Development of a Restoration and Monitoring Strategy in Relation to Fire Effects and Natural Disturbances in West Arm Provincial Park

BC Fires: August 2003. Courtesy of NASA

Rachel F. Holt, Ph.D., R.P.Bio.

Veridian Ecological Consulting Ltd.

Marlene Machmer, M.Sc., R.P.Bio.

Pandion Ecological Consulting Ltd.

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Project Overview and Scope

Overview of Approach

During 2003, a wildfire reaching a maximum size of approximately 8000ha broke out in West Arm Provincial Park located in the West Kootenays (see Figure 1). As a result of the fire, a funding opportunity become available (through sale of timber removed through fire-fighting activities) for Parks to examine the impacts of the fire, restoration needs, and future monitoring to support natural disturbance management within the West Arm Park. This opportunity led to a working group that was asked to identify priority monitoring areas. This project came out of that work and provides a more structured assessment of monitoring priorities within the Park.

The monitoring priorities identified here have a number of different foci, but all are aimed at providing information to Parks managers which will a) support any required restoration needs arising from the 2003 Kutetl fire and b) will aid decision-making in relation to future natural disturbances in the West Arm Park.

Specifically, WLAP required a background report to summarise:

- what is known about the impacts of the 2003 wildfire (relative to both conservation and recreation values) and what field work priorities[1] are required to address key knowledge gaps;
- what options exist for ecosystem restoration and what field work is required to address key knowledge gaps;
- the key lessons learned from the 2003 wildfire that need to be considered in developing a longer-term natural disturbance strategy for the park that supports both the ecological conservation role of the park and concerns related to wildland/urban fire interface; and,
- options for longer-term monitoring of disturbance-related impacts and risks.

In order to achieve these broad project goals, we undertook a number of different tasks. First, we summarise the natural disturbances relevant to the park, and a summary of values provided by the park, in relation to the greater park ecosystem. In addition, we include some comments that relate to recreation values and disturbances because these are important values and may also interact with natural disturbances within the park. Without this background, it is not possible to learn from the previous fire, or understand what actions may be appropriate in light of future disturbances. Second, we use the summary of values to prioritise future monitoring for the park in relation to natural disturbance management in future. Third, we summarise the specific impacts relating to the Kutetl fire, and as a result highlight both potential restoration actions and required monitoring.

Monitoring Strategies and Restoration

Developing a monitoring strategy requires a clear set of goals and objectives. For this project, we assessed the ecological and social values within the park and prioritised monitoring activities in relation to the extent and vulnerability of these values. Monitoring priorities should be reviewed if management objectives are different than those we identify.

Monitoring can take different forms, and be intended to answer different types of questions:

1. general learning or research;
2. assessment of previous impacts;
3. assessment to ensure future actions are appropriate; and
4. assessment of the effectiveness of actions taken for restoration.

[1] It is understood that funding will be limited, so recommendations will be made that address only the priority monitoring tasks. A broader list of potential useful monitoring will be generated which will allow a rapid response should additional funding become available.

This project was specifically intended to address monitoring needs that provide decision-making ability. The 'monitoring' that we suggest here includes some aspects of all of the above, but focuses mainly on questions (2) and (3) relating to previous impacts and future actions.

As a result of this approach we identify a large (40) number of potential questions that would provide relevant information to Managers. However, we additionally prioritise these to identify which questions should be addressed initially and with limited funds. Where appropriate, workplans for these top questions are identified in Appendix 1.

A Framework for Natural Disturbance Action:

Determining whether to undertake restoration actions or how to manage natural disturbances requires an assessment of the same kinds of information. For example – what values are present? What are the implications of acting, or of not acting, under a particular scenario? We suggest that the need for action can be answered by considering four sets of questions shown in Table 1:

Table 1. Determining the need for action.

Restoration?	Natural Disturbance Management Action?
Was the disturbance outside the range of natural variability? If yes, then restoration of general conditions may be appropriate even if particular values are not outstanding. If no, then restoration may be appropriate if values are outstanding, within the context of the greater ecosystem.	Are conditions such that a future uncontrolled disturbance will likely be outside the range of natural variability? If yes, then immediate action may be necessary to change local conditions. If no, then allowing natural disturbance may be the most appropriate action – unless outstanding values will be negatively affected.
Does the park contain or affect external ecological values that are locally, or regionally unique? Are these values sensitive / threatened by the disturbance? Can they be restored?	Does the park contain or impact ecological values that are locally, or regionally rare or unique? How sensitive are these values to potential disturbances? Can action today lower the chance of loss?
Does the park contain or affect external social values that are locally, or regionally unique? Are these values sensitive or threatened by the disturbance? Can they be restored?	Does the park contain or impact social values that are locally, or regionally unique? Are these values sensitive / threatened by future disturbances? Can action today lower the chance of loss?
Were there incidental impacts associated with fire-fighting activities for the 2003 Kutetl fire that require mitigation?	Are there likely to be incidental impacts associated with infrastructure related to disturbance management that may influence whether management should occur? Are appropriate plans in place to reduce or mitigate any impacts upfront?

We used the framework outlined in Table 1 as a basis to develop relevant questions as part of an overall monitoring strategy for the West Arm Provincial Park.

Methods

A review of available information, background reports and other relevant literature was undertaken in relation to the ecological values, natural disturbance regimes and prevalent disturbance agents of West Arm Provincial Park and surrounding areas.

Documentation pertaining to the circumstances and chronology of the 2003 Kutetl fire, as well as fire-fighting response and post-fire rehabilitation efforts were also gathered. Maps (forest cover, caribou

habitat and telemetry locations, fire boundary and fire-fighting infrastructure) and photos taken during the fire-fighting and rehabilitation phases were obtained from the Ministry of Forests and the Ministry of Water, Land & Air Protection.

The above information was supplemented by interviewing personnel from BC Parks (Mike Gall, Kevin Giles, Gary Glintz, Dan Harlow, Tory Stevens); Ministry of Forests (Ross Noble, Alan Bond, Kristine Sacenieks, Doug Nicol); Ministry of Water; Land and Air Protection (Guy Woods, Leo DeGroot, Alan Davidson); Ministry of Sustainable Resource Management (Ted Antifeau, Marta Donavan), Columbia Basin Fish & Wildlife Compensation Program (John Krebs), other stakeholders (Ramona Faust, Harrop-Proctor Community Forest; Christian Schadendorf, Darkwoods Forestry Ltd.; Mike Adams, Whitewater Ski Hill; Gil Bogart and Peter Hartridge, City of Nelson), and various other subject experts (Greg Utzig, Val Miller, Julie Castonguay, Don Mortimer, Juliet Craig, Heather Pinnell, Cathy Scott-May).

For each ecological value of the park identified from above, the questions outlined in Table 1 were asked in relation to the 2003 Kutetl fire, and in relation to potential future natural disturbances. These questions were explored based on available site-specific as well as general background information. To provide some direction on key values likely to be impacted by fire, selected monitoring and research initiatives associated with the 2003 Okanagan Mountain Park Fire and other recent large-scale fires in the Pacific Northwest were considered.

For each of the ecological values, a series of potentially important monitoring questions were developed. Recognizing the fiscal and practical limitations, these questions were then prioritized based on a) perceived importance of the value, b) perceived threat to the value, and c) cost of monitoring. We determined which were the priority questions in each category and for these, a detailed monitoring plan with an approach and methods is itemized in Appendix 1.

Report Outline

The remainder of the report is laid out in the following way:

Section 1: Park Background and Values

- Overview of West Arm Provincial Park, including forest and natural disturbance types and prevalent disturbance agents
- Identification of key ecological and social values associated with West Arm Provincial Park in the context of the surrounding landscape of the Southern Columbia Mountains

Section 2: Monitoring to support future natural disturbance management

- Potential impacts of disturbances on the values present in the park
- Potential monitoring questions and actions associated with each value
- Recommendations on ranked projects

Section 3: The 2003 Kutetl Fire

- Site-specific fire and fire-fighting impacts
- Potential monitoring and restoration actions

Section 4: Detailed Recommendations

- Natural Disturbance monitoring
- Restoration and restoration monitoring

Appendix 1: Workplans for key questions

Section 1: Park Background and Values

Park Location, Setting and Access

West Arm Provincial Park (WAP) is located just east of the City of Nelson on the south shore of the West Arm of Kootenay Lake. The park is 25,319 ha in size and includes the headwaters of Selous, Anderson and Fell Creeks just southeast of Nelson, the drainages of Five Mile, Lasca and Strickland Creeks between Nelson and Harrop, as well as the headwaters of Kutetl and Midge Creeks (Figure 2).

