Interface Steering Team (unpublished meeting minutes, 2002) conducted informal focus groups to gather additional information and opinions regarding the link between forest structure and aesthetic values. Although these values are difficult to quantify, it is clear that managing for the presence of wildlife, and frequent opportunities to view it, are also considered to be important values of local citizens. As well, a distinct preference for open (low-density) Douglas fir and pine forests with some multi-aged regeneration (vertical complexity), and amounts of surface logs that do not impede walking have emerged from these discussions.

The Community Land Use Plan also linked the issues of wildfire protection and forest conservation. It states that, "a community-based strategy for protecting against wildfire that both restores forest structure in the Three Valley Confluence Area and improves public safety will be developed" (Parks Canada 2001a).

3.2.3 Parks Canada Policy and Management Context

Guidance set out by Parks Canada in management and planning documents provides an important context for all activities within the park, including this research and the associated prototype fuel reduction/forest restoration project. Several key documents provide the policy and management context for example: the recently amended National Park Act (Parks Canada 2000b) which places first priority on the maintenance of "ecological integrity[2]"; the Guiding Principles and Operational Policies (Parks Canada 1994) which require that the ecological integrity of vegetation resources and processes be maintained; the Jasper National Park of Canada Park Management Plan[3] (Parks Canada 2000); the Jasper Community Land Use Plan (Parks Canada 2001a); the Three Valley Confluence Recovery Framework (Parks Canada 2002) and; the Terms of Reference for preparation of the Environmental Screening for the *FireSmart – ForestWise* Project (Parks Canada 2003). In addition to these, more detailed, direction regarding vegetation management and fuel hazard reduction is provided in the Vegetation Management Strategy for Jasper National Park (Westhaver and Achuff 2000), Principles for the Management of Vegetation in

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[2] With respect to a park, ecological integrity is a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes. (Parks Canada 2001b, McRae et al. 2001). The concept of ecological integrity is a binding tenet of that policy, its parent legislation, and a theme that underlies each of the guiding documents.

[3] In turn, the park management plan incorporates and reflects the intent of the National Parks Act (Parks Canada 2000), the Guiding Principles and Operational Policies (Parks Canada 1994), and Directive 2.4.4 – Fire Management. (Parks Canada 2005).

Canadian Mountain Parks (Woodley et al. 1995), and Parks Canada Directive 2.4.4 – Fire Management (Parks Canada 2005).

3.3 Wildfire Risk in the Municipality of Jasper, Alberta.

Wildfire risk is the product of the probability of a wildfire event and the potential consequences of that event (La Morte 1996). In the case of Jasper, Alberta there is a high probability of fire occurrence due to the combined frequency of lightning, industrial, transportation, and other human-caused ignitions. Furthermore, extreme consequences are expected in the event of an interface fire due to the proximity of large numbers of people and concentrated values at risk to forests that are expected to combust with extraordinary fire intensity. The combination results in extreme wildfire risk within the Municipality of Jasper.

Elevated wildfire risk in Jasper has been recognized for many years. Several internal reports and externally commissioned studies prepared for Parks Canada during the past 30 years quantify wildland/urban interface risks and/or propose corrective actions (Carnell and Anderson 1974, Haney and Anderson 1978, Fenton 1986, FireLine Consulting 1997, Mortimer 1998, Mortimer 1999, Blackwell and Mortimer 2004). Each concluded that the configuration of local topography, regional weather patterns, and the nature of forest fuels that surround urban developments within Jasper National Park combine to create conditions for extremely intense and fast moving wildfires that would seriously threaten developed areas. AXYS Consulting (2001) reiterated these concerns and stated that "fuel accumulations would generate wildfires of size and intensity beyond natural ranges of variation" in the Athabasca valley.

Beginning in 1999, park priorities for the protection of human life and property in the wildland/urban interface began to be systematically implemented. Through programs of communication, wildfire hazard assessments, demonstration areas and community work bees, and efforts to collaborate and engage with stakeholders, local fire authorities and residents of Jasper initiated important preventative actions to mitigate wildfire risk.

Initial fire preparedness efforts were directed towards infrastructure improvements, structural modifications, and improved emergency preparedness (Jasper Interface Steering Team 2002). By 2001, the focus of risk management efforts began to shift towards preventative activities including fuel reduction activities, both by owners working on their property and by Parks Canada on surrounding lands. At this time, wildlife-related deficiencies in current fuel standards became increasingly apparent. Without more appropriate fuel measures that address other resource concerns, it seemed unlikely that sufficient public (or management) support for wildfire risk management could be attained, and vital resource management programs heavily impacted.

CHAPTER 4: Effects of Fuel Treatments on Wildlife Habitat and Selected Wildlife Species.

Developing fuel management approaches more sensitive to wildlife required that the potential effects of standard fuel treatments on wildlife be identified. This chapter undertakes a series of analytical steps, supported by literature review, to achieve this objective. It begins with a review of current standards, then progresses through an analysis to examine the effect of fuel reduction on key habitat elements, establish life requirements of chosen wildlife species, and finally, to determine how these species will be affected.

4.1 Summary of Current Fuel Management Standards

Published standards for fuel management (Partners in Protection 2003) are organized according to distance from the structure to be protected. To begin the analysis of impacts, major fuel management treatments are summarized in Table 4-1, by "priority zone" (Figure 1.1) as defined by Partners in Protection (2003).

Table 4-1. Summary of FireSmart fuel management treatments by fuel bed stratum and priority zone (Partners in Protection 2003).

FUEL BED STRATA	PRIORITY ZONE 1	PRIORITY ZONE 2	PRIORITY ZONE 3
Ground fuel (duff)	No standard	No standard	No standard
Moss, lichen, litter	Reduce or remove	No standard	No standard
Coarse woody fuel	Remove	No standard	No standard
Fine woody fuel	Reduce or remove	No standard	No standard
Low herbs, grass	Mow to <10 cm., or remove	No standard	No standard
Shrubs, trees <5m.	Remove, convert, or isolate	Reduce/space conifers	Reduce/space conifers
Tree canopy (coniferous understory)	Remove, convert, or isolate; remove dead/dying trees	Remove or reduce + remove overstory trees (thin <40% canopy cover, 4m spaces, prune	Remove or reduce + remove overstory trees (thin <40% canopy cover, 4m spaces, prune
Tree canopy (coniferous overstory)	Remove, convert, or isolate; remove dead/dying trees	Reduce + prune, thin <40% canopy cover with 3-4m gaps	Reduce + prune, thin <40% canopy cover with 3-4m gaps

Other, treatments set out by Partners in Protection (2003) are listed in Table 4-2.

Table 4-2. Summary of other FireSmart fuel management treatments (Partners in Protection 2003).

FOREST COMPONENT	PRESCRIBED TREATMENT
Mature conifers	With few exceptions, prune conifer branches below 2 metres.
Mature conifers	In Priority Zone 2 it is recommended that mature conifers be thinned to a distance of 3 crown widths[1] between trees. In Priority Zone 3, a spacing of 1-2 crown widths is recommended.
Conifers and tall shrubs	For aesthetic reasons, some coniferous trees and tall shrubs may remain un-pruned but should be isolated from other, nearby conifers.
Conifers and tall shrubs	Coniferous trees and tall shrubs that are retained, should be isolated and not in clumps or groups.
Deciduous trees	Thinning or removal of deciduous trees is not required in any priority zone.
Deciduous shrubs	Deciduous shrubs exempt from treatments except in Priority Zone 1.

Details of FireSmart canopy thinning standards for crown fire hazard reduction (Partners in Protection 2003, Appendix II) are replicated below.

Table 4-3. Approximate number of tree stems/hectare related to crown diameter and thinning regime (Partners in Protection 2003).

	Density C – One Crown Width		**Density B – Two Crown Widths**		**Density A – Three Crown Widths**	
Crown Diameter (m)	Distance between stems (m)	Stems per hectare	Distance between stems (m)	Stems per hectare	Distance between stems (m)	Stems per hectare
1	2	2500	3	1100	4	625
1.5	3	1100	4.5	500	6	280
2	4	625	6	280	8	160
2.5	5	400	7.5	175	10	100
3	6	280	9	125	12	70
3.5	7	200	10.5	90	14	50
5	10	100	15	45	20	25
7.5	15	45	22.5	20	30	10
10	20	25	30	10	40	6

[1] A crown width is equal to the average distance between the outer tips of the branches of an individual tree.

To facilitate a consistent review of their ecological effects, FireSmart standards and subsequent analyses have been summarized in relation to six horizontal fuel bed layers described by Sandberg et al. (2001). These layers are found in most forested environments. Each stratum contributes differently to fire behavior and has unique properties pertaining to wildlife. From forest floor to forest canopy these layers are:

1. Ground fuel stratum: duff or organic soil horizons, roots, and buried wood. Generally, ground fuels are consumed by long duration smoldering fire, after passage of the flame front characteristic of surface and crown fires.

2. Moss-lichen-litter stratum: "fine" fuels consisting of bryophytes and loose un-decayed needles and leaves. These burn during flaming and glowing combustion phases of surface fires.

3. Woody fuel stratum: fine (<.76 cm), medium (.76 – 7.5 cm), and coarse (>7.5 cm) woody material on, or in contact with, the ground; may be sound or rotting, and arranged individually (stumps), loosely, or in piles.

4. Low vegetation stratum: grasses and herbs. Fine fuels burn quickly contributing to surface fire intensity, but not to fire residence time.

5. Shrub stratum: dwarf shrubs, tall shrubs, and coniferous regeneration. Burn vigorously in surface fires to increase fire intensity. These fuels serve as connecting "fuel ladders" and transmit surface fire into the canopy.

6. Tree canopy stratum: crown or "aerial" fuels consisting of live and dead trees (needles and branches <.76 cm) and arboreal lichens. Continuous, high density, canopies lead to crown fire and ember spotting.

4.2 Effects of Fuel Management Activities on Abiotic Forest Components

It is clear that the fuel management activities prescribed above will alter the structure, composition, and function of the forest. In particular, by thinning dominant, co-dominant, intermediate, suppressed trees, and dead trees. Even though this is done selectively, basic abiotic properties of the forest environment are expected to change and, in turn, influence biological components of forest systems. A review of literature was conducted to identify the effects of fuel management on abiotic elements of the wildland/urban interface environment.

4.2.1 Insolation

The amount of sunlight reaching the forest floor and vegetation in lower layers of the forest increases as a result of overstory thinning or removal. Since sunlight is often a limiting factor, it is therefore expected that plant productivity and the amount of biomass in lower forest strata will increase as a consequence of fuel management activities (Rugarrio et al. 1991). Increased sunlight favors shade intolerant species like grasses, wildflowers, and most shrubs, but leads to a decline in bryophyte cover in previously shaded sites (Mitchell 1994). Hamer (1996) reported a dramatic increase in productivity of *Shepherdia canadensis* (buffaloberry) when canopy cover of pine stands dips below 50%.

4.2.2 Temperature

Thinned forests experience increased amounts of direct sunlight during the day. They also exhibit an increase in average ambient air and soil temperature. Increased temperatures make the forest suitable for a greater variety of vascular species (e.g., grasses, flowering herbs, and shrubs). Increased solar radiation may benefit some wildlife by decreasing the energy required for maintaining body temperature. (Graham and Jain 1998, Verbisky 1997, Mitchell 1994)

4.2.3 Wind Flow

As a result of thinning the upper layers of the forest canopy, winds penetrate more easily towards the forest floor and increased wind velocity can be expected in all forest layers. This can result in a greater tendency for "windthrow" or stem breakage in standing trees (Wang et al. 1998). From a fire perspective, increased wind also increases the potential rate of fire spread along the forest floor due to lowered humidity and desiccation of surface vegetation (Graham et al. 1999, Mitchell 1994). However, unpublished research indicates that the difference between thinned and un-thinned stands is insignificant (B. Hawkes, pers.comm.).

4.2.4 Effective Precipitation

The canopy of a coniferous forest can intercept 25–35% of gross rainfall. While some of the intercepted precipitation reaches the forest floor, the remainder either evaporates or sublimates to the atmosphere, and is lost to plant growth. Consequently, the net or "effective" precipitation increases under a forest canopy reduced by thinning (Sauchyn 2004). Since moisture can be a limiting factor in plant growth, more available moisture creates potential for increased growth and increased biomass of near the forest floor. (Graham et al. 1999). Although snow accumulation will also increase, decreased shading hastens snow melt, and some potential gain is lost to run-off (R. Revel, pers. comm.).

4.2.5 Relative Humidity

Competing forces affect relative humidity in a thinned forest. An increase in effective precipitation will tend to increase biomass and soil moisture, however in the presence of wind and elevated temperatures, moisture (humidity) may be pulled away at a faster rate. Relative humidity near the forest floor will also be influenced by factors such as ambient temperature; amount, duration, and intensity of precipitation; plant biomass; and time since last precipitation (Graham et al. 1999, Rugerrio 1991, Sauchyn 2004). Preliminary results from a British Columbia study indicate that differences in relative humidity between thinned and un-thinned stands does not appear to be significant (B. Hawkes, pers.comm.).

4.2.6 Soil Moisture

Thinning decreases the volume of forest canopy, reduces interception of precipitation, and limits the amount of evaporation and transpiration of intercepted moisture back to the atmosphere by trees. The result is that an increased proportion of gross precipitation reaches the forest floor (Sauchyn 2004). Although the moisture requirements of the canopy itself are reduced by thinning, increased cover of shrub and herbaceous plants will result in greater consumption of soil moisture in the upper soil horizons. On balance, a thinned forest has reduced water requirements and transpiration levels and the net effect of thinning is an increase in available soil moisture and subsequent hydrological flows (Graham et al. 1999, Brown and Kapler 2004, Sauchyn 2004).

4.2.7 Soil Nutrient Status

Woody debris, litter, and needles contain vital bacteria, fungi, and other microorganisms essential to healthy soil and forest function (Hammond 1991, 2003). While some nutrients are initially tied up during decomposition processes, eventually nutrients are released to the soil and are once again available for new growth (Hammond 1991). Retention, or augmentation, of coarse woody debris is generally beneficial to nutrient flow (Hammond, 2003). As a result of increased light and temperature, and an increase in deciduous plant growth the rate of decomposition will increase (R.Revel, pers. comm.). As well, many of the herbaceous and shrub species expected to increase or colonize following forest thinning (e.g., *Shepherdia, Elaeagnus*) have the ability to “fix” nitrogen, often a limiting element for plant growth and decomposition in northern and mountain ecosystems. Depending on the methods of thinning and post-thinning treatment, the amount and size proportions of woody debris could increase or decrease. Therefore, variable outcomes for soil nutrient status are possible.

4.3 Effects of Fuel Management on Biological Attributes of Fuel Bed Strata

It is certain that fuel management activities will have direct and/or indirect effects on biological attributes of fuel bed strata (i.e., forest layers) important to wildlife. However, impact studies specific to fuel treatments are scarce to non-existent. Therefore, a literature review was conducted to determine the habitat roles of each forest/fuel bed layer relative to wildlife and, indirectly, implications to biological attributes of the forest of applying current fuel standards.

4.3.1 Fine Woody Debris

Habitat Roles

Fine woody debris includes small diameter twigs and branch-wood pieces < 7.5 cm in diameter (Scott and Reinhardt 2001, Taylor 1997). It is naturally scattered across the forest floor and bushy habitats. When scarce, it gradually decays and returns nutrients to the soil, playing only a minor role as wildlife habitat. However, when fine woody debris accumulates in thick layers or occurs as small or large piles it supplies important nesting, shelter, and escape cover for rodents and amphibians, perching and foraging sites for songbirds, and hunting sites for small carnivores like weasels (Brittingham and De Long 1998).

Squirrel middens are a special case in terms of fine woody debris. Aside from being key food storage and feeding locations for squirrels, middens also serve as foraging locations for red-backed voles and nocturnal species like deer mice and flying squirrels; denning and resting sites for marten; and hunting loci for raptors and small carnivores (Pearson and Ruggiero 2001).

Effects of Fuel Treatments on Fine Woody Debris

Slash and fine woody debris are a primary by-product of fuel management programs. Disposing of it is vital to risk reduction. However, eliminating too much fine woody debris or “brush” from the forest floor would likely have detrimental effects on many species of wildlife (Hammond 2006), by reducing cover and limiting their ability to use or move through local habitats (Brittingham and De Long 1998). Conversely, leaving small existing brush piles or creating new ones with debris from forest thinning would likely improve habitat quality for many forest species (Bull and Blumton 1999) but doing so could also increase overall wildfire risk by contributing to surface fire intensity. Reducing needle and litter to less than 2-3 cm at the base of mature trees will damage soil function (Hammond 2003).

4.3.2 Coarse Woody Debris (Logs)

Habitat Roles

Coarse woody debris includes tree sections over 7.5 cm in diameter and 2.5 m in length. Fallen trees and logs of all sizes and stages of decay are critical natural components of forest ecosystems and highly significant for many wildlife species (Maser et al. 1988) and the quantity of coarse woody debris varies between forests of differing locations, ages, and species compositions. Downed and decaying logs pass through several stages of decay as bark loosens, needles and fine twigs fall away, internal wood softens, and larger branches are shed. Initially, fallen trees are elevated above the ground by their branches or other trees, but progressively move downwards, eventually being incorporated into the forest floor. Consequently, they are long lasting habitat features that provide wildlife with unique places to forage, cache food, den, and seek shelter or security during each stage of decomposition (Mc Clelland 1979, Bull et al. 1997). Coarse woody debris also provides essential micro-habitats and food sources for a rich and complex progression of insect and invertebrate species, and rich substrates for many species of plants and fungus for a century or more. In turn, these decay-related organisms provide a succession of food sources and conditions suited to numerous species of birds, small mammals, amphibians, and even carnivores (Bull and Blumpton 1999).

There is a positive correlation between the size, distribution, and orientation of logs on the forest floor and populations of small mammals (Bull et al. 1995). Bull et al. (1997) generalized that the relative value of a log increases with increasing log diameter and length, however they also noted that small mammals and amphibians appear to use a range of log sizes as locations for escape or shelter. Large logs are sought out by marten, mink, bobcats, coyotes and black bears (Bull and Blumton 1999).

Logs also offer safe routes for small mammals to move about their habitat by providing travel corridors. Small mammals prefer to travel under elevated portions of logs or beside the log, beneath the overhang but also move about on top of logs. In winter, logs protruding from the snow provide small mammals (and their predators) with important access points to enter or leave the undersnow environment (Pearson 1999).

Coarse woody debris also contributes continuously to the long-term flow of nutrients, and to the moisture, physical and chemical properties of forest soils (Bull et al. 1997, Hammond 2003). Logs running parallel to slope contours trap soil and moisture, help prevent soil erosion, and are more heavily used by small mammals than logs oriented perpendicular to the slope. Logs in advanced stages of decay are more susceptible to damage by heavy equipment. Course woody debris is combustible under droughty burning conditions and may be consumed by smoldering fire.

E*ffects of Fuel Treatments on Coarse Woody Debris*

Experience shows that residents, crews, and contractors have a tendency to remove far too much of the native and project-generated coarse woody debris from the forest floor, more than is necessary for fire protection purposes. Loss of coarse woody debris is among the most significant potential impacts of fuel management activities. Therefore, removing an excessive proportion of downed logs eliminates or reduces the short and long-term ecological benefits described above, and wildlife at several trophic levels could be impacted. Crushing or compacting logs in advanced stages of decay during fuel management treatments greatly reduces their utility for wildlife (Hammond 2006). Use of inappropriate burning practices during the latter stages of fuel management projects can also have detrimental impacts. For example, burning slash piles too close to logs, or prescribed burning in thinned stands when the drought code[2] is too high can ignite and destroy a high proportion of coarse woody debris.

4.3.3 Surface Vegetation (grasses and forbs)

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[2] Drought code is a measure of the moisture content of large logs and deep organic fuels on the forest floor as measured by the Canadian Forest Fire Danger Rating System. High values indicate low moisture content and conditions that will lead to consumption of coarse woody debris by smoldering fire.

Habitat Roles

Grasses and forbs comprise the low vegetation fuel bed stratum and provide a wide range of habitat roles. The plants themselves are forage for many species. Small mammals, elk, deer, bears and hare graze on these species, while songbirds, chipmunks, and ground squirrels consume their seeds. Butterflies, hummingbirds, and bees depend upon the nectar they provide. In addition, the many species of insects that inhabit low-growing grasses and forbs provide important secondary food sources for wildlife (Thysell and Carey 2000).

Herbaceous plants at the forest floor provide nesting sites for voles, upland game birds, and many species of songbirds such as juncos and sparrows. In addition, grasses and wildflowers provide year round thermal and hiding cover for small mammals and birds. Open grassy areas support populations of prey species such as mice and voles, therefore providing excellent hunting grounds for owls, hawks, coyotes and fox (Brittingham and De Long 1998).

Effects of Fuel Treatments on Surface Vegetation (grasses and forbs)

Thinning the forest canopy and removal of younger trees reduces competition for sunlight, nutrients and moisture. As a result, there will also be an increase or shift in the variety of grasses and forb species (Thysell and Carey 2000) in some areas. For similar reasons, the nutritional (protein, digestible energy, minerals), production, and palatability of forage will also increase (Powell and Box 1978). While environmental conditions will change to the detriment of some shade-loving species (e.g., bryophytes) many more desirable forage and cover-providing species are expected to respond by increasing. Sprouting from dormant seed, re-colonization, and release of plants previously limited by shade, nutrients, or moisture are forecast to result in significantly increased biomass and species richness following forest thinning (Thysell and Carey 2000). Subsequently, increased complexity in the forest strata most used by wildlife is anticipated in the medium to longer term.

Disturbance of soil and native vegetation during the course of fuel management activities may create opportunities for non-native plants to establish or spread. Highly aggressive non–native species often out-compete and reduce the diversity of native species, and provide limited value to wildlife in terms of forage and cover, relative to native species (Brittingham and De Long 1998).

4.3.4 The Forest Shrub Layer

Habitat Roles

Annual growth on many deciduous shrubs and young deciduous trees supplies the major dietary source for browsers such as ungulates, beaver, and snowshoe hare. Tall fruit-bearing shrubs provide important seasonal food sources for migratory and resident songbirds and wildlife. Mast-bearing plants are important seasonal sources of food in some forest regions (Brittingham and De Long 1998). Low-growing "dwarf" shrubs also provide abundant seasonal food sources for small mammals and ground-foraging birds. Some species, like kinnikinnick

(*Arctostaphylos uva-ursi*), retain berries during much of the winter. All shrubs, regardless of height, provide important hiding or security cover for various forest animals by reducing sight lines near the forest floor; carnivores also use this cover to advantage when hunting. To some degree, shrubs also provide thermal protection to wildlife by providing shade and slowing the flow of surface winds thus helping them to conserve energy. Coniferous regeneration <2 m tall, and advanced regeneration 2-5 m tall provide year round cover.

Effects of Fuel Treatments on the Forest Shrub Layer

Although mechanical activity may set back shrub density temporarily, thinning the forest canopy has the effect of "releasing" the majority of understory shrubs, deciduous trees, and young conifers. Rapid growth follows thinning because competition for light, moisture, and nutrients is reduced due to removal of some overstory trees (Thysell and Carey 2000). As existing shrubs become more vigorous and new individuals have the opportunity to grow, additional browse and foliage becomes available (Brittingham and De Long 1998). Similarly, a significant increase in berry production of some shrubs and dwarf-shrubs will also occur within several years (Hamer 1996). Potential for surprise encounters between wildlife and people is expected to increase directly with decreasing horizontal sight distance and shrub density (W. Bradford, pers. comm.).

Mechanical equipment used during large fuel management projects can break or injure woody shrubs, particularly during cold weather. Therefore, shrub density, browse, and berry production suffer a setback, but are expected to increase to levels greater than pre-treatment levels after several growing seasons.

4.3.5 <u>The Forest Canopy</u>

Habitat Roles

As noted in section 4.2 the forest canopy plays significant roles in regulating the micro-climate of the forest understory and forest floor. Changes in tree density and overall crown bulk density will alter this role, thus allowing additional sunlight and precipitation to reach lower strata of the forest. As well, the forest canopy provides specialized habitats for songbirds and arboreal mammals adapted for feeding and nesting in various parts of tree crowns.

Effects of Fuel Treatments on the Forest Canopy

The diversity of plant species in the lower stratum, as well as size class distribution of mature trees will be altered by selective thinning. However, the ecological implications of canopy thinning for fuel management can be positive or negative depending upon the natural disturbance history of the site, the degree of thinning, and selection rules for species and age/size classes removed or retained. After canopy thinning, residual trees are subject to structural failures such as windthrow and stem breakage caused by increased wind exposure (Whitehead and Brown 1997, Wang et al. 1998). If windthrow is significant, further changes in habitat structure and characteristics will result. More detailed information on the effect of fuel treatments on specific components of the forest canopy follow in section 4.4

4.4 Potential Effects of Fuel Management on Selected Habitat Attributes and Habitat Types

Fuel management activities will affect wildlife habitats[3], and some of these impacts may be adverse. In the absence of specific studies about habitat response to fuel management treatments, relevant literature was reviewed to anticipate possible effects. This review was directed towards habitats and habitat attributes of particular importance to wildlife in the context of the Rocky Mountains and foothills of Alberta.

[3] Habitat is an area where a particular animal can find the full complement of critical resources (food, shelter, nesting or breeding sites, roosting areas, and suitable temperatures or soil conditions) necessary for its survival and reproduction (Flather et al. 1999).

4.4.1 Habitat Trees

Living or dead trees with cavities, nests, or dens that are, have been, or are likely to be occupied by wildlife are called *habitat trees*. Over 80 species of birds, small mammals, amphibians, and reptiles use living trees with decay, dead trees, hollow trees, or trees with brooms (Bull et al. 1997).

The Role of Snags

Dead standing trees, or "snags", are an essential wildlife resource (Mc Clelland 1979). Snags have a finite life depending on species, soil conditions, size and their cause of death. Over time, dead trees change in form due to progressive decay, therefore it is important that an ongoing supply of snags be sustained (Bull et al. 1995). Snag numbers vary depending on the location and age of the forest, but are often a limiting resource. The importance of snags are generally proportional to diameter. Snags <25 cm in diameter have less value as cavities, but still provide food sources and perching sites (Mc Clelland et al. 1979).

Three structural forms of snags are recognized (Bull et al. 1997) and each plays a unique role. Recently dead snags have some visible decay and their bark is mostly intact. These are mostly used by birds that forage in and under the bark for bark beetles, engraver beetles, and other insects. Snags of the moderately decayed form have shedding bark, decaying branches, and broken tops. They host the majority of primary cavity nesting species. These are used extensively by birds and other animals that forage under the bark, and in the soft wood, to locate wood borers, ants, and other insects. Extensively decayed trees with little bark, shortened and broken tops, and few branches are the third snag form. These snags are used heavily by secondary cavity nesters and provide wildlife opportunities for foraging deep in the decayed wood.

Dead trees provide habitat attributes that cannot be duplicated by living trees. Snags serve as perches for hunting, feeding, and resting; sites for platform nests to rear young; locations to excavate cavities; hibernation and over-wintering sites; places to forage and cache food; locations for courtship, displaying or singing; and preferred locations to roost at night (Maser et al. 1988). As well, loose bark on snags provides nesting and roosting sites for some birds and bats.

Altogether, at least 50 species of birds, and several species of mammals, nest in cavities of dead trees in Canada (Canadian Wildlife Service 1989).

Although the value of snags is generally in proportion to their diameter, nuthatches and chickadees use aspen snags as small as 8 cm diameter as nesting sites. Some wildlife species (e.g., bluebirds and kestrels) occupy snags that occur in open exposed locations while others only utilize snags with adjacent cover. Still others show preferences for snags in particular topographic locations or aspects. Aside from shelter, the decaying wood of dead trees harbor many species of insects that provide food for wildlife (Brittingham and De Long 1998). High stumps also offer insect food sources (Ferguson 2002).

Snags (and living trees) that are leaning provide additional habitat value in the forest. Aside from all the benefits of vertical snags, they provide variation and structural complexity to the stand that serve as pathways through the canopy and escape routes for squirrels or other mammals. Ultimately, snags (and living trees) become coarse woody debris as a result of the natural process of falldown. Although lost to the forest canopy, death prolongs their contribution as wildlife habitat (Crites and Hanus 2001).

The Role of Legacy Trees

Legacy trees are living, large diameter trees with high potential to become habitat trees due to the presence of internal pockets of decay[4], broken or forked tops, bole defects (e.g., fire scars or mechanical damage), or obvious signs of disease or insect attack. Live trees with dead tops are especially important. Some wildlife species specialize in nesting in dead treetops and several species of woodpecker prefer the dead tops as territorial drumming sites (Bull et al. 1997).

Legacy trees have added value because they are likely to remain standing for a long time, far outlasting most snags. They are the next generation of snags but are also important in the present, since woodpeckers dig through the sound outer layer of sapwood to form nest cavities in the soft, decaying heartwood (Mc Clelland et al. 1979). Ants often colonize decaying or dead wood near the base of legacy trees, making them valuable forage sources (Bull et al. 1997).

Similar to snags, larger trees are generally more valuable, but small diameter trees cannot be discounted. In the Jasper study area, Douglas fir over 50 cm diameter at breast height, trembling aspen, balsam poplar, low-branched lodgepole pine (wolf trees), and large diameter fire-scarred pine were considered to be the best candidates for legacy trees.

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[4] Decay in live trees results when heart-rot fungi colonize the inner wood of a tree. Downed and dead logs are colonized by saprophytic fungi.

Broomed and Hollow Trees

Trees with dense clumps of misshapen branches caused by dwarf mistletoe, rust fungi, or needle cast fungus (i.e., "brooms") fulfill habitat needs for many species of wildlife. Brooms caused by dwarf mistletoe are common in pines and Douglas fir. Brooms caused by pathogenic fungi (i.e., rusts) more frequently form on spruce trees, are very dense, and make good denning sites for flying squirrels. Aside from providing cover and nesting sites for birds and marten, mistletoe-infested twigs and the shoots themselves are eaten by chipmunks, squirrels and porcupines. Further, the brooms attract insects that are fed upon by other birds. Particularly large brooms form platforms that are used as nesting sites by owls, goshawks and cooper's hawks (Bull et al. 1997). Deer and elk feed on brooms that sweep close to the ground. Bennetts (1996) found that three times more cavity nesting species were found in forests heavily infected with mistletoe. Hollow trees are significant, but infrequent, habitat features. They form when heartwood decay advances to the extent that the entire inner portion of the tree pulls away from the outer sapwood, collapses downward, and creates an empty chamber inside the tree. Hollow trees are particularly used by Vaux' swifts, flying squirrels, wood rats, bats, and marten (Nagorsen and Brigham 1993). When located more than 10 m above ground, these chambers provide good refuge from predators. Multiple woodpecker entrance holes or broken, bayonet-shaped tops are clues to identify and preserve hollow trees in the field (Bull et al. 1997).

Effects of Fuel Treatments on Habitat Trees in the Forest Canopy

Because of their potential effect on fire behavior, habitat trees are targeted by standard fuel management criterion. For example, FireSmart guidelines call for complete removal of dead or dying trees in Priority Zone 1. In Priority Zones 2 and 3 it is recommended that "concentrations of overmature, dead and dying trees, that have high potential to ignite and carry fire to the building", and highly flammable individuals be removed. Providing that snags have shed their needles, snags and hollow trees do not contribute significantly to frontal fire intensity. However they are combustible, and enhance fires ability to persist by smoldering beneath the surface. Once hollowed out by this process, snags can spout embers onto the surrounding area. Therefore, snags are a concern and removal of snags from burn areas is a basic technique taught to wildland fire fighters (D. Mortimer, pers. comm.). Legacy trees, broomed trees, and recent snags with needles still on may present hold-over concerns, but are more likely to enhance potential for fire spread into, and through, the forest crowns (B. Hawkes, pers.comm.).

Considering the many important ecological roles played by dead and dying trees in the forest canopy, reducing or eliminating them would have significant adverse impacts on the quality of habitat, on many species of wildlife, and on the enjoyment of residents and visitors to the wildland/urban interface (Bull et al. 1995). Competition for nest holes and trees suitable for excavating cavities would also increase in nearby forests (Bull et al. 2005).

4.4.2 Coarse Woody Debris

Habitat roles and the effect of fuel treatments on coarse woody debris are discussed in section 4.3.2

4.4.3 Forest Edge

Habitat Roles

Edge is the area of transition from one type of vegetation (i.e. cover) to another. Edge occurs naturally across topographic or edaphic boundaries, or it can be induced by natural disturbances and management actions (Farm Woodlot Association of Saskatchewan 1993). Forest openings and edges are significant habitat features used for traveling, feeding, nesting, and resting by wildlife species that specialize in meadows or forest openings, species of the forest interior, and species that prefer the edge itself (Brittingham and De Long 1998).

Site conditions at the forest edge (e.g., more sunlight) provide ideal growing conditions for a wider variety of plant species and result in a mix of vegetation layers. As a result many species of wildlife are able to satisfy some or all of their habitat needs here, and edges are usually richer in wildlife than adjoining interior habitats. Because of this, forest edges may also attract small carnivores and raptors (Farm Woodlot Association of Saskatchewan 1993 Bull et al. 1995).

Effects of Fuel Treatments on Forest Edge

The vegetative characteristics and extent of edge can be increased (or decreased) by varying the degree and pattern of fuel thinning, creating or enhancing openings in the forest, and working with natural topographic and soil changes. In the wildland/urban interface, structures and the fuel-modified "home ignition zones" around them can be treated as forest opening and the vegetation around them managed as habitat edges. Consequently these openings can be beneficial, especially if forest edge and openings are lacking nearby.

4.4.4 <u>Wildlife Corridors</u>

Habitat Roles

A wildlife corridor is a linear 2-dimensional landscape element that connects two or more important patches of habitat (Duke et al. 1998). The presence of corridors allows wildlife to persist in human dominated (fragmented) landscapes by allowing wildlife to move in relative security. Corridors are used as travel routes by wildlife and birds as they move about their home range, but also provide forage, resting cover, and protection from wind, sun and excessive cold. Wildlife are more likely to use corridors that include important components of their preferred habitat (Duke 2001). Corridors exist at many different scales, and linking habitat patches that range in size from square kilometers to square metres. For example, a line of shrubs or a dense area of tall grass along a fence between two groves of trees forms an effective corridor for some species (Brittingham and De Long 1998). Riparian areas are particularly important travel corridors (Farm Woodlot Association of Saskatchewan 1993).

Effects of Fuel Treatments on Wildlife Corridors

Development or other activities that destroy connections and fragment habitat into isolated patches without effective corridors are serious problems for wildlife, and for residents who appreciate wildlife. Duke (2001) found that factors such as prey availability, preference for slopes, and distance from hiking trails might override vegetation cover attributes in determining travel routes chosen by wolves and cougar. The Bow Corridor Ecosystem Advisory Group (1998) identified vegetation management for fire and forest health purposes as an acceptable land use within wildlife corridors and noted that fuel management would only be a constraining factor for wildlife travel in areas where there is little or no human use (i.e., in areas other than the wildland/urban interface). Nevertheless, poorly planned thinning activities or excessive clearing of vegetation for fire prevention purposes could exacerbate fragmentation at various scales. For example, failing to retain understory cover may deter use by wary carnivores, whereas removal of coarse woody debris may limit movement of voles and deer mice on the forest floor. On the other hand, awareness and good planning can help sustain, or even enhance wildlife corridors by providing forage and all types of cover.

4.4.5 Grasslands

Habitat Roles

Grasslands are critical but rare and declining habitat elements in Jasper National Park. They currently make up less than 0.2% of the park (Tables 2-2 and 2-3). Studies show that more than half of the grasslands and small openings in the forest have been lost or dramatically diminished in size during the last eighty years due to the absence of periodic fires and subsequent encroached by woody shrubs trees (Rhemtulla 1999, Mitchell 2005). Grasslands are primary foraging areas for ungulates and the sole habitat for several species of songbirds (Holroyd and Van Tighem 1983). As a consequence of sustained encroachment by shrubs and trees, studies show that grassland bird species are decreasing more significantly across North America than for any other group of bird species (Saab and Rich 1997). Songbird species specializing in grasslands are, in particular, heavily impacted by tree invasion; even slight increases in tree density resulted in serious impacts (Krannitz and Rohner 1999).

Effects of Fuel Treatments on Grasslands

Fuel management techniques that create small grassy areas, enlarge remnants of former grasslands, or restore open forests (e.g. <30% canopy cover) would also help maintain endangered grassland bird populations (Krannitz and Rohner 1999) and also provide attractive forage for grazing animals like elk (Amiro et al. 2001). The adverse impacts of ubiquitous species such as crows, magpies, and brown-headed cowbirds that prey on grassland songbirds or nests (Krannitz and Rohner 1999) would be reduced by increasing the area of grasslands.

4.4.6 Aspen Forests

Habitat Roles

In many landscapes, aspen forests are the most productive plant community in terms of wildlife diversity and richness of understory species (USDA Forest Service 2005a, Holroyd and Van Tighem 1983). They provide a wide variety of herbaceous forage, browse, and berries, as well as a wide array of thermal, escape, and protective cover for wildlife. Like grasslands, numerous studies document the decline of aspen forests in the Rocky Mountains due to overgrazing and fire suppression (Bartos and Campbell 1998, Kay 1997, White 2001). In the absence of fire, aspen stands are invaded by longer-lived coniferous species that gradually dominate the canopy and understory.

Effects of Fuel Treatments on Aspen Forests

Selectively thinning of mature aspen forests to remove or reduce the abundance of invading conifers will restore the structure and species composition of aspen stands, preserve habitat attributes important for many species of songbirds, and concurrently reduce fire potential by providing a less flammable fuel type in the wildland urban interface. In conifer stands with scattered aspen reducing the coniferous cover near aspen would reduce competition, allow additional sunlight penetration soil warming, and encourage an increase in aspen reproduction by suckering. Mechanical disturbance of the soil and shallow aspen roots during thinning projects will also trigger suckering and clone expansion (Peterson and Peterson 1992). Clearings created by thinning adjacent to existing aspen clones would also open up areas for vegetative aspen reproduction. Experience demonstrates that mature aspen are susceptible to stem breakage during cold temperatures; hence care is required during falling of adjacent conifers to avoid excessive mortality and aesthetic impacts.

4.4.7 Wetland and Riparian Areas

Habitat Roles

Riparian areas (i.e., vegetation next to any standing or flowing water body) and wetlands are special habitats common within the wildland/urban interface. Three categories of wetlands are commonly found in the wildland/urban interface: spring seeps (i.e., groundwater discharge areas) are locations where ground water reaches the surface and persists as open water; temporary pools are similar but more ephemeral, being more likely to accumulate open water in spring only; moist depressions are locations where the water table does not quite reach the ground surface but still significantly influences plant growth.

In general, all three of these wetland sites are rare, highly significant habitats for wildlife, and heavily used refugia by many species (Brittingham and De Long 1998). Aside from providing year round or extended seasonal sources of water, these areas produce more plant growth earlier, and sustain it longer, than surrounding dry sites (Pearson 1999). The dense, varied growth provides excellent hiding, nesting and thermal cover, and a wide variety of forage. As well, the irregular shape of riparian zones maximizes the amount of edge (Farm Woodlot Association of Saskatchewan 1993). Often, the diversity of plant species is greater, including some species unique to wetter habitats. Wetland areas are particularly important to amphibians (e.g., frogs, toads, newts) and, in parts of Canada, reptiles like snakes and turtles (Pearson 1999).

Effects of Fuel Treatments on Wetlands and Riparian Areas

Wetlands and riparian areas are susceptible to direct effects of fuel management and secondary effects caused by equipment and crews. Clearing or excessive thinning of the forest canopy could result in additional sunlight, increased exposure to wind, or in changes to the underlying water regime (hydrology), which could cause drying out of the site and significant habitat loss.

4.5 Life Requirements of Wildlife Common to the Wildland/Urban Interface and Potential Effects of Fuel Management.

Much is known about the distribution and behavior of wildlife, their habitat requirements, and the ways that wildlife respond to major forest disturbances like logging and intense wildfires. Fuel management activities are a similar, but milder form of habitat modification. Unlike timber harvesting, fuel treatments are a relatively new concept. Consequently, there are very few studies, and little experimental data, to document the response of wildlife to fuel treatments. In lieu of scientific studies, this section synthesizes existing information about the needs of various wildife species with previously gathered information about the effects of fuel management on their habitat, to determine potential effects of fuel activities on wildlife. For simplicity, the results are presented in table format.

Thirty-five wildlife species were selected for this analysis. These species were selected because they are representative of the study area and common to many wildland/urban interface areas across Canada. Some emphasis was placed on selecting species of “watchable wildlife” (i.e., wildlife species that are commonly observed and familiar to residents of the wildland/urban interface). Others were chosen because of their ecological significance. The species were grouped into categories with similar habits. The species considered in this study are listed in Table 4-4.

Table 4-4: Common and scientific names of representative interface wildlife species.

COMMON NAME	SCIENTIFIC NAME
PRIMARY CAVITY EXCAVATORS	
Pileated woodpecker	*Dryocopus pileatus*
Hairy woodpecker	*Picoides villosus*
Three-toed woodpecker	*Picoides tridactylus*
Downy woodpecker	*Picoides pubescens*
SONGBIRDS - LANDBIRDS	
Brown creeper	*Certhia Americana*
Warbling vireo	*Vireo gilvus*
Yellow warbler	*Dendroica petechia*
Black-capped chickadee	*Parus atricapillus*
Ruffed grouse	*Bonnasa umbellus*
Golden-crowned kinglet	*Regulus satrapa*
RAPTORS	
Northern goshawk	*Accipiter gentilis*
Great gray owl	*Strix nebulosa*
Boreal owl	*Aegolius funereus*
SMALL MAMMALS	
Snowshoe hare	*Lepus americanus*
Meadow vole	*Microtus pennsylvanicus*
Montane vole	*Microtus montanus*
Red-backed vole	*Clethrionomys gapperi*
Northern flying squirrel	*Glaucomys sabrinus*
Deer mouse	*Peromyscus maniculatus*
White-footed mouse	*Peromyscus leucopus*
Red squirrel	*Tamiasciurius hudsonicus*
Chipmunks	*Tamias/Neotamias*
Columbian ground squirrel	*Spermophilus columbianus*
Golden-mantled ground squirrel	*Spermophilus lateralis*
Bushy-tailed woodrat (packrat)	*Neotoma cinerea*
BATS	
Hoary bat	*Lasiurus cinereus*
CARNIVORES	
Weasel	*Mustela erminea/freneta*
Marten	*Martes americana*
Fisher	*Martes martes*
Lynx	*Lynx canadensis*
Black bear	*Ursus americanus*
UNGULATES	
Elk	*Cervus elaphus*
White-tailed deer	*Odocoileus virginianus*
Mule deer	*Odocoileus hemionus*
AMPHIBIANS	
Long-toed salamander	*Ambystoma macrodactylum*

4.5.1 Primary Cavity Excavators

Only primary cavity excavators like woodpeckers, flickers, and sapsuckers have the ability to drill through the hard outer sapwood and hollow out cavities in trees. Primary excavators are particularly important species because at least 50 other species of birds and mammals (i.e., secondary cavity nesters like bluebirds, chickadees, wood ducks, squirrels, marten, and small owls) use these cavities for nesting, denning, or shelter once abandoned by their originators.

Table 4-5: Life requirements and potential effects of fuel management on primary cavity excavators.

SPECIES	LIFE REQUIREMENTS	POTENTIAL EFFECT OF FUEL MGMT
Pileated Woodpecker Bull et al. (2005) Bull et al. (1997) Mc Clelland (1979) Hutto and Young (1999) Bonar (1999)	Widespread but relatively uncommon year round resident of most Canadian forests; has a large territory; needs large (minimum 33cm. diameter snags or live trees with decay for excavating nests and roosts; ants and insects in trees and logs are main year round food; uses live hollow or decaying trees for drumming; attracted to sheltered clumps of dead trees and downed logs.	Tree selection during forest thinning can have negative or theoretically neutral effect on pileated woodpeckers; they continue to use thinned or harvested forests if adjacent to uncut areas.
Hairy woodpecker Three-toed woodpecker Hutto and Young (1999) Hoover et al. (1999a) Zapisocki et al. (2000)	Permanent residents of North American boreal and Montane forest; prefer older conifer forest - use mixedwood and deciduous forest too; feed mostly by gleaning or chipping bark for beetles and probing or drilling for wood-boring insects on snags, live trees, or logs; often use harvested forests; excavate 3 separate cavities each year to nest, roost and winter in trees >20cm. diameter; prefer dense canopy but use edges and open forest.	Will likely to adapt well and use forests subjected to careful thinning and/or prescribed burns if food sources and cavity trees are retained; likely to increase if prescribed burns are part of fuel treatments
Downy Woodpecker Schroeder (1982b)	Year-round residents of most N. American forests; glean insects foods from tree/log surface and digging into the bark; 25% of food is berries, seeds, nuts; weak excavators, require advanced decayed wood; construct 2-4 cavities per pair/year; use deciduous and nearly mature to mature conifer forest; prefer live broken-topped nest trees.	Forest thinning projects that leave some debris are well used by downy woodpeckers for foraging.

The most probable impacts of fuel reduction to this group are the loss of dead or decaying trees that provide forage and nesting sites. These impacts are compounding since they also affect secondary cavity users.

4.5.2 Songbirds – Landbirds

Table 4-6: Life requirements and potential effects of fuel management on songbirds/landbirds.

SPECIES	LIFE REQUIREMENTS	POTENTIAL EFFECT OF FUEL MGMT
Brown Creeper Banks et al. (1999c)	Widely distributed North American species; prefers old or mature forests; feeds on conifers and large snags with nearby cover by gleaning insects and spiders; nest in loose bark or cavities of snags or dying trees.	Reduction in snags and living trees infested with insects would impact nesting/feeding sites; loss of large mature trees and adjacent cover would limit foraging opportunities.
Yellow Warbler Schroder (1982a) Hutto and Young (1999)	A widespread insect-feeding songbird; strong preference for wetter, shrubby areas and edges of wetlands or water courses; nests in shrubs >1m.;avoids coniferous forest.	Conversion of mixed-wood to deciduous forest favors yellow warbler; commonly adapts to urban areas.
Warbling vireo Hutto + Young (1999), Banks et al. (1999a)	Common bird of riparian and harvested forest across N. Amer.; frequent in mature aspen; linked to shrub cover/edges; does well in conifer forest; feeds on insects, spiders, berries; open nester.	Likely to respond well in areas where shrub cover increases due to fuel work; may increase at edge of new openings in the interface.
Mountain Chickadee Hutto and Young (1999)	Common songbird of most Rocky Mountain forests; cavity nester that uses cavities in trees and rotting stumps; generalist food habits; adapts to urban areas; abounds in aspen.	Unlikely to be impacted significantly by thinning due to its adaptability;
Black-capped Chickadee Schroeder (1983)	Common year-round resident Canada-wide; feed by gleaning insects and insect eggs from bark, twigs, boles, and foliage of trees and shrubs from ground to crowns; seeds, berries augment diet; can excavate own nests in rotting wood or use existing cavities or hollow trees; short stubs are important nest sites; select nest trees down to 10cm. diameter, often in open areas; roost in cavities or dense conifers out of wind.	Volume of tree/shrub crowns dictates availability of insect foods - and this will decline with thinning for fuel purposes; preserving good numbers of dead or dying trees for nesting and foraging; seed sources from flowering plants, berry trees, feeders could counteract foliage losses and maintain or increase use of interface areas by chickadees.
Red-breasted Nuthatch Hutto and Young (1999)	Very common in western conifer forests at low elevations; prefers older forest but found in forest dominated by all tree species; cavity nester that feeds on insects	May decline in thinned forest but will continue to use thinned forests;
Golden-crowned Kinglet Piorecky et al. (1999b)	Summer resident found across Canada; gleans insects and insect eggs from foliage of tall conifers and hovers to catch insects on the wing; active in the forest canopy about 10m. up; strong preference for conifers (spruce and fir) but also inhabits mixedwood stands; feeds in groups.	Could be expected to decline if significant portion of mature conifer component is removed from a stand
Ruffed Grouse Schaffer et al. (1999b)	The most common woodland grouse; found across Canada; year-round resident of aspen and mixedwood forest; uses ground, shrub, and tree layers for food and cover; feeds on buds, twigs, flowering plants, berries, insects; winter reliance on aspen and willow buds, catkins; thrives soon after fire or logging disturbance; uses select logs for drumming displays; nest on ground.	Ruffed grouse should increase with fuel treatments that favor retention of aspen, and deciduous shrubs or create an open under-story with aspen regeneration and good sight distances; removal of logs could limit drumming/ display sites; respond well to forest disturbance and thrive in early seral stages.

The effects of traditional logging activities on birds vary among groups of birds with similar habits, between species within such groups, and between habitats within species. This makes generalizations difficult, but review of current literature revealed useful information. For example, variable retention logging in mixed conifer stands in Arizona (Scott and Gottfried 1983) resulted in no change to total species richness but a decrease in the overall number of birds; no changes in feeding and nesting guilds were observed. Several other studies (Ferguson 2002) suggested that retention of individual trees and uncut patches within cutblocks are beneficial, and that retaining more trees reduces the differences between logged and old growth forest sites. Many studies indicated that foliage and bark gleaning species that specialize in the forest interior (e.g., golden–crowned kinglets, Swainson's thrush, varied thrush and Townsend's warbler) were more likely to decline as a result of logging. Conversely, species like dark-eyed junco, pine siskin, American robin, chipping sparrow, and Cassin's finch specialized in foraging in the open canopy or on the ground were more numerous following logging activity (Ferguson 2002). Norton and Hannon (1997) also showed that retaining 30 – 40% of the forest cover in boreal mixedwood forest resulted in less impact to songbirds than other forms of logging.

Following extensive literature review, Ferguson (2002) predicted that thinning of relatively even-aged lodgepole pine forest in Banff National Park would increase habitat for 39 species of birds, result in no impact for 30 species of birds, and locally decrease habitat availability for 28 bird species. He recommended that leaving live trees in large forest gaps, large diameter snags, and understory shrubs in thinned areas would further alleviate adverse impacts to birds when creating fire breaks.

4.5.3 Raptors

Table 4-7: Life requirements and potential effects of fuel management on raptors.

SPECIES	LIFE REQUIREMENTS	POTENTIAL IMPACT OF FUEL MGMT
Boreal Owl Pearson (1999) Heinrich et al. (1999) USFS (2005a)	Nocturnal secondary cavity nester found across Canada; feed on red-backed voles, deer mice, shrews, other small mammals, and birds hunted from low perches; need a mix of closed mature conifer and deciduous forest, and clearings; nest in cavities excavated by pileated woodpeckers in trees 25-38+cm diameter; preference for open understory, multiple layer forest.	Thinning strategies that impact snags, living cavity trees, and habitat characteristics of old forest that provide owl cover and habitat for prey species would reduce suitability for boreal owls and other small owls.
Great Horned Owl USFS (2005a) Bull et al. (1995)	Platform nesters. Use brooms and platforms built by goshawks, red-tailed hawks. Hunt on forest edges. Like semi-open areas for nesting, nest close to dense forest. In forests, prefer to hunt near logs for small mammals.	Loss of large, broken topped trees, brooms impacts nesting. Reduced logs on forest floor decrease food resources.
Cooper's + Sharp-Shinned Hawks Salt + Salt (1976)	Secretive summer resident of woodlands + riparian forest across Canada; nest is a platform high in canopy in brooms, crux of branches, horizontal branches of conifer near bole; woodland hunters of birds/small mammals in open/closed forest; prefer dense deciduous forest.	Loss of current nest trees and potential nest sites; increased human presence/disturbance; loss of habitat for small mammal or songbird prey; loss of dense, deciduous forest in regional landscape.
Northern Goshawk USFS (2005a) Reynolds et al. (1992) Schaffer et al. (1999a)	Occur across Canada; may remain year-round or migrate; feed on small mammals (90%) and birds; sensitive to human presence; strong preference for very dense, mature/old mixedwood forest with high % deciduous and open understory; require large territory; build platform nest high in the canopy; conifers near nest tree offer important shelter.	Unlikely to be impacted by fuel management as mixedwood stands with high % deciduous are fire-resistant and rarely treated; high levels of human activity in the interface may discourage use by goshawks.
Great Gray Owl Piorecky et al. (1999a)	Widespread in Canada from B.C. to Quebec but low in numbers; year-round residents; prey mostly on mice, voles, shrews, other small mammals; hunt from perches in or near forest openings, fields, bogs; require hunting areas with low tree density; prefer mature conifer, mixedwood forest; cannot build own nests, take over raptor stick nests or nests on top of broken trees (aspen, poplar, conifer); nest in variety of forest densities; leaning trees critical for young to climb back to forest canopy.	Forests managed for less fuel should be able to retain key habitat attributes and maintain or attract great gray owls; preserving or enhancing habitat for small mammal prey base is critical; open understory and canopy required for hunting is a likely benefit of thinning activities. Great gray owls are resilient to human disturbance outside of breeding season and could persist in an interface environment.

The most probable impacts of fuel reduction on raptors are the potential loss of nesting sites (i.e., secondary cavities and platforms) and habitat elements that help support prey species such as small mammals (e.g., coarse woody debris).

4.5.4 Small Mammals

Small mammals are diverse in their habits, widely distributed in forest habitats, and play central roles in many forest ecosystems (Pearson 1999). Some species are active in the day, others are nocturnal. Food preferences include insects, seeds, plants, carrion, and fungus. Some species live on or under the ground, others spend most of their time in the forest canopy. Because small mammals are numerous and reproduce quickly, they form the base of many food chains and support numerous predators and raptors. They play other key roles such as: helping regulate forest insects which damage and kill trees or, like mosquitoes, are considered "pests" by humans; collecting and caching seeds which disperses seed and generates new trees within the forest and; dispersing the spores of fungal species essential for plant health and the nutrient status of forest soils.

Table 4-8: Life requirements and potential effects of fuel management on small mammals.

SPECIES	LIFE REQUIREMENTS	POTENTIAL EFFECT OF FUEL MGMT
Snowshoe Hare USFS (2005a) Ferguson (2002) Hoover et al. (1999b) Woodlot Assoc. of Sask. (1993)	Key prey species common across N. Amer. in boreal, mountain, deciduous forests; active after dark; depend on dense understory (<2m.) cover as most important habitat factor; prefer young to mature conifer forest but also use hardwood and mixedwood forest; browse on buds, woody stems, bark, needles in winter; forage on grass and flowering plants, twigs in summer; use open areas more in summer; brush piles beneficial for cover.	Thinning practices that preserve or promote shrub, hardwood understory or young conifers will improve thermal and hiding cover and favor hares; focus on preserving low shrubs; provide good mix of open areas with grass and flowering plants and thickets, hedges, or forest with understory shelter.
Red Squirrel Pearson (1999) Wheatly (1997) Banks et al. (1999b) Ferguson (2002)	Found across Canada; prefers mature dense conifer forest but found in mixed +hardwood forests; active in daytime; key prey species; lives in forest canopy; feeds on berries, insects, eggs, rodents, carrion, and fungi but depends on stored cones and seeds of evergreens in winter; also feeds on twigs infected by mistletoe; nest in cavities, branches, underground.	Most likely to decline with reduced density of mature conifers and cone-bearing species. Important prey for owls, goshawks, red-tailed hawks, marten and other carnivores.

Northern Flying Squirrel Bull et al. (2005) Pearson (1999) Takats et al. (1999a) Ferguson (2002)	Occur across Canada; nest in large natural or woodpecker cavities and brooms; prefer live trees to nest; linked to older forest; prefer coniferous forest but also use mixedwood and hardwood forests; nocturnal; forage mainly on forest fungi but use lichens, berries, seeds, insects; use 2-4 nests/year.	Abundance will decline if thinning does not incorporate key habitat features; flying squirrels do inhabit forest with medium densities (20-60%).
Columbian and golden mantled ground squirrels. Pearson (1999)	Rocky mountain and foothills species that range from dry low elevation open forest to sub-alpine meadows; Columbians live in colonies and prefer grasslands/meadows; both species live and "hibernate" in underground burrows where they store seeds, fruit, and bulbs; also eat green plants, insects and fungi; GM den near or under tree or large logs.	Both species, if present before thinning, are likely to increase after forest thinning as open habitats and foods like grass, flowering plants, and berry producing shrubs and dwarf-shrubs become more abundant.
Deer Mouse and White-footed Mouse Pearson (1999)	Two of the most common and widely dispersed small mammal habitat generalists in north America; active year-round; mostly nocturnal; prefer young dry forest types but also found in moister old forests, brushy sites, and prairies; feed on seeds, berries, insects, fungi; nest in cavities in logs, trees, squirrel middens, likes shrubby micro-sites. Key food sources for raptors and many carnivores.	Response may vary with location and thinning effects on local food sources. Will likely increase in logged or disturbed areas.
Chipmunks (eastern, least, yellow-pine, red-tailed, Townsend's) Bull + Blumton (1999) Pearson (1999) C.W.S. (1989)	Several species are dispersed across forests of North America; live in underground burrows or tree cavities; active during daytime; "hibernate" with short waking periods in winter; depend on low vegetation, woody debris and rocky ground for cover; prefer young forest and edges of clearings; associated with gaps and small openings in moist or dry forest; climb shrubs + trees for seeds or berries; forage on conifer seeds, grass, flowers, insects, fungus (mushrooms).	May increase after thinning in pine forests; loss of variability in undergrowth or mix of open and closed canopy could reduce numbers.
Meadow Vole Ferguson (2002) Pearson (1999)	A dominant species in grasslands and open forests with grassy understories; numbers increase with grass density; downed woody material aids cover; feed mostly on grass, flowers, and shrubs – less on seeds and insects.	Likely to increase in thinned forests and forest openings that result from fuel reduction.
Red-backed Vole Bull and Blumton (1999) Pearson (1999) Nordyke + Buskirk (1991) Buckmaster et al. (1999a)	Common in boreal and Montane forest across Canada; closely linked with moist, mossy, mature conifer forest; downed woody material very important for cover; feeds heavily on fungi (mushrooms) associated with decaying wood but also eats seeds, insects, berries; uses squirrel middens; key prey species.	Vole numbers can remain stable or increase in thinned stands; likely to decrease in stands that lose majority of moss cover to increased grass; will decline in burned areas; reduction in downed logs would reduce numbers.
Shrews Pearson (1999) Ferguson (2002)	Mostly associated with moist mature forest, mossy areas, riparian areas, dense ground cover; feed on insects	Mixed response to logging but more likely to decline; response to forest thinning is not clear.
Bushy-tailed woodrat or "packrat" (Pearson 1999)	Western provinces and states; active year-round; nocturnal; feed on leaves, fruits, needles, mushrooms, and seeds; build bulky nests in trees, roots, and outcrops - but have an uncanny ability to adapt to humans, buildings and Ford Mustangs; collect, cure, and cache food for later use; collect shiny objects.	Suitability for woodrats may decline if cavity nests, seed sources, brush –piles and human clutter around buildings in the interface were reduced.

The diversity and abundance of small mammals following moderate disturbance by fuel reduction will vary according to location, but can increase with measures that are carefully planned and implemented to preserve or enhance key habitat attributes. Their ability to reproduce rapidly, move about on the landscape, and reside in small habitat patches make small mammals well adapted to rebound or take advantage of changes in the forest resulting from fuel management actions.

Several species are highly adapted to open forests or small openings, and are easily accommodated by fuel management programs. A study in Banff National Park to assess thinning impacts (Ferguson 2002) predicted that 18 species of small mammals would increase, 3 remain unchanged, and 2 species decline as a result of fuel management. Increases in grasses and flowering plants after forest thinning quickly benefit species adapted to younger or more open forests like meadow voles, chipmunks, and ground squirrels. Choices to promote old forest characteristics (i.e., snags, legacy trees, logs) ensures habitat for species like red-backed voles, red squirrels, and flying squirrels that favour mature forests.

4.5.5 Bats

Table 4-9: Life requirements and potential effects of fuel management on bats.

SPECIES	LIFE REQUIREMENTS	POTENTIAL EFFECT OF FUEL MGMT
Bats in general Pearson (1999) Ferguson (2002) USFS (2005a)	Roost in flaking, loose, or cracked tree bark, tree cavities in the forest interior, and buildings; prefer to forage on forest edges, small openings, over ponds, roads, and trails where insects are abundant; aspen stands have the highest number of roosting sites; little and big brown bats are resident and hibernate in Canada; other species like hoary and long-eared bats migrate and spend their winters in more southern climates.	Very sensitive to disturbance of hibernation or maternity sites; removal of snags or trees with loose bark and openings for roosting would limit bats; populations of several species of bats are precarious.
Hoary Bat Heinrich et al. (1999)	Occur across Canada in boreal and south, winter in U.S. and Mexico; solitary; hunt insects above canopy or in open spaces; roost in tree branches, cavities, or under loose bark.	As above.

Loss of roosting sites is the most probable impact of fuel reduction on bats.

4.5.6 Carnivores

Table 4-10: Life requirements and potential effects of fuel management on carnivores.

SPECIES	LIFE REQUIREMENTS	POTENTIAL EFFECT OF FUEL MGMT
Weasel Ferguson (2002)	Coarse woody debris provides access to under-snow environments and cover for potential prey species; most common in regenerating forest and grassy areas suited to high prey densities; diverse understory.	Weasel abundance follows that of their small mammal prey. Numbers should remain stable or increase if residual trees and woody debris are provided.
American Marten Bull and Blumton (1999) Takats et al. (1999b) Ferguson (2002)	Scattered populations across Canada in boreal and Montane forests; prefer multi-layered, older forests but need interspersion with seral habitats; require significant amounts of surface debris; nest, rest, and shelter in cavities, hollow trees, brooms, middens, and uprooted trees; prey on small mammals but also use berries, nuts and carrion; active year round; forage beneath snow.	Reduced layering of forest, thinning of conifer overstory, and reduction of logs on forest floor will limit habitat suitability for marten and prey species. Hedges and ornamental shrubs can provide corridors and link habitats; mix of old and young seral stages would benefit marten.
Fisher Woodlot Assoc. of Sask. (1993)	Use closed canopy mature to oldgrowth and deciduous forests. Interspersion of types is important. Use cavities in live and dead trees and large down logs as den sites for rearing young.	Potential loss of den sites through removal of snags, cavity trees or large logs
Lynx Woodlot Assoc. of Sask. (1993)	Mixture of mature and successional habitats is optimal; coniferous forest with many seedlings and diverse understory vegetation attracts prey (hares).	Selective thinning may benefit lynx by encouraging new undergrowth and coniferous seedlings that support its major prey (hares).
Mink/Otter Woodlot Assoc. of Sask. (1993)	Open water; logs and deadfall in and adjacent to streams provide shelter and den sites; riparian travel routes foraging locations.	Removal of course woody debris in riparian areas can reduce habitat quality.
Black Bears	Logs and decaying trees provide forage micro-sites for ants, beetles, and other insects. Forage on roots, various forbs and berries. Prey on small mammals and newborn ungulates. Den in large hollow trees, ground.	Logging and thinning open the forest canopy and increase production of berries and other key food items; loss of hollow trees, snags, live decaying trees, windthrown trees with upturned roots will impact food sources and den/resting sites. Loss of riparian areas and wetland vegetation will impact bears.

The most probable impacts of fuel reduction to this group are the loss of food sources as an indirect result of reduction in habitat quality or feeding sites for prey species.

4.5.7 Ungulates

Table 4-11: Life requirements and potential effects of fuel management on ungulates.

SPECIES	LIFE REQUIREMENTS	POTENTIAL EFFECT OF FUEL MGMT
Ungulates in general Wishart et al. (1993) Gayton et al. (1995) Cook et al. (1998)	Openings with vigorous grass, forb, and shrub growth for grazing and browsing; Dense forest for security, reduced snow cover, easier foraging conditions and thermal cover in winter	Generally more abundant in young, regenerating forests following disturbance by fire or logging
Mule Deer Wood et al. (1999) USFS(2005a)	Found from B.C. to Manitoba in prairie, foothills, Montane, and subalpine habitats; mostly browse shrubs in fall/winter but forage much on grass and forbs in summer; adapt well to younger forest stages and presence of humans in interface.	Adaptability to prairies and preference for forest habitat with a 60/40 ratio of cover to forage make mule deer well suited to interface areas; forest thinning is likely to increase forage including grass, forbs, and shrubs.
Elk Buckmaster et al. (1999b) Woodlot Assoc. of Sask. (1993)	Range from southern B.C., across Alberta to boreal mixedwood of Sask. and Manitoba; highly adaptable species; primarily grazers they also browse in winter; feed freely in open within 200m. of cover; in winter elk use dense conifer, mixedwood, and shrubs 1-2m. for shelter but may also bed in open; adapt to presence of humans.	Thinning and thin/burn treatments that reverse forest encroachment and encourage grass, forb and shrub production and reduce the extent of dense continuous conifer forest will favor elk populations. Elk find refuge from major predators in and around interface communities; thin to favor mixedwood and aspen forests; leave thickets and downed trees for hiding calves preferred to conifer forest.
White-tailed Deer Gould et al. (1999) Woodlot Assoc. of Sask. (1993)	Found across Canada in grassland, parkland and boreal mixedwood; spring/summer diet mostly flowering plants, grasses; browse on deciduous trees and shrubs in winter; mostly inhabit forest edges to feed in open and seek cover in forest/shrubs; small conifer thickets are winter refuge; adapt well to agriculture human use.	A thinned canopy that promotes flowering plants would benefit white-tailed deer; significant reduction of local conifers would restrict thermal cover and perhaps reduce use; mixedwood types are optimal; increased forest/opening edges would benefit this species; protect riparian and corridor areas; provide thickets for thermal cover.

Overall, ungulates appear to be resilient to fuel management activities. Loss of thermal cover and hiding cover is a potential impact for some species.

4.5.8 Amphibians

Table 4-12: Life requirements and potential effects of fuel management on amphibians.

SPECIES	LIFE REQUIREMENTS	POTENTIAL EFFECT OF FUEL MGMT
Amphibians in General (Salamanders and Frogs) Ferguson (2002) K. Graham et al. (1977)	Deep or shallow ponds for egg and larval stage development; CWD not correlated to amphibian use	Compaction or drying of soils and deep litter layers due to forest thinning and understory removal would impact amphibians; subject to injury by mechanical operations during active season for amphibians.
Long-toed Salamander K. Graham et al. (1999) Ferguson (2002)	Found across B.C. and western Alberta in ponds, marshes and along watercourses; roam into forests mostly within 250m.of breeding ponds; feed on aquatic and land invertebrates; active at night; use clearcuts and forested areas equally.	Compaction or drying of soils and deep litter layers due to forest thinning and understory removal would impact amphibians; subject to injury by mechanical operations during active season for amphibians.

Compaction of soil, disturbance of deep duff and litter layers, and damage or removal of coarse woody debris - particularly in riparian or wetland sites are the most significant potential impacts to amphibious species in relation to fuel management. Due to the secretive nature of amphibians, it is advisable to seek local knowledge of amphibian populations and distribution to limit potential for adverse impacts.

4.6 Summary

The foregoing analysis provides a firm biological foundation to begin formulating modified fuel treatments to accommodate wildlife while managing vegetation in the wildland/urban interface for the primary objective of reducing wildfire risk.

CHAPTER 5. Results: Mitigations, Guidelines, and Modified Practices to Manage Interface Vegetation for Benefits to Wildlife.

Based on literature review, Chapter Five provides mitigations, practicable guidelines, and best practices for managing vegetation of the wildland/urban interface in ways that optimize conditions for wildlife. The chapter begins by identifying potential opportunities for accommodating wildlife, habitat attributes, and other resource values within the constraints of current fuel reduction (i.e., FireSmart®) standards. The potential to combine objectives for ecological restoration and fuel management is also explored. Closing sections propose species-specific mitigations for wildlife, practicable guidelines for optimizing wildlife conditions, and best practices for conducting fuel management with increased environmental sensitivity. These are designed for use by residents or by agencies in the wildland/urban interface.

5.1 Opportunities to Accommodate Wildlife and Habitat Attributes Within Current Fuel Management Standards.

Previous chapters of this research described fuel management standards, their potential effects on wildlife, and outlined the habitat requirements of a cross section of common interface wildlife species. By manipulating fuel characteristics such as total fuel load, horizontal and vertical arrangement of fuels, the size of fuels, or the chemical composition of fuels for the purpose of risk reduction, interface residents or agencies with jurisdiction are effectively managing wildlife habitat. This section conducts a step-wise examination of current fuel management standards for each forest stratum to identify opportunities that could reduce adverse impacts to for wildlife or habitat attributes, or result in improvements. FireSmart fuel management standards (Partners in Protection 2003) are the accepted national criterion and are the basis of this analysis. These standards were summarized in Tables 4-1, 4-2, and 4-3.

5.1.1 Opportunities for Wildlife in Management of the Forest Canopy

The forest canopy consists of live and dead trees >5 m tall, and is inclusive of dominant, co-dominant, intermediate, and suppressed or overtopped trees (Graham et al. 1999). Current fuel management standards for the tree canopy call for removal of coniferous trees (i.e., the canopy) from Priority Zone 1, with an allowance that "individual trees and shrubs may be kept if this vegetation would not readily transmit fire to the building". In Priority Zone 2, standards call for reduction (i.e., thinning) of the coniferous canopy cover to less than 40% cover with a minimum of three metres between crowns (four-metre separation of crowns is recommended for intermediate and suppressed trees), and pruning of lower branches to a minimum height of two metres. Following review of literature and on-site visits to a variety of fuel reduction projects, five general strategies were identified for managing the tree canopy in ways that could also benefit wildlife. The strategies are spacing of individual trees, cluster thinning, selective preservation of habitat trees, stand type conversion, and selection for prevention of windthrow.

Spacing of Individual Trees

Single-tree thinning is the selective removal of individual trees and is carried out by making conscious decisions to remove (or keep) particular trees to create more open space between the residual trees. From a fire behavior perspective, single-tree thinning is an effective means of breaking up the horizontal continuity of fuel and reducing crown bulk density. These actions reduce highly flammable stands to a less hazardous condition.

Because of the requirement for removal of all or most trees from Priority Zone 1, there is little opportunity for creative thinning. However, thinning can be used in Priority Zones 2 and 3 to great advantage, and is the primary treatment strategy for achieving a desired density, composition and/or structure of forest canopy. From an ecological perspective, thinning can be applied to:

1. Mimic the historical role of fire in stands that were periodically "cleaned" of surface fuels and coniferous regeneration by low intensity fires.
2. Restore the structure and species composition of fire-adapted forests to within their historical (natural) range of variability.
3. Optimize or enhance the amount of biological/structural diversity and promote essential wildlife habitat features within forest stands.
4. Accelerate the process of forest succession to establish seral stages that are more vigorous, longer lasting, and also suited wildlife.
5. Create conditions more conducive to restoring managed fire into wildland/urban interface ecosystems, thus perpetuating composition, structure, and functional elements essential to native fauna of all types.

There are several techniques (Graham et al. 1999) of forest thinning. Thinning from below (low thinning) is done by removing suppressed, intermediate or co-dominant trees while selectively retaining large (i.e., dominant and co-dominant) trees within a stand. Thinning from above (crown thinning) is achieved when some dominant and co-dominant trees are removed so that crowding is reduced and remaining trees in the same layers are favored. Selection thinning occurs when dominant trees are removed to favor smaller ones. Free thinning is a method directed toward "releasing" specific target trees (e.g. dominant veteran Douglas fir and lodgepole pine) from competition by removing many of the surrounding intermediate and suppressed trees. Each of these techniques can be adapted to provide benefits for wildlife and are incorporated into the guidelines.

Thinning programs often use measures of basal area, tree density, or distance between stems to guide tree spacing. However, in this study thinning objectives have been expressed in measures of "crown width". A crown width is the distance between the outer tips of the branches of an individual tree. For example if a tree were imagined as a vertical cylinder defined by its outer branch tips and the trunk at the center, the diameter of that cylinder is one crown width. Since trees vary in size and form, so do crown widths. Therefore, using this measure (e.g., thin to a spacing of three crown widths) recognizes the natural variability of forests and encourages diversity in the structure of treated stands, an essential element of wildlife habitat.

Cluster Thinning - Spacing Groups of Trees

Cluster thinning is the practice of leaving small groups, or clumps, of trees with interconnected crowns. It is an alternative to single-tree spacing, and a potential means of creating variation within the structure of interface forests for the benefit of wildlife. Cluster thinning is applicable to forest stands of all types. In cluster thinning, each group of trees is treated as though it is a single, very large diameter, tree and a correspondingly larger space cleared around it. Just as "crown width" is used as the measure when conducting single-tree thinning, one or more "cluster widths" are used as the measure of spacing between clumps of trees. The cluster thinning technique is most applicable to Priority Zones 2 and 3.

From an ecological perspective, the cluster thinning technique can be applied in many situations. Some examples are: to create or enhance forest openings; to increase the amount of forest edge habitat; to isolate and preserving groups of trees (i.e., patches of habitat) that have particular value to wildlife, but would otherwise be removed given fuel considerations alone; to provide wildlife cover in the vicinity of significant habitat features (e.g., squirrel middens, underground burrows or dens, drumming logs, seeps, etc.) and sustain or enhance their value to wildlife; to protect habitat trees from wind, and provide adjacent cover to increase their utility for nesting, roosting, or feeding; to provide shelter for younger shade-tolerant trees or protection from ungulate browsing or antler-rubbing until they reach maturity and; to retain more wind resistant groups of trees when thinning dense stands with narrow crowns.