There are two access roads into the park. The deactivated Lasca Creek Forest Service Road accesses the roadside trailhead at km 7.8. In the Five Mile drainage, Svoboda Road accesses residential properties and the City of Nelson water intake at km 5. Recreational access into the park is via the Lasca Creek trailhead; the Svoboda Road mountain bike trails (traversing Five Mile, Hermitage, Fell and Anderson Creeks); the Whitewater Ski Resort and the inactive Hummingbird Forest Service Road; a private forestry road on Darkwoods tree farm to the confluence of Midge and Kutetl Creeks; the inactive Burlington Northern Rail line to Troup and the active Canadian Pacific Rail line along the south shore of the West Arm; the Harrop Creek trail to Mill Lake; and a trail adjacent to Procter Creek that accesses eastern portions of the park. The south shore of the West Arm is accessible year-round by boat.

Boundaries of West Arm Provincial Park extend 100 m into the water along the West Arm of Kootenay Lake foreshore where the Canadian Pacific railway line bisects the park along its northern boundary (Figure 2). The northeastern and southwestern portions of West Arm Park are bounded by crown land managed by the Harrop-Procter Community Forest and the Whitewater Ski Resort, respectively. The park borders the Midge Creek Wildlife Management Area to the southeast and Managed Forest #40 owned by Darkwoods Forestry Ltd. to the south. To the west, the park abuts private residential lands in the Mountain Station area of Nelson.

The Greater Park Ecosystem

Determining appropriate management actions within a particular park, and especially within smaller parks, requires an understanding of the 'greater park ecosystem' (Zorn et al. 2001; Utzig and Scott-May 2003). The greater park ecosystem is an area that encompasses the full extent of ecosystem functional relationships that impact on the ecological integrity of an individual park. This larger area provides context for understanding the importance and vulnerability of values within the park, particularly in relation to large-scale phenomena such as natural disturbances. We use this context throughout this report to assess impacts and potential threats to specific values within the West Arm Provincial Park. In addition, the greater park ecosystem is often required to help the park maintain its conservation goals, especially for wide-ranging species, or in relation to natural disturbances (Utzig and Scott-May 2003); this broader area may also therefore need to be included in a broad monitoring strategy for an individual park.

Forest and Natural Disturbance Types

The biogeoclimatic ecosystem classification (BEC) zonation and associated natural disturbance regimes pertaining to the Southern Columbia Mountains ecosystem and to West Arm Provincial Park in particular were recently updated (reviewed in Utzig et al. 2003 and Utzig and Scott-May 2003, respectively). The following biogeoclimatic ecosystem classification (BEC) units are encountered within the park proceeding upslope along an elevational gradient:

The *Dry Warm Interior Cedar - Hemlock Subzone (ICHdw)* is found from the shores of the West Arm to about 1,100 m. It is characterized by very hot, moist summers and very mild winters with light snowfall and snowpacks are generally shallow to very shallow and of short duration. Major growth-limiting factors are moisture availability on drier sites and frost in some depression areas. Climax vegetation on zonal sites includes an overstory of western red cedar (Cw) and western hemlock (Hw), with an understory often including falsebox, Douglas maple, black huckleberry and baldhip rose. On cooler aspects, there tends to be an increased occurrence of Cw and Hw and high occurrence of moss in the understory. Due to the relatively high frequency fire regime of the ICHdw, most sites are

occupied by seral stands dominated by species such as Douglas-fir (Fd), western larch (Lw), western white pine (Pw), lodgepole pine (Pl), paper birch (Ep) and trembling aspen (At). Drier sites are generally occupied by more fire resistant Fd, ponderosa pine (Py) and Lw, while mesic and wetter sites also include grand for (Bg), black cottonwood (Ac), hybrid white spruce (Sxw) and rarely (sub-alpine fir) Bl. This subzone has the highest tree species diversity in the province.

The *Salmo Moist Warm Interior Cedar – Hemlock Variant (ICHmw4)* occurs above the ICHdw on middle slopes of the park (from 1,200-1,500 on warm aspects and 1,075-1,450 m on cool aspects)and is characterized by hot, moist summers and very mild winters with light to moderate snowfall. Moisture deficits in late summer occur occasionally on mesic and drier sites and snowpacks are generally of moderate depth and duration. Due to the relatively mild winters and significant snowpack, frozen soils are relatively rare under forested conditions. Climate is generally not growth-limiting, except for moisture availability on very dry sites and frost in some depression areas. Climax vegetation on zonal sites includes an overstory of Hw and Cw, with an understory often including falsebox, black huckleberry and Utah honeysuckle. Relatively frequent fires have created a mosaic of climax and seral stands across the ICHmw4. However, due to the extensive burning in the area associated with European settlement near the turn of the century, many sites are occupied by seral stands dominated by species such as Pl, Fd, Lw, Pw, Ep and At.

The *Salmo Wet Cold Engelmann Spruce – subalpine Fir Variant (ESSFwc5)* forms a narrow transitional band (1,500 – 1,650m on warm aspects, and from 1,450 – 1,600m on cool aspects) between the ICHmw4 and the ESSFwc6. The climate is characterized by cool, moist summers and cold, wet winters with moderately heavy snowfall. Frozen soils are relatively rare under forested conditions. Moisture deficits in late summer are rare and are generally restricted to very dry sites. Climax vegetation on zonal sites is characterized by an overstory of Bl and Se (Engelmann spruce), with Cw and Hw in the understory as intermediate trees. Pl and Fd occur on drier sites. Understory shrub vegetation generally includes white flowered rhododendron, black huckleberry and Utah honeysuckle. Fire cycles are relatively long, small-scale disturbances are common, and mountain pine beetle is an important disturbance agent where Pl occurs.

The *Ymir Wet Cold Engelmann Spruce – Subalpine Fir variant (ESSFwc6)* is found above the ESSFwc5 (1,650 – 1,950m on warm aspects and 1,550 – 1,850m on cool aspects). The ESSFwc6 is characterized by cool, moist summers and cold, wet winters with moderately heavy snowfall. Moisture deficits in late summer are rare and are generally restricted to very dry sites. Cold soils and air temperature are limiting factors for tree growth. Climax vegetation on zonal sites includes an overstory of Bl and Se, with an understory often dominated by white flowered rhododendron, black huckleberry and gooseberry. Fire frequency is very low and old seral stands are common. Relatively small-scale disturbances from insects, disease and windthrow characterize stand dynamics and lead to regeneration within canopy gaps. Pl occurs occasionally on drier south facing sites.

The upper open forested *Ymir Wet Cold Engelmann Spruce – Subalpine Fir variant (ESSFwc6u)* occurs above the ESSFwc6 and below the ESSFwcp6 (ESSF parkland) on high elevation (1,900 – 2,100 m) forested slopes. The climate is characterized by cool, moist summers and very cold winters with heavy snowfall. Cold soils and air temperature are limiting factors for tree growth, which becomes particularly restricted at the transition to the ESSFwcp6 where regeneration is inhibited by slow growth and a high snowpack. Long winters, frequent avalanches and colluvial action, frost pocketing, and thin soils lead to a mosaic of scree slopes, avalanche tracks, permanent meadows and closed forests. Forest vegetation characteristic of climax and mature zonal sites includes mainly Bl and Se, with drier sites occasionally including whitebark pine (Pa) and alpine larch (La). Understory vegetation commonly includes mountain heathers. This zone is a transition from subalpine closed forest to parkland areas.

The *Alpine Tundra (AT)* zone is limited to the uppermost elevations of the park (above 2,200). Fragile low-growing herbaceous and shrubby vegetation growth in this zone is limited by a constant annual cycle of deep freezing and thawing.

In terms of natural disturbance types, the ICHmw4, ESSFwc5 and ESSFwc6 variants occurring in the park are classified as *Natural Disturbance Type 2 (NDT2)*, and are subject to infrequent stand-replacing disturbance events (Province of British Columbia 1995; BC Ministry of Forests 2001).

Estimated fire return intervals for ICHmw2 and ESSFwc4 variants are about 100 years for dry sites on warm aspects, to over 500 years on wet sites and cool aspects (Dorner et al. 2003). Although the ICHmw4 and ESSFwc6 variants found in the park are slightly warmer and drier than the latter variants, the predominance of cooler more northerly aspects within the park likely compensates and these estimates are considered applicable.

Lower elevations of the park in the ICHdw are classified as *Natural Disturbance Type 3 (NDT3)*, and are subject to frequent (150-200 year return intervals) stand-replacing disturbance events (BC Ministry of Forests 1995). Warmer westerly and southwesterly aspects (such as those found at the mouths of Five Mile and Lasca Creeks) likely include areas experiencing mixed severity fire regimes, as reported by Quesnel and Pinnell (2000) for the north side of the West Arm. Mixed severity fire regimes have fires at intermediate frequencies (average intervals ranging from 30-100 years), leaving a patchy erratic pattern of mortality on the landscape (Arno et al. 2000).