Preservation of Habitat Trees

FireSmart standards call for the removal of "dead or dying trees with potential to ignite and carry fire", from Priority Zone 1. Obviously, recently dead coniferous trees with full crowns fall into this category and must be removed. However, deciduous snags and older coniferous snags that have shed their needles do not burn in a manner that contributes significantly to frontal fire intensity. Nor are they likely to cause direct flame impingement to structures more than 3-5 metres away since their ability to carry fire is limited to smoldering or ember spotting if hollowed out by flames. Therefore, selected habitat trees in these stages of decay should be retained for the benefit of wildlife.

Isolating a snag (i.e., vertically and horizontally) from adjacent fuels, or "topping" or "stubbing" the snag to reduce its height can reduce hazards associated with snags in Priority Zone 1, yet retain some of their wildlife attributes. Deciduous legacy trees are much less flammable, have greater habitat value relative to conifers, and are permissible within current standards. Retention of "broomed" conifers or coniferous legacy trees in Priority Zone 1 is not recommended due to their high flammability and concentrated fuel load.

In Priority Zones 2 and 3, current standards call for removal of "concentrations of dead and dying trees that have high potential to ignite and carry fire to the building". This provides considerable latitude for preserving occupied habitat trees, suitable unoccupied snags, and adequate numbers of legacy trees that will supply snags into the future. Although a large concentration of dead trees would be ideal to provide a flush of foraging opportunities for insectivorous birds, preserving one or more snags interspersed with live trees, or a small cluster of 3-5 snags would be an appropriate alternative.

Cluster thinning techniques have strong potential for protecting habitat trees from windthrow and encourage greater use by wildlife by providing a source of adjacent cover. Topping or "stubbing" of habitat trees is a good alternative to complete removal, if a dead or decaying habitat trees poses a safety hazard to people from falling, or occurs within striking distance of overhead electrical lines.

Stand Conversion

Stand conversion is the practice of selective cutting to favor one type or species of tree in the remaining stand. As an example, in the Jasper prototype study all or most of the coniferous trees were removed from mixedwood stands to restore ecologically scarce aspen stands and produce a stand more resistant to fire spread as encouraged by FireSmart standards. As another example, spruce and pine were heavily thinned in stands containing significant amounts of Douglas fir to restore disappearing "savannah-like" ecosites and allow for future use of prescribed fire to maintain ecological process and low fuel loads.

Prevention of Windthrow

In forests that have been subjected to fuel treatments, the residual trees are more susceptible to windthrow (Whitehead and Brown 1997). Excessive windthrow can negate some of the intended fire protection benefits by adding to surface fuel loads, and also significantly impact the wildlife, habitat, and aesthetic values of the resultant forest. Within the limitations of FireSmart standards, there is an opportunity to merge knowledge from literature and existing silvicultural guidelines, so that more windfirm trees are retained and windthrow is reduced. These criteria are applicable throughout the interface and are included into guidelines presented in section 5.5.5.

5.1.2 <u>Opportunities for Wildlife in Management of Shrubs</u>

Current fire prevention standards differentiate between coniferous and deciduous forest shrubs. Given the importance of shrubs for wildlife cover and forage, it is important to identify options for retaining shrubbery, but within the constraints of FireSmart standards.

Coniferous Regeneration

FireSmart standards leave little latitude for retention of young conifer trees or shrubs (e.g., native junipers or ornamental species) in Priority Zone 1. However, landowners frequently insist on preserving a particular young conifer or "feature" shrubs because of values other than fire protection. This implies accepting more risk, but also provides wildlife habitat that is otherwise absent from Priority Zone 1. In cases such as this, clearance from the structure should be maximized, distance from nearest conifers in Priority Zone 2 increased, and a means of removing the tree in the event of an emergency established.

In Priority Zones 2 and 3, regeneration can be preserved by adapting various methods of single-tree and cluster thinning to this lower, but highly combustible, forest layer. These techniques can be used to separate particular young conifers (horizontally and vertically) from larger trees, but allowing some of them to grow into the forest canopy as replacement trees. By managing coniferous regeneration in this way, habitat benefits for many species can be sustained over a long period of time.

Deciduous Shrubs

Due to their low flammability, deciduous shrubs are much less stringently regulated by FireSmart standards. Deciduous shrubs can be managed individually, or clumped with other classes of plants to serve multiple habitat, forage, and aesthetic objectives; the flexibility to do this varies according to Priority Zone with increasing flexibility as distance from structures increase.

Dwarf Shrubs

Guidelines specific to management of dwarf shrubs (i.e., woody stemmed plants usually <25 cm in height at maturity) are not specifically provided in FireSmart standards. However, they are common elements of Montane and foothills forests. Examples include bearberry (*Arctostaphylos sp.*), twin flower (*Linnea borealis*), blueberry (*Vaccinium sp*.), and various other plants of the heath (*Ericaceae*) family. Dwarf shrubs have significant value to wildlife as year round cover and forage, and the fire behavior associated with them is distinctly less than for other shrub species.

5.1.3 Opportunities for Wildlife in Management of Low Vegetation

In Priority Zone 1, FireSmart standards call for grassed areas to be watered, and mowed to a height of 10 cm or less. Herbaceous plants are to be selected for fire-resistant qualities (e.g., low fuel volume, low growing habit, and high moisture content). No standards are established for Priority Zones 2 and 3.

Within Priority Zone 1 there are opportunities to manage low vegetation to maintain or enhance habitat quality and provide forage requirements for wildlife by using native species, carefully isolating small islands of low vegetation that will not burn intensely (i.e., with long flame lengths), and electing to retain or plant vegetation with fire-resistant qualities as noted in FireSmart. Given the absence of restrictive standards in Priority Zones 2 and 3, managers and residents are free to exercise a wide range of options to encourage native biodiversity in terms of low vegetation species and spatial arrangements to benefit wildlife. Measures to prevent introduction and spread of aggressive non-native species are warranted.

5.1.4 Opportunities for Wildlife in Management of Woody Fuels

FireSmart standards suggest removal of fine and coarse woody debris in Priority Zone 1. No prescriptive standards apply within Priority Zones 2 and 3, however hazard assessment ratings imply limitations on the continuity of fine woody fuels.

Coarse Woody Debris

Given the slow burning rate of coarse woody debris (i.e., smoldering combustion) coupled with its exceptional importance to wildlife and ecological function, it is logical to seek opportunities for safely retaining some its benefits. Isolating large logs from all other fuels, ensuring that they are adequately separated from structures to prevent convective heat transfer, and periodic watering are measures that will allow exceptionally valuable logs to be retained in Priority Zone 1. As distance from values at risk increases in Priority Zones 2 and 3, proportionally less risk accrues from coarse woody debris. Therefore, large logs in all stages of decay should be retained to benefit wildlife.

Fine and Medium Woody Debris

Fine and medium woody debris (material <7.5 cm in diameter) dries quickly, and combusts fiercely. There is little or no flexibility to include it in Priority Zone 1 however, in Priority Zones 2 and 3 there is tolerance for scattered woody debris or isolated, small accumulations. This offers many options for managing it to the advantage of wildlife. For instance, it may be re-arranged, supplemented, diversified in size, and accumulated in isolated brush piles.

5.2 Combining Forest Management Practices for Wildfire Protection with Actions to Restore Ecological Conditions

Individually, the concepts of proper fuel management and ecological restoration are well established, but they are frequently managed in isolation from each other (Omi and Joyce 2003). Given the success in finding opportunities for accommodating wildlife and habitat needs concurrent with fuel objectives (i.e., section 5.1), it seems reasonable to also investigate the potential for achieving additional resource management goals, such as ecological restoration, when planning and implementing measures for community wildfire protection.

Firstly, as described in Chapters One and Three, there is a strong similarity between the physical symptoms of ecological problems (i.e., forest in-growth, forest encroachment, and replacement of deciduous species by conifers) and fire protection problems (i.e., hazardous fuel accumulations). Both problems stem from the dynamic nature of forests, and exhibit themselves as continuous, closed canopy forests.

Second, there is a significant spatial overlap in the location of areas that could benefit from restoration of ecological conditions and the wildland/urban interface. This is because there is a propensity for rural residential development to expand into biological "hotspots" that coincide with lower elevation, moderate climate, good soils, and low or mixed intensity fire regimes (Duke et al. 2003). The analysis in Chapter One demonstrated the overlapping nature of this problem within the study area, in other locations elsewhere in the Canadian Rocky Mountains and foothills, and in the western United States.

Third, numerous authors have advocated that fuel management and ecosystem management solutions can be complementary (Arno and Wakimoto 1987, Covington and Moore 1994, Fule at al. 2001, Brown 2002). As well, Parks Canada policy guidance (2000a, 2002, 2003) supports a concurrent approach to ecosystem restoration and fire management.

Finally, there are numerous precedents and justifications for integrated management approaches of this type. For example, Rodewald and Yahner (2000) pointed out other models in the forest industry that demonstrate how innovative approaches which retain structural forest components can produce benefits for wildlife, as well as meeting forestry objectives. Haufler et al. (2002) also emphasized that to manage landscapes in a sustainable[1] way requires that social, economic, and ecological goals be successfully integrated.

Based on this, I suggest that there are strong links between the ecological and fire protection issues at the wildland/urban interface and also substantial overlaps in the physical measures required to resolve them. That is, by selectively thinning the forest canopy to restore the structure and composition of forest stands and the heterogeneity of landscapes (in certain fire regimes) to within their historic (natural) ranges of variability, the effect on forest fuels and fire behavior is to further reduce wildfire risk. Therefore, measures to restore ecological conditions have been included in this endeavor to develop ecologically based fuel management approaches and tested in the prototype Jasper project.

5.3 Species-specific Actions to Mitigate the Effects of Fuel Management on Wildlife in the Wildland/Urban Interface.

5.3.1 Introduction

Specific mitigations to reduce adverse effects of fuel management on a variety of wildlife species common to the wildland/urban interface, and/or to provide benefits to them are outlined in this section. The species-specific mitigations presented here are the final result of adaptively testing, implementing, and refining preliminary versions in the Jasper prototype fuel management project between November 2003 and October 2005, as described in Chapter Six. These mitigations are summarized in table format, grouped by species with similar habits and life requirements. Within each table, key habitat requirements for each species are noted, then a list of practicable mitigations is provided in column three.

[1] Sustainable use as defined by Haufler et al. (2002) is possible only where the three spheres of ecosystem management (i.e., social, ecological , and economic) intersect.

5.3.2 Primary Cavity Excavators

Table 5-1: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for primary cavity nesters.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS TO MINIMIZE IMPACT OR OBTAIN BENEFITS
Pileated Woodpecker	Widespread but relatively uncommon year round resident of most Canadian forests; has a large territory; needs large (minimum 33 cm Diameter) snags or live trees with decay for excavating nests and roosts; ants and insects in trees and logs are main year round food; uses live hollow or decaying trees for drumming; attracted to sheltered clumps of dead trees and downed logs.	Retain a mix of forest ages and types in the region; retain 12-15 snags and 12-15 living trees with decay (legacy trees) per hectare of all diameters, species and sizes with bias towards large diameter (>33 cm) trees; broken-top trees most important; use cluster thinning technique to retain cover adjacent habitat trees; retain trees infested with ants/insects; retain up to 50 logs/hectare on ground (longer and larger is better) and extra snags for forage and future logs; keep tall stumps of all sizes; survey areas for active use by woodpeckers first.
Hairy woodpecker Three-toed woodpecker	Permanent residents of North American boreal and Montane forest; prefer older conifer forest - use mixedwood and deciduous forest too; feed mostly by gleaning or chipping bark for beetles and probing or drilling for wood-boring insects on snags, live trees, or logs; often use harvested forests; excavate 3 separate cavities each year to nest, roost and winter in trees >20 cm diameter; prefer dense canopy but use edges and open forest.	Preserve snags as above; retain stubs (70% of nests found here), live trees with decay and, future re-placement trees; retain habitat trees in clumps with living trees for cover to encourage use; select to favor aspen and poplar species; protect or enhance log numbers and some course debris from thinning; retain un-thinned forest beyond interface zone nearby; retain small diameter dead and dying trees for foraging insects.
Downy Woodpecker	Year-round resident of most N. American forests; glean insects from tree/log surface and digging into the bark; 25% of food is berries, seeds, nuts; weak excavators, require advanced decayed wood; construct 2-4 cavities per pair/year; use deciduous and nearly mature to mature conifer forest; prefer live broken-topped nest trees.	Preserve snags as above; include >12 snags/ hectare of 15-25 cm dbh for nesting, feeding, reserve; leave adjacent cover trees; leave logs and coarse woody debris for feeding; manage for mix of forest types and densities adjacent to interface fuel zones; protect or promote shrubby understory, berry producing shrubs, mast; manually or mechanically top trees to create "stub" habitat trees.

5.3.3 Songbirds - Landbirds

Table 5-2: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for songbirds - landbirds.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS MINIMIZE IMPACT OR OBTAIN BENEFITS
Brown Creeper[2]	Widely distributed North American species; prefers old or mature forests; feeds on conifers and large snags with nearby cover by gleaning insects and spiders; nest in loose bark or cavities of snags or dying trees.	Retain snags, legacy trees, cavity trees, and live trees with loose bark; retain cover trees and shrub patches surrounding snags and small groups of mature trees using cluster thinning methods; retain mature un-thinned forests adjacent interface areas as possible.
Yellow Warbler	A widespread insect-feeding songbird; strong preference for wetter, shrubby areas and edges of wetlands or watercourses; nests in shrubs >1m; avoids conifer forest.	Retain deciduous shrubs adjacent water bodies and wetlands; preserve thickets of tall shrubs within forests; retain deciduous hedges away from buildings; protect aspen and cottonwood.
Warbling vireo	Common songbird of riparian and harvested forest across N. Amer; often found in mature aspen; linked to shrub cover/edges; does well in conifer forest; feeds on insects, spiders, berries; nests in open.	Retain or promote tall deciduous shrubs, aspen sapling areas, and aspen/deciduous forest; maximize forest edge; retain conifer forest regionally.
Mountain Chickadee [2]	Common songbird of most Rocky Mountain forests; cavity nesters that use cavities in trees and rotting stumps; generalist food habits; adapts to urban areas; abounds in aspen.	Favor chickadees by retaining snags of all sizes and decay stages, tall stumps, insect attacked trees; retain aspen and poplars when selection thinning; easily attracted to feeders; manage for edge and clusters that provide protection from wind.
Black-capped Chickadee [2]	Common year-round resident Canada-wide; feed by gleaning insects and insect eggs from bark, twigs, boles, and foliage of trees and shrubs from ground to crowns; seeds, berries augment diet; can excavate own nests in rotting wood or use existing cavities or hollow trees; short stubs are important nest sites; select nest trees down to 10cm. diameter, often in open areas; roost in cavities or dense conifers out of wind.	Retain or create a variety of dead or dying trees of different diameters and species for nesting and foraging; preserve broken- topped trees – even short stubs; thinning will encourage seed sources from native flowering plants and berry production; augment these with planted landscapes around home and/or bird feeders; preserve shelter around habitat trees and small clusters of conifers for roosting out of the wind and rain.
Red-breasted Nuthatch [2]	Very common in western conifer forests at low elev.; prefers older forest but found in all forest types; cavity nester; feeds on insects.	Retain habitat and feeding trees of all types and sizes down to 8 cm diameter; preserve known nesting sites; preserve broken- topped trees – even short stubs; thinning will encourage seed sources from native flowering plants and berry production; augment these with planted landscapes around home and/or bird feeders.

[2] Secondary cavity nesters are species of birds and mammals that require pre-made nesting, resting, or roosting chambers in living or dead trees, but cannot excavate these chambers themselves. They include tree swallows, wrens, robins, bluebirds, purple martins, Vaux's swifts, chickadees, wood ducks, bufflehead, nuthatches, golden eye, mergansers, kestrels, squirrels, some owls, and many others (Bull and others 1997). While only a few of these are noted in the tables, observing the guidelines should benefit this entire group of species.

Golden-crowned Kinglet	Summer resident found across Canada; gleans insects and insect eggs from foliage of tall conifers and hovers to catch insects on the wing; active in the forest canopy about 10m. up; strong preference for conifers (spruce and fir) but also inhabit mixedwood stands; feed in groups.	Retain scattered mature conifers in mixedwood when converting these to higher % deciduous for fire protection purposes. Retain mature conifer individually, and in clumps with cluster thinning. Retain dense conifer patches regionally, outside of interface zone.
Ruffed Grouse	The most common woodland grouse; found across Canada; year-round resident of aspen/mixedwood forest; uses ground, shrub, and tree layers for food and cover; feeds on buds, twigs, flowering plants, berries, insects; winter reliance on aspen buds, catkins; thrives soon after fire or logging; uses logs for drumming displays; nests on the ground.	Retain aspen of all ages and encourage suckering; preserve and provide 18 – 30 cm drumming logs; retain or encourage deciduous shrubs with berries; retain smaller logs for nesting cover and to shelter chicks; scattered conifer regeneration will provide good shelter for grouse on the forest floor; protect deciduous shrub understory.

5.3.4 Raptors

Table 5-3: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for raptors.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS TO MINIMIZE IMPACT OR OBTAIN BENEFITS
Boreal Owl[2]	Nocturnal secondary cavity nester found across Canada; feed on red-backed voles, deer mice, shrews, other small mammals, and birds hunted from low perches; need a mix of closed mature conifer and deciduous forest, and clearings; nest in existing cavities in trees 25-38+cm diameter; preference for open understory, multiple layer forest.	Mark and retain all cavity trees and provide large trees for snag replacement. Favor red-backed voles (see notes) and preserve middens used by nocturnal small mammals. Leave large diameter trees in clusters.
Great Horned Owl	Platform nesters. Use brooms and platforms built by goshawks, red-tailed hawks. Hunt on forest edges. Like semi-open areas for nesting, close to dense forest. In forests, prefer to hunt near logs for small mammals.	Leave large, broken topped trees, mistletoe clumps; build artificial platforms; favor voles, edges, and openings; retain perching trees with adjacent openings for hunting.
Northern Goshawk	Occur across Canada; may remain year-round or migrate; feed on small mammals (90%) and birds; sensitive to human presence; strong preference for very dense, mature/old mixedwood forest with high % deciduous and open understory; require large territory; build platform nest high in the canopy; conifers near nest tree offer important shelter.	If goshawks are present in interface deciduous forests do not remove conifers adjacent nest site; similarly protect other potential nest sites (up to 6 required per territory); thin understory conifers saplings to retain deciduous dominance and keep sight lines open for hunting; retain snags and coarse woody debris; manage for small mammal prey.
Cooper's + Sharp-Shinned Hawks	Secretive summer resident of woodlands + riparian forest; nest on high platform or in brooms, crux of branches, horizontal branches of conifer near bole; woodland hunters of birds/small mammals in open/closed forest; prefer dense deciduous forest.	Retain deciduous and mixedwood forests; favor habitat for prey species; protect platform nests and potential sites (broken tops and brooms); minimize human disturbance.

Great Gray Owl	Widespread in Canada from B.C. to Quebec but low in numbers; year-round residents; prey mostly on mice, voles, shrews, other small mammals; hunt from perches in or near forest openings, fields, bogs; require hunting areas with low tree density; prefer mature conifer, mixedwood forest; cannot build own nests, take over raptor stick nests or nests on top of broken trees (aspen, poplar, conifer); nest in variety of forest densities; leaning trees critical for young to climb back to forest canopy.	Preserve all existing raptor stick (platform) nests and broken-topped trees that have potential for nest building by raptors; retain snags with leaning trees anchored to them as ramps for unfledged owls to climb back to safety; utilize suggested measures for encouraging small mammal populations (below); use cluster thinning methods to provide sound shelter trees adjacent to nest or potential nest trees; retain a variety of perching trees.

5.3.5 Small Mammals

Table 5-4: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for small mammals.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS TO MINIMIZE IMPACT OR OBTAIN BENEFITS
Snowshoe Hare	Key prey species common across N. Amer. in boreal, mountain, deciduous forests; active after dark; depend on dense understory (<2 m) cover as most important habitat factor; prefer young to mature conifer forest but also use hardwood and mixedwood forest; browse on buds, woody stems, bark, needles in winter; forage on grass and flowering plants, twigs in summer; use open areas more in summer; brush piles beneficial for cover.	Protect, promote, or plant deciduous shrubs; manage for scattered individuals or thickets of coniferous regeneration <.75 m for winter forage but separate these from nearby conifers; encourage deciduous tree species or push mixedwood forest towards high (>75%) deciduous cover; be tolerant of winter browsing on ornamental shrubs.
Red Squirrel [2]	Found across Canada; prefers mature dense conifer forest but found in mixedwood and hardwood forests; active in daytime; they are key prey species for raptors and some predators; live in the forest canopy; feeds on berries, insects, eggs, rodents, carrion, berries, and fungi but depends on stored cones and seeds of evergreens in winter; also feeds on twigs infected by mistletoe; nest in cavities, branches, underground.	Retain mixture of conifer species and ages; cone bearing individuals are critical; spruce more nutritious than pine; protect middens (food caches); retain current and potential cavity trees/perching sites; leave trees in clumps for cover and access; preserve some upper “brooms” if mistletoe is present; preserve network of logs (~50 per hectare) of various size, vertical structure – leaning snags.
Northern Flying Squirrel [2]	Occur across Canada; nest in large natural or woodpecker cavities and brooms; prefer live trees to nest; linked to older forest; prefer coniferous forest but also use mixedwood and hardwood forests; nocturnal; forage mainly on forest fungi but use lichens, berries, seeds, insects; use 2-4 nests each year.	Retain characteristics of old growth forest during thinning such as large diameter cavity trees, snags, and live trees with decay for nest sites, and trees with decay, coarse woody debris and moist micro-sites that produce fungi for forage; use cluster thinning methods to meet these objectives; if present, leave some mistletoe brooms close to tree trunks.

Columbian and Golden-Mantled Ground Squirrels	Rocky mountain/foothills species; ranges from dry low elevation open forest to sub-alpine meadows; Columbian lives in colonies and prefer grasslands/meadows; both species live and "hibernate" in long underground burrows where they store seeds, fruit, bulbs; also eat green plants, insects, fungi; GM den near or under tree or logs and use rocky outcrops.	Creating open grassy areas will encourage Columbian ground squirrels; open forests with large logs and woody debris increase potential for golden-mantled; retain or enhance the diversity of grasses, flowers, and berry or nut producing shrubs and ground covers; use native plant species for landscaping.
Deer Mouse and White-footed Mouse	Two of the most common and widely dispersed small mammal habitat generalists in north America; active year-round; mostly nocturnal; prefer young dry forest types but also found in moister old forests, brushy and riparian sites, and prairies; feed on seeds, berries, insects, fungi; nest in cavities in logs, trees, squirrel middens, likes shrubby micro-sites. Key food sources for raptors and many carnivores.	Retain coarse woody debris (~50 per hectare) of various sizes and decay classes, connected logs best; preserve cavity and legacy trees; where appropriate, allow for small brush piles; preserve squirrel middens; increased hiding cover provided by the surge of grasses and herbs that follow thinning will likely increase their populations.
Chipmunks[2] (eastern, least, yellow-pine, red-tailed, Townsend's)	Several species dispersed across N. American forests; live in underground burrows or tree cavities; active during day; "hibernate" with short waking periods in winter; depend on low vegetation, woody debris, rocky areas for cover; prefer young forest and edges as habitat; associated with gaps and openings in moist or dry forest; climb shrubs and trees for seeds, berries; forage on conifers seeds, grass, flowers, insects and fungus (mushrooms).	Retain understory vegetation and coarse woody debris; preserve habitat trees; enhance property with native berry producing shrubs and rockeries; promote diverse species of plants and mix of open and closed forest canopy.
Meadow Vole	A dominant species in grasslands and open forests with grassy understories; numbers increase with grass density; downed woody material aids cover; feed mostly on grass, flowers, and shrubs – less on seeds and insects.	Manage to favor edge and open, sunny sites; retain understory vegetation and variety of coarse woody debris; enhance property with native berry producing shrubs and rockeries; promote diverse species of plants and favor grasses.
Red-backed Vole	Common in boreal and Montane forest across Canada; closely linked with moist, mossy, mature conifer forest; downed woody material very important for cover; feeds heavily on fungi (mushrooms) associated with decaying wood but also eats seeds, insects, berries; uses squirrel middens; key prey species.	Leave abundant coarse woody debris, large logs, small brush piles, and decaying matter to foster fungus foods and provide shelter and moisture; use cluster thinning and protect shrubby understory to preserve pockets of dense forest and shaded sites; limit thinning in moist forest areas where possible; protect squirrel middens.
Shrews	Mostly associated with moist mature forest, mossy areas, riparian areas, dense ground cover; feed on insects	Retain moist micro-sites and pockets of denser forest with complex understory if possible. Shrews will persist in adjacent closed forest.
Bushy-tailed woodrat [2]	Western provinces and states; active year-round; nocturnal; feed on leaves, fruits, needles, mushrooms, and seeds; builds bulky nests in trees, roots, crevices, and outcrops; have uncanny ability to adapt to humans, buildings and Ford Mustangs; collects, cures, and caches food for later use.	Retain cavity trees and large diameter snags with cavity potential; preserve coarse woody debris and brush piles as appropriate to fuel considerations; preserve caves, rocky crevices, or boulder piles; be tolerant of mischief if buildings or vehicles left accessible.

5.3.6 Bats

Table 5-5: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for bats.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS TO MINIMIZE IMPACT OR OBTAIN BENEFITS
Bats in general [2]	Roost in flaking, loose, or cracked tree bark, tree cavities in the forest interior, and buildings; prefer to forage on forest edges, small openings, over ponds, roads, and trails where insects are abundant; aspen stands have the highest number of roosting sites; little and big brown bats are resident and hibernate in Canada; other species like hoary and long-eared bats migrate and spend their winters in more southern climates.	Retain characteristics of older forest like dead and dying trees, especially large trees with cracks, hollows or loose bark for day roosting; preserve roosting sites in buildings, augment with artificial roosting sites; retain a mix of tree species and provide open areas and water bodies with good flight-paths for hunting insects.
Hoary Bat [2]	Occur across Canada in boreal and south, winter in U.S. and Mexico; solitary; hunt insects above canopy or in open spaces; roost in tree branches, cavities, or under loose bark.	As above.

5.3.7 Carnivores

Providing conditions suitable for abundant prey, and habitat features that allow freedom of movement within the interface are key actions that benefit predators.

Table 5-6: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for carnivores.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS TO MINIMIZE IMPACT OR OBTAIN BENEFITS
Weasel	Coarse woody debris provides access to under-snow environments and cover for potential prey species; most common in regenerating forest and grassy areas suited to prey species, residual trees.	Leave abundant coarse woody debris, large logs, and small brush piles where possible to foster abundant prey and provide cover. Leave protruding debris to provide access routes and under-snow travel routes in winter; use cluster thinning and protect shrubby understory to preserve pockets of dense forest and shaded sites; protect squirrel middens.
American Marten [2]	Scattered populations across Canada in boreal and Montane forests; prefer multi-layered, older forests; require significant amounts of surface debris; nest, rest, and shelter in cavities, hollow trees, brooms, middens, and uprooted trees; prey on small mammals but also use berries, nuts and carrion; active year round; forage beneath snow.	Retain complex vertical layers and horizontal forest structure as much as possible; protect existing cavity trees and provide legacy trees to replace them in future; leave up to 50 large logs/hectare to favor prey species and under-snow access; retain variety of forest densities and squirrel middens using cluster thinning techniques; retain conifer “brooms”; provide dense conifer patches in the landscape – beyond the interface zone.
Fisher [2]	Use cavities in live and dead trees and large down logs as den sites for rearing young.	Same as for marten. Large diameter snags are particularly important.

Lynx	Year round resident of coniferous forest; forests with many seedlings attract prey (hares).	Manage the forest understory to provide coniferous seedlings, shrubs and herbaceous plants that provide food and cover for major prey species (snowshoe hares).
Mink/Otter	Logs in and adjacent to streams provide shelter, travel routes foraging locations. Feed on small mammals, aquatic fauna and fish.	Protect vegetation and woody debris along stream edges and other riparian/moist areas. Manage for small mammals that provide food sources.
Black Bears	Logs and decaying trees provide forage micro-sites for ants, beetles, and other insects. Forage on roots, various forbs and berries. Prey on small mammals, newborn ungulates. May den in large hollow trees, ground, under uprooted trees.	Manage the forest canopy to provide a range of micro-sites and the understory to provide a variety of plant foods and berries. Retain large woody debris and decaying trees that are insect sources. Open understory improves visibility and helps avoid bear/human conflicts.

5.3.8 Ungulates

Table 5-7: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for ungulates.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS TO MINIMIZE IMPACT OR OBTAIN BENEFITS
Mule Deer	Found from B.C. to Manitoba in prairie, foothills, Montane, and subalpine habitats; mostly browse shrubs in fall/winter but forage much on grass and forbs in summer; adapt well to younger forest stages and presence of humans in interface.	Well planned fuel treatments provide a good mix of forest types, edge, and openings; retain deciduous understory shrubs for winter browse; retain thickets of young conifer (remove overtopping conifers) and clusters of mature trees as appropriate for shelter and hiding cover.
Elk	Range from southern B.C., across Alberta to boreal mixedwood of Sask. and Manitoba; highly adaptable species; primarily grazers they also browse in winter; feed freely in open within 200 m of cover; in winter elk use dense conifer, mixedwood, and shrubs 1-2 m for shelter but may also bed in open; adapt quickly to the presence of humans.	Fuel treatments should provide a good mix of forest types, edge, and openings; retain deciduous understory shrubs for winter browse; retain thickets of young conifer (remove overtopping conifers) and clusters of mature trees as appropriate for shelter and hiding cover; retain logs, deadfall, and thickets - important sites to hide newborn calves when cows leave to feed.
White-tailed Deer	Found across Canada in grassland, parkland and boreal mixedwood; spring/summer diet mostly flowering plants, grasses; browse on deciduous trees and shrubs in winter; mostly inhabit forest edges to feed in open and seek cover in forest/shrubs; small conifer thickets are winter refuge.	Interface and intermix areas can provide forest edge favorable to white-tailed deer; encourage and preserve deciduous shrubs and aspen during thinning; open canopy will increase summer forage availability; preserve thickets of coniferous saplings in deciduous or mixedwood forest for cover (remove conifers that overtop thickets to reduce fire potential).

5.3.9 Amphibians

Table 5-8: Habitat requirements and mitigations to minimize impacts of fuel management or obtain benefits for amphibians.

SPECIES	HABITAT REQUIREMENTS	MITIGATIONS TO MINIMIZE IMPACT OR OBTAIN BENEFITS
Amphibians in General (Graham 1977)	Deep or shallow ponds for egg and larval stage development; CWD not correlated to amphibian use	Leave undisturbed buffer zones around aquatic areas and seeps; retain deep litter close to breeding ponds; protect large, well-decayed logs and ensure a long-term supply of coarse woody debris in stages of early decay; undertake machine-aided thinning in winter when soil is frozen and resistant to compaction.
Long-toed Salamander	Found across B.C. and western Alberta in ponds, marshes and along watercourses; roam into forests mostly within 250m of breeding ponds; feed on aquatic and land invertebrates; active at night; use clearcuts and forested areas equally.	Same as above

5.4 Ecosystem Based Fuel Management Guidelines for Wildlife – by Priority Zone and Fuel Bed Strata

5.4.1 Introduction

The following section presents guidelines for incorporating wildlife habitat attributes and the needs of wildlife into current standards for fuel management in the wildland/urban interface. The guidelines integrate information gathered in previous phases of the study. They are the final result of adaptively testing, implementing, and refining preliminary versions in the Jasper prototype fuel management project between November 2003 and October 2005, as described in Chapter Six. These guidelines are presented in accord with interface "Priority Zones"(Figure 1-1) established by Partners in Protection (2003) and by fuel bed strata beginning with the forest canopy. The guidelines respect the over-riding principle that FireSmart® standards for fuel management be followed.

5.4.2 Guidelines for Priority Zone 1: Within 10 Metres of a Home or Structure.

The fuel management goal in Priority Zone 1 "is to create a fuel modified area in which flammable vegetation surrounding buildings is eliminated or converted to less flammable species" (Partners in Protection 2003). Within the limitations placed by this goal, there are significant prospects to realize wildlife benefits or reduce potentially adverse impacts of fuel management activities on habitat.

Guidelines for Live Trees

Although standards for tree removal in Priority Zone 1 are strict, there are still opportunities for maintaining wildlife benefits:

- Retain existing deciduous trees. They present less fire hazard than coniferous trees and provide important seasonal habitat for birds and wildlife.
- Embark on a long-term strategy to establish deciduous trees in this zone, if the pre-treatment forest was entirely or predominantly coniferous.
- Consider "topping" one or more of the larger coniferous trees by removing most of the live crown to create a wildlife snag for future occupancy by wildlife, as an alternative to removing all conifers.
- In cases where owners or agencies wish to apply discretion (i.e., accept more risk) to preserve one or more mature coniferous "feature" trees (e.g., habitat trees, shade trees, or "pet" trees):
    - Plan a practical strategy for removing these trees if an emergency wildfire situation develops.
    - Prune lower branches of these trees to at least 2 m to reduce ignition potential.
    - Clear away all flammable surface material and needle accumulations more than 2 cm deep from beneath the tree crown.
    - Establish a space of at least 3 crown widths to separate feature trees from their nearest conifer neighbors.

Guidelines for Snags

- Retain snags that are located at least two metres from the nearest live conifer to attract species adapted to nesting in the open (e.g., bluebirds, American Kestrels, or Lewis' woodpecker).
- Ensure that any snag retained in this zone is located beyond striking distance of structures, have a natural lean away from the home, or is independently anchored to prevent consequences if it does fall.
- Remove all surface fuels at the base of snags to prevent surface fire from digging into the snag, or establish green lawn or other inflammable landscaping options at the tree base.
- Check snags annually to monitor stability as their roots gradually decay and the probability of falling increases.

Guidelines for Habitat Trees (trees with nests)

- Retain stable deciduous trees with cavities or nests.
- "Top" living coniferous trees with cavities or shorten them into tall stumps (i.e. 2-8 metres) to preserve the cavity.
- Defer tree removal until the nest is unoccupied.

Guidelines for Shrubs

In accord with existing standards, shrubs are acceptable in this zone but should be <u>deciduous</u> rather than coniferous; planted singly or in small groups rather than in large masses; low versus tall shrubs; and open-crowned as opposed to shrubs with bulky crowns. Additional guidelines for wildlife are:

- Promote or transplant native shrub species in preference to introduced ornamentals in order to maximize benefits for wildlife. A variety of native shrubs is best.
- Retain or transplant native species of fruit, berry, or nut-bearing shrubs in preference to species without.

- Encourage native shrubs that provide nutritious winter browse to wildlife (e.g., saskatoon, aspen, chokecherry, pin cherry, red-osier dogwood, and willow). Browsing by wildlife checks fuel amounts and reduces the amount of upkeep required by owners.
- Establish low-growing shrubs to provide better three-season shelter for songbirds, but locate them away from structures and adjacent tall vegetation so they unlikely to become fuel "ladders".
- Incorporate small shrubs into flowerbeds and rockeries to increase the diversity of habitat available and make it easier for smaller wildlife and birds to move about their habitat.
- Locate junipers or cedar shrubs at the outer edge of Priority Zone 1, if any are retained at all. These should be pruned back to a diameter/height of less than 1.5 m, thinned in terms of bulk, and organic litter cleaned from beneath them.

Guidelines for Ground Cover Plants

Ground cover plants include many types of low-growing annual or perennial flowers and dwarf shrubs. They are considered fire resistant and acceptable in Zone 1, but should not be located within 1 to 2 m of a structure. To optimize wildlife benefits:

- Plant a variety of fire resistant ground cover species in individual clumps to add habitat diversity, sheltering opportunities, varied insect habitat, and varied sources of forage for wildlife.
- Locate dense, matt-forming ground covers (e.g. perennials or dwarf shrubs) in open locations well away from structures to provide shade for small animals. These also hold in moisture to reduce flammability and deter weeds that contribute to combustible biomass.
- Include perennial dwarf shrubs and evergreen herbs since these ground covers provide year-round wildlife benefits.

- Combine ground covers with deciduous shrubs and wildflowers to create "wild islands" of shelter and linear strips of habitat that help smaller wildlife and birds navigate through interface communities; habitat islands and strips must be located away from structures and isolated by watered lawns or other inflammable landscaping.

Guidelines for Grasses and Forbs

Grasses and flowering plants should be well watered during the growing season, and grasses cropped as they cure to prevent fire spread and reduce hazards. Additional guidelines for wildlife are:

- Plant or transplant native wildflower species in preference to introduced bedding plants.
- Do not allow weeds to colonize landscaped areas in the wildland/urban interface since they detract from wildlife habitat values and add hazardous fuels around homes.
- Plant forbs or wildflowers in isolated patches or together with shrubs and/or low ground covers to create "wild islands" that encourage wildlife but limit fuel continuity.
- Maintain lawns but use inflammable landscaping materials or walkways to separate them from buildings and other structures.
- Include tall herbs and vines in the wildland/urban interface landscape but not within Priority Zone 1.

Guidelines for Fine and Medium Woody Debris

Scattering of small branches is <u>not</u> advised in Priority Zone 1. Therefore plan to remove all fine and medium fuel that exists, or is created during fuel treatments.

The following guidelines will limit adverse environmental impacts regarding disposal of fine and medium woody debris:

- Burn woody debris in preference to chipping or scattering methods. Burning recycles forest nutrients to the benefit of soil, plants, and wildlife.

- Chips add to surface fuel loads and fuel continuity that increases fire risk. Chips can also smother native grasses and flowering plants thus reducing habitat quality for insects, birds, and mammals.
- Gather and burn many small piles of debris in preference to fewer, large piles to minimize heat damage to the soil, encourage rapid re-vegetation, and more widely distribute nutrients contained in the ash.
- Do not leave brush piles of any size for wildlife in Priority Zone 1.

Guidelines for Coarse Woody Debris

Large logs without branches do not add significantly to wildfire intensity or its rate of spread, but are extremely important to wildlife.

- Only in rare circumstances (e.g., logs over 50 cm in diameter, hollow logs) should logs be retained for habitat values in this zone.
- Completely isolate logs that are retained from other fuels and maintain a clearance of at least 3 m from the closest structure.

5.4.3 Guidelines for Priority Zone 2: 10 to 30 Metres from a Home or Structure

In Priority Zone 2 the fuel management goal is "to further extend the fuel modified area by reducing flammable vegetation with a variety of thinning and pruning actions" (Partners in Protection 2003). Current standards are designed to prevent crown fires during all but the most extreme wind-driven fire events, and to reduce the behavior of an oncoming wildfire to the status of a surface fire that is more readily extinguished.

Guidelines for Live Trees

- Space conifers within this zone in accord with FireSmart criteria (i.e., 3 crown widths), more if open forest is the ecological norm for your area.
- Refrain from thinning of deciduous forests. It is not necessary under current standards, and is also discouraged from a wildlife perspective.

- Retain all existing deciduous trees in mixedwood stands. Under most circumstances they are resistant to wildfire and also provide important year-round habitat for birds and wildlife.
- Use the following principles to preserve long-term wildlife benefits when deciding which conifers to retain or remove from mixedwood or pure conifer stands:
  - Mark and retain all trees with existing nests or cavities.
  - To create initial separation between trees, selectively remove most, but not all, of the dead and dying trees less than 10 cm dbh from the forest canopy. (see "Snags" below for details).
  - Preferentially select and retain thick-barked tree species adapted to withstand the heat of low and moderate intensity wildfires (e.g., Douglas fir, western larch, and ponderosa pine).
  - Preferentially retain tree species like pine and Douglas fir that have strong root systems (i.e., lateral and tap roots) and more ability to resist windthrow.
  - Retain the tallest, healthy, mature trees in the stand with the largest and bulkiest living crown[3]. Conversely, slender trees of the same species that do not reach into the uppermost layer of the forest are rarely windfirm and good candidates for removal.
  - Select in favor of trees that are more long-lived in your particular geographic area. For example, Douglas fir and ponderosa pine generally outlive lodgepole pine and balsam fir.
  - Selectively remove individuals that are most impacted by infectious diseases, like mistletoe, that may spread and cause mortality of remaining trees.

[3] The tallest healthy trees are "dominant" within the stand. Their stature indicates that they have a competitive advantage, more stable and well-developed root systems, and are less likely to be broken or tipped over due to wind exposure after other trees are removed from the stand.

- Preferentially retain trees with "defects". That is, live trees with twin or multiple tops, broken tops, and large fire scars or mechanical damage near the base. These trees have significantly greater habitat potential than more perfectly formed trees – now and in the future (i.e., legacy trees).
- Make selections that allow for a variety of tree species, diameters, and ages within the stand.
- Selectively retain a cross section of younger trees in older stands, to allow for long-term (successional) tree replacement within the forest. Because younger trees may have less developed root systems, and be more subject to windthrow, apply cluster thinning[4] to afford interim wind shelter.
- Thin stands progressively over several years if possible. The risk of windthrow is reduced since trees are gradually exposed to more wind and have time to generate stronger roots.

- Create small "gaps" in the forest canopy by varying the spacing of trees (i.e., by exceeding the 3 crown-width standard in small areas, use of cluster thinning). Openings support many plant species and provide habitat opportunities for wildlife not available in the rest of the forest - and also provide additional fire security.
- Prune lower branches of mature conifers to a height of 2 m in this zone, but provide for cover and screening for wildlife closer to the ground by allowing for younger, unpruned trees in this zone (see saplings below).

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[4] Cluster thinning is the practice of leaving a small group, or clump, of trees with interconnected crowns as an alternative to single-tree spacing. Cluster thinning works well in stands with narrow crowns. It can be used to create variation in the spacing of the stand, to form more wind resistant groups of trees, to help protect special habitat features like cavity trees or snags, and to shelter younger shade-tolerant individuals until they reach maturity. A cluster is treated as if it were a single, very large diameter tree and a correspondingly larger space cleared around it.

- Consider "topping" large diameter trees that would otherwise be removed to Priority Zone 2. In this method the live crown portion of the tree is removed to create a snag (i.e., potential habitat trees for wildlife). Trees with decay or other defects near the base are well suited for this purpose, 2-5 per hectare is adequate.
- Rake excess litter and needles away from tree bases; leave 2-3 cm of litter over mineral soil to retain soil functions.

Guidelines for Snags, Habitat Trees, and Legacy Trees

- All habitat trees (i.e., trees with cavities, nests, or platform nests) should be preserved during the thinning process.
- Preserve a minimum of twelve to fifteen snags, and at least as many legacy trees, per hectare. To maximize their value to wildlife, these should be scattered throughout the forest. More specifically:
    - Preserve snags and legacy trees representative of all tree species in the forest, in a range of diameters (even as small as 5-15 cm dbh), but giving priority to the largest individuals.
    - Preserve snags in all stages of decay.
    - Preferentially, preserve <u>broken-topped</u> snags and legacy trees, these have a higher occupancy rates by wildlife.
    - Supplement the benefits of full size snags, preserve tall stumps, or create them by topping live trees that would otherwise be removed.
- As an alternative to removing snags, habitat trees, and legacy trees that threaten overhead power lines (i.e., trees with an obvious lean towards utility lines), these can be topped to eliminate potential for contact with lines, and potential fire ignitions if they do fall.
- Preserve some of the habitat value of snags, habitat trees, and legacy trees >10 m in height and oriented to strike the home or structure by "topping" them to reduce the risk of damage if they do topple.

- Pair snags, habitat trees, and legacy trees during the thinning process with at least one living tree that is touching or nearby, rather than isolating it. Alternately the snag should be incorporated into a "cluster" of retained trees. Either option provides wildlife with adjacent cover and makes the snag or habitat tree more attractive to wildlife. Note that additional clearance around the cluster is required to avoid increased fire risk (see cluster thinning technique).
- In rare cases where <u>concentrations</u> of dead or dying standing trees do occur but present a fire hazard, owners should:
    - Conduct a survey to identify trees with signs of bird activity (e.g., cavities, nests, recent drilling, bark chipping by woodpeckers), and large diameter trees with signs of decay.
    - Mark these trees to be retained.
    - Conduct the thinning process selectively by removing the <u>smallest</u> diameter snags first until the standard is achieved.

Guidelines for Saplings and Tall Shrubs

- Retain deciduous tree saplings and shrubs over 2 m in height as they have low flammability, nutritional importance, and provide valuable cover/ screening for wildlife.
- Accommodate a scattering of younger conifers (and more complexity in the lower forest layers), but take care to prevent flame "laddering" and increased fire risk by:
    - Isolating younger conifers, both horizontally and vertically, from nearby conifers.
    - Removing overtopping or nearby mature conifer trees that are located within 4 m of the young conifer.

- Limiting young conifers (over 2 m in height) to less than 50 per hectare[5].
- Monitor the clearances around and above retained seedling and sapling conifers every two to three years; re-thinning will be required periodically since new seedlings constantly germinate and retained saplings rapidly increase their crown volume.

Guidelines for Shrubs

- Select to favor deciduous shrubs over coniferous or resinous evergreens, but a mixture is most beneficial.
- Encourage or transplant native shrub species in preference to introduced ornamental species, and a variety of species should be included in the landscaping plan to attract and hold wildlife.
- Favor shrub species that bear fruit, berries, mast, or palatable browse for wildlife (e.g., red osier dogwood, saskatoon, chokecherry, pin cherry, raspberry, wild rose) in preference to non-fruiting or less palatable shrubs.
- Select low-growing deciduous shrubs (e.g., shrubs less than 2 m tall) over taller shrubs. These provide better three-season shelter for songbirds and are less likely to become fuel "ladders".
- Arrange shrubs singly or in small clumps, rather than in large masses.
- Combine shrubs with low ground covers and wildflowers in landscaped portions of Priority Zone 2 to create "wild islands" of shelter and linear strips of habitat. These help small mammals and birds better utilize, and move through, interface areas.
- Create small-scale wildlife corridors and provide screening with hedges, but ensure that they do not connect to fuels in the forest canopy above or wick fire to structures in Zone 1. Hedges also provide visual and audio screening for human occupants of the interface.

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[5] Extenuating circumstances (e.g., an expectation for short-term high mortality of the forest canopy or preserved regeneration) may require retention of more than 50 individual per hectare but increased fire risk will result in the interim.

- Manage junipers carefully to provide important food and shelter elements, while restricting their volatile contribution to fire intensity by:
    - Pruning them back in size and volume - to no more than 2 m in diameter and 1 metre in height.
    - Providing at least 5 m of clearance from overtopping or adjacent conifers.

Guidelines for Ground Cover Plants

- Plant or transplant a variety of fire resistant ground cover species to add habitat diversity and complexity, increase sheltering opportunities, and supply varied sources of forage for wildlife in Priority Zone 2.
- Promote dense, matt-forming ground covers that provide shade for landbirds and small mammals. They also help to retain soil moisture, reduce flammability, and deter weeds that add to combustible biomass.
- Preserve or encourage patches of native perennial dwarf shrubs and evergreen herbs, since these ground covers provide year-round wildlife benefits.
- Combine native ground covers with deciduous shrubs and wildflowers to create "wild islands" of shelter and linear strips of habitat in the wildland/urban interface.

Guidelines for Grasses and Forbs

- Encourage a variety of native grasses and wildflowers; these are likely to thrive under the thinned canopy of Priority Zone 2.
- Transplant addition species of wildflowers in isolated patches to enhance diversity and attract additional wildlife and insects.
- Provide for tall herbs and climbing plants or vines that could not be included in Priority Zone 1.

Guidelines for Fine and Medium Woody Debris

Current standards (Partners in Protection 2003) state that scattering of branches is not advised in Priority Zone 2, unless the existing load of surface fuels exceedingly low and the amount to be added is very small. Therefore, plan to remove the majority of existing fine and medium fuels and debris created by thinning activities. Observe the following guidelines for the benefit of wildlife:

- Leave an occasional, small (i.e. less than 1/3 cubic metre) pile of twigs or brush as these provide valuable nesting and cover sites for rodents. No more than ten such piles per hectare are suggested. Care must be taken not to place these within 5 m of coniferous vegetation.

Guidelines for Coarse Woody Debris

Coarse woody debris is among the most important habitat elements. To realize potential benefits for wildlife:

- Take precautions to preserve and/or provide downed logs that represent the full range of tree diameters in the surrounding forest. In general, longer and larger diameter logs have more value to wildlife.
- Preserve trees in all stages of decay. The rarest and most valuable individuals are those in the most advanced state of decay, these may be covered by moss and only recognizable as a linear mound on the forest floor.
- Leave at least 25—350 linear m of logs per hectare (equal to 50 pieces of at 5-7 m each). Up to 50 downed and decaying trees per hectare (each up to 20 m in length) was left in the Jasper project and judged not to be hazardous from a fire perspective.
- Visibly mark downed logs so that compaction or damage can be avoided during thinning operations. Instruct workers and residents not to remove sound logs; scavenging for firewood is a concern in this regard.
- Supplement existing coarse woody debris, if their density is low, by limbing and distributing additional logs (i.e., tree boles greater than 10 cm

dbh) on the forest floor, or cutting and leaving un-limbed trees into open areas within the stand to further mimic natural disturbances.

- As an option, leave more standing dead trees within the stand; these will eventually decay, fall, and become coarse woody debris.
- Leave combinations of connecting logs, parallel logs, and logs aligned across the slope. Small mammals use these more heavily than isolated downed logs, or logs that are aligned up and down the slope.
- Strategic placement of logs may deter off-trail cyclists and help prevent plant damage, soil erosion, and invasive plant problems on steep terrain.

5.4.4 Guidelines for Priority Zone 3: 30 to 100 Metres from a Home or Structure

Priority Zone 3 extends from the outer edge of Priority Zone 2, (a distance of 30 m from the structure) for a minimum of another 70 m in all directions. Current fuel management standards for Priority Zone 3 (Partners in Protection 2003) are very similar to those for Priority Zone 2 but emphasize the principles of fuel reduction and conversion (to less flammable conditions) rather than fuel removal. In Priority Zone 3, it is recommended that interface residents apply the same guidelines for each forest layer as provided for Priority Zone 2.

5.5 Guidelines for Modified Fuel Management Practices

The following guidelines propose modifications to existing fuel management practices, and new practices that are more sensitive to ecological considerations in the wildland/urban interface. These guidelines amalgamate information from previous phases of this study. They are the final result of adaptively testing, implementing, and refining preliminary versions in the Jasper prototype fuel management project between November 2003 and October 2005, as described in Chapter Six. They are designed for general application throughout the wildland/urban interface and in construction of shaded fuel breaks (i.e., fuel breaks that retain open forest structure as opposed to complete forest clearing).

5.5.1 Guidelines for General Practices

Guidelines for Disposal of Woody Debris

- Avoid the tendency to overly "clean" or sanitize interface areas of coarse woody debris. Random firewood gathering can be detrimental to wildlife.
- Burn woody debris in preference to chipping and spreading methods. Chips add to surface fuel loads and continuity, which increases fire risk. Chips also smother native grasses and flowering plants thus reducing habitat quality for insects, birds, and mammals.
- Burn excess amounts of fine and medium woody debris in many small piles as opposed to fewer, large piles. This minimizes damage to the soil by heating, encourages rapid re-vegetation, and more widely distributes nutrients contained in the ash.
- Rake the ashes into the mineral soil after burning debris and seed burn pile areas with native grass species to hasten establishment of forage and cover for wildlife, especially if weeds are present in the area.

Guidelines for Season of Work and Hours of Operation

- Restrict the operation of heavy equipment for fuel management to winter when the mineral soil, moist organic layers, and heavily decomposed logs are frozen and covered with an insulating layer of snow. This results in less compaction and churning of soils and less physical damage to surface vegetation. For wildlife, less surface disturbance generally equates to less disruption to habitat structure and a shorter period of habitat recovery.
- Conduct small non-mechanized operations in winter or during warmer times of the year. Woody-stemmed plants are generally more flexible and resistant to breakage when temperatures are above freezing.
- Avoid thinning activities during the nesting season to prevent inadvertent impacts to landbirds, or thoroughly survey stands prior to tree removal.
- Alter the seasonal timing of fuel management activities to minimize conflicts and/or alter the length of the work day to provide adequate

access through the area by wary species, particularly in landscapes where seasonal travel patterns of wildlife are constricted by topography or constrained by human activity.

5.5.2 Guidelines to Protect Key Habitats in the Wildland/Urban Interface.

Guidelines for Edge Habitats

- Enhance the amount of edge habitat by enlarging and making existing openings more irregular in shape. Also, create new openings in forest types where there is evidence of forest in-growth or formerly more heterogeneous landscape vegetation patterns.
- Aside from openings, enhance or establish other transitional habitats (e.g., shrubby areas adjacent forest stands) by selective management of overstory vegetation, deciduous saplings, and coniferous regeneration.
- In locations in the wildland/urban interface where the density of homes or structures is low, consider the "fuel modified zone" (Partners in Protection 2003) or "home ignition zone" (Cohen 2000a) as any other forest opening and creatively manage the vegetation of the concentric Priority Zones as transitional or edge habitats for wildlife.

Guidelines for Wildlife Corridors

- When planning fuel management projects on individual properties or around communities, seek out information and look for evidence regarding the habits and travel patterns of large mammals and carnivores at all scales (e.g., landscape, regional, local).
- Apply knowledge of wildlife travel patterns to ensure that fuel management activities do not break existing linkages between important habitat patches and further fragment the landscape.
- Manage the understory of known corridors used by large mammals to ensure that adequate hiding/security cover is retained and foraging opportunities are provided.

- Use the guidelines above to manage surface vegetation and woody debris for the benefit of small mammals and amphibians that must move freely within small territories to meet their life requirements.
- Acknowledge the exceptional importance of stream-side (riparian) habitats as corridors for many species of wildlife, and manage the vegetation of these with particular caution.

Guidelines for Grasslands and Aspen Forest

- Reverse the trend towards declining native grasslands by removing woody vegetation to expand the area of remnant grasslands, and/or creating open areas where native grassland species survive and may increase in the future.
- Actively restore/re-vegetate disturbed or bare-soil areas within the wildland/urban interface to native grasses and forbs.
- Perpetuate and revitalize aspen clones and mixedwood stands by selectively removing conifers, thinning the forest canopy surrounding aspen clones to enhance soil heating, and managing grazing/browsing to increase survival of new shoots (i.e., suckers).

Guidelines for Wetland and Riparian Areas

- Manage groundwater discharge areas, temporary pools, and moist depressions in the wildland/urban interface with minimal disturbance in recognition that they are exceptionally important in terms of wildlife. They are also areas of higher humidity, and potentially more resistant to fire spread.
- Balance denser vegetation of riparian areas with adjacent areas of relatively more stringent fuel reduction in order to isolate them and hinder fire spread into or from riparian areas.

5.5.3 Guidelines for Specific Forest Types and Fire Regimes

Thinning From Below in (formerly) Fire-maintained Douglas Fir Stands

Thinning from below was used extensively in Douglas fir stands of the study area to reduce crown fire potential and to replicate, as closely as possible, the stand structure that resulted from the pre-settlement regime of frequent, low intensity fires. Guidelines for thinning from below in fire-dependent Douglas fir stands are:

- Retain the vast majority of dominant, older, large-diameter Douglas fir.
- Using large-diameter Douglas fir trees as "anchor" points, remove all but a very few advanced regeneration, younger suppressed and intermediate classes of Douglas fir for a distance of four to five crown-widths[6] around these large veterans.
- Take care to retain some scattered Douglas fir of smaller diameter classes within the surrounding stand to mimic fire survival of younger individuals and allow for long-term replacement of dominant trees.
- Preferentially remove lodgepole pine, spruce, or other conifer species by mechanical or manual means to reverse the trend of forest "in-growth" in these stands.
- Retain a scattering of other fire-resistant trees (e.g., large diameter lodgepole pine) in addition to Douglas fir, to help maintain biodiversity. Include older pine, particularly those with fire scars and defects that make them potentially valuable as future habitat trees.
- In areas where large, dominant Douglas fire trees are not regularly distributed within the stand (i.e., sometimes occurring in groups or clusters), respect that pattern and retain this natural variation as part of the thinning operation.
- Inspect the age class distribution and search for remnants populations of characteristic grassland species (e.g., *Stipa, Festuca, Artemisia*) as clues

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[6] Use local knowledge about historical fire regimes, forest density, and structure as a guide to thinning density targets. Users are cautioned not to interpolate information from other locations without sound justification.

to allow "backcasting" the presence of un-treed openings or grasslands in this forest type. If these are evident, adapt the thinning strategy to re-establish openings and gaps in the forest.

- Accommodate occasional thickets of younger Douglas fir. These provide low screening cover for wildlife, habitat for other species, and visual or sound buffers between transportation corridors and homes. On sites where small thickets of coniferous regeneration are left, compensate for the anticipated local increase in fire behavior by removing overtopping older trees and trees at margin of thickets to break horizontal and vertical fuel continuity.

Thinning From Below in (formerly) *Open, Fire-maintained Lodgepole Pine Stands*
In lower elevations, some Montane and foothills lodgepole pine stands were also subject to frequent, low intensity fire that maintained them is an open, parklike condition. Like Douglas fir stands, these forests have also increased significantly in density, and been converted to multi-species, multi-layered stands with trees of nearly all ages. Guidelines for thinning these stands are much like those for the Douglas fir stands noted above, with some important modifications:

- Retain the vast majority of dominant, older, large-diameter lodgepole pine.
- Retain all deciduous trees within the stand.
- Retain suitable snags, habitat trees, and legacy trees (including larger diameter twin-topped or broken-topped trees).
- Thin to a spacing of four to five crown widths using the following sequence to achieve canopy reductions:
    - Using the larger lodgepole leave-trees as "anchor" points, remove all but very few advanced regeneration pine or well-rooted but younger Douglas fir, for a distance of four to five crown-widths around these large veterans.

- Preferentially remove fire–intolerant species such as spruce and true firs (*Abies*).
- Preferentially retain dominant or co-dominant Douglas fir over pine, wherever windfirm individuals are present. Eventually, this may lead to a species shift towards longer-live Douglas fir, but will further enable the use of prescribed fire as the most practical and economic tool for maintenance of these stands in the future.

Thinning from Above – in Dense Lodgepole Pine Stands

In this study, thinning from above was applied extensively to mature (90-130$^+$ year old) even-aged lodgepole pine stands that originated from stand-replacing fires. Typically, these stands have a simple structure with a dense (60 to 90%) canopy of co-dominant pine, minor amounts of dominant, intermediate, and suppressed trees; low amounts of coniferous regeneration and deciduous trees; and poorly developed shrub and low vegetation layers. Guidelines for tree retention and thinning from below in this stand type are:

- Retain any dominant lodgepole pine (i.e., trees with crowns extending above the general crown layer) and late successional species that are fire resistant and windfirm (e.g. Douglas fir); these are usually uncommon.
- Retain all deciduous trees within the stand.
- Retain suitable snags, habitat trees, and legacy trees (including larger diameter twin-topped or broken-topped trees).
- Thin to a spacing of three to four crown widths using the following sequence to achieve additional canopy reductions.
    - Remove the majority of smaller diameter intermediate and suppressed pine, living or dead, making provision for wildlife by retaining occupied habitat trees, suitable snags and legacy trees.

- Remove dead and dying co-dominant pine trees, making provision for wildlife by retaining occupied habitat trees, suitable snags and legacy trees.
- Selectively remove dominant or co-dominant trees of other species that are susceptible to windthrow (e.g., white spruce), except in rare situations where they are sheltered by a cluster of trees, have exceptional habitat value, or have survived in very wind-exposed sites.
- If infectious diseases, like mistletoe[7], are present in the stand at low levels, selectively remove the most affected individuals from the canopy.
- Remove live co-dominant pine with the shortest height of living crown[8] while retaining habitat and legacy trees as noted above.

- Retain and protect appropriate amounts (up to 50 stems/hectare) of shade-tolerant (late successional) coniferous regeneration and advanced regeneration to promote diverse forest structure for wildlife, aesthetic purposes, and long-term viability of the forest.
- Where coniferous regeneration has been retained, reduce vertical fuel continuity (i.e., ladder fuels) by removing over-topping or adjacent mature pine, in favor of retaining adequate coniferous understory.
- Use cluster thinning generously (i.e., ten to fifteen clusters per hectare or as required) to protect significant wildlife attributes and to add structural complexity to the stand.

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[7] Mistletoe is able to infect surrounding mature and regenerating pine. Removal of infected individuals from the upper canopy will prolong life of the current interface forest and provide time for replacement by more resistant species. Active efforts to encourage conversion to resistant tree species (e.g., planting of seedlings) is important in locations with high disease occurrence.

[8] Select to favor trees with the greatest height of live crown, look for healthy dominant trees with living branches extending closer to the ground and greater crown volume. These trees typically also have greater root volume, and respond more quickly with additional roots when released from surrounding competition.

- In areas with dense populations of ungulates or livestock where young trees are subject to intense browsing or rubbing, these trees can be "guarded" by leaving small diameter standing trees (dead or live) within one metre of the conifer to be protected.

Thinning from Above – in Mixed Conifer Stands

In stands of mixed conifer species, thinning from above was used in the study to reduce crown fire potential and simultaneously shift species composition towards more long-lived and fire-resistant species, such as Douglas fir. This was desirable in the study area because stands dominated by Douglas fir are relatively rare in this ecosystem, present relatively lower wildfire risk when properly managed, and can be effectively maintained over the long-term with prescribed fire. Generally, stands of this type occur in Jasper where shade-tolerant species, like Douglas fir and white spruce, have established under mature lodgepole pine forest, grown to be part of the dominant and/or co-dominant canopy layers, and comprise from 20 to 50% of the upper tree canopy. The following set of guidelines were developed to assist in decision-making in mixed conifer stands:

- Retain all deciduous (e.g., aspen and balsam poplar) trees within each canopy layer.
- Preferentially retain individuals or clumps of fire-resistant trees in the dominant and co-dominant layers (e.g., Douglas fir) wherever they are present and can be accommodated within the FireSmart spacing standards.
- Retain suitable snags, habitat trees, and legacy[9] trees (including larger diameter twin-topped or broken-topped trees).
- Thin to a spacing of three to four crown widths using the following sequence to achieve canopy reductions:

[9] Legacy trees are living, large diameter trees that have high potential to become habitat trees. Examples in this stand type are Douglas fir over 50 cm diameter at breast height, trembling aspen, balsam poplars, low-branched ("wolf-tree") lodgepole pine and any conifer >30 cm dbh with fire scars, bole defects or obvious signs of disease or decay.

    - As a first priority, selectively remove the majority of dead and dying trees from all forest layers, making provision for wildlife by retaining occupied habitat trees, suitable snags, and legacy trees.
    - As a second priority, retain individual pine with the largest height of live crown to the extent possible within the FireSmart standards. Conversely, remove slender trees with less living crown.
    - Selectively remove dominant or co-dominant trees of species that are prone to windthrow (e.g., white spruce in the Jasper study area), except for rare situations where they are sheltered by a cluster of trees, have exceptional habitat value, or have survived in very wind-exposed sites.
    - Selectively remove the most affected individuals from the canopy if disease, like mistletoe, is present in the stand.
- Selectively retain younger trees in the suppressed and intermediate layers trees (e.g., Douglas fir and lodgepole pine) to allow for continued species shift and eventual replacement of the mature pine canopy. Provide these with interim wind shelter by retaining one to three nearby trees, preferably suppressed, small-diameter pine that lack lower branches and competitive ability.
- Where it is appropriate, retain up to 50 stems/hectare of coniferous regeneration and/or advanced regeneration. Where these individuals occur under or within five metres of mature pine overstory, remove the adjacent or overtopping mature pine to avoid fuel ladders.

5.5.4 Guidelines for Specialized Thinning Methods

Selection thinning

In the Jasper study, a modified form of selection thinning was used in mixedwood forests where natural disturbance had been absent for an extended period and mature conifers had become a significant proportion of the dominant and/or co-dominant forest layers. In these cases the dominant, overtopping conifers (i.e., white spruce and pine) were partially removed to reverse the successional trend and revert stand composition to a more fire-resistant state. Care was taken not to damage residual aspen. Traditional selection thinning techniques (i.e., removing trees over a specified diameter) were not applied to conifer stands in the wildland/urban interface because of concerns regarding loss of genetic diversity, increased susceptibility to disease and insect attack, and higher potential for windthrow.

Free thinning

There were limited applications of free thinning (i.e., thinning to release target trees from competition) in the Jasper study area. This was primarily because the lengthy fire-free period and extensive changes to forest stand structure. Guidelines for application of free thinning are:

- Apply free thinning on a micro-scale to release specific trees from competition in conjunction with thinning from below and above.
- Use free thinning in dry Douglas fir sites with few, large veterans per hectare to remove in-growth and prepare these sites for prescribed fire.
- Use free thinning to remove dominant/co-dominant trees and favor regeneration or intermediate trees of other species. For example, in pine stands where overtopping trees carry and transmit contagious mistletoe.
- Apply free thinning to reduce insect potential (e.g., Douglas fir beetle) by removing green-attacked trees that host maturing larvae. This reduces beetle pressure and competitive stress on remaining trees.

5.5.5 Guidelines for Reducing Windthrow Potential

Windthrow, or the structural damage to trees caused by wind following stand thinning (Sinton et al. 2000), is a significant concern in the study area, and for fuel management projects in general. Excessive post-thinning windthrow could negatively impact public safety, wildlife habitat, and aesthetic qualities in the interface. Studies suggest that wind exposure combined with soil conditions and forest characteristics such as height, density, and slenderness of trees are key factors contributing to windthrow susceptibility (Wang et al. 1998, Whitehead and Brown 1997, Sinton et al. 2000). Based on literature and the knowledge of experienced local foresters, guidelines were developed to reduce the potential for windthrow and retain the most windfirm trees within treated stands:

- Select for retention of tree species that have both lateral and tap root systems, over species with lateral roots only. In Jasper we chose lodgepole pine and Douglas fir over white spruce using this criterion.
- Select to retain dominant trees that have grown up with sun from all sides, exposure to wind, and have a greater height and width of live crown[10], over suppressed trees without these traits.
- Retain trees that taper quickly and, consequently, have a low slenderness coefficient (i.e., low ratio of total height to diameter at breast height), as these are much less susceptible to wind damage (Wang et al. 1997).
- Reduce thinning intensity to reduce wind penetration into stands located on topography that is exposed to more wind (e.g., upper portion of ridges). Conversely, thin more intensely in wind-protected terrain.
- Examine the soil profile for sub-surface clay (i.e., Bt) horizons. These conditions impede root growth, lead to saturated soil conditions, and make trees more susceptible to windthrow (Hammond 2003). Reduce thinning intensity in these areas to anticipate post-thinning wind losses.
- Utilize cluster thinning liberally in areas prone to windthrow, and to provide increased wind protection for trees that are more susceptible to windthrow (e.g., slender trees, spruce, snags, or legacy trees).

[10] This tree form is characteristic of lodgepole pine trees that established and grew to maturity in the presence of an active, low-intensity fire regime. More live crown often correlates to a larger, more stable root system that contributes to stability and responds quickly to reduced competition to further solidify its root base. Trees of this form are locally called "wolf" trees or "bull pine."

- Use a progressive thinning approach (i.e, multiple passes over a span of years) wherever possible. This allows stands to gradually adapt and increase their windfirmness over time as stronger root systems develop.
- Recognize that even-aged conifer stands are more susceptible to windthrow after thinning. Leave 50–70 m wide strips of un-thinned trees, oriented diagonal to prevailing winds, as buffers to reduce wind pressure in large thinned areas (e.g., one strip every 400 m).
- Wherever possible, thin less intensively (e.g., two-three crown widths) in wind-susceptible stands in recognition that wind will continue the thinning process after treatments are completed.
- Regardless of guidelines to reduce windthrow, recognize that thinned stands have increased susceptibility and that follow-up maintenance to remove excessive amounts of windthrown fuel may be required.

5.5.6 Guidelines for Managing "Wildlife" Trees

Habitat Trees and Snags

Guidelines for living or dead trees with cavities, nests or dens that are, or have been, occupied by wildlife, and snags are as follows:

Ideally, an area of un-thinned forest cover 5 – 10 m in diameter should be left surrounding each habitat tree. Given fuel standards, it is rare that this condition can be met, however cluster thinning can be applied to enhance buffers around habitat trees and compensate for the extra fuel retained.

Leave a minimum of 10–15 snags/ha; more are required in order to allow for recruitment of coarse woody debris (logs) on the forest floor.

Retain deciduous snags in greater numbers wherever possible since they decay more rapidly and are short-lived, but especially valuable to wildlife.

Retain a variety of snag species and forms within the forest. Different wildlife species show preferences for tree species, the presence or absence of limbs, and hardness of wood (stage of decay).

Leave snags in a variety of diameters. Apply a bias towards larger trees but preserve some small diameter too for foraging, resting, and nesting by smaller birds like chickadees. Generally, snag value is in proportion to diameter, with those over 50 cm having the greatest habitat value.

Leave coniferous snags <25 cm dbh if larger trees are not available.

Retain snags in a variety of topographic situations (e.g. different aspects, top and bottom of slopes, in gullies, etc.).

Rake excess litter and needles away from tree bases to reduce ignition potential but leave 2-3 cm of litter over mineral soil to retain soil function.
Leave snags distributed across the landscape because many woodpeckers are territorial. Small clumps of snags are beneficial too as they may attract multiple wildlife species, and provide abundant foraging sources.
"Topping" or "stubbing" of potentially hazardous snags is a good alternative to complete removal.
Leave some snags in open areas to attract species such as bluebirds, American Kestrels, or Lewis' woodpecker that prefer open situations.
Retain large broken-topped trees, they are particularly important for platform nesting raptors.
Create snags artificially if natural ones are in short supply. The methods that yield greatest frequency of woodpecker occupation in Douglas fir (Brandeis et al. 2002) are topping at the base of the crown or injecting with lethal trichlopyr herbicide. Girdling is not recommended. Created snags are prone to windthrow and have a shorter life than natural snags.
Retain well-anchored leaning snags that are secured to other trees.

Legacy Trees

Guidelines for conserving living, large diameter trees that have high potential to become habitat trees are as follows:
Retain at least 10 - 15 legacy trees/ha; these are snags of the future.
Rake organic debris away from the base of legacy trees to prevent ignition by wildfire or prescribed burns. Leave 2-3 cm to preserve soil function.
Apply cluster-thinning principles wherever possible to retain wildlife cover close to legacy trees and increase long-term habitat values for a range of cavity nesting species.
Leave occasional leaning trees that are securely anchored to other living trees. These provide valuable habitat complexity, but may also result in elevated levels of risk since these features can act as fuel "ladders". Leaning trees can be incorporated into clusters, and lower branches liberally pruned to counter increased risk.

Hollow Trees

Hollow trees or logs are rare and significant resources; considerable efforts are warranted to preserve them. Guidelines for conserving hollow trees are as follows:

- Preserve hollow trees intact wherever possible but consider having them professionally topped if safety hazards are a concern.

- Rake organic debris away from the base of hollow trees to help prevent ignition of the decaying tree trunk by wildfires or prescribed burns. Leave 2-3 cm of litter over mineral soil to retain soil function.
- Use cluster-thinning to retain living trees close to hollow trees, increase habitat value, and encourage use by cavity nesting species. If this is not possible, retain a single live tree nearby whenever possible.
- Protect hollow logs (fallen individuals) as a high priority for wildlife.

Broomed Trees

Guidelines for managing broomed trees are as follows:

- Retain spruce with brooms caused by rust as these are not infectious.
- Isolate trees infected with mistletoe from other trees of the same species either individually or small clusters to reduce potential for spread of the disease and satisfy fire hazard reduction objectives.
- Prune broomed trees to at least 2 m and remove surrounding coniferous shrubs and regrowth to reduce their potential as fuel ladders.

5.5.7 Other Guidelines to Benefit Wildlife and Biodiversity in the Wildland/Urban Interface

Aside from those listed in previous sections, there are a number of other practices that interface residents or managers can implement to enhance wildlife habitat and viewing opportunities in their neighborhood - while removing and reducing hazardous fuels.

General Guidelines for Maintaining Biodiversity

General guidelines to promote biodiversity in conjunction with fuel management activities are:

- Maintain the fullest possible range of native species within the stand.

- Maintain a range of tree diameters and forms (e.g. deformities, broken tops, multiple tops, fire scars).
- Recognize, and work with, the natural variation in tree spacing and canopy cover caused by variable site conditions (e.g., soil, topography).
- Maintain the maximum possible amount of vertical structure and complexity in the stand.
- Sustain the supply of coarse woody debris (logs) on the forest floor by retention of replacement trees in the forest canopy.
- Survey stands on foot and engage knowledgeable local people to identify special habitat features such as seasonal denning or nesting sites, cavity trees, drumming logs, rutting areas, etc., prior to flagging and thinning forest stands.