Based on this information, the natural disturbance regime in the park is likely dominated by moderate to long intervals of low intensity gap-replacement stand dynamics attributable to agents such as insects, fungi and wind that operate on a continual basis (Utzig et al. 2003). These dynamics would be interrupted by infrequent stand-replacing disturbances such as wildfires of various sizes, but they may also include outbreaks of bark beetles, defoliating insects and root diseases.

Steeper slopes in the park with shallow soils may be subject to occasional landslide disturbances, as evidenced by the debris flows on the Lasca Creek Road during 1995 and 1997 (Ministry of Environment, Lands and Parks 2000). Based on shallow soil types, steep slopes, and high amounts of precipitation, terrain stability analysis indicates that there is moderate to high slope instability all along the lakeshore into Nelson, as well as in the upper portions of Fell and Hermitage Creeks, and in the draws of Lasca, Eight Mile, and Five Mile Creeks. There is also potential for significant debris flows on west-facing gullies in Anderson Creek (Ministry of Environment, Lands and Parks 2000).

Floodplains and alluvial fans within the park were once subject to regular spring flooding and channel migration. The construction of dams (i.e., Libby and Duncan Dams) and flooding of reservoirs on the Kootenay system has fundamentally disrupted these processes (Holt et al. 1998, Holt and Wood 2001, Slaney et al. 2003) and altered natural river hydraulic, temperature, sediment and nutrient transport cycles (Utzig et al 2003).

Natural Disturbance Agents

A variety of disturbance agents (e.g., fire, insects, diseases, wind, snow, animals) contribute to the ecological values and habitat complexity of West Arm Provincial Park. These agents operate at differing spatial and temporal scales that collectively maintain a mosaic of seral stages and stand types. The following discussion summarizes available information with respect to the main disturbance agents (fire, insects, diseases) active within West Arm Provincial Park:

Fire

Large tracts of forested land in and surrounding West Arm Provincial Park were subject to large-scale burning at the end of the last century in association with mining, railway construction, and other human activities. These stands have regenerated and based on forest cover mapping, the park now supports mainly stands in later stages of succession (i.e., age class 6 or older). With exception of a small fire in 1985, no significant fire history has been recorded in the park for the last 80 years (Ministry of Environment, Lands and Parks 2000). As a result, mature lodgepole pine, which comprises an estimated 23% of the forested landbase in and around the park, has become susceptible to beetle infestation and associated fire hazard (Miller 1993; Castonguay 2002).

The Kutetl fire within West Arm Provincial Park started on August 8, 2003, as a result of a lightning strike. By September 6, 2003, this fire grew to its maximum size of 7,916 ha, and it was extinguished by late September (Figure 3). Fire severity was extremely variable (ranging from high intensity running crown fire to low intensity ground fire; R. Noble, pers. comm.) and fire severity mapping is currently underway (G. Utzig, pers. comm.); Figure 1 shows preliminary map. This fire impacted significant portions of the Kutetl drainage, as well as upper Midge, Lasca and Five Mile Creek drainage basins.

Insects

Mountain Pine Beetle – Many areas of the West Arm that burned near the turn of the century have regenerated to lodgepole pine stands that are now ≥80 years old and therefore highly susceptible to mountain pine beetle (Miller 1993). Fire suppression activities conducted since the mid 1900's have contributed to the abundance of susceptible mature lodgepole pine, as fire would normally have converted a portion of these stands to an earlier successional stage.

Few historical records of mountain pine beetle-induced mortality are available for the West Arm, presumably due to a lack of susceptible hosts, but spot infestations have been detected locally since 1987 in the ICH and ESSF zones (Miller 1993). Aerial and ground surveys in 1993 revealed generally low endemic infestation levels, with significant mountain pine beetle-induced mortality between Tunstall and Eight Mile Creeks, and on the eastern slope of Lasca Creek (Miller 1993). Areas of high to extreme mountain pine beetle susceptibility (determined based on presence of >80 year-old pine, pine basal area, stand density and geographic location) were noted at lower elevations of Fell, Anderson, Five Mile drainages, along Tunstall-Eight Mile Creeks, east slope of Lasca Creek, west slope of Harrop Creek and Slater Creek. The threat of stand-replacement fire in West Arm Park was raised as a potential impact of the increasing susceptibility of mountain pine beetle-killed trees (Miller 1993).

Overview aerial and detailed flights of the park in summer 2001 identified two areas (east slope of Lasca Creek and Anderson Creek) with symptoms of mountain pine beetle (Castonguay 2002). The population in Anderson Creek was estimated to have grown 2.5 fold between 2000 and 2001. More recent (2002-2004) overview aerial surveys confirm a continuing mountain pine beetle expansion both inside and outside of the park and throughout the Kootenay Lake Forest District and other parts of BC, due primarily to low overwinter mortality rates (BC Ministry of Forests 2004; K. Sacenieks, pers. comm.). The recent incidence and rate of spread of mountain pine beetle within the park is comparable in pattern and trend to some other areas within the Kootenay Lake (e.g., Kokanee Creek, Bradley Face, Laird Creek) and Arrow Forest Districts (K. Sacenieks, pers. comm.; Figure 4).

Other Beetles – Douglas-fir beetle, western balsam bark beetle and fir engraver beetle are present in pockets at endemic levels along the West Arm (BC Ministry of Forests 2004). Douglas-fir beetle incidence is increasing in ICHdw and ICHmw variants because of fire suppression, particularly on dry stressed sites with an increasing fir component (K. Sacinieks, pers. comm.).

Spruce beetles are found at endemic levels in ESSF stands along the West Arm and windthrow trees are most susceptible (Quesnel and Pinnell 1998). Spruce beetle was noted in abundance on harvested trees piled at landings in Lasca Creek during 2004 (K. Sacenieks, pers. comm.). There is also a potential spruce beetle concern in Five Mile Creek where logs were also piled over winter (R. Noble, pers. comm.). A portion of the wood harvested from the roads, trails, helicopter pads and fireguards in these areas was removed in 2004, however some remained over winter due to time and seasonal constraints. Crews will be dispatched in spring 2005 to burn and peel the residual trees in order to reduce the potential for spruce beetle outbreak (R. Noble, pers. comm.).

Defoliators – Defoliators such as western spruce budworm, 2-year cycle budworm and western hemlock looper are either absent or found at very low levels along the West Arm (Ministry of Forests 2004).

Diseases

Root Diseases - Armillaria root disease is present along the West Arm in ICHmw4 and ICHdw stands, and is found in pockets within ESSF variants, especially in dense stands of subalpine fir or lodgepole pine (Quesnel and Pinnell 1998). Laminated root rot, blackstain root disease and to a lesser extent tomentosus root rot (in moist spruce stands) are also present. .

Other Diseases - White pine blister rust, which frequently interacts with mountain pine beetle, has devastated local whitebark pine stands in the ESSF as well as western white pine stands in the ICH. Larch and lodgepole pine dwarf mistletoe are also present in mature trees along the West Arm and have lead to some mortality in smaller less vigorous trees (Quesnel and Pinnell 1998).

Invasive Species

Invasive species are a significant threat to native plant communities and their ability to quickly establish and dominate disturbed areas is well known. Several highly damaging invasive species are known to occur in the lower elevations of West Arm Provincial Park, including Spotted Knapweed, Common Tansy, Yellow and Orange Hawkweed, Scotch Broom, Canada Thistle, Rush Skeletonweed and Purple Loosestrife (Val Miller, pers. comm.). No systematic invasive species surveys have been undertaken in the park and additional species are likely to be present. The Canadian Pacific Railroad line bisecting the northern park boundary provides an ideal vector for weed establishment and spread and well-traveled access roads into Lasca and Five Mile Creeks provide additional entrance routes. Well-used mountain bike trails in the Five Mile drainage (located on steep terrain susceptible to erosion) also contribute to soil disturbance and promote weed invasion.

Ecological Values of West Arm Provincial Park

West Arm Provincial Park was designated a *Class A Provincial Park* in July of 1995 in order to protect watershed, viewscape, biodiversity and recreation values in the under-represented Southern Columbia Mountains (SCM) ecosection. The park lies within the Nelson Range of the Selkirk Mountains and ranges in elevation from 530 to 2,377 m from the Kootenay Lake shoreline to the peak of Mount Lasca, respectively. It includes long, gentle rolling wide valleys with densely vegetated corridors of mature to old growth pine, larch, cedar and hemlock in undeveloped watersheds; numerous avalanche tracks; a small number of high elevation wetlands and tarn-like water bodies; and rocky and steep shorelines, large alluvial fans, and pockets of natural sandy beaches on the south shore of the West Arm.