Guidelines for Artificial Habitat Enhancement

- Compensate for the lack of natural nesting sites in urban areas by providing home made nest boxes. Many guides are available for reference.
- Set out roosting boxes for bats or posts with platforms for raptors.
- Augment natural sources of fresh water for wildlife and birds in wildland/urban interface areas where they are in short supply.
- Consider setting up bird feeders but be aware that these may cause conflicts with other, unwanted species such as deer, bear, or squirrels.

Guidelines for Management of Human Use in the Wildland/Urban Interface

- Control pets to reduce harassment of wildlife.
- Minimize the use of herbicides and chemicals that may stress wildlife.
- Take preventative measure to clean equipment of soil and seeds to avoid introducing non-native plant species that damage wildlife habitat values.
- Ensure that garbage is stored securely indoors to avoid conditioning wildlife to human presence and eventual habituation.
- Encourage land developers and regional planners to incorporate appropriate wildlife measures in community design.

5.6 Summary

Together, the foregoing species-specific mitigations, guidelines, and best practices form a set of ecologically based criteria for modifying current fuel management practices in ways that benefit wildlife, but do not compromise existing risk reduction objectives of current FireSmart standards. These have been refined during an operational fuel management project, and proven to be practicable in situations where fuel management treatments are applied by manual crews or with the aid of specialized forestry equipment in the hands of skilled operators.

CHAPTER SIX. Results: Preferred Techniques and Equipment for Implementing Ecosystem Based Fuel Management Prescriptions in the Wildland/Urban Interface – THE JASPER PROTOTYPE PROJECT.

This chapter outlines the prototype Foothills Model Forest program of intensive, ecosystem based fuel management conducted within the wildland/urban interface setting at Jasper, Alberta. In addition, it describes techniques and equipment for implementing large-scale, ecologically based fuel management practices as determined through this study.

6.1 The Prototype Fuel Management Program at Jasper, Alberta.

6.1.1 <u>Introduction</u>

The problem being addressed by this research (i.e., to develop ecologically based approaches for managing the forest vegetation of wildland/urban interface areas in ways that seek to optimize or improve conditions for wildlife) is a difficult resource management issue. Within the problem lie complexities, uncertainties, ambiguities in relationships between ecosystem components, and potential for controversy and societal constraints. It is a problem that could be approached on a theoretical basis, but would benefit from practical experimentation.

The management commitment by Parks Canada Agency at Jasper National Park to move ahead with community wildfire protection (including programs of fuel management), the Agencies caveat that this would take place in the most ecologically sensitive manner possible, and involvement by the research-oriented Foothills Model Forest provided an opportunity to merge theoretical and practical problem-solving approaches to this operational requirement.

One approach for resolving problems of this type is called "adaptive management" (Walters and Holling 1990). In this approach management actions are viewed as experiments and designed to provide critical information about the resources being managed. The information obtained is quickly incorporated back into management operations for the purpose of adjusting plans and trying revised approaches to improve the effectiveness of management (Johnson 1999). The central tenet of adaptive management is that management involves a continual learning process that is not easily separated into discrete functions like research, regulations, or monitoring (Walters 1986). It its most simple terms, it is "learning by doing" (Walters and Holling 1990). In the absence of known solutions, the adaptive management approach seemed ideally suited to this problem, and was adopted as the model for integrating this research with operational requirements in the study area.

6.1.2 Description of the Prototype Jasper Project

Pre-treatment conditions within the study area, including the ecological, social, and risk settings relevant to the problem being addressed by this research were thoroughly described in Chapter Three. This section provides a more detailed description of the project itself.

Over a period of two and one half years, between April 2003 and October 2005, crews and timber industry contractors were scheduled to apply forest-thinning treatments to approximately 205 hectares (see Figures 6-1 and 6-2) surrounding the Town of Jasper, and the nearby Lake Edith Cottage subdivision. Shaded areas in these Figures illustrate areas completed during the winters of 2003/04 and 2004/05. The total area is broken down into seventeen (17) individual "operating areas" as outlined in Table 6-1.

Figure 6-1: Wildland/urban interface operating areas surrounding the Town of Jasper.

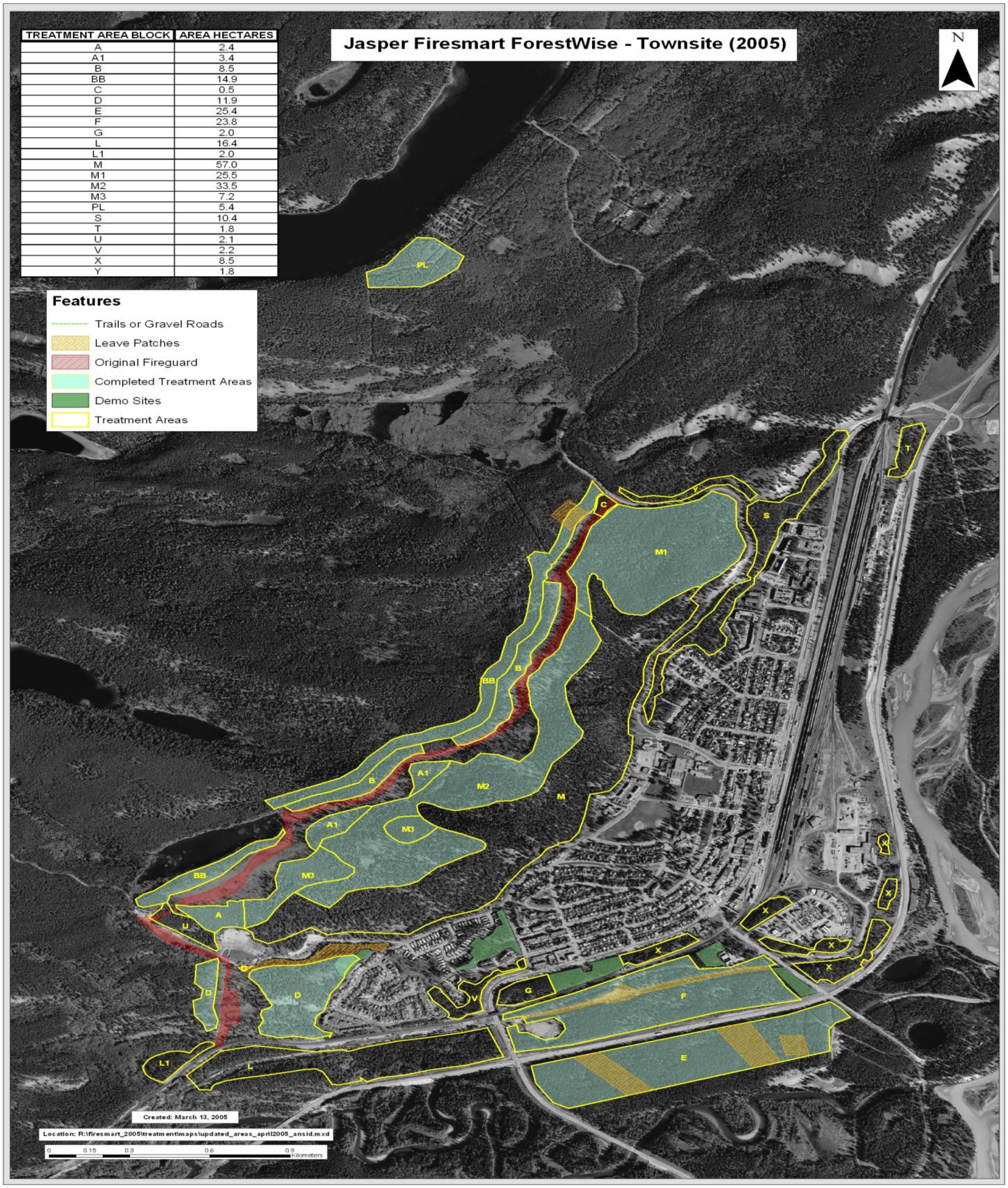

Figure 6-2: Wildland/urban interface operating areas surrounding the Lake Edith cottage subdivision.

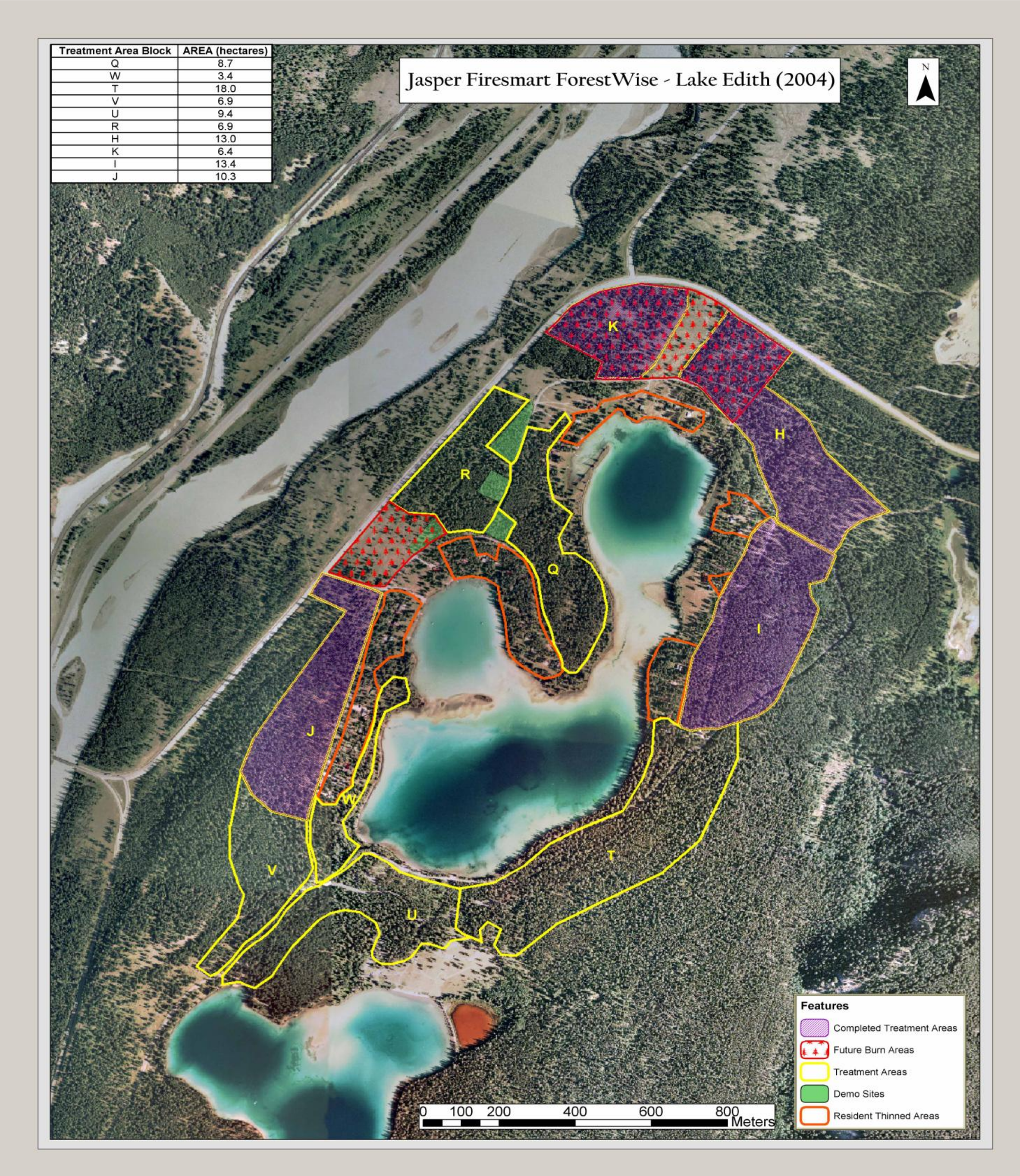

Table 6-1: Study area operating areas near the town of Jasper.

OPERATING AREA	LOCATION	FOREST TYPE	AREA (hectares)	DATE
A	Pyramid Bench	Closed pine	2.5	2003/04
A1	Pyramid Bench	Mixed conifer	3.4	2003/04
B	Pyramid Bench	Closed pine	8.6	2003/04
BB	Pyramid Bench	Mixed conifer	14.9	2003/04
C	Pyramid Bench	Mixed conifer	0.5	2003/04
D	Cabin Creek	Mixed conifer	11.9	2004/05
E	Highway #16	Closed pine	25.4	2003/04
F	Highway #16	Closed pine	23.8	2003/04
H	Lake Edith	Open pine	13.0	2003/04
I	Lake Edith	Closed pine	13.4	2003/04
J	Lake Edith	Open pine	10.3	2003/04
K	Lake Edith	Open pine	6.4	2003/04
M1	Pyramid Bench	Douglas fir	25.5	2004/05
M2	Pyramid Bench	Douglas fir	33.5	2004/05
M3	Pyramid Bench	Closed pine	7.2	2004/05
PL	Patricia Lake	Mixed conifer	5.4	2004/05
S	Town site	Douglas fir	2.0	2004/05
TOTAL			**205.2**	

6.1.3 Integrated Fuel Management Prescriptions

Detailed treatment prescriptions were developed for each major forest type in the study area. These were based on literature review, assessment of potential effects of fuel management, fuel management standards, and concerns for resource values conducted in earlier phases of this research. A generic outline for an integrated fuel management prescription is provided in Figure 6-3.

6.1.4 Small Scale Demonstration Projects

Preliminary stand prescriptions were developed for each major forest type in the study area. These were then implemented on 0.5 to 1.5 ha "demonstration sites" by resident volunteers who joined with Parks Canada personnel during community "work-bees". Only hand tools and power saws were used. These small, demonstration sites provided an opportunity to implement the prescription incrementally (e.g., in several passes). This facilitated an adaptive process of assessing results at each stage; refinement of the prescription; and then re-testing and re-evaluation as required. Several trials were conducted in each forest type, and some demonstration sites were re-worked as many as three times, until a satisfactory prescription evolved.

6.1.5 Large Scale Operational Testing

Following small-scale testing and assessment of prescriptions, the Jasper prototype project progressed to a larger, operational scale involving tens to hundreds of hectares. The adaptive process continued to be used for evaluation and improvement of treatment prescriptions. However, adaptive management techniques were also applied to the operation of equipment, and industry-based methods for selective forest thinning. To facilitate adaptive management in an operational setting it was essential to establish an atmosphere of constructive critique about field operations, coupled with free-flowing information between the contractors, crews, and project managers. Several techniques were used to facilitate this iterative process. These included a contract tender process that encouraged innovation; classroom and field orientation sessions for operators and contractors; intensive field monitoring and 360 degree feedback sessions with operators; provision of field reference guides to operators; two-way radio communications between equipment operators, contractors, and researchers/project managers to respond to new situations, consult on problems, and find improved solutions; well established lines of authority and; regular joint field inspections by the contractor and researchers/ project managers to review the results of modified field methods and ensure constructive exchanges between project personnel. These mechanisms are common features of environmental assessment follow-up studies as outlined by Ross (2002). As a result of this approach, there was constructive, ongoing dialogue between operational staff, contractors and research/project management personnel.

Figure 6-3: Template for integrated fuel management prescriptions.

1. Fuel Reduction Objectives
   - 1.1. Forest Canopy (dominant and co-dominant trees)
     - 1.1.1. Desired spacing distance between overstory tree crowns.
     - 1.1.2. Species selection criteria for removal and retention.
     - 1.1.3. Diameter criteria for removal and retention.
     - 1.1.4. Retention or removal of insect/disease attacked and windthrown trees.
     - 1.1.5. Retention or creation of tree clusters and openings.
     - 1.1.6. Criteria for removal of snags not considered to be habitat trees.
     - 1.1.7. Pruning
   - 1.2. Forest Understory (intermediate and suppressed trees).
     - 1.2.1. Desired spacing distance between understory tree crowns.
     - 1.2.2. Species selection criteria for removal and retention.
     - 1.2.3. Diameter criteria for removal and retention.
     - 1.2.4. Retention or removal of insect/disease attacked trees.
     - 1.2.5. Retention or creation of understory tree clusters.
     - 1.2.6. Pruning criteria.
   - 1.3. Shrub Stratum and Coniferous Regeneration
     - 1.3.1. Species selection criteria for removal/retention of conifers <2m
     - 1.3.2. Species selection criteria for removal/retention of advanced regeneration (2-5m tall).
     - 1.3.3. Density of young conifers and advanced regeneration.
     - 1.3.4. Priority for retention of young conifers versus removal of overtopping mature conifers.
     - 1.3.5. Criteria for retention or removal of coniferous thickets.
     - 1.3.6. Criteria for retention/removal of highly flammable shrubs (e.g. juniper).
   - 1.4. Woody Surface Fuels
     - 1.4.1. Requirements for disposal or limbing of windthrown conifers.
     - 1.4.2. Criteria for disposal or burning of fine and medium surface fuels; brush piles.
     - 1.4.3. Criteria for removal of slash from tree/shrub strata thinning.

2. Ecological/Wildlife/Habitat Objectives.
     - 2.1.1. Criteria for retention of habitat trees (snags and legacy trees) and desired densities.
     - 2.1.2. Species and diameter criteria for snag retention.
     - 2.1.3. Species and diameter criteria for legacy tree retention.
     - 2.1.4. Requirements for retention or removal of insect/disease attacked and windthrown trees.
     - 2.1.5. Requirement for cluster thinning around snags/habitat trees.
     - 2.1.6. Retention of deciduous shrubs.
     - 2.1.7. Specifics for retention of other habitat features.
     - 2.1.8. Criteria for creation of brush piles and location/clearances
     - 2.1.9. Definition of riparian buffers, "no-go" zones, corridors, and area boundaries.
     - 2.1.10. Retention of coarse woody debris/logs by density, decay class, species, and size class.

3. Aesthetic and Other Objectives.
   - 3.1. Requirements for retention of shrubbery for visual and sound buffers.
   - 3.2. Rehabilitation requirements, plantings.
   - 3.3. Criteria for understory protection during falling and forwarding, access trails.
   - 3.4. Maximum stump heights.
   - 3.5. Trail and safety precautions.
   - 3.6. Smoke considerations.
   - 3.7 Directions for protection of archeological and cultural resources.

6.2 Selection of Forest Thinning Techniques and Equipment

6.2.1 Introduction

Once satisfactorily refined on small-scale demonstration sites, treatment prescriptions were ready for implementation on larger tracts of interface forest. Given the spatial scale of the study area (i.e., hundreds of hectares), it was presupposed that a mechanized approach, in tandem with manual labor from specialized crews, would be required. Consequently, five operational phases were defined to implement the ecosystem based fuel management approach: 1). flagging of trees by the researcher and technical staff in accord with the stand-specific prescriptions; 2). selective cutting, processing, and removal of salvageable wood (winter) with commercially available harvesting equipment, and mechanical piling of debris; 3). winter disposal of thinning slash by trained crews using hand tools, power saws, and pile burning; 4). summer rehabilitation of minor environmental impacts and monitoring of project results.

6.2.2 Equipment Selection and Operation

Information about the capabilities and limitations of various types of logging systems, forestry equipment, and appropriate modes of operation was gathered from numerous sources including: site visits to numerous other fuel management and selective commercial thinning operations in the United States, and Western and Northern Canada; interviews with forest industry managers, managers of fuel reduction projects, and equipment sales representatives in Alberta and British Columbia; hosted tours of the Jasper study area for invited forestry officials, industry regulators, and timber industry contractors; review of literature from manufacturers, the Forest Engineering Research Institute of Canada (Sutherland 2003), and industry “best practice” manuals (Weldwood of Canada Ltd. 2002); and participation in professional forums and workshops. During the course of the research over 350 managers and scientists from the forest industry and other natural resource agencies toured the Jasper study area to inspect project activities as part of technology transfer initiatives of the Foothills Model Forest. These visits provided exceptional opportunities for candid discussions, information exchange, and peer review with individuals from across North America and delegations from Scandinavia, Spain, Japan, Korea, Indonesia, Australia, and New Zealand. These were multi-day scholarship visits to Jasper by interface managers or researchers from Sweden, Australia, and New Zealand[4].

Traditional whole-tree logging, horse logging, and more specialized "cut-to-length" or "processing-at-the-stump" systems were considered for application to the prototype project. These were evaluated on the basis of several criteria including low ground pressure; ability to work without a formal road or trail network; maneuverability, narrow width and rotational clearance; stability on moderate slopes; ability to handle trees of up to 60 centimetres in diameter; and high rates of wood utilization.

As a result of these investigations, the cut-to-length logging system was selected as most capable of meeting the multiple resource objectives of this project with minimal environmental impacts. Some of the expected advantages of this system were:

- Cut-to-length processors are small and agile with good ability to move between residual and habitat trees with minimal "collateral" damage.
- Improved roads or formal trail networks are not required.
- Cut-to-length processors are light (i.e., relative to feller-bunchers), with lower ground pressure per area than whole tree or horse logging systems.
- Cut-to-length processors have an extendable boom (6–7 metres) giving good reach, and directional falling capability to limit damage to adjacent vegetation.

[4] Dr. Juha Nurmi of Sweden, visiting professor at the University of Alberta; Mr. Phil Millar, Fire Manager and Town Councilor, Daylesford, Victoria, Australia; Mr. Jack Dinkgrieve, Ranger in Charge, Parks Victoria, Mt. Dandegong, Australia; and Mr. Wayne Hamilton, Senior Firefighter, New Zealand Fire Service, Christchurch, New Zealand.

- The dexterous processing head can be used to re-arrange coarse woody debris and manipulate snags, thus preserving them.
- Cut-to-length processors perform de-limbing operations in the forest, thus nutrients are better distributed and some logistical and aesthetic problems associated with roadside processing are avoided.
- Wheeled forwarders are used in tandem with processors to carry, rather than drag, logs from the forest to decking sites to limit soil disturbance and direct impacts to residual vegetation.
- It was anticipated that fewer equipment passes per trail would be required and less area would be disturbed than with other systems.

Over the span of two winter operating seasons (December 2003 to March 2005) the following equipment was utilized to implement multi-purpose thinning objectives on 215 hectares of interface forest within the study area:

- Neusson MHT 2002 tracked single-grip wood processor.
- Rottne 11 tonne wheeled forwarder.
- Timberjack 1270 wheeled single-grip wood processor (2).
- Timberjack 1210B wheeled forwarder, and
- John Deere 160 excavator (for piling slash only).

Thinning Operations

In the hands of expert operators and under the direction of innovative, dedicated industry managers, this equipment met and exceeded stringent environmental standards while performing efficiently to reduce interface fuel hazards. Trees flagged for removal (Figure 6-4) were cut, limbed, processed into specified lengths, and piled according to diameter on-site (Figure 6-5). Salvageable timber was cut to length and segregated into piles at the stump (i.e., posts and rail, pulpwood, saw timber, and peeler logs). Tops and limbs were piled on site by the wood processor, sometimes aided by a small excavator. Contrary to standard commercial thinning operations, uniform spacing of residual trees was strongly discouraged in favor of creating variability in density and patchiness within the stand. Rather than following straight, equally spaced, lines of travel through the forest (a.k.a. ghost trails) and employing uni-directional falling techniques, operators of the wood processors were directed to randomize ghost trails as much as possible. Wherever possible, mechanical de-limbing was done to create debris piles within pre-existing forest openings, or openings created by the thinning itself. This facilitated subsequent burning of debris in a manner that prevented scorching or root damage to surrounding trees. Later, the wood was picked up and transported by wheeled forwarders (Figure 6-6) to decking areas adjacent truck-accessible roads for loading and transport (Figure 6-7). Wheeled log forwarders followed the when recovering the timber. To minimize the amount of disturbed area, and to protect the forest understory and coarse woody debris, all equipment followed the same "ghost trails created by the wood processor.

Figure 6-4: Flagging of retention trees in the Jasper study area.

Figure 6-5: Small, maneuverable wood processor used for selective thinning in Jasper project.

Figure 6-6: Low-impact wheeled forwarder used during Jasper project.

Figure 6-7: Transport of salvaged logs from Jasper project.

Figure 6-8: Winter crew engaged in gathering and burning debris.

6.2.3 Manual Fuel Management Techniques

In addition to mechanical inputs, significant amounts of manual labor were required to complete the tasks of fuel reduction and removal, and to implement the prescriptions on areas considered too fragile, or inaccessible by equipment. Much of this involved gathering, piling, and burning debris from thinning operations. A winter crew of up to fifteen people was hired[5] and trained in fuel/habitat management principles to implement these tasks (Figure 6-8). A smaller crew of three persons was employed during the intervening spring and summer periods to follow-up with remediation tasks such as rehabilitation of disturbed soils (Figure 6-9), reclamation of burn pile sites, detection and control of non-native plants, and monitoring of environmental impacts and windthrow occurrence.

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[5] Seven youths were hired and trained each winter through a career development partnership agreement with the Metis Nation of Alberta. These workers were supplemented by volunteers from the Katimavik Canada program who were also trained and equipped for the project.

Figure 6-9: Summer rehabilitation work in the Jasper study area.

6.2.4 Testing of Preliminary Mitigations, Guidelines, and Practices.

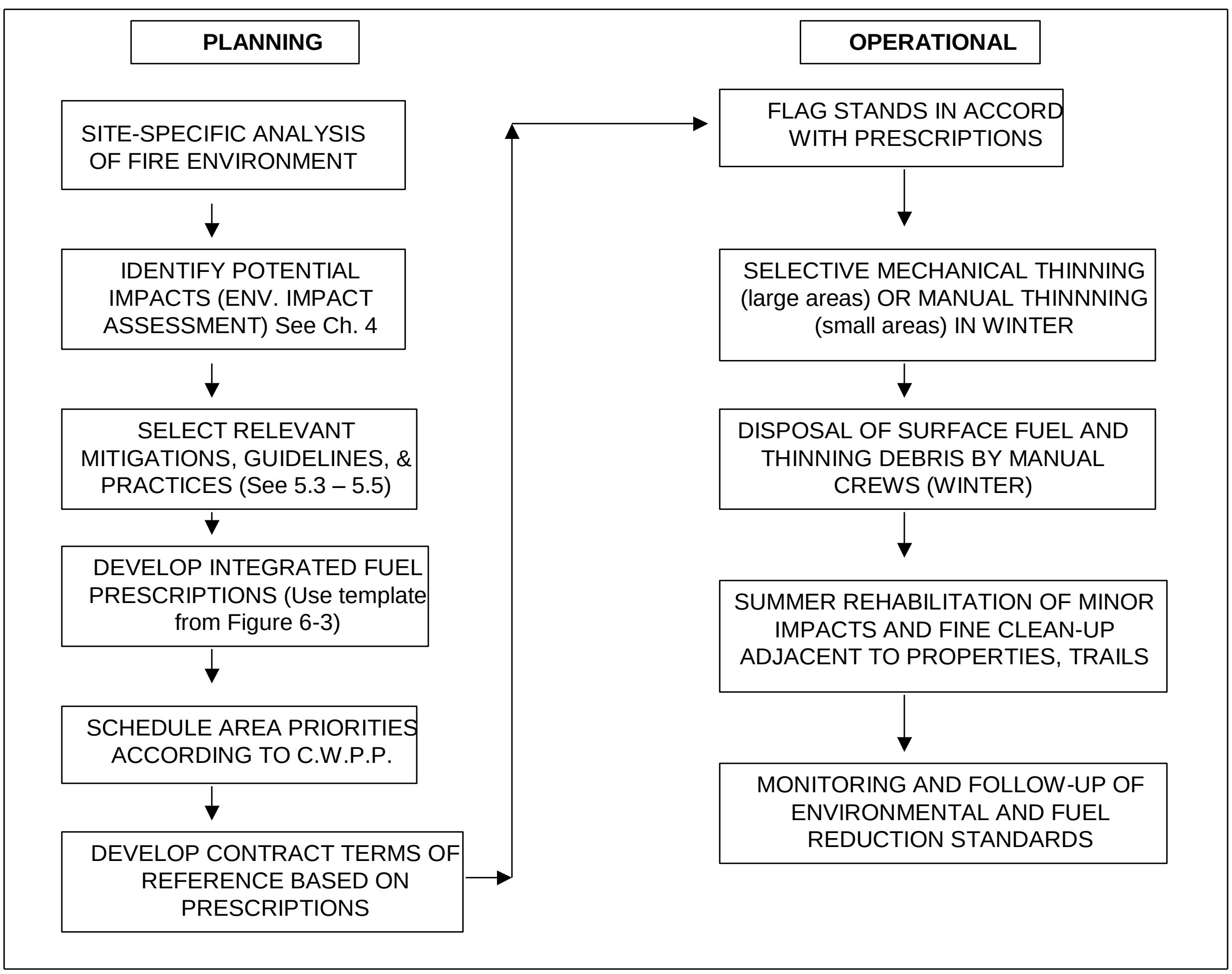
Species-specific mitigations to reduce the impact of fuel management activities on wildlife, preliminary guidelines for integrating habitat attributes and wildlife needs into fuel management standards, and guidelines for innovative fuel management practices were implemented, assessed, and repeatedly refined in the Jasper study area between November 2003 and October 2005. During this time over 225 hectares of Montane forest were flagged and mechanically thinned, field crews completed manual debris removal on more than 200 hectares, and a summer rehabilitation crew treated the entire area (Table 6-1).

6.3 Summary and Decision Support Guide

Ecosystem based mitigations, guidelines, and practices suggested in this Chapter could be combined with existing fuel management standards to maintain or restore ecological conditions in the wildland/urban interface. Collectively, I have called this the FireSmart – ForestWise approach to interface fuel management.

The following diagram offers a suggested progression of decisions and actions to plan and implement ecosystem based fuel management actions in other jurisdictions. It is not a process for establishing a community wildfire protection plan, but can be used in conjunction with such plans to accommodate wildlife conservation and other values into interface fire risk programs.

Figure 6-10: Decision support guide for interface managers.



Chapter 7: Results: A Methodology for Monitoring the Ecological Effects of Fuel Management on Wildlife

7.1 Introduction

Monitoring is an essential element of any adaptive management process (Bormann et al. 1995). Therefore, it would be prudent to measure the response of selected habitat and wildlife variables over time to see if the desired outcome of improved wildlife habitat, consistent with wildfire risk reduction, was achieved. As a component of this research, a rigorous scientific monitoring methodology was developed. Its purpose is twofold. First, to provide future practitioners with a way of evaluating the Jasper ecosystem manipulations and, second for establishing monitoring programs in other wildland urban interface areas.

The methodology was tested and implemented while documenting initial (i.e., pre-treatment) forest conditions, and conditions after the first year following treatment. However, due to temporal and fiscal constraints, long-term monitoring of ecosystem based fuel reduction/forest restoration activities was not possible. Analysis of that data is not part of this study, but will be done separately through the Foothills Model Forest. A new methodology for monitoring the ecological effects of fuel management on wildlife is described in this chapter.

7.2 Monitoring and Sampling Considerations

A number of practical and scientific considerations influenced the design of the monitoring methodology. While some vegetation attributes will change immediately as a direct result of the treatments themselves, indirect responses to forest thinning are anticipated to take place more gradually. Constraints were placed on the design by the wide variation of forest types, a requirement to assess multiple forest treatments, and the configuration of fuel management zones. Effective sampling methods had to be found or adapted to deal with these limitations.

7.2.1 Management Treatments to be Monitored

Four potential fuel management/forest restoration treatments were identified for application in the study area. These were: 1) selective overstory thinning and surface debris removal; 2) selective thinning with follow-up prescribed burning; 3) prescribed burning only[1] and, 4) untreated controls.

7.2.2 Stand Types to be Sampled

The 350-hectare study area was delineated into five distinct stand types (section 3.1.7). Due to limited extent of mixed conifer and Douglas fir stands on steep terrain, these were not sampled. Therefore, sampling was restricted to fire-maintained upland lodgepole pine forests; fire-maintained Douglas fir forest on level terrain; and even-aged pine forest originated from stand-replacing fire.

7.2.3 Response Variables

Vegetation

The main independent variable in this study is the structure and composition of forest stands, as measured by canopy cover. These are regulated by the type and intensity of treatments. Dependent variables monitored in this methodology are: 1) volume, number of pieces, and decay class of coarse woody debris; 2) production of berries of *Shepherdia canadensis* (buffaloberry); 3) horizontal sight distance and, 4) biomass production of grasses and forbs.

Coarse woody debris was chosen because of its influence on habitat quality and many species of wildlife. As well, it plays important roles in nutrient and water cycling. From a recreational perspective, coarse woody debris may also discourage off-trail cycling, a concern in the study area. Depending on treatments, the amount of course woody debris could increase or decrease following treatments, and is expected to change over time as standing trees fall.

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[1] Prescribed burn only treatment was not implemented or included in the sampling design.

Shepherdia berries were monitored because they provide a significant seasonal source of forage for many species of wildlife including birds, small mammals, and bears. Rates of berry production vary with canopy cover, and may correlate with changes in levels of wildlife use (Hamer 1996). *Shepherdia* production could also be a factor in bear/human conflicts (W. Bradford, pers.comm.). Production is expected to drop initially due to mechanical impacts, then rise above pre-treatment levels after 3-5 years of growth under a more open canopy.

Horizontal sight distance reflects the amount of vegetation in low and mid-forest layers <2 metres. It is important since it relates to the availability of thermal and security cover, seclusion for wary carnivores, and effectiveness of travel corridors (Rahme 1991, Duke 2001). From an aesthetic perspective, horizontal sight distance is also an indicator of vegetation available for visual screening and sound buffering, and privacy of residents. It is expected to decrease after thinning but should eventually rise above pre-treatment levels (Hamer 1996).

Change in herbaceous biomass is of interest because of its multiple influences on forage availability for grazers and granivores, cover for small mammals and birds, and aesthetic values. Biomass is expected to increase the first growing season after treatment, and to continue changing (Thysell and Carey 2000).

Wildlife

Sampling attention was directed to wildlife species likely to respond to fuel treatments, abundant enough to be adequately sampled, of interest for other management reasons, and able to be sampled with modest effort. Consequently, wildlife response variables selected for monitoring were: relative composition and abundance of ungulates; relative composition and abundance of small mammals, and; relative composition and abundance of breeding landbirds[2].

[2] Breeding landbirds include year-round residents as well as migrating neo-tropical songbirds.

7.2.4 Sampling Intensity and Replicates

To obtain an adequate number of replicates, sampling was carried out in three separate stands of each forest type, with an equal number of untreated control sites in each stand type. The methodology was designed to allow comparison of pre and post-treatment conditions at each site (i.e., at the same site over time) and comparisons between treated and untreated (control) stands of the same forest type. This required that 23 sampling grids be established (Table 7-1).

Table 7-1: Distribution of treatments within sampling grids.

Stand Type	Treatment	Grid Numbers
Open Pine	Thin Only	1, 2, 6
Open Pine	Thin and Burn	3, 4, 5
Open Pine	Control	8, 9, 27
Closed Pine	Thin Only	22, 23, 24
Closed Pine	Control	20, 25, 26
Douglas Fir	Thin Only	10, 11, 12
Douglas Fir[3]	Thin and Burn	15, 17
Douglas Fir	Control	13, 14, 16

7.2.5 Time Frame for Sampling Ecological Effects of Fuel Management

It is expected that monitoring will be required for 10 to 20 years to establish long-term trends in the chosen response variables. Therefore, permanent techniques and marking systems were selected and implemented.

7.3 Design and Installation of Integrated Sampling Grids

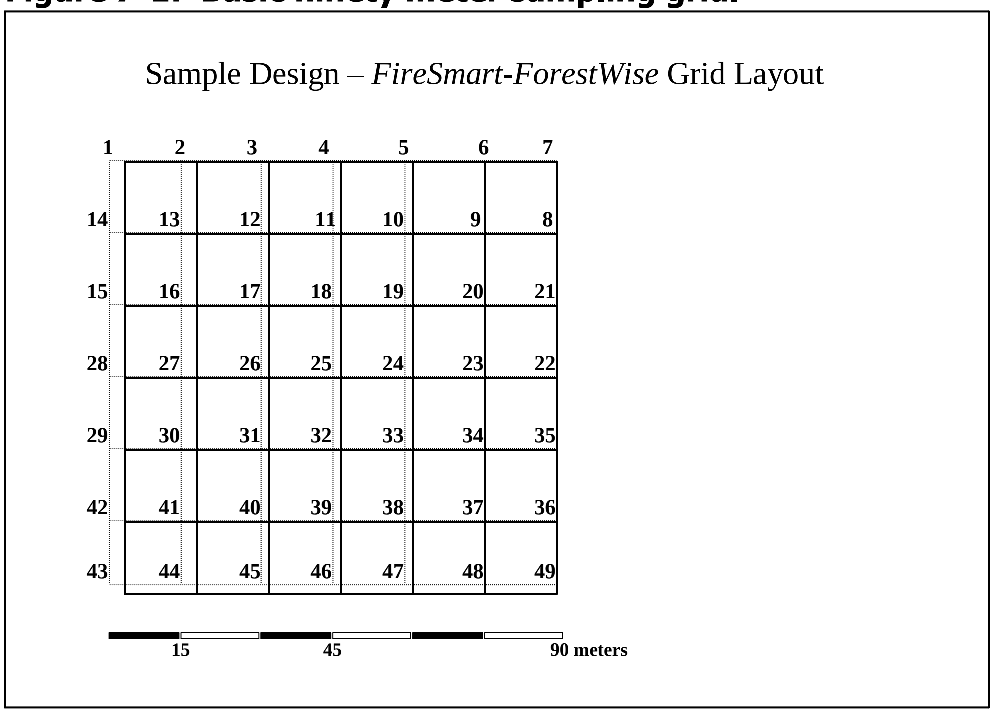
7.3.1 Grid Design

To efficiently monitor these attributes, an integrated grid-based sampling approach was adapted from the design proposed by the U.S. Joint Fire Science

[3] One additional grid for Douglas fir thin and burn is to be added at a later date.

Program for the National Study of the Consequences of Fire and Fire Surrogate Treatments (Weatherspoon and Mc Ivor 2000). It allowed point, line, and area data to be collected within a single area. The 90 x 90 m square plot size was selected because it is a multiple of the recommended interval (i.e., 15 m) for sampling horizontal sight distance and small mammal populations. Ninety metres allowed seven sampling points within each linear transect, and a square grid of 7 x 7, or forty-nine, sampling points. The forty-nine intersection points within the grid, called "grid points", were consistently numbered as shown in Figure 7-1. Within this figure, the numbers that correspond to each grid point are located slightly above and to the left of each grid point.

Figure 7-1: Basic ninety meter sampling grid.



7.3.2 <u>Procedure for Grid Establishment Within Forest Types</u>

A geographic information system (GIS) was used to overlay potential sampling polygons onto an aerial photo of the study area, within the boundary of pre-mapped forest types. Polygons measured 120 m square to allow for the 90 m grid, plus a fifteen m buffer. These were positioned to avoid "edge effects" by leaving the maximum possible distance between sample sites and features such as roads, trails or buildings. When a potential fit was found, the co-ordinates of the grid corners were read from the GIS, to be located in the field later. Possible sampling sites were oriented so that one side (i.e., grid points 1,2,3…7) was parallel to the margin of the nearest urban area. Using the coordinates provided by the GIS, each site was located in the field using a geographic positioning system (GPS) device. Based on guidelines provided by Mueller-Dombois and Ellenberg (1974), potential sample sites were evaluated for homogeneity, uniformity, and adequacy of size. If these requirements were not met (i.e., if the grid area included more than a 40 m x 40 m area of a distinctly different stand type, or if the grid inadvertently included linear disturbances such roads or right of ways exceeding 8 metres) the grid was alternately shifted 25 m parallel to the urban area, then 25 m farther away until the guidelines were met.

Equipment and Materials

Establishing the permanent 90 m^2 sampling grid in the field required:

- 6 - one hundred metre retractable surveyor tapes,
- 1 - Silva Ranger compass corrected for local declination,
- 1 - geographic positioning system (GPS) device,
- 49 – steel drift pins (9 mm iron bar cut to 50 cm lengths) and sledge,
- flagging tape for temporary markings,
- 4 - aluminum caps each engraved with grid number and corner grid point,
- 45 - plastic caps numbered for all remaining grid points, and
- permanent marker, clipboard, sampling grid lay-out forms (Figure 7.2).

Construction of Sampling Grid

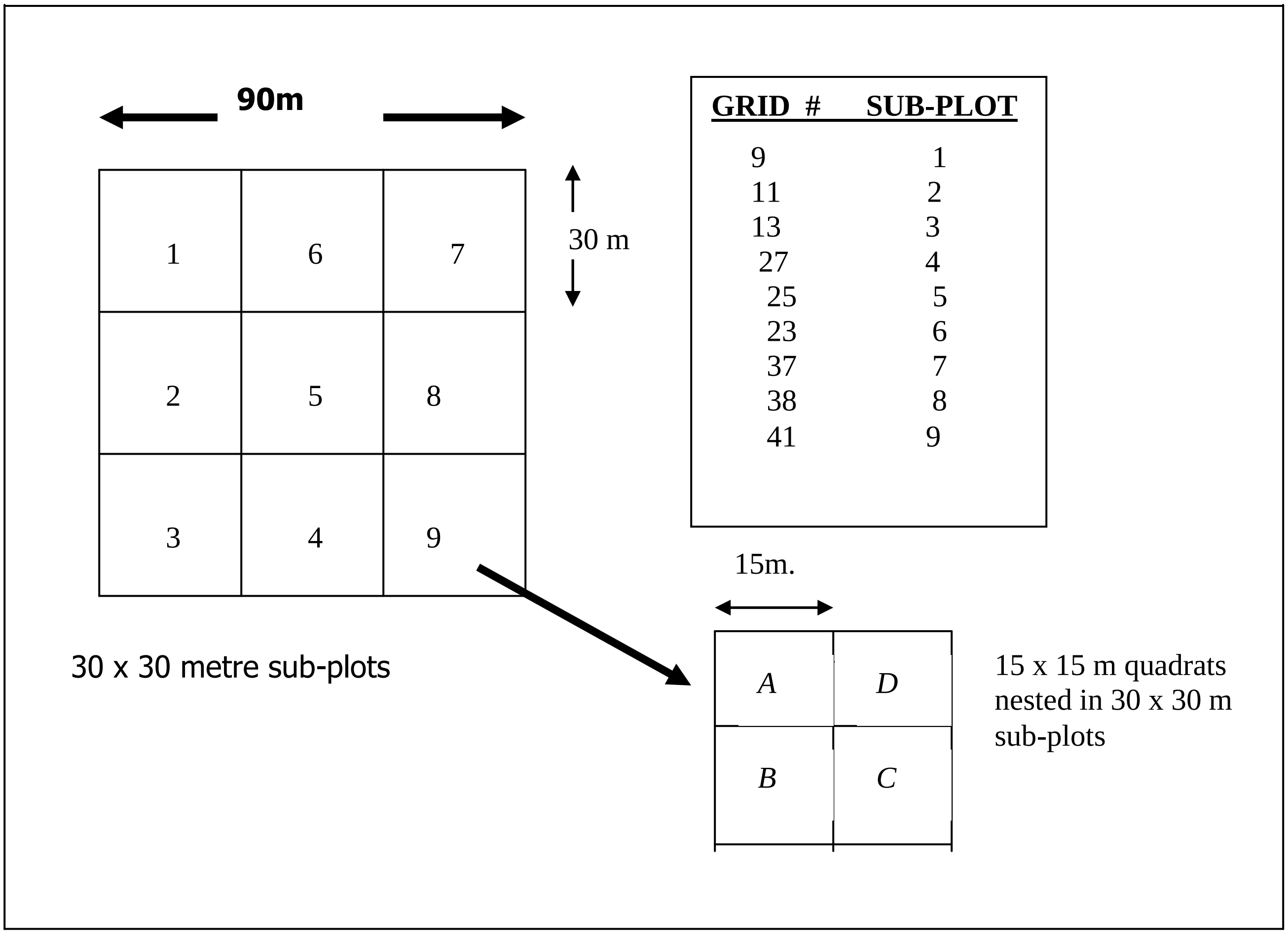
The position of grid point #1 was located on the ground using the GPS and permanently marked by driving an iron pin into the ground, until only 3 cm was exposed. Then, using the compass bearing generated by the geographic information system, a measured 90 m baseline was compassed to position grid point #7, and this point marked. The compass was then rotated 90 degrees and a second baseline surveyed to locate grid point #49. This process was repeated twice more to locate grid point #43, set the remaining two baselines, and close the box on grid point #1. If the closing distance was not within one metre of the starting point, the process was repeated until an acceptable closing distance was obtained. Iron pins were then driven into the ground at 15 m intervals around the perimeter of the grid. Finally, straight lines parallel to the first base line were surveyed using compass and tape between grid point pairs (i.e. 14/8, 15/21, 28/22, 29/35, 42/36), and drift pins installed at 15 m intervals. Engraved aluminum caps were placed on the corner pins, and hand-labeled plastic caps on intervening pins to aid in relocation and reduce potential for wildlife injuries.

Vegetation Sampling Sub-Plots

For the purpose of documenting vegetation cover, the 90 x 90 m grid was subdivided into nine (9) 30 x 30 m sub-plots. The sub-plots were centred on grid points 13, 11, 9, 27, 25, 23, 41, 39, and 37 as shown in Figure 7-2.

To aid in relocating the permanent sampling grids in the future, corner GPS coordinates were verified, and compass bearings and distances to identifiable tie points (e.g., gate posts, hydro poles) noted. This information was then recorded on “site maps” (Figure 7-3). A 30 cm piece of blue surveyors ribbon was attached to each drift pin and labeled for short-term visual reference. Iron pins allow for future relocation with a metal detector.

Figure 7-2: 30 m sub-plots and nested quadrats within 90 m grids.



GRID #	SUB-PLOT
9	1
11	2
13	3
27	4
25	5
23	6
37	7
38	8
41	9

Figure 7-3: Location of sampling grids near Lake Edith, Jasper National Park.

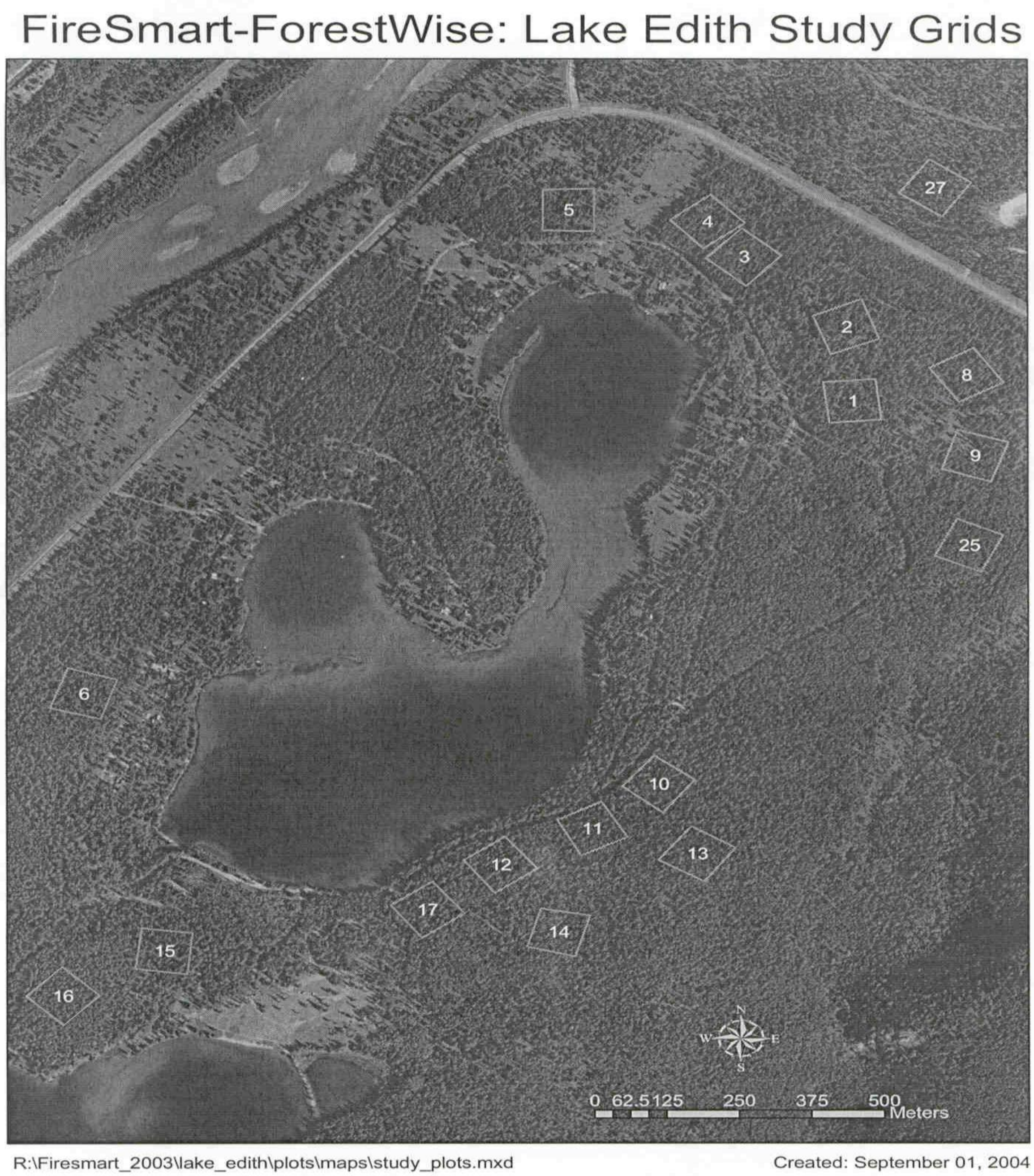
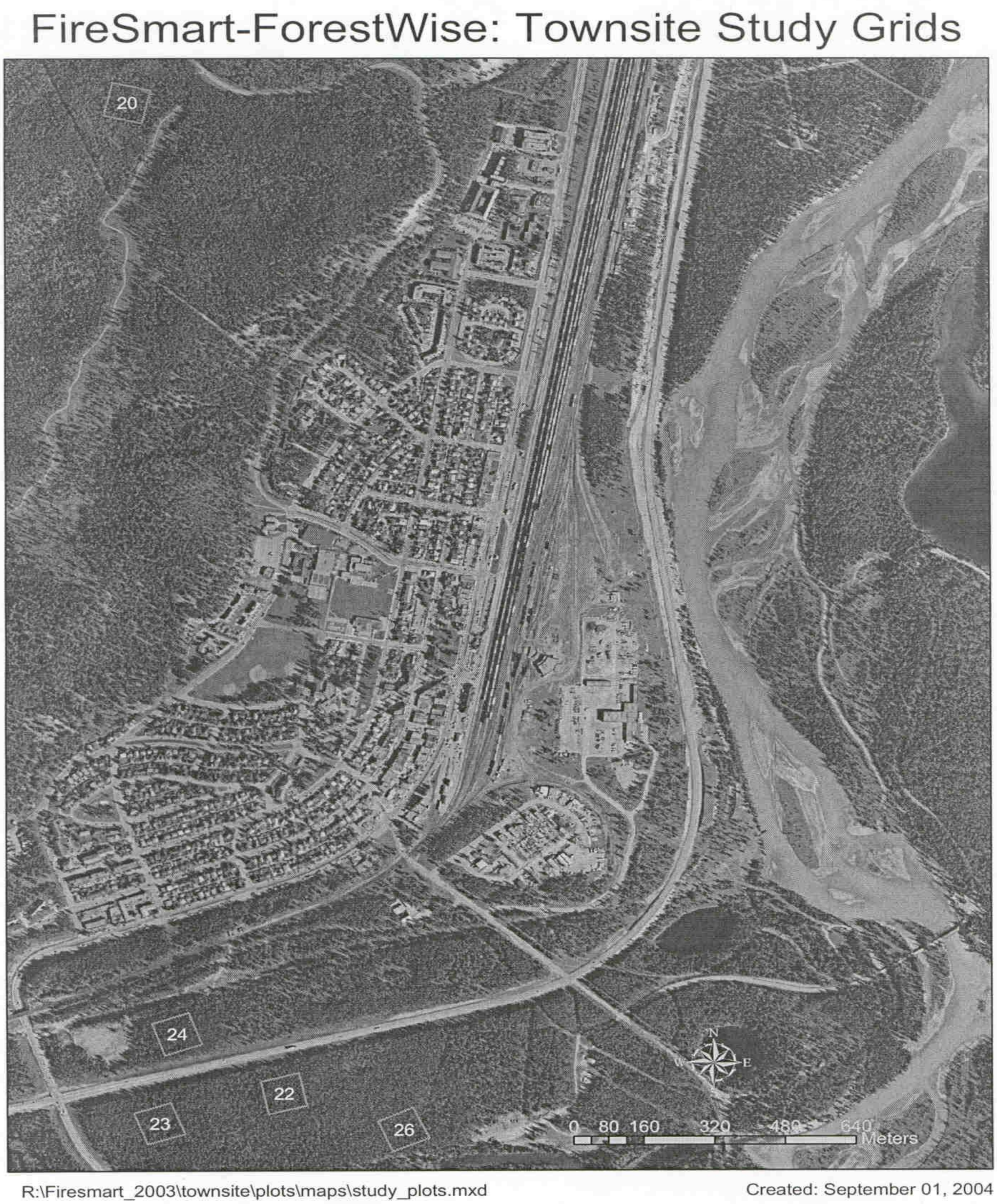


Figure 7-4: Location of sampling grids near Town of Jasper, Jasper National Park.



7.4 Sampling for Stand Structure and Composition

7.4.1 General Sampling Design

This method is based on established releve techniques detailed by Achuff (In: Holland Coen 1982), and was used to describe structural aspects and species composition of forest types and stands in the study area.

7.4.2 Equipment

- clipboard, stand description form, random numbers table,
- grid Placement Description Form (site map as shown in Figure7-3),
- increment borer and 10-power hand lens,
- Haglof "Vertek III" digital clinometer, digital camera,
- DBH calipers,
- GPS and compass, and
- 100 meter tape, high visibility flagging.

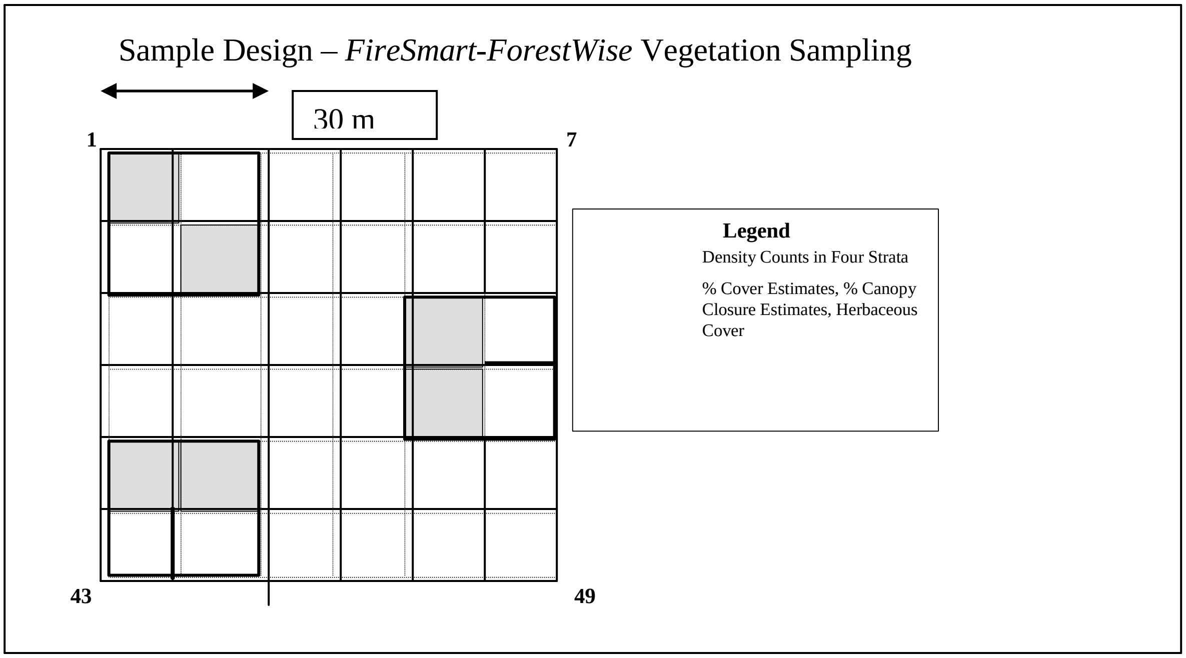
7.4.3 Sampling Location

Three 30 m square sub-plots were randomly selected in each grid using a random numbers table. Within each 30 x 30 m sub-plot, the random numbers table was used again to pick two of the four quadrants for stand density counts. See Figure 7- 6 for an example of sub-plot locations within a grid.

7.4.4 Field Sampling Procedure

Upon entering each sub-plot, the corners and perimeter mid-points of each 30 m^2 sub-plot were temporarily flagged to simplify cover estimation. Vegetation composition was recorded and an ocular estimate of percent crown cover for each species in each major forest strata (e.g., tree, shrub, herb, and bryoid) assigned (Daubenmire 1959). If more than one forest canopy tree layer existed, the tree layer was split into A1 (dominant trees) and A2 (sub-dominant trees).

Figure 7-5: Example of sub-plot locations for stand description sampling within permanent grid.



The shrub layer was also split into B1 (shrubs 2-5 m tall) and B2 (shrubs 0.5-2 m tall). Dwarf shrubs (Cw) < 0.5 m in height were tallied separately from grasses and forbs in the herb layer, while mosses (Db) and lichens (Dl) were distinguished within the bryophyte layer. Ground cover other than vegetation was also estimated by the ocular technique for categories of ground litter, rocks and stones, exposed mineral soil, deadfall, water, ash, slash and unburned debris piles. Using a consistent observer for all cover estimates is recommended.

Age structure information for each sub-plot was obtained by taking tree cores from one or more representative individuals in the A1 and A2 tree strata using a standard increment corer and conducting field counts of annual rings with the aid of a 10-power hand lens. Cores are taken at 45 cm above ground and a correction factor of five years added to account for time to reach that height.

Tree diameters are taken at breast height using calipers. Height data is obtained using a Haglof "Vertek III" digital clinometer.

Site information was recorded at each sub-plot and included slope, aspect, topographic position, relief shape, elevation, UTM co-ordinates of the plot center and moisture regimes outlined in Holland and Coen, Volume II, page 72 (1982). Stand density information was obtained by counting all individuals within the A1, A2, B1, and B2 strata within two randomly chosen 15 x 15 m quadrants of each sub-plot (shaded areas shown in Figure 7–6), and converting these values to stems/hectare.

7.4.5 Data Collection Form

A two-sided "Stand Description" field data form (Appendix B: Figures B-1, B-2) was created and standardized vegetation sampling protocols established for filling out each data field determined (Appendix B: Figures B-3). One form was completed for each 30 m^2 sub-plot; and 3 sub-plots sampled in each grid.

7.5 Sampling for Coarse Woody Debris

7.5.1 General Sampling Design

This method generally follows the technique of Taylor (1997) for gathering information about the volume and number of pieces of coarse woody debris on the forest floor. It has been adapted to include information about the condition (i.e., decay class) of the woody debris using criteria established by Maser et al. (1988) and Hammond (2003). See Figure 7-6 for decay classes.

7.5.2 Equipment

- clipboard, coarse woody debris form, stand description form for each grid,
- 3 - 100 metre survey tapes, 1- 30 metre tape, 1 – carpenters tape,
- compass and flagging tape, and
- DBH calipers.

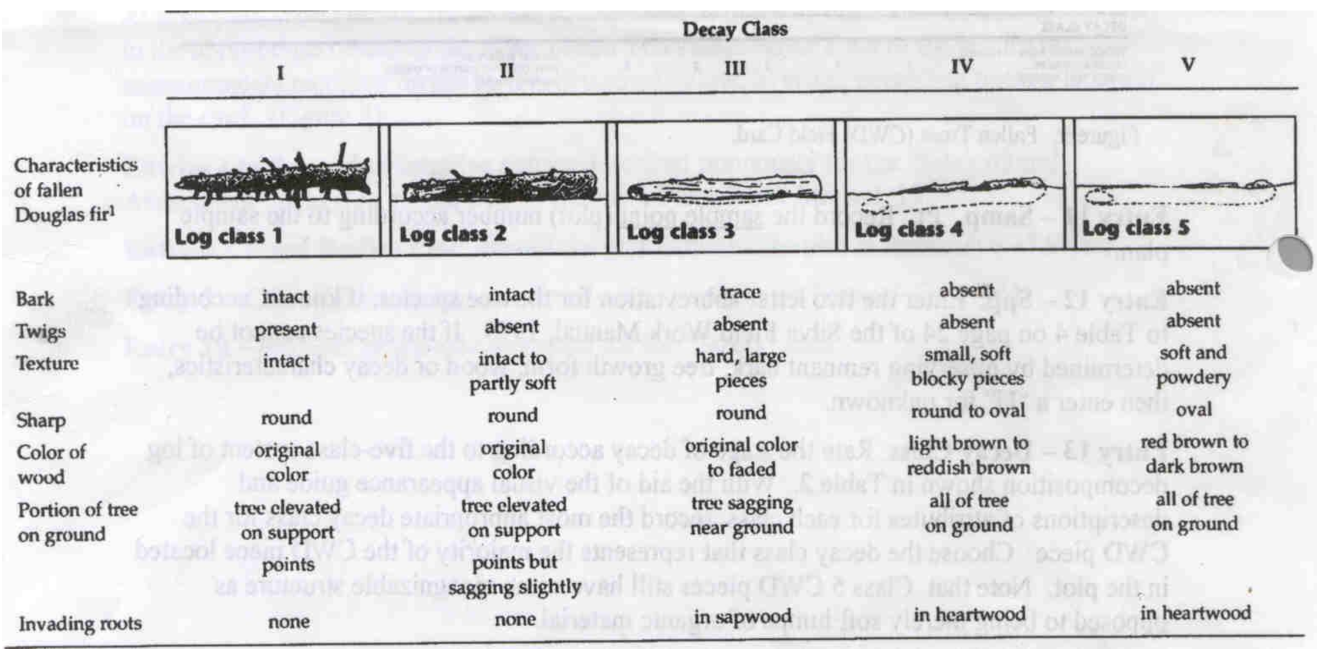
7.5.3 Sampling Locations

Each of the 5 interior lines within sampling grids was sampled beginning at the grid perimeter closest to the interface values and progressing in a perpendicular direction away from the interface (i.e., start at grid points #2, 3, 4, 5 and 6).

7.5.4 Field Sampling Procedure

A survey tape was anchored to the starting (perimeter) grid point and stretched to the grid point thirty metres distant (i.e., grid points 16, 17, 18, 19, or 20). The tape was then pulled tight, any deflecting vegetation shifted away, and the tape "snapped" to straighten the alignment. The tape was then tied off to that grid pin, and the tape alignment procedure repeated for the second and third segments of the transect. Every piece of CWD greater than 7.5 cm diameter at the point of intersection with the tape is measured as per Taylor (1997). That is, data on diameter class (using intervals on the data sheet), data on length class (using intervals on the data sheet), and decay class (using diagrams from Hammond 2003), is recorded in the left table (Appendix B-4).

Figure 7–6: Coarse woody debris decay classes (Hammond 2003).



	Decay Class I	II	III	IV	V
Characteristics of fallen Douglas fir[1]	Log class 1	Log class 2	Log class 3	Log class 4	Log class 5
Bark	intact	intact	trace	absent	absent
Twigs	present	absent	absent	absent	absent
Texture	intact	intact to partly soft	hard, large pieces	small, soft blocky pieces	soft and powdery
Sharp	round	round	round	round to oval	oval
Color of wood	original color	original color	original color to faded	light brown to reddish brown	red brown to dark brown
Portion of tree on ground	tree elevated on support points	tree elevated on support points but sagging slightly	tree sagging near ground	all of tree on ground	all of tree on ground
Invading roots	none	none	in sapwood	in heartwood	in heartwood

More than one data sheet was required if more than 20 pieces were encountered per 30 m segment. Once the first 30 m segment of the 90 m transect was completed, the tape was advanced an additional 30 m (to grid points 30, 31, 32, 33, 34) and steps 5 – 7 repeated on a new data sheet. To capture data for the final 30 m segment, the tape was advanced to grid points 44, 45, 46, 47, 48.

Calculations from Field Data Sheets

In the lab, the second (right hand) table on each data sheet was completed (Appendix B-4) by filling out the "class tally" columns based on numbers of pieces in each diameter and length class recorded in the field. The look-up tables provided by Taylor (1997) were used to find volume in cubic metres/hectare and number of pieces/hectare for each diameter and length class, then entering these values in the columns to the right of the class tally column. Individual volume and number factor values were summed into the boxes at the bottom of the data sheet and the number of pieces in each of the 5 decay classes recorded.

7.5.5 Data Collection Form

See Appendix B-4.

7.5.6 Assessment of Technique

This sampling technique works well within the fixed grids. It is best implemented by three-person team. It can easily be explained to volunteers, working under supervision, to encourage public engagement and increase efficiency.

7.6 Sampling for Berry Production (*Shepherdia canadensis*)

7.6.1 Sampling Design – General

A simple, belt transect type sampling technique was developed for sampling productivity of buffaloberry, the most common berry-producing shrub in the study area. Transects were conducted within the fixed sampling grids.

7.6.2 Equipment

- clipboard, berry productivity form, stand description form for each grid,
- 3 - 100 metre survey tapes, 1 – retractable carpenters measuring tape,
- compass and flagging tape, and
- 1 – two meter wooden rod marked at the center point.

7.6.3 Sampling Locations and Timing

Three 90 m interior lines within each permanent grid were sampled. These were aligned parallel to the interface boundary, beginning at grid points 14, 28, and 42 and ending at grid points 8, 22, and 36 (see Figure 7-12). Sampling must be conducted at the same phenological stage each year, preferably when (or just before) 50% of the berries reach maturity. Some berries remain green at this stage but most are relatively large and visible; this makes them easier to detect but minimizes the loss of data due to shedding of berries or consumption.

7.6.4 Field Sampling Procedure

A system (Table 7-2) was developed to classify berry production.

Table 7–2. Productivity classes for *Shepherdia canadaensis*.

CLASS	DESCRIPTION
1	No berries
2	Berries scattered on <25% on branches
3	Berries scattered on 25 – 50% of the branches
4	Berries scattered on >50% of branches; bunches on <25%
5	Berries hvy. or bunched on 25-50% of stem, scattered on others
6	Berries heavy or bunched on >50% of ranches

To begin, fill out general transect information on the data sheet (Appendix B-5). Anchor the survey tape at the starting (perimeter) grid point (i.e., grid point 14) and pull the tape along the compass bearing 90 metres to the end grid point (i.e., grid point 8). To ensure proper line location, loop the tape around the grid point midway between the end points (i.e., grid point 11). Pull each section tight after shifting obstructing vegetation away from the tape, then tie the tape off to the distal grid pin. Record data for every *Shepherdia canadensis* shrub that is over 50 cm in height, has two or more woody stems, and that originates from within one metre on either side of the tightened survey tape. In the case of shrubs with multiple stems, the shrub is considered "in" and tallied if more than 50% of the stems in the clump originate within one metre of the survey tape.

7.6.5 Data Collection Form

See Appendix B-5.

7.6.6 Assessment of Technique

Used in conjunction with the permanent sampling grid this technique is quickly learned and rapidly implemented in the field. Data forms could be expanded to record information regarding damage to individual shrubs due to the thinning process. Depending on the amount of woody debris, this technique can require 4-8 hours to complete each permanent grid.

7.7 Sampling for Horizontal Sight Distance

7.7.1 General Sampling Design

Horizontal sight distance is a measure of habitat cover and is an important factor for wildlife. It was measured along the same transects utilized for the *Shepherdia canadensis* productivity measurements, using techniques documented by Rahme (1991) and by Griffith and Youtie (1988), and adapted by Mercer, Dobson, and Westbrook (2002). In the standard technique, the rod is held only in the vertical position for reading by the nearby observer. In our study, the rod is to be read in the vertical position and horizontal positions (at each sampling point) to document changes in vegetation cover and sight distance in two dimensions, rather than just one.

7.7.2 Equipment

- clipboard, horizontal sight distance data form, stand description form for each grid,
- compass and flagging tape, and
- 1 – two meter graduated wooden rod painted in alternating red and white segments of 25 cm each.

7.7.3 Sampling Locations and Timing

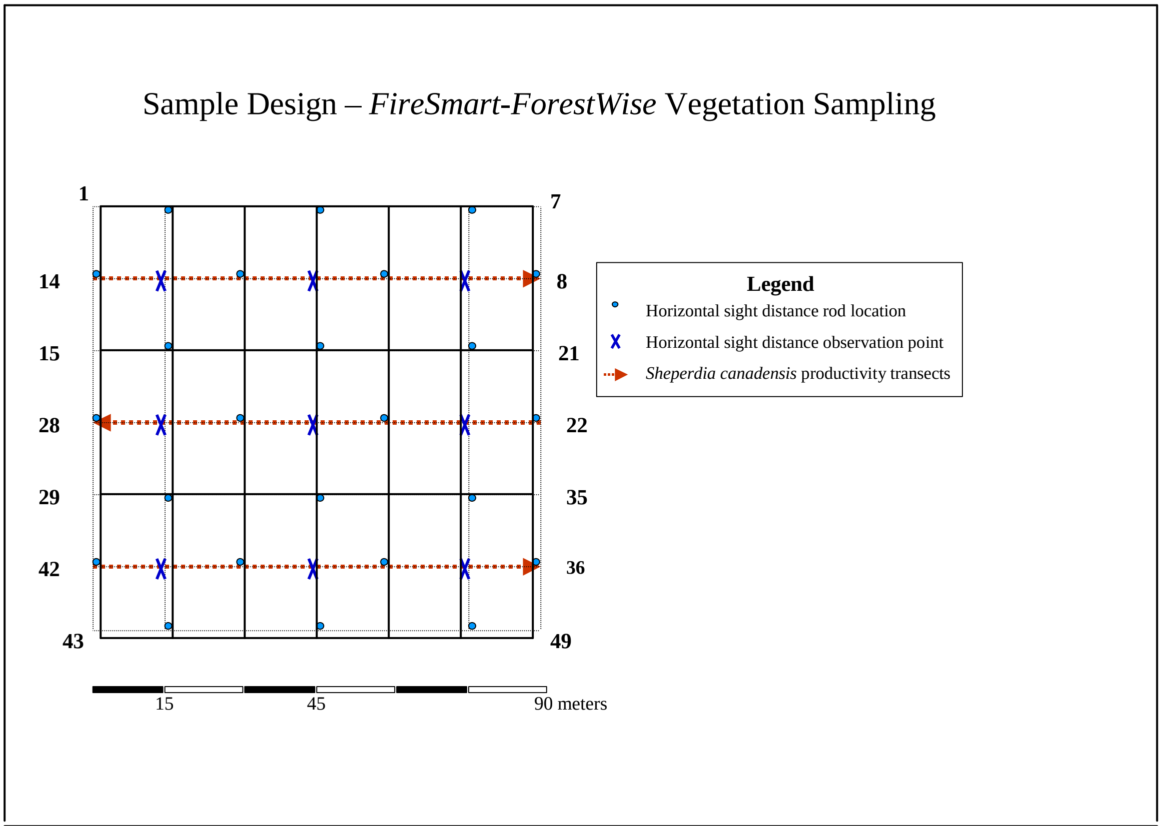
Three interior lines in each permanent grid were sampled. The 90 m transects were placed parallel to the interface boundary, beginning at grid points 14, 28, and 42 and terminating at grid points 8, 22, and 36 (see Figure 7-7). Sampling must be conducted when summer vegetation is at its peak volume, and before foliage begins to senesce or leaf-shed begins.

7.7.4 Field Sampling Procedure

This method required one observer, and one person to hold the graduated wooden rod. Locate the initial grid point at the grid perimeter (i.e., grid point 14) then position the observer at the next grid point (i.e., "center" grid point at #13, with the clipboard), while the rod holder remains at the start point. The rod holder sets the rod vertically on grid point 14 while the observer views and records the percentage of each of the 8 rod segments that are visible (not occluded by vegetation). When completed, the rod holder remains in place but moves the rod to the horizontal position at breast height; again the observer records the percentage of each rod segment that is visible. The rod holder then moves to the next grid point, 15 m from the stationary observer and at 90 degrees from the original orientation (i.e. grid point 2), and a second set of vertical and horizontal readings are taken. This process is repeated twice more as the rod holder moves to the other grid points the "center" point. When four sets of readings are completed from the original center point, the observer moves 30 m further along the transect to the next center point (i.e., to grid point

#11) and the process is repeated. The process is repeated once more using grid point #13 as the center, thus completing the first transect. The second and third transects within the grid are completed in the same way.

Figure 7-7: Location of horizontal sight distance and *Shepherdia canadensis* sampling transects within permanent sampling grids.



7.7.5 Data Collection Form

See Appendix B-6.

7.7.6 Assessment of Technique

This technique requires about two hours per transect, once a routine is well established. Use of the same observer is recommended. Working during mid-day (i.e., when the sun is high) to avoid eye fatigue and possible error due to difficulty in reading the graduated rod is recommended.