The vision for the park, as outlined in the Draft Management Plan (Ministry of Water, Land & Air Protection 2002) is to provide a "*scenic forested setting for the City of Nelson that protects and preserves significant natural and cultural values that are managed in perpetuity for wilderness. Enhancement of natural wilderness values [is to] occur over time through restoration of unnatural areas, minimization of human impacts and emphasis on a more scientific ecosystem-based approach to management. Wilderness recreation opportunities and ecologically sustainable ecotourism continue to play an important role in fostering a greater understanding and appreciation for natural and cultural heritage values*". The draft management plan therefore emphasizes wilderness conservation but also provides direction with respect to management of recreation, tourism and cultural/heritage values in the park.

Understanding the importance of the values within the park requires a broad assessment of the Greater Park Ecosystem, i.e. the area around the park that is large enough to encompass the full extent of ecosystem functional relationships that impact on the ecological integrity of an individual park (Zorn et al. 2001). For the West Arm provincial park, an area suitable to provide this context is the Southern Columbia Mountains ecosection (Utzig and Scott-May 2003). This following section reviews the natural and social/cultural values of the park within this broader ecological context of the greater park ecosystem. For each value, the importance of the park is highlighted, and this information is used to guide prioritisation of potential monitoring in Section 4.0.

Ecosystems and Forests

Representation

West Arm Provincial Park protects representative natural ecosystems of the SCM and comprises 4.1% of this ecosection by area. It encompasses a series of relatively undisturbed complete forested drainages and includes seven BEC zones/variants (notably the provincially significant ICHdw) within its full elevational range from valley bottom to height-of-land (Utzig et al. 2003). By virtue of its relatively large size, it captures many of the landforms, wildlife, vegetation and habitat types found in the SCM ecosystem, although cooler aspects and drier site types predominate within its boundaries (Utzig and Scott-May 2003).

No other intact valleys of this size exist in the Southern Columbia Mountains ecosection, therefore representation values are significant. Maintaining these ecosystems, and their associated natural disturbances should therefore be an important consideration in this park. However, note that there are significant conflicts between maintaining representative ecosystems and their associated natural disturbances and some of the other regionally important values (see below).

Old Growth and Other Forests

Much of the forest within the park boundary has advanced to a mature stage (age class ≥6; >120 years old) of succession as a result of persistent fire suppression. Detailed evaluations of the distribution and specific values contained within different older stands within each biogeoclimatic variant are currently unavailable.

Prior to the Kutetl fire, the park did support large stands of old-growth ESSF in the upper portion of the Kutetl and Lasca watersheds and the estimated proportion of mature and old forest combined was ≥70% (BC Ministry of Water, Land and Air Protection 2000). A portion of these stands were impacted by the 2003 Kutetl fire and fire severity mapping currently underway will be extremely helpful in quantifying the extent of old growth forest lost (G. Utzig, pers. comm.).

Old growth forests are locally relatively rare within the SCM ecosection as a result of the combined impacts of extensive fires in the early 1900s, forest harvesting and land settlement. Most landscape units in Kootenay Lake and Arrow Forest District are in relatively poor condition (particularly at lower elevations) in relation to the amount of mature and old forest that would be expected there, as predicted by natural disturbances (Holt, 2005 unpublished analysis). For this reason, the ecological value associated with large unharvested areas of mature and old forest within the park is very high. Although fires are a natural part of this ecosystem, extensive disturbance in the form of clearcut harvesting has significantly altered the seral stage and patch dynamics across the landscape. In this context, the need for restoration and/or protection of older forest values is also very high.

Riparian

The park includes most of the Lasca and Five Mile Creek (3rd order) watersheds, and almost all of the headwaters of Midge Creek above its confluence with Kutetl Creek. Five smaller watersheds mostly contained within the park include Strickland, Eight Mile, Tunstall, Hermitage and Fell Creeks. Portions of Anderson, Selous and Kutetl Creeks are within the park boundaries and some small subalpine lakes and wetland areas are found within the headwaters of Lasca, Five Mile, Kutetl and Midge Creeks (Utzig and Scott-May 2003).

Included within the park boundaries is a 100 meter wide section of the foreshore along the West Arm of Kootenay Lake, except where it is interrupted by the railroad right-of-way or private land along the shoreline and on the fans of Hermitage, Five Mile, Tunstall, Eight Mile and Lasca Creeks. The latter areas have been negatively impacted by habitat conversion associated with human activity.

Within the Southern Columbia Mountains ecosection, these watersheds represent the only intact valleys of this size, except for those adjacent now contained within the Harrop / Proctor Community Forest. Much of this area is found within the park, except for the lower portions that are included in private land. The riparian foreshore area is quite significant – due to the lack of cottonwood ecosystems around major river systems – though these areas are likely to be under duress due to lack of flooding caused by the regulated water levels from the dams on the Kootenay River system. Smaller creeks are not known to have particularly significant riparian values, though there are some fairly significant fisheries values on some creeks (see below). In addition, riparian areas may provide foraging opportunities for grizzly bears. The significance of these riparian values is primarily a result of their intactness, providing reference ecosystems with which to compare the many other non-intact riparian ecosystems in the greater park ecosystem.

Biodiversity Values

Mountain Caribou Habitat

The park provides critical habitat for the internationally significant Southern Selkirk herd of the provincially red-listed and federally threatened Woodland Caribou (*Rangifer tarandus caribou*). This herd is part of a trans-boundary population of the Mountain Caribou ecotype that feeds on arboreal lichens in winter and occupies areas in southern BC, Washington and Idaho. The population is imperiled due to historical over-hunting, habitat loss and fragmentation, and disturbance pressures. There have been a series of caribou transplants undertaken in recent decades in an attempt to augment the herd (estimated at 33 animals in 2004; Hatter 2004) and recovery planning efforts are ongoing (Steeger et al. 2003). Based on long-term radio-telemetry monitoring data, West Arm Park is known to provide important habitat for this population (Leo DeGroot, pers. comm.; Figure 5). Furthermore much of the forested and parkland ESSF zone, as well some upper portions of the ICH zone within the park are part of the designated Mountain Caribou habitat management zone and the proposed Mountain Caribou recovery area. Management of Caribou habitat in these areas requires retention of significant areas of old and mature forest.

This caribou herd ranges from south of the US border, through the southern Selkirk, and has been known to cross the west arm of Kootenay Lake. Throughout this large area much of the original caribou habitat has been lost primarily as a result of forest harvesting. This is particularly the case in lower elevation forest types that may provide critical habitat values in some years. In addition, there is intensive recreational use across this region (extensive snowmobiling, general public back-country skiing, ski resorts, back-country lodges or tenures and summer biking, hunting, hiking and ATV access) all of which likely impact habitat use of remaining areas by these animals. West Arm provincial park was one of very few areas where relatively extensive habitat remained for this herd, and where at least some of the recreational activities did not occur (particularly those relating to motorised transport). However, there is extensive back-country skiing and biking currently occurring in this park.

The importance of all remaining habitat to caribou cannot be over-stated. Since there have to date been no assessments of the amount of habitat required to maintain caribou herds, the carrying capacity (number of animals that can be supported by available habitat) of this region is currently unknown. The Kutetl fire impacted caribou habitat in the park, and a preliminary analysis suggests a loss of about 41% within the park. Understanding the extent to which habitat was impacted, how it may be recovered, and how much or where additional habitat may be required to compensate for this is key to meeting the Park's conservation mandate.

Grizzly Bear Habitat

West Arm Park protects internationally significant habitat for a Grizzly Bear recovery program and supports a small blue-listed (special concern) population of Grizzly Bears that use the area year-round. Wetland/riparian areas and avalanche chutes free from human disturbance are critical for this species. Low elevation avalanche chutes on warm aspects are rated of highest value because they are the first to 'green-up' when bears emerge and food availability is most limiting. A recent study evaluating avalanche chute habitats in the SCM concluded that Midge and Apex (Whitewater) Creeks in particular support a very high abundance of such high value chutes (Mowat et al. 2002).

West Arm Park also provides an important link for bears moving south to the Stagleap Provincial Park area and across the international boundary. A recent study investigating Grizzly Bear habitat use and fragmentation in the West Kootenays (Proctor 2001) indicated that the sub-population of bears using West Arm Park are genetically isolated from bears across the West Arm of Kootenay Lake, and from bears across the south Arm of Kootenay Lake in the Purcells. The study found no evidence of recent movement or dispersal of bears into or out of the area surrounding West Arm Park and concluded that populations north and south of the West Arm of Kootenay Lake are demographically isolated. This lack of connectivity is attributed mainly to dense rural settlement along the West Arm and an associated increase in human activity and loss of ecological integrity.