7.8 Sampling for Biomass of Grass and Forbs

7.8.1 General Sampling Design

A direct sampling method, based on published techniques (Arizona 2002) was developed to quantify response of herb species to protection/restoration treatments. A photographic technique for documenting herbaceous changes was also used (Troxel and White 1988). A 1 m^2 clip plot size was selected due to the low amount of herbaceous biomass under coniferous forest (B. Irving, pers. comm.). In each permanent grid, a random numbers table was used to select 10 grid points for sampling. At each of the selected grid pins, random numbers were drawn again to determine the quadrant to be sampled (Figure 7-9).

7.8.2 Equipment

- hinged wooden frame with inside measurements of 100 centimetres,
- 2 pairs of scissor-type clipping sheers, paper lunch bags, marker,
- 1 - retractable 30 m tape, compass, ventilated electric drying oven,
- electronic scale capable of measuring to the nearest 100th gram,
- digital camera and a set of 7.5 cm x 7.5 cm plot marker cards.

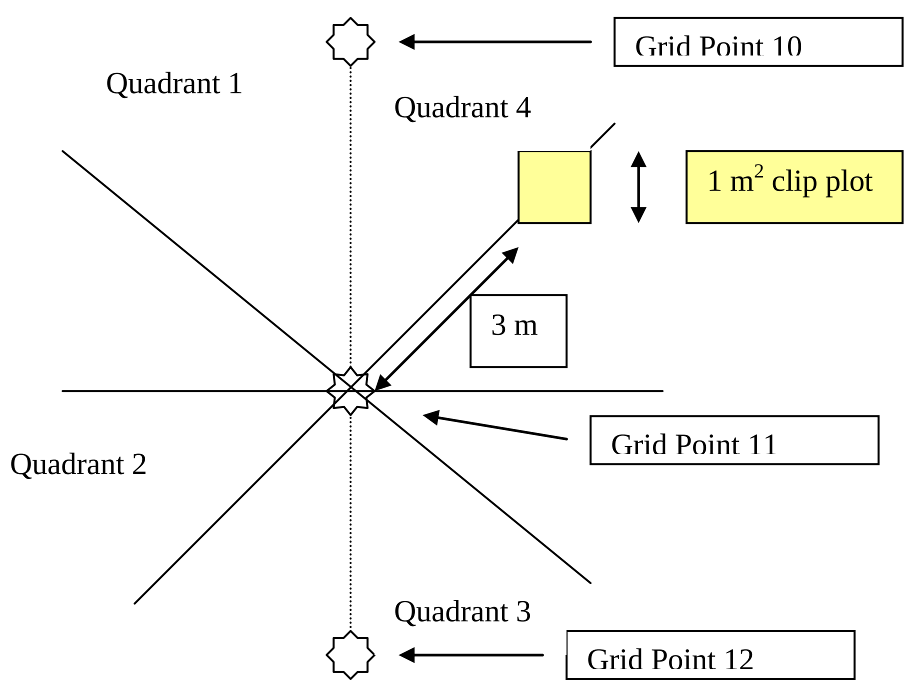
7.8.3 Placement of Sampling Frame

The 1m^2 sampling frame was placed by stretching a survey tape from the chosen grid pin into the randomly chosen quadrant, on a compass bearing 45 degrees off the main axis of the sampling grid. The frame was then placed onto the survey tape so that the tape bisects the frame diagonally with the 3.0 m mark resting at the frame corner closest to the grid pin. The sample site was rejected if > 4% (i.e., 20 x 20 cm) of the area within the frame was obstructed by a tree, stump, unburned brush pile, ash pile, or dense shrub patch, and the frame re-positioned at a distance of 5 m. If that location was obstructed, the frame was moved to 7 m. Failing that, the frame was moved into the next quadrant going in a clockwise direction, and placed at 3 m. Sampling locations should be chosen to avoid overlap with area clipped in the previous year.

7.8.4 Field Sampling Procedure

Sampling was conducted in mid-August to early September once maximum biomass had been attained, but before senescence of plants (Elzinga et al. 1998) or significant grazing by ungulates. All current year herbaceous growth rooted within the $1m^2$ frame was clipped at a height of 1 cm above ground. For efficiency (B. Irving, pers. comm.), forbs and grasses are clipped independently and placed into separate paper bags, pre-labelled with the date, grid number, grid point, quadrant, and distance from grid pin. To facilitate preparation of a photo-guide for predicting forest biomass quantities, a 7.5 cm x 7.5 cm card showing the sample number was placed inside each $1m^2$ frame and the plot photographed before clipping. Sampling is best accomplished by a 2-person team.

Figure 7–8: Biomass sampling design.



Preparation and Weighing of Samples

Filled bags were stored in a well-ventilated room until oven dried in small batches for a minimum of 24 hours at 40 degrees Celsius (Troxel and White 1988). After drying, each bag was weighed on an electronic scale to the nearest 100^{th} gram (the average weight of an empty bag was subtracted from this value). Separate weights were recorded for grasses and forbs, along with grid number, grid point, quadrant, and date for each sample.

7.8.5 Assessment of Technique

It was found that two to three grids (i.e. 20 to 30 samples total) could be sampled in a day using this field technique. In this forested environment, few 1 m^2 clip plots required more than three sampling bags. Field sorting of forbs and grasses, and clipping of forbs first (followed by clipping of current year grasses) proved to be most efficient method for stratification of the biomass sample.

7.9 Sampling for Ungulate Use – Pellet Counts

7.9.1 General Sampling Design

A belt transect design adapted from methods described by Edge and Marcum (1989), Stelfox (1995), and White (2001) was used for collecting pellet data to monitor levels of ungulate use in the study area. Sampling lines were located perpendicular to the interface zone, away from the perimeter of each grid to avoid areas trampled during other sampling efforts, and to capture variation that may result from increasing distance from roadways and human disturbance (Neff 1968, Rogers and Robinette 1958). Three 90 m x 2 m wide transects were placed within each grid for a total of 270 linear m or 540 m^2 of sample. Sampling was conducted twice per year to reduce error due to age of pellets.

7.9.2 Equipment

- clipboard, pellet count form, stand description form for each grid,
- 3 - 100 metre survey tapes, compass, flagging tape, and
- 1 – two meter wooden rod marked at the center point.

7.9.3 Sampling Locations and Timing

Three transects were placed in each permanent sampling grid and aligned between grid point pairs 2 – 44, 4 – 46, and 6 – 48. (see Figure 7-10). For optimal visibility of pellets, sampling was conducted prior to spring green-up and before collapse of herbaceous vegetation in the fall (Stelfox 1995). Spring and fall sampling was conducted to reduce error probability in aging and detection of pellet-groups. Sampling was not conducted when pellet groups had been exposed to rain within 18 hours causing the pellet surface to be moist, and colors altered. It was preferred to sample later in the day when relative humidity is low.

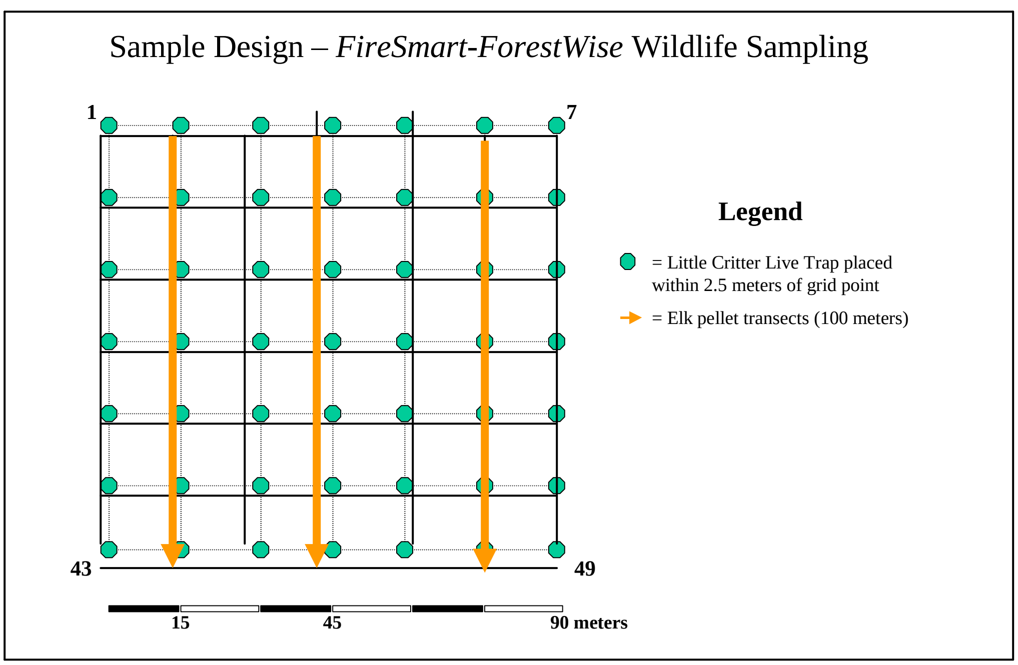
7.9.4 Field Sampling Procedure

Using information from literature and field observation trials, criteria were established to help standardize aging of pellets and reduce sampling error. "Summer" pellets are generally clumped, while "winter" pellets are separated. Not all age class criteria need be present to age pellets; these criteria are summarized in Table 7-3. The start and end points of each transect are defined by pairs of edge grid points, as in Figure 7-10. To ensure that the centre line of each 90 m transect was always located in the same position on subsequent surveys, the mid-point grid pin was used to further define the line. That is, one observer located the mid-point 45m away from the origin then the second observer walks directly to that point pulling the tape. The tape is tightened and "snapped" straight after re-positioning any vegetation that deflects the line. The tape is then secured around the mid-point pin and the process repeated sighting on the end grid point 90 m from the transect origin. The transects therefore extend from origin to mid-point, to end point and are pegged at grid points 2 – 27 - 44, 4 – 25 – 46, and 6 – 23 – 48.

Table 7–3: Criteria for making pellet age class decisions.

	SUMMER PELLETS	WINTER PELLETS
CURRENT YEAR	- soft - clumped - no grass grown through - not white fringed - distinct edges - not decomposed, usually without insect galleries - vegetation under pellets is still identifiable	- outside hard and shiny, minor cracks/peeling (rumen coating intact) - color dark (brown to black) - inside of tightly packed fibers, distinct, little or no insect activity - hard or brittle, resistant to crushing - show shades of green internally - versus brown or grey - grass growing around - but not through - little or no needle litter on top of pellets
PREVIOUS YEARS	- hard, brittle - edges crumbling, indistinct - grass growing through pellets - bleached, mottled color, or white fringed - vegetation underneath gone, decomposed - in contact with LFH soil	- outside cracked, scaling, curled - color bleached, may be white fringed - inside decayed, insects or insect galleries obvious - softer, less resistant to crushing - grass growing through pellets - vegetation underneath gone, decomposed - pellets in contact with LFH soil

Figure 7-9. Location of wildlife sampling within permanent grids.



A 2 m rod, marked at its center point was is held perpendicular to, and passed along the survey tape to help determine whether or not pellet groups are "in" or "out" and not tallied. A pellet group is considered "in" only if more than 50% of the pellets are within 1 m of the transect centre line. In the case of pellet groups deposited while the animal is moving, a minimum of 20 pellets must be within 1 m of the centre line to be included. Groups of less than 20 pellets do not constitute a pellet group and are not recorded.

To be considered "summer" pellets, groups must have at least 1 cluster of attached pellets, and the majority of the remaining pellets deformed and irregular in shape. All pellets are removed from the plot once observed, with the exception of recently deposited "winter" pellets that are observed in fall, when only ungulate use from that summer is being recorded.

7.9.5 Data Collection Form

See Appendix B-7.

7.10 Sampling for Small Mammal Use – Live Trapping

7.10.1 General Sampling Design

Live trapping sessions to capture, mark, and release small mammals were carried twice per season in each of the sampling grids to determine the relative abundance and species composition present. Methods were adapted from Sullivan et al. (2001), Stelfox (1995), and MacKenzie (2002). Trapping and safety standards set British Columbia Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee (RIC) for inventory of small mammals (1998a) and capture and handling of live animals (1998b), and by Mills et al. (1995) were utilized. Additional technical advice on methods was provided by Dr. Jack Millar of the University of Western Ontario/Kananaskis Research Centre, and by Tom Sullivan of the Applied Mammal Research Institute, Summerland, B. C.

7.10.2 Equipment

- 270 "Little Critter" 2-part live traps (Rogers Manufacturing Peachland BC.),
- Monnel #1 ear tags – size 1-018-M (National Band and Tag, Kentucky),
- ear tag applicator – model 1005S1 (National Band and Tag, Kentucky),
- clipboard, capture data forms, stand description forms,
- bait, coarse cotton trap filler, carrot pieces for moisture,
- 2 litre ziplock bags with sliding closures, 5 gallon plastic buckets (4),
- latex or vinyl gloves, sanitizing alcohol based hand cleaner,
- vile of 10% sugar solution and syringe (for reviving animals in shock),
- flagging/survey tape, compass, and Pesola field weigh-scale.

7.10.3 Sampling Locations and Timing

Traps were deployed at each grid point within the grid, within 2.5 m of the grid pin, at logs, runways, or under shrubs. Traps were baited with peanut-butter mixed with oats. Carrot slices for moisture, and cotton ticking for bedding and insulation were placed in the box portion of each trap. Traps were set, then covered with moss, or litter to shelter it from direct sun and rain, then checked before departing. Each trapping session was 48 hours in length. During each session, traps were checked four times at 12-hour intervals. Spring trapping sessions were held in May and fall sessions in early September. Ideally, traps are set and checked as early and as late as possible, as light conditions permit.

7.10.4 Field Sampling Procedures

Minimum handling of captured animals, in the most efficient and brief manner is essential for health of the animals, and to avoid shock. Captured animals were emptied into a ziplock bag (held inside a 5-gallon bucket), then weighed. The animal was then grasped to perform a visual health inspection, the sex determined, and a numbered ear tag applied to each ear before release. Traps were then re-set or pulled. A 2-person team allowed all data to be recorded immediately.

7.10.5 Data Collection Form

See Appendix B-7.

7.10.6 Assessment of Technique

Small mammal trapping is labor-intensive and must be done with a high degree of discipline and organization to ensure humane and safe practices. It was critical to have attentive team leaders and volunteers to assist with intensive seasonal trapping sessions; four to five grids can be sampled simultaneously.

7.11 Sampling for Landbirds – Breeding Bird Surveys

7.11.1 General Sampling Design

The purpose of sampling for landbirds is to gather information regarding species composition, relative abundance, distribution, and habitat relationships with regard to study area treatments. The fixed-radius point count sampling approach was selected. Permanent sampling points were established and marked at locations within the interior of uniform polygons of each of the three main forest types within the study area, including untreated controls. The monitoring techniques used in this project closely follow standards established by Ralph et al. (1995), Hutto (1995, 1996), and the British Columbia Resources Inventory Committee (1999). Observers with previous training and experience in identifying birds by song, calls, and visual cues were utilized. Bird songs and visual identification skills were reviewed annually. Two consistent observers, one primary and one secondary, were used from year to year to limit observer error.

7.11.2 Equipment

- clipboard, field data sheet, pencils, map with point coordinates,
- index sheets with wind, cloud cover, and bird codes,
- binoculars, bird identification field guide (Field Guide for Western Birds)
- compass and flagging tape, and
- GPS, spare batteries, stopwatch or timer, thermometer.

7.11.3 Sampling Locations, Timing, and Conditions

Sampling sites were chosen in areas of at least 250 m of contiguous vegetation type, and separated a minimum of 300 m from all other sampling sites. Point counts were conducted during breeding season, when preliminary observations indicated that the majority of species had arrived and were singing to establish territories, generally between May 10 and June 20. The observation period extended from one hour before official sunrise to three hours after sunrise. Surveys were not conducted during periods of constant heavy rain, when temperatures were below 3 ^{0}C, or when winds rose above 12 km/hour (Table 7-4). To avoid sampling error due to noise, individual ten-minute counts were deferred during the passage of trains, and counts near highway corridors were conducted early during the observation period, prior to significant traffic activity.

Table 7-4: Beaufort wind codes.

Beaufort Code	Windspeed km/hour	Indicators of Wind Speed
0	<2 km	Smoke rises vertically
1	2-5 km	Wind direction shown by wind drift
2	6-12 km	Wind felt on face, leaves rustle
3	12-19 km	Leaves, small twigs in constant motion; flag extended
4	20-29 km	Raises dust and loose paper; small branches moved
5	30-39	Small trees in leaf sway; crested wavelets on lakes

7.11.4 Field Sampling Procedure

Sampling sites were organized into transects (i.e., routes) to minimize travel time and increase efficiency. Transects were conducted in the same order each year. Mountain bikes were used effectively to move between sites along each transect. Once closeby, observers (2) walked to the site, completed the preliminary data, and oriented a stick on the ground in a north-south direction to assist in completing the bearing information as each bird was identified. After waiting quietly for 2 minutes, the timer was set for 10 minutes and the count initiated. For each bird identified, distance was estimated to nearest ten metres, bearing to nearest 5 degrees, and it was indicated if the bird is in, or outside, the habitat type. Visual confirmation was attempted from the sampling point, as possible (Hutto and Hoffland 1996). Observations were segregated on the field form into those recorded in the first 3-minute period, the next 2-minuter period, and the final 5-minute period to facilitate comparison with data from other studies (Ralph et al. 1995). Unknown birds were noted and an attempt made to follow and verify their identity at the end of the timed session. Both observers participated in identification of birds, but only one person records data. Supplementary to bird observations, data on red squirrels was also recorded.

7.11.5 Data Collection Form

See Appendix B-11.

Figure 7-10: FireSmart – ForestWise Lake Edith birding plots.

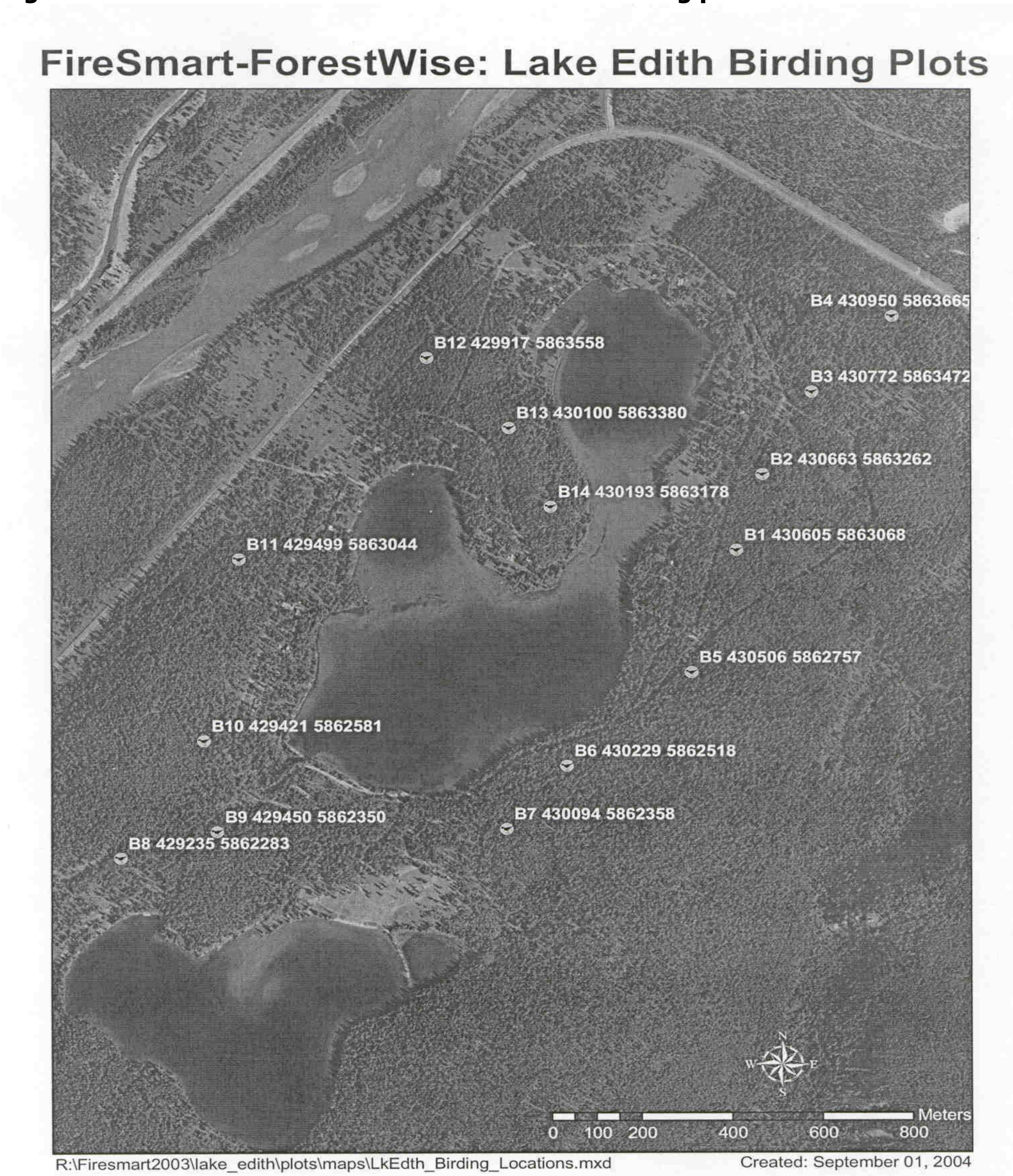
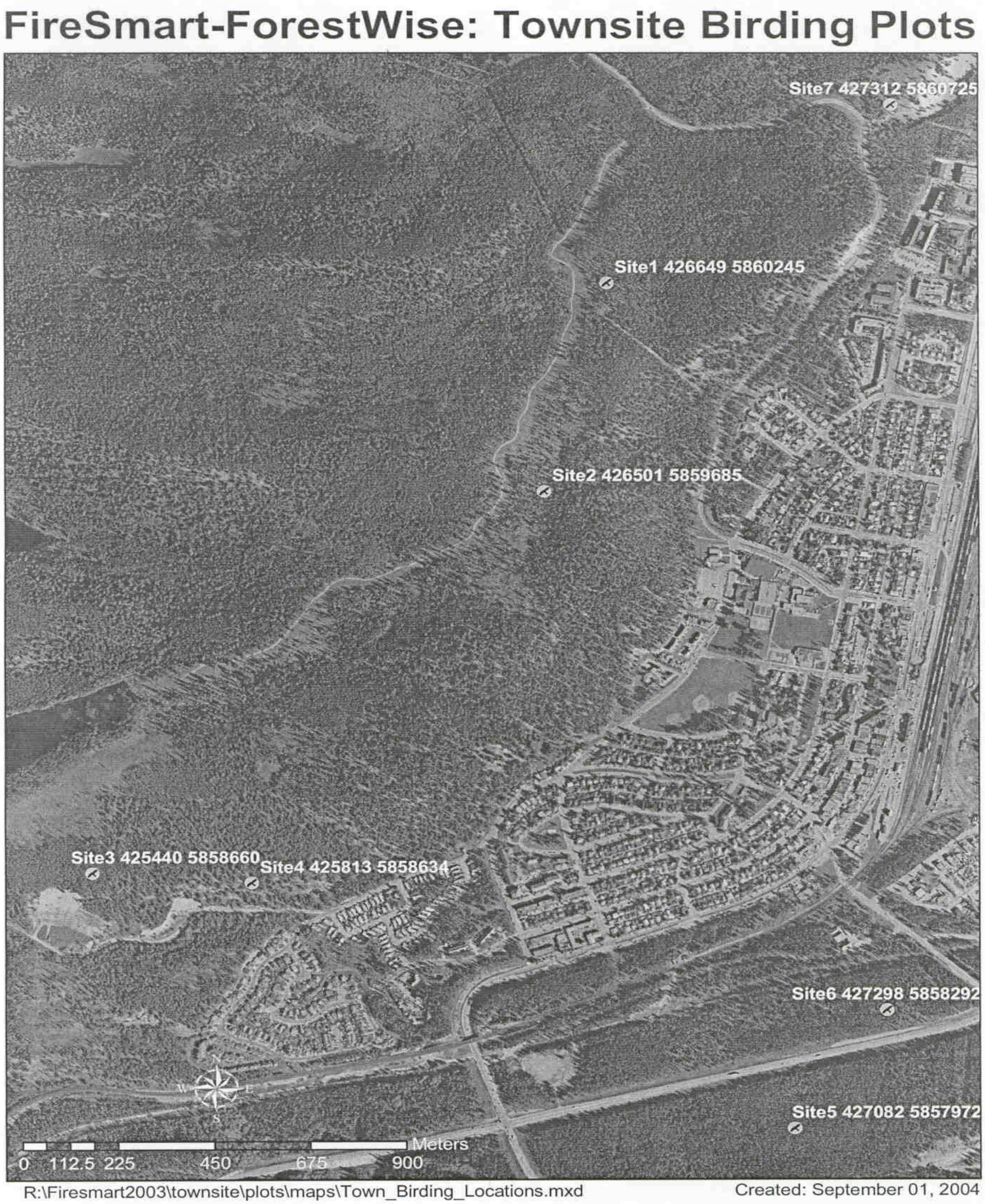


Figure 7-11: FireSmart – ForestWise townsite birding plots.



7.11.6 Assessment of Technique

Three seasons of breeding bird surveys were conducted to gather pre-treatment baseline date for subsequent research. Although no analysis of the data has yet been carried out, it was felt that several factors may effect the value of the data:

- The relatively narrow interface fuel treatment areas and their narrow, linear shape allow birds from outside the treated zone to be included in the sample,
- Noise from nearby highways and railways made identification more difficult.
- Extreme variations in seasonal conditions and plant phenology appeared to hamper migration of songbirds and change their representation in the sample.

7.12 Baseline Data Collection and Database Management

In 2003, the above methods were employed to collect baseline data describing stand conditions prior to forest thinning and prescribed burning activities. The full suite of follow-up studies were conducted in stands treated in the winter of 2003/2004 (i.e., sampling grids 1, 2, 3, 4, 5, 6, 20, 22, 23, and 24), during the summer of 2004. In 2004, second year data was collected for ungulate use and *Shepherdia* production in all grids, and biomass production data was collected from paired treated sites and control sites.

All original data and electronic database files for this project, including metadata, is housed in the Jasper National Park geographic information system. Electronic files are in Microsoft Access format. Back-up copies of all original data and electronic files are maintained at the Foothills Model Forest, Hinton, Alberta.

CHAPTER 8. Conclusions, Recommendations, and Future Research

In essence, the guidelines, mitigations, and best practices presented in Chapter Six form conclusions regarding ecologically based approaches to managing interface fuels to optimize conditions for wildlife. In addition, I have also drawn a series of other conclusions and recommendations regarding the stated purpose of this research, and the subsequent research objectives. Finally, some suggestions for future research to support this area of knowledge are offered.

8.1 General Conclusions

Several overall conclusions arise from the literature evaluation and field manipulations undertaken during this research. I concluded that:

1. There are many practicable opportunities for managing vegetation of the wildland/urban interface in ways that optimize conditions for wildlife and wildlife habitat, within constraints of current fuel management standards.

2. If adopted, the species-specific mitigations, guidelines, and practices developed through this research could augment existing national (e.g., FireSmart) fuel management standards to help resolve deficiencies pertaining to conservation of wildlife and wildlife habitat, and to mitigate adverse impacts of fuel management on related resource values.

3. The results of this research should be applicable to many other Canadian landscapes given that forest fuel types (Hirsch 1996) of the study area are common to many other boreal and Montane landscapes.

4. Selective forest thinning for the purpose of reducing wildfire risk in the wildland/urban interface can be compatible with ecological restoration actions in fire-deprived Montane and foothills ecosystems, and complementary to the needs of native wildlife native to these habitats.

5. Some public concerns about adverse impacts to wildlife and native biodiversity due to current fuel standards could be addressed by applying the mitigations, guidelines and practices developed in this study. Reducing these concerns could accelerate the progress of interface fire prevention.

6. Managing fuels using the FireSmart – ForestWise approach (i.e., taking ecosystem based approaches to current fuel standards) has potential to reduce habitat loss and promote conditions more favorable to wildlife in the rapidly expanding interface zone of the Rocky Mountains and foothills.

7. First-hand knowledge about the effects of fuel management is scarce. Applying methodologies, such as in Chapter Seven, to monitor the long-term effects of fuel management on vegetation and wildlife could further assist development of ecologically based fuel management programs.

8.2 Specific Conclusions

More specific conclusions flowed from the analysis of wildland/urban interface issues conducted in Chapters One and Three, and from the sequential investigative steps (Figure 2-1) conducted to achieve the four main objectives of this thesis. Those conclusions are presented in that order.

8.2.1 Interface Problem and Study Area

Deficiencies in Current Fuel Management Standards

There is evidence that recurrent conflicts between existing standards for risk/fuel reduction and other resource values such as wildlife conservation may deter interface residents or communities from taking preventive fuel management actions.

Application of Study Results

I conclude that the prototype Jasper project area is broadly representative of the biophysical, fuel, and socio-economic/risk conditions that exist in many other interface communities in forested environments across Canada and the western United States, and that research applications may extend to these areas.

8.2.2 Objective 1: Identify the potential effects of standard fuel management treatments on wildlife habitat and selected wildlife species in interface areas.

Assessment of Current Fuel Management Standards

In section 4-1, the FireSmart® fuel management treatments were described in relation to each fuel bed stratum, within each of the designated interface "priority zones". I concluded that fuel bed strata coincide closely with the ecological structure of forests, and that examining the forest in sequential horizontal layers allows correlations between fuel bed characteristics governing fire behaviour and wildlife attributes such as food and cover to become obvious.

I also judged fuel bed strata to be a useful concept for discussing the effects of current standards and benefits of ecosystem based fuel management practices. This nomenclature may also be effective in communicating with managers and the public about holistic fuel management approaches.

Predicted Effects of Fuel Management

The effects of applying standard fuel management treatments on habitat and wildlife were described in sections 4.2 – 4.5. From this investigation I found that fuel treatments, directly or indirectly affect most aspects of forest structure, forest composition, and forest function, and that these effects can lead to a wide range of adverse impacts upon wildlife and wildlife habitat. As a corollary, I conclude that this knowledge can be used to guide fuel manipulation programs in a more informed way, by allowing adverse impacts to be avoided and potential benefits for wildlife to be realized.

8.2.3 Objective 2: Develop mitigations, guidelines, and practices for managing vegetation of the wildland/urban interface in ways that optimize conditions for wildlife, compatible with current fuel management standards.

Opportunities for Multiple Resource Benefits.

By conducting a step-wise examination of fuel management standards for each forest layer (section 5.1), I conclude that a wide range of opportunities are available to forest managers for accommodating significant wildlife benefits, within constraints of the current standards designed to reduce wildfire risks.

I concluded that five general strategies for managing the forest canopy (i.e., single-tree spacing, cluster thinning, preservation of habitat trees, stand type conversion, and prevention of post-thinning windthrow) hold potential to benefit wildlife (section 5.1.1).

I found that variations on single-tree spacing methods have much potential for maintaining or enhancing structural diversity, species composition, and restoring a structure more characteristic of the historic range of variation in fire-adapted forests. I also concluded that cluster-thinning techniques have similar benefits, as well as the ability to enhance forest openings, increase edge habitat, and isolate and preserve habitat features or patches of particular value to wildlife.

I conclude that there are numerous options for preserving or modifying habitat trees, inclusive of snags and legacy trees, within each of the interface priority zones. Likewise, I conclude that there are opportunities for preserving or enhancing wildlife habitat attributes in the shrub and dwarf shrub layers (section 5.1.2), low vegetation layer (section 5.1.3), and the forest floor (section 5.1.4).

Combining Ecological Restoration and Fire Protection.

Section 5.2 examined potential for achieving objectives for ecological restoration concurrent with objectives for fuel management in the Montane and foothills forests of Alberta. I concluded that there are important similarities between ecological problems being encountered in fire-adapted forests (i.e., forest in-growth, forest encroachment, and replacement of deciduous forest by conifers) and problems regarding hazardous fuel conditions in the wildland/urban interface.

Based on this, I conclude that there are also substantial overlaps in the physical measures required to resolve them. That is, by selectively thinning the forest canopy to restore the structure and composition of forest stands and the heterogeneity of landscapes (in certain fire regimes) to within their historic (natural) ranges of variability, the effect on forest fuels and fire behavior is to reduce wildfire risk.

Further, I concluded that by using information about historical forest density and structure as a guide to thinning intensity, wildfire risk can be reduced to levels <u>below</u> what can be expected by applying FireSmart standards alone (i.e., by replicating historically open stands of 15 – 30% canopy cover, crown spacing greater than distances prescribed in Appendix 2 of the FireSmart manual, Partners in Protection 2003 will be achieved).

Species–specific Mitigations

Section 5.3 synthesizes information regarding the life/habitat requirements of various wildlife, the potential impact of fuel management actions on these, and the limitations and capabilities to mitigate such impacts within the context of current fuel management standards. As a result of this synthesis, I found that many species-specific conservation measures can be identified to minimize adverse impacts to wildlife or, alternatively, optimize wildlife benefits from fuel management treatments. Further, I suggest that protection of habitat trees, coarse woody debris, and structural diversity within the stand are perhaps the most significant wildlife factors.

Species-specific wildlife mitigations were tested for practicality during the two-year Jasper prototype project, and are identified in Tables 5-1 to 5-8. Although I suspect that the benefits of these mitigations will be positive, this cannot be concluded at this time. It seems reasonable to speculate that the suggested mitigations offer substantially more wildlife benefits than current fuel management standards alone.

Ecosystem Based Guidelines

I concluded that it was possible to develop ecologically based guidelines specific to fuel bed layers and interface priority zones that are compatible with current FireSmart standards. These are presented as results in section 5.4

Guidelines for Modified Fuel Management Practices

I concluded that it is possible to improve general fuel management practices (e.g., woody debris disposal, season and hours of work) and to develop guidelines for practices to protect key habitats (e.g., forest edge, wildlife corridors, grasslands and aspen forest, and riparian areas). Therefore, new or modified guidelines for integrated fuel management practices that better address interface wildlife and habitat issues are proposed in section 5.5.

I also concluded that ecosystem-based guidelines specific to common forest types and various fire regimes are appropriate, and possible. These are explained in sections 5.3.3 and 5.3.4, and are based on variations to standard canopy thinning techniques used by industry.

I concluded that there is a need for better guidance to reduce windthrow potential in thinned stands, for improved management of habitat trees, and for other interface practices (i.e., maintenance of biodiversity, artificial habitat enhancement, human use management). These guidelines are presented in section 5.5.3.

Last, because these species-specific mitigations, guidelines, and practices have been field-tested and refined within an operational interface setting, they are judged to be practical, rather than theoretical.

8.2.4 Objective 3: Recommend methods and equipment for large-scale implementation of ecologically based fuel management practices as determined in a prototype program implemented at Jasper, Alberta.

Small Scale Field Trials

I found that small-scale field trials (section 6.1.4) were valuable in refining stand-specific prescriptions for implementation by contactors and harvesting industry equipment at the larger, operational scale. I also speculate that field trials (i.e., demonstration sites) play a valuable role in educating and engaging the public.

Adaptive Management

After applying the adaptive management approach of Walters and Holling (1990) to the complex wildland/urban interface scenario being confronted in Jasper, I conclude that this approach is well suited to achieving multiple resource objectives in the interface. Based on experience in the Jasper prototype project, I conclude that stand-specific prescriptions are an effective and tangible means of expressing integrated fuel management objectives to operational personnel. The template provided in Table 6-3 outlines prescription content (Appendix I).

Methods and Equipment for Implementing Holistic Fuel Management Guidelines

Following field trials and two years of large-scale (i.e., 215 hectares) implementation, I concluded that a five-phased progression is best suited for conducting community wildfire protection projects: 1) develop stand-specific prescriptions; 2) flagging of trees by the researcher and technical staff in accord with the stand-specific prescriptions; 3) selective cutting, processing, and removal of salvageable wood (winter) with commercially available harvesting equipment, and mechanical piling of debris; 4) winter disposal of thinning slash by trained crews using hand tools, power saws, and pile burning; 5) summer rehabilitation of minor environmental impacts and monitoring of project results.

Criteria were established to select the most suitable equipment for conducting mechanical forest thinning and debris management. Based on these, it was concluded that specialized "cut-to-length" (i.e., "processing-at-the-stump") harvesting systems are capable of achieving fuel management objectives with low impacts and great sensitivity to wildlife criteria, and were preferable to traditional whole-tree logging or horse logging systems within this study.

8.2.5 <u>Objective 4: Propose a standardized methodology for quantitatively assessing long-term effects of fuel management treatments on key vegetation/habitat attributes and wildlife utilization, thus enabling follow-up studies in the prototype Jasper study area and other locations</u>.