Spatial analyses from the East Slopes Grizzly Bear Project (McLellan et al. 1999) clearly demonstrate that most Grizzly Bear mortality occurs within a relatively narrow zone close to roads, trails, and

human settlements. West Arm Park and adjacent linked drainages represent a relatively large intact area supporting high value Grizzly Bear habitat that is largely buffered from traveled roads or intensively used trails. In this context, the park is of very high ecological value and there is a need to promote access management and to sustain ecological processes that maintain or enhance these values through time.

Grizzly bears are at risk within the broader park ecosystem surrounding the West Arm Provincial Park. Forage values in this area are not particularly high, except locally on limited avalanche tracks, but predictions are that future forage values will increase as a result of berry fields created by the Kutetl fire. Potential conflicts between bear habitat capability and suitability likely revolve around disturbance factors caused from human use of this area.

Other Biodiversity Values

Although no systematic wildlife/biodiversity inventories have been conducted within the park, based on its size and habitat representation, a large portion of the 266 vertebrate wildlife species found within the SCM (see review in Utzig et al. 2003) are also expected to occur locally. These include selected species in Table 2 that are currently listed by the BC Conservation Data Center (CDC) and/or the Committee On The Status Of Endangered Wildlife In Canada (COSEWIC).

Table 2. Summary of listed vertebrate animal and vascular plant species potentially present, based on the habitats represented within West Arm Provincial Park.

Common Name	Scientific Name	CDC Status	COSEWIC Status	Park Records
Vertebrate Species				
Coeur d'Alene Salamander	Plethodon idahoensis	B	SC	N
Western Toad	Bufo boreas	Y	SC	N
Rubber Boa	Charina bottae	Y	SC	N
Western Grebe	Aechmophorus occidentalis	R	-	Y
Great Blue Heron	Ardea herodias	B	-	Y
Western Screech-Owl	Otus kennicottii macfarlanei	R	E	N
Lewis' Woodopecker	Melanerpes lewis	B	SC	N
Townsend's Big-eared Bat	Corynorhinus townsendii	B	-	N
Red-tailed Chipmunk	Tamias ruficaudus simuilans	B	-	N
Wolverine	Gulo gulo luscus	B	SC	N
Fisher	Martes pennanti	R	-	N
Grizzly bear	Ursus arctos	B	SC	Y
Caribou	Rangifer tarandus	R	T	Y
White Sturgeon (Kootenay R.)	Acipenser transmontanus (pop. 1)	R	E	N
Bull Trout	Salvelinus confluentus	B	-	Y
Plant Species				
Tender Sedge	Carex tenera	B	-	N
Lace Fern	Cheilanthes gracillima	B	-	N
Tall Bluebells	Mertensia paniculata var. borealis	B	-	N
Monardella	Monardella odoratissima ssp. odoratissima	R	-	N
Spurless Touch-Me-Not	Impatiens escalcarata	B	-	N
Ussurian Water-milfoil	Myriophyllum ussuriense	B	-	N
Smith's melic	Melica smithii	B	-	N

CDC status: B = blue-listed (special concern); R = red-listed (threatened or endangered).
COSEWIC status: E = endangered; SC = special concern; T = threatened.

In terms of listed wildlife species, the CDC's database only contains records for Mountain Caribou in West Arm Park (Marta Donavan, pers. comm.). However there are local records for Western Grebe, Great Blue Heron, Grizzly Bear (L. DeGroot, pers. comm.) and Bull Trout. Based on the provincial trapping database (1928 - present), there are no trapping records for Wolverine or Fisher within the park, and trapping continues to be permitted within park boundaries.

Ohanjanian (1997) conducted a preliminary assessment of listed Coeur d'Alene Salamander and its habitat in West Arm Provincial Park. The species was not detected but the park provides excellent habitat potential for this species in the form of fractured rock and moist vegetation in association with water. The study concluded that Kootenay Lake may represent a barrier to salamander dispersal however recent confirmation of this species on lower and upper Arrow Lakes suggests it is more widely dispersed in BC than previously thought (Ted Antifeau, pers. comm.).

The park potentially provides habitat for Western Toad, Rubber Boa, Western Screech-Owl, Lewis' Woodpecker, Townsend's Big-eared Bat and Red-tailed Chipmunk (Table 2), although there are no confirmed records for these species within the park boundaries. Also listed in Table 2 are seven listed plant species that have been confirmed at locations adjacent to the park in habitats and biogeoclimatic variants comparable to those found within the park. No systematic rare plant or plant community surveys have been conducted within West Arm Park to date. There is also no information on rare invertebrate species (e.g., butterflies, dragonflies, moths) for this area.

Based on the elevations, forest types and associated habitat impacts resulting from the Kutetl fire, only a few of the terrestrial listed species in Table 2 would be likely to suffer long term habitat impacts as a result of the Kutetl fire. These would include Mountain Caribou, and potentially also Western Toad, Fisher, and Red-tailed Chipmunk, if they were to occur in the park. Habitats of the latter species would be candidates for potential restoration (fish and fish habitats are addressed separately in the next section).

Fisheries

Based on information compiled by Utzig and Scott-May (2003), the West Arm of Kootenay Lake supports 20 or more fish species: naturally occurring Kokanee, Bull Trout (blue-listed), Rainbow Trout, Mountain Whitefish, White Sturgeon (red-listed), Largescale Sucker, Lake Chub, Peamouth Chub, Northern Squawfish, Longnose Dace, Redside Shiner, Northern Pikeminnow, Longnose Sucker, Largescale Sucker, Prickly Sculpin and Torrent Sculpin. Introduced species include Yellow Perch, Westslope Cutthroat, Pumpkinseed, Brook Trout and Largemouth Bass (Slaney et al. 2003 and MSRM 2003). Fish species reported in the various Creeks of West Arm Provincial Park are summarized in Table 3. No fish species have been recorded in Strickland, Tunstall, Anderson and Selous Creeks.

Table 3. Summary of fish species (native and introduced) confirmed for the West Arm of Kootenay Lake and various creeks within West Arm Provincial Park that flow into Kootenay Lake.

Common Name	Native, or not	West Arm	Lasca	Eight-Mile	Five-Mile	Kutetl	Midge
Kokanee	Y	*	*	*			*
Bull Trout	Y	*	*			*	*
Rainbow Trout	Y	*	*	*	*		*
Mountain Whitefish	Y	*	*				*
White Sturgeon (Kootenay R.)	Y	*					
Largescale Sucker	Y	*					
Lake Chub	Y	*					
Peamouth Chub	Y	*					
Northern Squawfish	Y	*					
Longnose Dace	Y	*	*		*		
Redside Shiner	Y	*					
Northern Pikeminnow	Y	*					
Longnose Sucker	Y	*					
Prickly Sculpin	Y	*					
Torrent Sculpin	Y	*					

Unidentified Sculpin	Y				*
Yellow Perch	N	*			
Westslope (Yellowstone) Cutthroat Trout	N	*	*	*	*
Pumpkinseed	N	*			
Brook Trout	N	*	*		
Largemouth Bass	N	*			

From a hydrologic and fisheries perspective, the park includes a number of drainages that flow into the West Arm and a portion of Kutetl and Midge Creeks flow into the South Arm of Kootenay Lake.

The West Arm of Kootenay Lake is regionally significant from a fisheries perspective. The area has increasing populations of Kokanee salmon and has high species diversity compared to many areas. There have also been introductions of non-native species into some of these creeks and their impacts are unknown at this time. All creeks entering into the West Arm are important as they provide food supplies and spawning habitat for species in the Arm itself. Lasca Creek is the most diverse, and has extensive spawning habitat in the fan area. Eight mile, Midge, Kutetl, and Five mile also merit fisheries consideration.

Connectivity/Migration Corridors

By virtue of its relatively large size and broad elevational gradient, West Arm Park provides contiguous year-round habitat for a variety of wildlife species. The park also represents an important regional connectivity network that extends from north to south along the Nelson Range of the Selkirk Mountains. To the southeast, the Midge Creek Wildlife Management Area (15,000 ha) extends from the height-of-land to the South Arm lakeshore and provides an important connectivity corridor to the park. It also includes south aspect lower elevation wildlife habitats not represented in the park that are essential for seasonal wildlife migration and movements (Utzig and Scott-May 2003). The Harrop-Procter Community Forest located directly east of the park is being managed to maintain a high degree of ecological integrity and it offers additional connectivity to the park.

The functional link between the park and surrounding habitats is to some extent limited because of its location at the junction of the West and South Arms of Kootenay Lake. Nevertheless, for ungulates and other wide-ranging species that are able to cross the lake, there is potential for interaction with a significant area surrounding the park. South Selkirk Caribou are known to move north across the West Arm of the lake (Figure 5) and as far south as the US border. Home ranges of other ungulates are also likely to extend to winter ranges across the West and South Arms of the lake.

On a finer scale, the Canadian Pacific railroad line and the privately owned lands along the shoreline and on the fans of Hermitage, Five Mile, Tunstall, Eight-Mile and Lasca Creeks represent a barrier to connectivity between the lakeshore and upland portions of the park.

This is an important value, but one that is difficult to manage because the extent to which natural disturbances potentially impact the park's function as a connectivity corridor depends on what species or guilds are considered as a frame of reference.

Key Social Values Relating to West Arm Provincial Park

Water Values

Five Mile Creek currently provides an estimated 80% of the City of Nelson's water supply. Under its water license, the city has a dam, spillway and intake house on Five Mile Creek. The City of Nelson also retains water rights to Anderson, Selous and Fell Creeks and obtains water from these streams when necessary. Maintaining this consistent and reliable source of clean water is a very high priority for residents of Nelson. Rural homes along the West Arm of Kootenay Lake have domestic and/or irrigation water licenses for Selous, Lasca, Eight Mile, Tunstall, Hermitage, Anderson, Strickland and

Stephanie Creeks that lie within the park. High water quality and consistent quantity would be a top priority for these area residents as well.

Ensuring water quality to outside sources is not an identified value of West Arm Provincial Park. However, there is obviously also a direct link between condition with the park and water sources being provided to surrounding urban and rural residents. The City of Nelson does not monitor water quality in systematic fashion prior to water treatment, and there are no data that could be used to assess impacts in relation to the Kutetl fire. An Environment Canada flow monitoring station is in place, but that focuses on flow rates rather than sediment monitoring. A cooperative partnership between the City, other communities (e.g. Harrop) and Parks may be appropriate in future to ensure that water values are adequately monitored and maintained into the future.

Cultural/Heritage Values

Lasca Creek and its delta in particular are considered of moderate to high significance to the Kutenai and Lakes people. There are several significant archeological features of pre-contact history adjacent to the park boundary and at least five archeological sites are found along the West Arm between Harrop and Tunstall Creeks (Ministry of Water, Land & Air Protection 2000). In addition, regionally significant themes of railway and boat transportation, mining, trapping, forestry, and First Nations traditional use are apparent in the park. The historic Lasca Creek trail (built in the early 1900's as evidenced by two cabins along the route) provided access to mineral claims in the upper portion of the drainage.

These values present in the park are either unlikely to be influenced by natural disturbances (e.g. shoreline features), or would be extremely difficult to protect. We do not consider them further in this project.

Recreation/Tourism Values

West Arm Provincial Park is used year-round and offers a wide range of front and backcountry recreational opportunities. These include hiking, camping, mountain biking, climbing, backcountry skiing, boating and water sports, beach activities, fishing, hunting and wildlife viewing. Key attributes of the park include the high elevation connected ridge systems that offer spectacular views and relatively gentle terrain; the sandy beaches on the south shore of the West Arm frequented in summer; the extensive system of forested user-built mountain bike trails accessed from Svoboda Road and the inactive Northern Burlington line; the ridges and slopes (e.g., Evening Ridge, Ymir Mountain, Five-Mile Basin, Kutetl Basin and associated Jamie Steed trespass cabin) used for back-country skiing and accessed from Whitewater Ski Hill and Hummingbird FSR; the 13 km Lasca Creek Trail to the headwaters and other accessible interconnected ridge systems; and the rock outcrops above Kootenay Lake offering climbing opportunities close to Nelson.

Viewscapes from the park as well as from Whitewater Ski Resort, the north shore of Kootenay Lake and the City of Nelson are highly valued by tourists and residents alike.

Recreation is a value provided by the park. However, there are also potential conflicts between recreational activities and some of the values within the park. Volume, exact locations and timing of activities will influence the extent of the potential impact. Lack of information on the extent of use and potential impacts currently limits Parks' ability to make management decisions regarding appropriate access management within the Park.

Forestry Values

West Arm Park is surrounded by community, crown and private forest tenures including the Harrop-Procter Community Forest Cooperative, Kootenay Lake Timber Supply Area, and Darkwoods Forestry Ltd, respectively.

Ensuring that the West Arm provincial park is not a significant threat to outside resources is part of the parks mandate (Mike Gall pers. comm.). Assessment of the potential for future fires, and future forest health issues that may negatively impact adjacent values would be part of a monitoring strategy, and must include an assessment of the broader regional context of fire and forest health issues.

Wildland/Urban Interface

The north and west boundary areas of West Arm Provincial Park include a wildland/ urban interface, where the forest meets structural development (Mortimer 2001). The 'interface' between wildland and rural areas is often considered in relation to the threat of wildfire. In an assessment of the prevailing threats, Mortimer (2001) highlights that given the physical location and prevailing weather conditions, the most likely scenario is one in which an urban or rural private land fire would spread upslope impacting surrounding private land and the Park. The hazard to private lands within the interface is ameliorated somewhat by their location at the base of the slope leading up to the park and a fire approaching these interface areas from upslope (in the park) would probably be in a backing (low fire intensity) condition. However the hazard to forests within the park and adjacent to interface areas is significant due to fuel and slope factors and the ignition risk is high due to high levels of human activity. Ignition risk is highest in the forested areas adjacent to the Nelson townsite and Kootenay Lake shoreline perimeters as trails, recreational facilities and structural accommodations all increase the risk of human caused ignitions. There are areas where a relatively minor accidental ignition on an interface perimeter could rapidly develop into a large fire, spreading quickly and spotting upslope into the park (Mortimer 2001). Townsite intermix properties (areas such as Mountain Station Rd. and Svoboda Road within the community perimeter where significant fuel buildup exists amongst structures) are not common. This lack of intermix isolates the interface fire hazard mainly to the Nelson townsite perimeter areas.

An independent review of the potential risks associated with fire in relation to the urban / rural and park interface identified that the most likely scenario involves fire being initiated in the urban or rural areas, and spreading into the park (Mortimer 2001). Under this scenario, parks cannot take responsibility for the urban / park interface because it does not control the most likely threat factor and has no legal mandate to operate outside the boundaries of the Park. As a result, this question is not relevant to a monitoring strategy for the park. However, there is the potential for significant values within the park to be negatively influenced by human-caused fires originating in the interface zone. It would therefore be of benefit for parks to work cooperatively with City of Nelson and the Regional District to ensure that key initial actions do occur in the interface zone.

In addition, the potential interface issues relating to other communities (particularly Harrop / Proctor) have not been assessed in detail. The proposed Mountain Pine Beetle susceptibility mapping will provide some information regarding potential future threats in relation to these communities.

Section 2: Monitoring to support future natural disturbance management

Monitoring of ecological values can mean many things. In its most typically used sense, monitoring involves a long-term process of gathering data that are adequate to detect ecologically significant changes. In order to design such a monitoring program, the appropriate indicators and the level of ecological change to be detected should be known. In the case of a management question, goals and objectives for the value must be known. Without these, it is difficult to determine how intensive or extensive the monitoring must be to provide useable information.

Monitoring can also be in relation to 'inventory'. Inventory of a resource is often the first phase of a real monitoring program.

Monitoring can also be a part of research. Research is more than simply monitoring change, and involves asking broader questions that are then tested using monitoring.

True monitoring of ecological values is almost always a long-term venture. This is simply because the natural variability in ecological systems is sufficiently large that many years are often required to gather even basic information. Inventory,, on the other hand can involve shorter term projects.

For long-term monitoring of biological change, information must be comparable over time and by location. The Ecological Monitoring and Assessment Network (EMAN) recommends that the groups who are involved in monitoring activities should coordinate their efforts through the use of standard protocols in study design, sampling procedures, sample and data analysis and reporting methods. This ensures that information gathered in Canada is as useful as possible at the national and international scale.

Priorities for Monitoring in West Arm Park

Setting priorities for monitoring in relation to future natural disturbance management should be guided by the management goals and objectives of the park. For West Arm Park, these are outlined in general fashion in the current management plan which identifies conservation objectives as being the highest priorities for the park, in addition to maintaining viewscapes and downstream water resources for external users. The plan also notes that recreational uses should be maintained at levels consistent with maintaining these objectives and it therefore follows that disturbance management should similarly comply with these goals.

However, there can be conflicts between allowing natural disturbances processes (which are integral parts of maintaining natural ecosystems functioning) with maintaining relatively 'static' values (such as caribou habitat). The approach taken here is to attempt to determine the extent to which disturbances may negatively impact the value, realising that this can only be assessed *in relation to the greater park ecosystem*. Section 1 itemizes the values in the park and summarises what is known about the significance of each value in relation to this broader context. We use this information to prioritise monitoring in each category below.

In addition, because funds are usually limited, monitoring strategies usually tend to prioritise those values most at risk or sensitive to the likely threats. In the section below, we assess each value in terms of its potential threats from a disturbance perspective. Conclusions from this will be used to direct potential monitoring questions – e.g. high values that are at high risk will be prioritised for monitoring, followed by medium values under high risk, etc.

Disturbances: Known and Potential Impacts to West Arm Values

In this section we first identify the potential impacts that may occur from different disturbances. We then link these with the values identified in the previous section to highlight priorities for monitoring.

In an review of threats to local parks, the West Arm park was given an environmental risk rating of low, possibly tending to moderate (Utzig and Scott-May 2003). This was a result of a combination of the parks size, shape, relatively isolated location combined with low development in the park and a management plan that outlines goals to maintain uses at levels that likely maintain the wilderness values of the park. Key threats that were identified include the potential for large fires or insect and disease epidemics, which have demonstrated the potential to impact the important old growth attributes within the park.

In this section, we focus on how natural disturbances interplay with park values and may sometimes be considered a threat to specific values.

Impacts of Fire on Ecosystem Components

Fire is a natural disturbance and local plant and animal species are typically thought to be adapted to the fire regimes (i.e., frequency, season, size, severity) that characterized their habitats in pre-settlement times. Significant impacts to ecosystem components are expected when fire (and/or other disturbance) regimes are substantially altered outside of their natural range of variability. Whether within or outside of the range of natural variability, fire can have profound effects on ecosystem structure and function through its influence on hydrological processes, soils, forest stand structure, vegetation, litter, wildlife and their habitats (reviews in Agee 1993; DeBano et al. 1998; Kapler-Smith 2000, Brown and Kapler-Smith 2000).

The extent and direction (positive or negative) of fire effects depends on fire severity and ecosystem resilience. Fire severity (a qualitative measure of the effects of fire on site resources; Robichaud et al.

2000) in particular, mediated to a large extent by the occurrence of hydrological events, determines watershed response to fire. For a wide range of fire severities, impacts to hydrology and sediment loss can be minimal in the absence of precipitation. However when a precipitation event follows a large-sized moderate to high severity fire, watershed impacts can be far-reaching. Soils, vegetation and litter are critical to watershed function and severe fire can destroy accumulated forest floor material, vegetation and litter layers, altering filtration processes and/or creating water repellent conditions. These changes can result in increased run-off, peak flows, erosion and sediment delivery to streams and lakes, thereby degrading water quality and impacting aquatic habitats and fish populations (Rinne 1996). Mass wasting in the form of debris flows and avalanches can result under some conditions. Loss of soil from hill slopes can also cause reductions in nutrient levels and site productivity, which in turn can affect rates of re-vegetation, forest regeneration and wildlife habitat availability and use (Brown and Kapler-Smith 2000; Kapler 2000).

Understanding whether a fire will have acceptable consequences also requires an understanding of the values present and the landscape context. For example, a resource such as caribou habitat would naturally have moved around on the landscape through time in response to natural disturbance events. However, due to extensive loss of habitat from forest harvesting, opportunities for caribou to use alternate habitat are currently very low. Maintaining such a value where it currently exists is therefore increasingly critical.

Forest Health

Forest health issues include other disturbance agents acting within the park boundaries and surrounding forest areas, as outlined in Section 1. A number of different species are potential threats to values within the park, and each is discussed below. As highlighted above, it is difficult to determine whether trends in forest health agents are 'natural' or not. Within the context of global warming they are perhaps not, but it is also likely that trends in beetles are variable through time as tree species composition changes through succession and as short- and long-term weather patterns change.

We assess each potential major forest health issue below, and identify the scope of the threat within the provincial park and surrounding areas, and identify whether action can potentially reduce the threat in future.

Mountain pine beetle: British Columbia is currently in the midst of the largest recorded mountain pine beetle outbreak in North America (BC Ministry of Forest 2004). Based on research by the Ministry of Forests and the Canadian Forest Service, the current BC infestation may peak in 2008 and under current conditions has the potential to kill at least 80 per cent of the merchantable pine in BC's Interior. In addition, significant volumes will continue to be killed until at least 2015 and volume killed will not decrease to pre-outbreak levels until after 2020 (Eng et al. 2004). Based on the 2004 aerial overview, mountain pine beetle continues to be the primary natural cause of the loss of timber in the province, with infested hectares seven times higher than four years ago (Westfall 2005).

Overall, growth rate projections of mountain pine beetle are expected to continue to expand in 2005 (Westfall 2005) and the current outbreak is most likely to continue unabated until the majority of the susceptible host stands in the province are affected. There is low probability that the province will experience sufficient severe cold weather of sufficient magnitude and duration to affect a significant proportion of the population (Eng et al. 2004), though of course this may still occur locally.

In the West Kootenay, based on the detailed information from the 2004 overview survey for Kootenay Lake district, mountain pine beetle infested areas will have quadrupled since 2003 (BC Ministry of Forest 2005). Based on a modeling study in the West Kootenay, the timing of the peak in annual trees killed by the mountain pine beetle outbreak in Kootenay Lake TSA is projected for 2011 (Eng et al. 2004). In the West Arm Park and vicinity, based on the 2004 aerial overview survey, the majority of the lodgepole pine stands have varying incidence of mountain pine beetle. Current conditions are similar to those found along the West Arm of Kootenay Lake, which is characterized by a combination of the existing infestation expanding and intensifying in several areas with scattered infestation centers located over the majority of the susceptible types.

Current infestation rates (i.e., proportion of pine infected) within the park are unknown, but have been estimated at 5% with less than 10% cumulative mortality since the onset of this outbreak in 2000 (Julie Castonguay pers. comm.). Considerable future mortality is therefore expected in pine stands.

Over the course of the infestation, single tree removal treatments have little impact on the total volume of pine killed. However, single tree treatments can be effective in protecting specific forest values under low attack levels (Eng et al. 2004, Fall et al. 2001). When populations are low, most beetles are thought to disperse locally however there are always a small proportion of beetles that disperse over a larger area (20 km from origin). At higher population levels, an increased proportion of beetles appear to disperse longer distances. Therefore, with the many sources of beetles (inside and outside the park), it is impossible to locate the sources of beetles affecting any given area. In addition, the level of management effort throughout the broad area is also relevant: although efforts are made to target beetle wood in the surrounding area, large infested areas are currently unmanaged outside the park and beetles are assumed to have 'outrun' management effort. Therefore, regardless of the effort expended on beetle management, the standing volume of green pine at the end of the outbreak is virtually the same. This means that at the provincial scale and given the extent and severity of the outbreak, beetle management appears to have little effect on the overall impact of the outbreak with respect to future timber supply considerations (Eng et al. 2004). **Therefore, managing mountain pine beetle in the Park will have no long term effect on the timber supply outside the park.**

With respect to beetle effects of fire, increased risk of fire in mountain pine beetle-affected stands has been postulated by many, but evidence in literature is equivocal (Turner et al. 1999). Conducting salvage operations based on the premises of reducing fire risk is not recommended, except in the wildland-urban interface (Eng. 2004) where a significant threat to urban areas has been identified.

Western balsam bark beetle: (*Dryocoetes confuses*) is the most damaging agent of mature sub-alpine fir in BC. This bark beetle in association with a pathogenic fungus can cause extensive tree mortality in high elevation ecosystems. Western balsam bark beetle mortality tends to occur at a chronic low level in susceptible stands, often resulting in extensive cumulative damage over time. Chronic levels of western balsam bark beetle have been noted in the upper reach of Lasca Creek since the mid-1990s. The 2003 Kutetl fire burnt the majority of the western balsam bark beetle infested areas in the Park (J. Castonguay pers. comm.). The question of how western balsam bark beetles may have played a role in fire spread is hard to answer after the fact, but occurrence and risk due to western balsam bark beetle is currently low in the park.

Spruce beetle: (*Dendroctonus rufipennis*) is the most destructive insect affecting mature spruce in BC. At low population levels the spruce beetle infests stressed trees and downed host material. Fire-caused charring of the lower bole may damage the tree's vascular cambium and provide large areas for bark beetle attack. Crown injury can also promote bark beetle attack with the best indicator of crown injury being the proportion of the crown scorched or killed by fire. If a large amount of preferred host such as windfall is available, populations can build to the point where beetles can attack healthy trees and cause wide spread mortality. Spruce that are weakened by fire or felled and left on site during the fire suppression activities can contribute in providing suitable material to build a spruce beetle population. The level of mature spruce in the park is considerable in the ESSF and is of high value as caribou habitat.

Local fire history has the greatest effect on spruce beetle susceptibility, however, dominance of neighbouring stands by spruce as well as elevation are also important predictors of outbreaks. Spatial interactions between fire and spruce beetle disturbances is influenced by time since last major disturbance, topographic position, and weather during windows of potential interaction (Bepi et al. 2003). Bepi et al. (2003) also noted that some areas mapped as post-fire stands in their study may have only partially burned, leaving large remnant trees that supported a spruce beetle outbreak.

Douglas-fir beetle: (*Dendroctonus pseudotsugae*) is an important species that attacks mature Douglas-fir in the province. At low population levels, the beetle infests scattered, weak trees. When Douglas-fir beetle populations build under favorable conditions large numbers of healthy trees can be attacked. Douglas-fir beetles are attracted to slash, stumps, windthrow, and trees weakened by fire, drought, defoliation or disease. Populations expand rapidly in such material and in subsequent generations beetles attack and kill surrounding green trees. Percent Douglas-fir basal area, stand

basal area, average Douglas-fir dbh, and stand age are all factors contributing to susceptibility to Douglas-fir beetle (Shore et al. 1999). The North Shore of the West Arm of Kootenay Lake has seen small outbreaks of Douglas-fir beetle in the mid to late 1990s. The Douglas-fir stands on the North shore of the West Arm are much drier, older and larger than the stand conditions found in the ICH located in the Park. However, some areas along the shore of the Park present some favorable conditions that potentially allow development of a Douglas-fir beetle infestation. Overall, the risk of Douglas-fir beetle negatively impacting park values is relatively low, however, depending on placement of these stands, it is possible that they may result in pockets of dead timber that may increase interface fire hazard in future.

Invasive species

Invasive species are a significant threat to native plant communities and their ability to quickly establish and dominate disturbed areas is well known. Several highly damaging invasive species are known to occur in the lower elevations of West Arm Provincial Park, including Spotted Knapweed, Common Tansy, Yellow and Orange Hawkweed, Scotch Broom, Canada Thistle, Rush Skeletonweed and Purple Loosestrife (V. Miller, pers. comm.).

We presume that any significant invasive species' infestations in the park are currently confined to lower elevations in the vicinity of the railway line and roaded areas, but predict that existing (and future) fire-fighting activities may result in significantly increased potential for spread along various access routes into the park.

Human Activities: Known and Potential Disturbances

Interface Fire Threat

The 'interface' of the park includes all the areas surrounding the park that can have both positive and negative impacts on park values. "Interface" types include a) the 'urban-interface' which includes areas adjacent to the city of Nelson, b) the "rural interface" which includes private land areas along the west arm and in Harrop, c) the "recreation interface" which primarily includes the boundary with Whitewater Ski Hill, d) the "forestry-interface" which includes the boundary with Darkwood's private land, Harrop-Proctor Community Forest and Kootenay Lake TSA, and e) infrastructure corridors (CPR railroad).

Typically, the 'interface' zone is considered a 100m wide buffer between the park and the surrounding area and this location is usually of primary concern. The 'meso-interface' is a wider band extending 0.5km onto either side of the boundary and can have implications for values on either side. This broader interface is typically considered a secondary concern after immediate 'primary' interface issues have been dealt with.

Threat of fire in relation to park values originates from two jurisdictions – a) at the park interface and b) inside the park boundary (~2 kilometres from the park interface). Fire can spread in two directions:

- from the community to the forest (i.e., human-caused fire threatens wildland managed area and community watershed values);
- from the forest to the community; wildland fire, however ignited can threaten rural urban area values by a) direct impingement along the community interface and; b) via the long-range spotting fire ignition processes that can threaten both interface and urban values at risk up to 2 kms inside urban boundary.

In a previous report, Mortimer (2001) summarised prevailing weather conditions, topography and potential threats in relation to the City of Nelson and West Arm Park interface areas, and identified that the primary risks for fire in this locale were identified as being from 'community to forest'. This fact leads to the conclusion that managing fire risk in the urban areas adjacent to the park boundary should be of primary concern, though it is clearly not under the jurisdiction of Parks. In addition, there may be a significant though unquantified threat of fire ignition in areas used for recreation within the park. This type of threat is extremely difficult to quantify and to manage.

In addition, Mortimer (2001) did not provide a direct assessment of the threat of fire moving through the interface adjacent to Harrop or Proctor – in this case the proposed mountain pine beetle

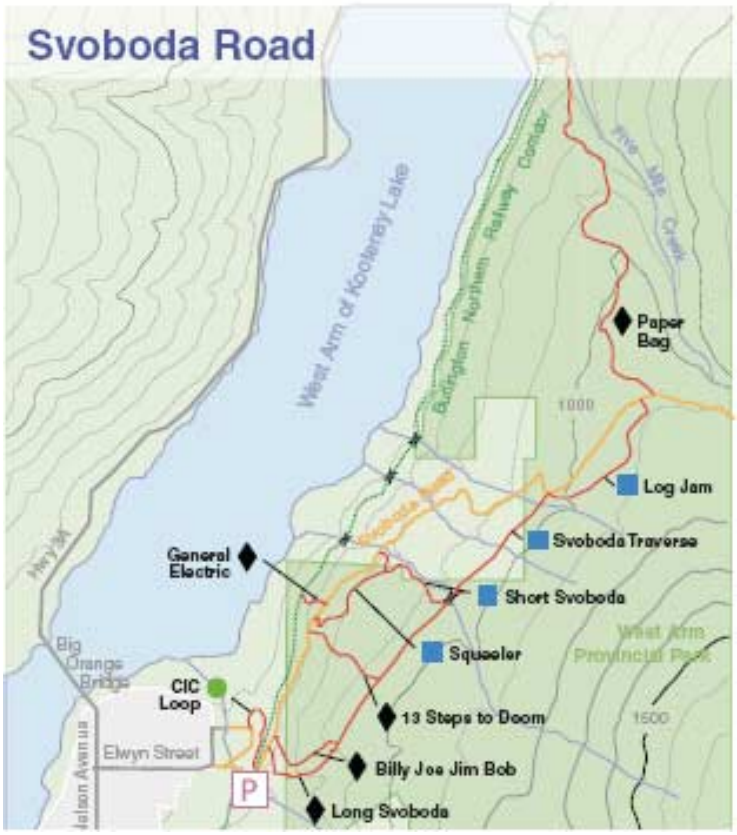
susceptibility mapping will provide one source of information to guide an understanding of the level of potential threat of fire posed in this area into the future. Similarly, undertaking FireSmart in this area would also reduce the risk of catastrophic fire spreading from the rural areas into the surrounding parklands.

Recreation

West Arm is primarily a 'wilderness park', however, it is located in close proximity to a relatively large community (Nelson), and extensive rural areas. Recreational activities in West Arm Park involve primarily mountain biking, backcountry skiing and hiking.

To date, recreation access is a relatively small threat (Utzig and Scott-May 2003), however, there is the potential for significant impact on some values, for example caribou habitat or grizzly bear habitat use. This question should be explored further to ensure conflicts are minimised or reduced.

The Figure below shows existing mountain bike trails that occur within West Arm Park.



Potential Monitoring: Considering Values and Threats.

In this section, the broad questions outlined in Table 1 are used to focus in on relevant questions for all the values identified in Section 1. Each 'value' starts with a statement as to its overall importance, and so whether future management of natural disturbances to preserve the value would be appropriate. This will help rank the questions and monitoring schemes. Note that a broad range of potential questions are raised, based on discussions with a range of people including Park staff and subject experts. We broadly prioritise these questions based on the 'value' and the perceived level of future threat from disturbances, to identify a small number of priorities as requested by the contract.

Forests and Ecosystems

The forested ecosystems of the West Arm provincial park are of importance as being generally 'representative' of the diversity of local ecosystems (unusual in many PAs). In addition, the old growth values associated with the park are not known to be exceptional, but they do (did) provide larger old growth forest patches that have been relatively uncommon in this region as a result of fires in the 1900s, plus forestry activities over the last 50 years. They also link to other critical values, see below (e.g., mountain caribou habitat).

Key threats include a) stand-replacing fire - large areas outside the park are significantly outside the range of natural variability for the amount of old growth present, as a result of fires and harvesting activity, b) forest health agents – there is an increase in forest