As a result of literature review, I found that studies to directly measure the effects of interface fuel treatments are very rare, and conclude that future knowledge gathered by continuing to monitor the Jasper study area would be of significant value to the forest/fire management community to document change over time resulting from fuel management activities.

Based on scientific literature, a methodology to monitor changes in wildlife habitat and responses of wildlife to fuel management treatments were selected. Following field implementation, I conclude that permanently fixed, grid-based sampling is highly efficient for monitoring multiple habitat and wildlife attributes.

8.3 Recommendations

This research has focused on development of ecologically based approaches for managing forest vegetation (fuels) of the wildland/urban interface in ways that optimize conditions for wildlife but within the constraints of current FireSmart standards. Based on the research presented in this thesis, a number of recommendations have been generated.

➢ *Use of the Research Results*

Research that could benefit present fuel reduction programs is currently being generated from a number of sources and disciplines. It is recommended that:

- An organized national initiative should be undertaken to ensure that standards for interface fuel management and risk reduction continue to evolve with the benefit of this, and other current research.

- The species-specific wildlife mitigations, integrated fuel management guidelines, and modified fuel management practices developed in this research be made widely accessible to agencies and the general public to encourage improved stewardship and conservation practices in the wildland/urban interface and reduce apparent conflicts between risk reduction and other resource values.

- In order to increase public acceptance of current fuel management standards and to accelerate implementation of fire prevention programs, a means of integrating the findings of this research into, or amending, current FireSmart standards should be established.

- Parks Canada and the Foothills Model Forest continue the long-term monitoring program initiated in this study to determine outcomes of ecosystem based fuel management treatments, and to continue the development of new knowledge from the prototype project.

➢ *Application to Other Locations*

The varied forests of the Jasper study area are a microcosm of boreal and cordilleran forests found across Canada. The diversity of conditions found in the study area result in forest and fuel types analogous to other Canadian landscapes. Therefore, what has been learned through this study is informative elsewhere. It is recommended that:

- The species-specific wildlife mitigations, ecosystem-based fuel management guidelines for interface priority zones, and guidelines for modified fuel management practices be considered for application to other communities in the Rocky Mountains and foothills of Alberta, and to communities beyond this geographic range that have similar natural disturbance regimes (i.e., frequent, low-intensity fire) in British Columbia and the western United States.

- Agencies responsible for the wildland/urban interface develop communication programs to inform residents about the potential impact of fuel management to wildlife, and the availability of solutions.

➢ *Achieving Multiple Resource Management Objectives in the Wildland/Urban Interface.*

This research demonstrated that multiple resource management objectives can be achieved concurrently in the wildland/urban interface, without compromising the objective for reducing wildfire risks. It is recommended that:

- Fire managers with responsibility for wildland/urban interface areas strive to replace the dominant viewpoint of "vegetation as fuel" with a more holistic perspective that includes a perspective of vegetation as the basis for local wildlife populations as well as many other ecological, social, and economic values held by interface residents.

- Equal consideration be given to objectives related to ecosystem management or ecological restoration and objectives for risk reduction when designing fuel management treatments in fire-adapted forests.

- Specialized training, education, and outreach tools be developed to extend an ecological perspective to interface practitioners and residents of the wildland/urban interface.

- Environmental impact assessments be conducted as a standard component of community wildfire protection planning. This would avoid or reduce adverse impacts to wildlife, and to limit incremental impacts that may be occurring as a result of expanding industrial or country-residential development in rural and forested areas.

- Wherever possible, ecosystems that were formerly maintained by fire and now structurally restored through ecologically based fuel management be managed using prescribed fire.

➢ *Adaptive Management*

It is recommended that the adaptive management approach be more widely applied in the wildland/urban interface. It should be continued in future phases of the prototype Foothills Model Forest project at Jasper, and should be included in other operational fuel management projects to expand these findings to other ecosystems and interface situations.

➢ *Scale of Vegetation Management Actions*

- Vegetation (fuel) management actions implemented within the wildland/urban interface take place at the site-specific or stand scales. However, these actions should be planned within the context of the greater landscape to incorporate ecological and fire protection considerations that operate across scales, or at the broader level.

8.4 Future Research

A number of knowledge gaps and potential research opportunities related to this study became apparent during this research. It is recommended that:

- To help resolve the scarcity of first-hand research regarding the long-term impact of fuel management activities on wildlife and other ecological issues, Parks Canada follow up the baseline studies initiated during this research by re-sampling and analyzing results of vegetation and wildlife response to forest thinning conducted at Jasper, at intervals of three to five years for the next fifteen to twenty years.

- The investigative process outlined in this research be applied as a template for additional studies to develop prescriptions specific to other forest types, fuel types, and forest regions elsewhere in Canada that are not directly analogous to forests within the study area.

- A collaborative, multi-agency effort to increase knowledge about the effects of fuel management on other resource management objectives (e.g., wildlife), and to continue improving Canadian standards for fuel management, be established. Given the extent of thinning work being conducted and the availability of baseline information, Parks Canada is well positioned to make a significant contribution to such an initiative.

- Optimally, Canadian fire management agencies should become active participants in related American research studies (i.e., the national study of the consequences of fire and fire surrogate treatments); at minimum, Canadian practitioners should track the results of those studies and incorporate the results into local practices.

- In the absence of direct scientific research, the approach taken in this study should be extended to include a greater diversity of wildlife species, and additional forest types so that considerations for them may also be incorporated into future fuel management planning.

- The present research in Jasper should be augmented with specific stand reconstruction studies that utilize dendrochronology methods to increase the level of understanding with regards to the species composition, density, and age class structure in the open pine and dry Douglas fir forest types, and areas that appear to have been grasslands.

- Sociological research should be initiated in conjunction with the Foothills Model Forest prototype project at Jasper to determine more about relevant values held by residents (e.g., wildlife in the interface, wildlife viewing opportunities aesthetic qualities of vegetation) and the reasons behind apparently high levels of public support and engagement in this project.

- Further studies of fire behavior should be initiated to provide quantitative information regarding threshold levels of course woody debris that can be retained for wildlife purposes without compromising fire protection objectives.

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Appendix A: Sample Prescription for Fuel/Restoration Thinning.

Thinning Prescription: Operating Area "M1"

Pyramid Bench: Pyramid Loop Area

Description:

This Operating Area includes 25.5 hectares of mature, lodgepole pine forest bounded by Pyramid Lake Road, the ATCO powerline and the lower end of the Community Fireguard. The area is moderately (5-15%) sloping to nearly level with minor undulations. About 5% of the area is considered inoperable due to short but steep slopes (flagged NO-GO). Several access points are available including the entire length of the adjacent fire road on the west, at least two roadside locations along the Pyramid Lake Road (traffic control required) and the ATCO power line to the south. Trails 8 and 2C bisect the area at right angles. The fireguard provides unrestricted decking and loading areas; with safety measures, additional decking/loading areas are possible along the Pyramid Lake road. Maximum forwarding distance is <350 metres. Other than the steep slopes, there are no other "no-go" zones in this OA.

Mature lodgepole pine dominates this area, 5 – 15% Douglas fir is present with a white spruce component in the few moister sites. Canopy cover ranges from 55 – 75%. Tree heights range from 18 to 22 m; average 21 m. Pine DBH ranges from 15 to 35+ cm with an average of 22 cm. Stand age is estimated at 90 - 110 years. Stem density ranges from 520 to over 1120 stems/hectare, but averages 950 stems/hectare. This area contains large amounts of Douglas fir regeneration, it is IMPORTANT to retain these.

Access for log haul vehicles is via Pyramid Lake public road. Trails 8c and 2 transect the operating area by may NOT be used for forwarding. Forwarding routes will be jointly agreed upon as the operation progresses.

Public trails and the ATCO Electric power transmission line special safety concerns and additional precautions are required. Only "utility tree" fallers will cut trees within striking range of the power lines.

Designated decking areas include the entire fireguard. Upon prior approval of the Parks Canada Representative, additional decking areas will be designated along the Pyramid Lake road. These are marked in **YELLOW**.

WITH EXCEPTION OF THE POWERLINE, BOUNDARIES ARE THE EDGE OF STEEP, INOPERABLE SLOPES TOWARDS THE TOWNSITE. ALL BOUNDARIES ARE FLAGGED (STRIPED BLUE/WHITE).

Prescribed Treatments: Thinning in this Operating Area is based both on ecological restoration goals and spacing standards for fire protection. The area has been pre-flagged by project supervisors using criterion on reverse side of this plasticized card. Habitat trees, and special features have been marked also. If additional features are located, alter thinning operations to accommodate them or contact site personnel on portable radio.

GENERAL:

- Forest in this OA is to be thinned such that the space between crowns of remaining trees **averages** **3 - 4 crown widths,** in areas **where Douglas fir forms 25 - 35% of the stand, thin to average of 4-6 crown-widths**.

- With the exception of those marked with **RED** ribbon, **all Douglas fir over 50 cm are to be retained**.

- **Douglas fir shall be retained over pine/spruce** when a choice exists.

- Spruce are late seral and not windfirm; preferentially flagged for removal.

- **All live or dead deciduous trees shall be retained** (safety excepted).

- **Dead standing trees (snags) >25 cm DBH shall be retained unless considered hazardous**. If so they should be topped at 5 or 6 m

- Trees flagged in **RED/ORANGE** are to be removed/ **BLUE** flagged kept

- Trees with **cavities or nests** are to be left undisturbed unless unsafe.

SPECIFIC:

- To meet spacing requirements and reduce windthrow, **dominant (WOLF) pine with the largest height of live crown are to be retained over subdominant pine** or pine with lesser height of live crown.
- **Straight, self-pruned pine will be selected for removal** over pine with low growing branches (wolf trees), twin stems, stem defects, fire scars and visible signs of decay where a choice exists.
- Pine with heavy mistletoe will be removed in favour of less infected trees.
- **Creating variation in tree spacing is essential** to facilitate diversity and accommodate burn piles. **Cluster thinning** is to be used; a minimum of **8 – 12 clusters/ hectare** is required. Openings up to 35m will be created.
- Stems <12 cm shall be cut and piled to facilitate burning; dead of this size to be left standing for wildlife or to fall later and contribute CWD.
- **Slash is to be left on site, but reasonably piled to facilitate burning**.
- Up to 50 stems of Douglas fir regen. (1 – 5m) and advanced regeneration (5 – 10m) is to be retained per hectare, leave "guard" trees for protection.
- **Up to 50 downed trees and decaying logs per hectare shall be retained on the forest floor** for wildlife habitat. **If fewer exist**, the operator may supplement these by placing live trees on the forest floor.
- **Compaction of decayed wood >30 cm is to be strictly avoided**.
- Downed trees in excess of this shall be cut and piled**.**
- **Recently fallen or leaning timber** that is sound and longer than 2.43 m with a minimum top diameter of 10 cm outside bark shall be removed for processing.

B-1: Example of grid placement description form.

Project Surveyors:
Alan Westhaver
Mike Suitor
Colin McKinley

Fire Smart-Forest Wise Grid Placement Description Form **Grid 01**

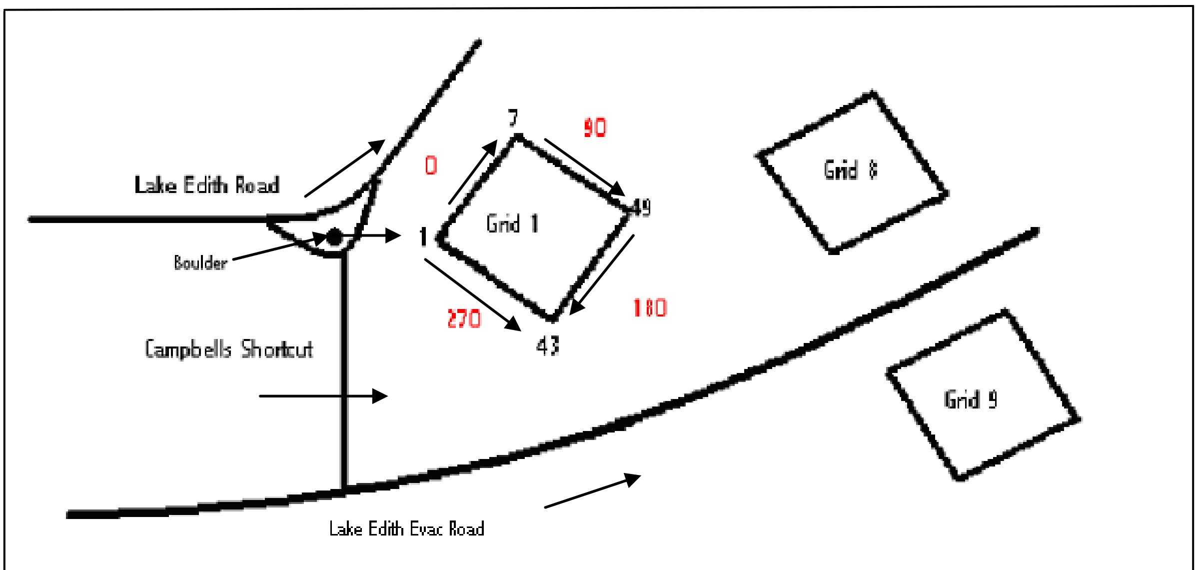
UTM 11u Location (NAD 83, GRS 80)

Point:	Easting:	Northing:
Grid Point 01	430770	5863455
Grid Point 07	430759	5963543
Grid Point 43	430860	5863462
Grid Point 49	430850	5863550

Grid Number 01

Survey Date: 3rd July 2003
Vegetation Type: Open Pine.
Treatment Type: Thin.

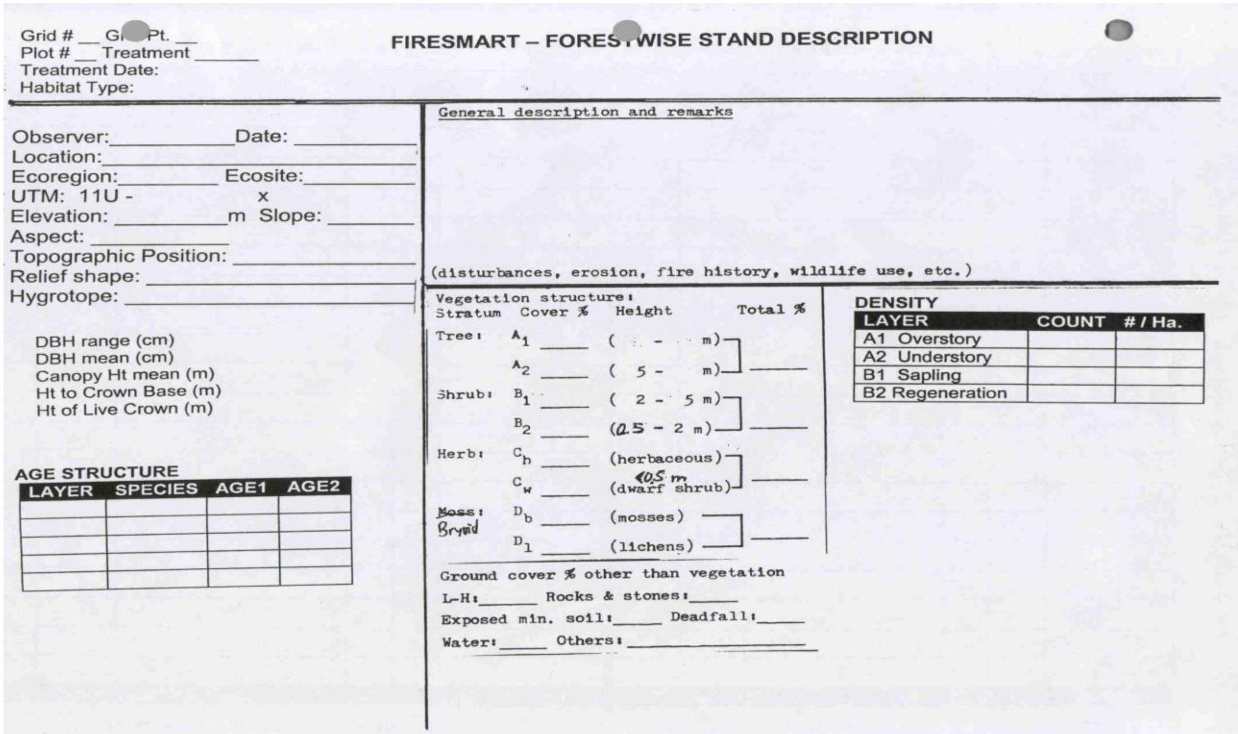
Location Description:
Grid point # 1 located 48m on bearing of 273^0 from round boulder in parking spot at Campbell's Shortcut.



Special Notes: This is the type location for the open pine stand type. Thinned in January 2004.

Data Entry By: Lorraine Wilkinson 15th Aug 2004

B-2. Side one of stand description form.



Grid # __ G Pt. __
Plot # __ Treatment ______
Treatment Date:
Habitat Type:

FIRESMART – FORESTWISE STAND DESCRIPTION

Observer:___________Date: ___________
Location:_______________________
Ecoregion:__________ Ecosite:__________
UTM: 11U - x
Elevation: _________m Slope: _______
Aspect: __________
Topographic Position: ______________
Relief shape: ___________________
Hygrotope: _____________________

DBH range (cm)
DBH mean (cm)
Canopy Ht mean (m)
Ht to Crown Base (m)
Ht of Live Crown (m)

AGE STRUCTURE

LAYER	SPECIES	AGE1	AGE2

General description and remarks

(disturbances, erosion, fire history, wildlife use, etc.)

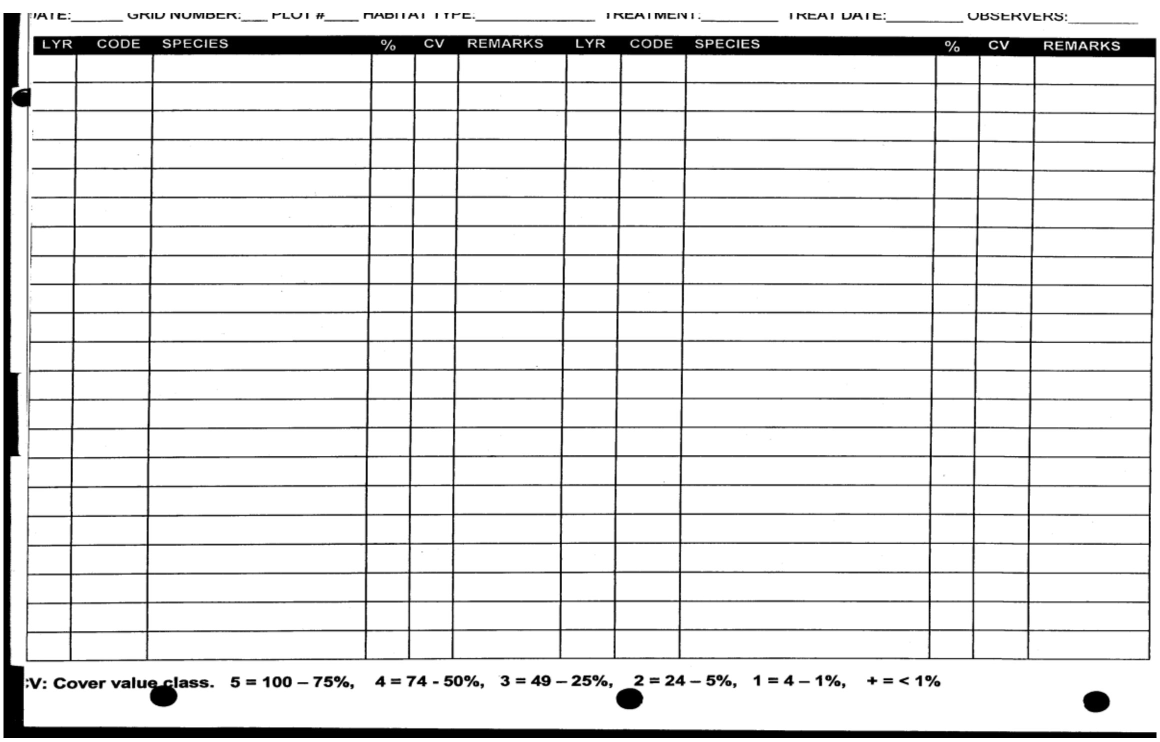
Vegetation structure:
Stratum Cover % Height Total %
Tree: A_1 ____ (- m)
A_2 ____ (5 - m) ____
Shrub: B_1 ____ (2 - 5 m)
B_2 ____ (0.5 - 2 m) ____
Herb: C_h ____ (herbaceous)
C_w ____ (dwarf shrub) <0.5 m ____
Moss: Bryoid D_b ____ (mosses)
D_l ____ (lichens) ____

Ground cover % other than vegetation
L-H:______ Rocks & stones:_____
Exposed min. soil:_____ Deadfall:_____
Water:_____ Others:______________

DENSITY

LAYER	COUNT	# / Ha.
A1 Overstory		
A2 Understory		
B1 Sapling		
B2 Regeneration		

B-3. Side two of stand description form.



DATE:______ GRID NUMBER:___ PLOT #____ HABITAT TYPE:____________ TREATMENT:_________ TREAT DATE:________ OBSERVERS:________

LYR	CODE	SPECIES	%	CV	REMARKS	LYR	CODE	SPECIES	%	CV	REMARKS

CV: Cover value class. 5 = 100 – 75%, 4 = 74 - 50%, 3 = 49 – 25%, 2 = 24 – 5%, 1 = 4 – 1%, + = < 1%

B-4: Vegetation sampling protocols (data sheet instructions).

1. Grid # is the number of the field sampling grid (e.g., 1 to 23).
2. Grid point is the grid point number at the centre of the plot (1 to 49).
3. Plot number is the number of the 30 m by 30 m sub-plot within each grid (e.g., 1 to 9).
4. Treatment is either control, thin only, or thin and burn.
5. Treatment date is the date the area/plot was treated (if treated).
6. Habitat type is the stand type (e.g., close pine, open pine, Douglas fir).
7. Observer is the name of person(s) doing the sampling.
8. Ecoregion is montane in all cases.
9. Ecosite is the Ecological Land Classification designation.
10. UTM is easting and northing in NAD 83.
11. Slope is measured in percent.
12. Aspect is given in compass degrees not cardinal directions.
13. Topographic Position: upper slope, mid-slope, lower slope, ridge top, or valley bottom.
14. Relief Shape: straight, convex, concave, rolling, or irregular.
15. Hygrotope: xeric, subxeric, mesic, subhygric, hygric, subhydric, or hydric.
16. DBH range: visual estimation of largest and smallest trees (i.e., single stemmed woody plants over 5 m) within the plot.
17. DBH mean: measured DBH of tree selected as representative of average DBH of overstory (A1).
18. Canopy Height Mean: Measured height of tree selected as average within the overstory (A1) layer.
19. Height to Crown Base: is the measured height to the lowest live branches of the crown of tree selected as average within the overstory (A1) layer.
20. Height of Live Crown: is the height of live crown of tree selected as average within the overstory (A1) layer.
21. Age Structure: Field count of tree age using at least two individuals from each age cohort (layer) in the stand from individual trees selected as average within the overstory (A1) layer (count three if there is poor agreement in first two ages).
22. Tree: single stemmed woody plants over 5 m tall.
23. Shrub: multi-stemmed woody plants less than 5 m tall; when estimating cover include saplings and smaller regeneration of tree species.
24. Density is obtained by actual count of stems within two 15 m by 15 m cells at each sampling plot.
25. A1 is the dominant overstory tree layer.
26. A2 is the second (understory) tree layer but is not always present.

B-5: Coarse woody debris form (field and lab sections).

***FireSmart-ForestWise* CWD Form**

Grid: _____ Study Area: _______________ Observers: ______________________ Date: _____dd _____mm ________yr
Veg Type: Open Pine / Closed Pine / Doug Fir Treatment: Control / Thin / Thin & Burn / Burn UTM: 11u __________E _________N

30m Transect #____ Start GP# ____ End GP# ____

CWD Piece #	Diameter Class	Length Class	Decay Class
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Diameter Class	Class Tally	Volume by Class	Length Class	Class Tally	# / ha by Class	Decay Class	# by Class
7.5-12.5cm			0.5-1.5m			1	
12.6-17.5cm			1.6-2.5m			2	
17.6-22.5cm			2.6-3.5m			3	
22.6-27.5cm			3.6-4.5m			4	
27.6-32.5cm			4.6-5.5m			5	
32.6-37.5cm			5.6-7.0m				
37.6-42.5cm			7.1-9.0m				
42.6-47.5cm			9.1-12.5m				
47.6-52.5cm			12.5-17.5m				
52.6-57.5cm			17.6-22.5m				
	Total Volume →			Total # of Pieces →			

FireSmart-ForestWise Page 1/2 03/10/2003

Field Portion

Lab Calculations

B-6: *Shepherdia canadensis* productivity data collection form.

FireSmart-ForestWise *Sheperdia canadensis* productivity

Surveyors____ Date____/_____/_________

Grid________ Bearing____/_______ Phenology________________

Vegetation Type___________ Treatment__________ Treatment Date___/___/____

Class	Productivity	Grd Pt. Start/End /	Grd Pt. Start/End /	Grd Pt. Start/End /	Total in Class
1	None				
2	Scattered on <25% of branches				
3	Scattered on 25-50% of branches				
4	Scattered on >50% of branches; bunches on <25% of branches				
5	Heavy or bunches on 25-50% of branches; scattered on other branches				
6	Heavy or bunches on >50% of branches				
Total on Transect	N/A				

Notes:

B-7: Horizontal sight distance data collection form.

FireSmart-ForestWise Horizontal Sight Distance Form

Grid: _____ Study Area: ___________________________ Observers: _______________________
Veg Type: Open Pine / Closed Pine / Doug Fir / __________ UTM: 11u __________E _________N
Treatment: Control / Thin / Thin & Burn / Burn Date: _____dd _____mm ________yr

Center GP #______

_____ Bearing/GP#	BOTTOM (white) ... TOP	_____ Bearing/GP#	BOTTOM (white) ... TOP
V		V	
_____% H		_____% H	
Canopy	LEFT (white) ... RIGHT	Canopy	LEFT (white) ... RIGHT
_____ Bearing/GP#	BOTTOM (white) ... TOP	_____ Bearing/GP#	BOTTOM (white) ... TOP
V		V	
_____% H		_____% H	
Canopy	LEFT (white) ... RIGHT	Canopy	LEFT (white) ... RIGHT

Center GP #______

_____ Bearing/GP#	BOTTOM (white) ... TOP	_____ Bearing/GP#	BOTTOM (white) ... TOP
V		V	
_____% H		_____% H	
Canopy	LEFT (white) ... RIGHT	Canopy	LEFT (white) ... RIGHT
_____ Bearing/GP#	BOTTOM (white) ... TOP	_____ Bearing/GP#	BOTTOM (white) ... TOP
V		V	
_____% H		_____% H	
Canopy	LEFT (white) ... RIGHT	Canopy	LEFT (white) ... RIGHT

Center GP #______

_____ Bearing/GP#	BOTTOM (white) ... TOP	_____ Bearing/GP#	BOTTOM (white) ... TOP
V		V	
_____% H		_____% H	
Canopy	LEFT (white) ... RIGHT	Canopy	LEFT (white) ... RIGHT
_____ Bearing/GP#	BOTTOM (white) ... TOP	_____ Bearing/GP#	BOTTOM (white) ... TOP
V		V	
_____% H		_____% H	
Canopy	LEFT (white) ... RIGHT	Canopy	LEFT (white) ... RIGHT

Site Sketch and Notes:

FireSmart-ForestWise Page 1/4 29/08/2003

B-8: Pellet count data collection form.

FireSmart-ForestWise Pellet Count Form

Grid: _____ Study Area: ______________________ Observers: ______________________ 48hr Precip: ____mm snow/rain
Veg Type: Open Pine / Closed Pine / Doug Fir / __________ UTM: 11u __________E __________N Total Pellet Counts:
Treatment: Control / Thin / Thin & Burn / Burn Date: _____dd _____mm _________yr E_____ D_____ M_____

Line 1 *GP#*____ *GP#*____

	0	15	30	45	60	75	90	
S 2003								Total E___ D___ M___
W 2003								Total E___ D___ M___
S Old								Total E___ D___ M___
W Old								Total E___ D___ M___

Line 2 *GP#*____ *GP#*____

	0	15	30	45	60	75	90	
S 2003								Total E___ D___ M___
W 2003								Total E___ D___ M___
S Old								Total E___ D___ M___
W Old								Total E___ D___ M___

Line 3 *GP#*____ *GP#*____

	0	15	30	45	60	75	90	
S 2003								Total E___ D___ M___
W 2003								Total E___ D___ M___
S Old								Total E___ D___ M___
W Old								Total E___ D___ M___

FireSmart-ForestWise Page 1/1 16/09/2003

B-9: Coding instructions for pellet count data form.

Coding Instructions for the *FireSmart-ForestWise* Pellet Count Form

Field Name	Description
Grid #	The # label of the Grid (1-27) within which pellet observations and counts are taken.
Study Area	Descriptive name of area in which trapping is to occur (i.e. Soggy Dog Slew – Lake Edith)
Observers	First name and last initial of observer(s)
48hr Precip	Give the total amount of precipitation in millimeters (mm) over the last 48hrs. Circle the form in which it fell (snow/rain). If both occurred, circle both and add notes in below space.
Veg Type	Circle vegetation type as per classification (i.e. Douglas Fir, Open Pine, Closed Pine) or if in new vegetation type, please list and describe below.
UTM	Location of grid point 01 (anchor point) for that particular grid; should be given in UTM 11u, NAD83 GRS80.
Treatment	Circle the correct or possible correct choices of treatment type (Control, Thin, Thin and Burn, Burn).
Date	List the current date in day, month, year format (i.e. 16dd 09mm 2003yy).
Total Pellet Counts	Total pellet counts should be filled out after survey is completed. All pellets including old and new should be included in the count. Fields are: Elk pellets (E___), Deer pellets (D___), Moose pellets (M___)
Line 1, 2, and 3	Lines in sequential order as they are completed. Fill out GP start and end #'s (see below).
GP#	Fill in twice per line (starting Grid Point and end Grid Point).
0, 15...90	Meter marker on each line as denoted by the tape used for the center marker. Observers should use this to try to mark the location of each pellet grouping as accurately and precisely as possible.
S New	Pellets along this line are dated from the most current summer past. Summer pellets are considered to be those clumped in one main ball. When found within 2 meters of the centreline (1m either side), the location is recorded on the data sheet line with either an E (elk pellets), D (deer pellets), or M (moose pellets). Greater than 50% or all pellets in that group must fall within the 2m range to be counted.
W New	Pellets along this line are dated from the most current winter past. Winter pellets are considered to be individual pellets not clumped together in one ball. Data is recorded the same as above.
S Old	Pellets along this line are summer pellets older than above (prior to the most current summer). Data is same as above.
W Old	Pellets along this line are winter pellets older than above (prior to the most current winter). Data is recorded as above.
Total E, D, M	Record the total number of pellets on that particular line for each animal (elk, deer, moose respectively).

Notes/Sketches:

B-10: Animal observation (small mammal capture) form.

Animal Observation Form - Small Mammal Capture Page __/__

Project _FireSmart-ForestWise_ **Survey** _Small Mammal Mark-Recapture_ **Study Area** ______

Grid Label ______ **Capt Sess Label** ______ **Total # of Traps Sprung** ______

Hours since last visit _____

Previous Night: Date ____dd____mm____yyyy CC _______ Wind _______ Precip _______ Temp _______

Obs Date ___ dd___mm____yyyy

Obs Day	Time	CC	Wind	Precip	Temp
Start					
End					

Marking Methods: *Little Critter Traps And National Tags Monnel 1 Ear Tags*

Surveyors ______

Capt Sta	# Spr	Obs #	Spp	Left Ear	Rght Ear	Marked (Y/N?)	Sex	Reprod Cond	Age Class	Hlth	Weight	Photo	Diag Feat / Comments
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										
			M-										

[Use this form whenever you check your traps.]

FireSmart-ForestWise 11/12/2005

B-11: Coding instructions for the animal observation form.

Coding Instructions for the Animal Observation Form - Small Mammal Capture

Field Name	Description
Study Area (Name)	Descriptive name of area in which trapping is occurring (i.e. Lake Edith)
Grid Label	The label of the Grid (1-27) within which animal observations are made.
Capt Sess Label	Each capture session should have a unique label. For instance, if all grids were checked between July 1st 2000 and July 14th 2000 these may be designated capture session 2000-1. Subsequent sessions that year should be labelled 2000-2 to 2000-n. The following year may begin with 2001-1 and continue to 2001-n.
Hours Since Last Visit	Record the number of hours that trapping took place or detection techniques were used since the last visit. This field will be later used to calculate effort.
Total # of traps sprung	For the current visit, record the total number of Capture Mechanisms (traps) or Detection Mechanisms of a particular type that are found to be set off (sprung/inoperable) without catching an animal. This will be used to calculate effort.
Page /	Record the page number (first page should always be the cover sheet). Record pages' such that any page with writing is given a unique number (i.e. 1,2,3).
Previous Night	Record the previous day's date (DD/MM/YYYY) and the weather conditions of that night. See below for specific weather field instructions.
Obs Date	The day/month/year (DD/MM/YYYY) on which the data on the form were gathered in the field. i.e. 17/04/1999.
Time Start/End	The time at which surveying the specified Design Component commences and finishes. Use the 24 hour clock.
CC	The extent of cloud cover at the start and end of the survey. Codes: 1 = clear; 2 = scattered clouds (<50%); 3 = scattered clouds (>50%); 4 = unbroken clouds.
Wind	The strength of wind at the start and end of the survey using the Beaufort Scale. Codes: 0 = calm (< 2 km/h); 1 = light air (2-5 km/h); 2 = light breeze, leaves rustle (6-12 km/h); 3 = gentle breeze, leaves and twigs constantly move 13-19 km/h); 4 = moderate breeze, small branches move, dust rises (20-29 km/h); 5 = fresh breeze, small trees sway (30-39 km/h); 6 = strong breeze, large branches moving, wind whistling (40-50 km/h).
Precip	The type of precipitation at the start and end of the survey. Codes: N = None; F = Fog; M = Misty drizzle; D = Drizzle; LR = Light Rain; HR = Hard Rain; S = Snow.
Temp	The temperature at the start and end of the survey (degrees Celsius).
Surveyors	The names of the people conducting the survey during the specified Design Component Visit.
Capt Sta Label	The label of the Capture Station at which observations are made. This field can be used to keep track of the stations that have been checked.
# Spr	The number of Capture Mechanisms (traps) or Detection Mechanisms of a particular type that were set off (sprung/inoperable) without catching an animal. This field will be later used to calculate effort.
Obs #	Observations must be numbered so that each is unique within a transect/grid. For each new transect/grid, start at 1 and continue numbering observations sequentially.
Spp	The 5-letter code that uniquely identifies the taxa of the observed animal (the first letter has already been filled in). Species codes must be taken from an approved list of valid animal species codes (Cannings and Harcombe 1990). If it is not possible to identify the animal in the field, record the best taxonomic description possible.
Left Ear	Record the number placed or already on the left ear of the animal. If tag is missing on one ear, record the number of the new tag.
Right Ear	See above.
Marked (Y/N?)	Indicate if the animal has been previously marked (i.e. tagged/collared)
Sex	The sex of the animal. Codes: M = Male; F = Female; UC = Unclassified.
Reprod Cond	The reproductive condition of the animal, where one of the pre-defined conditions is available.
Age Class	The age class of the animal. Codes: J = Juvenile; A = Adult; UC = Unclassified.
Hlth	Indicate the state of the captured animal at the time the Capture Mechanism is checked. Codes: A = Alive, (no comment on animal's condition); W = alive, appears Well; P = alive, but appears to be in Poor condition; D = Dead.
Weight [g]	The weight of the captured animal (g). This column will most often have two weights: the first while the animal and any debris is in the bag; the second with everything but the animal. Subtracting the latter from the former will give the weight of the animal. If this measurement can not be collected for some reason (i.e. animal escaped), provide an explanation in the "Comment" field.
Photo	If photo(s) are taken of trap site or animal(s), indicate catalogue/serial number for those respective photos.
Diag Feat/Comments	Morphometric or descriptive information of a captured animal, which is diagnostic for determining its taxa. Additional information that may be relevant to the observation (freeform text).

B-12: Breeding bird monitoring point count form.

JNP *FireSmart-ForestWise*
Monitoring Point-count Field Form

Sheet ID:

Plot:	Replicate #:	Observer:	Date mm/dd/yy:	Start Time:	End Time:

Plot Radius:	Sky (0-8):	Wind (0-5):		Temp:	Location in UTM 11u NAD 83 Northing:	Easting:
m				°C		

Species Code				#	Distance (meters)	Bearing (Nearest 5°)	Time Heard (min)		
							0-3	3-5	5-10

Notes: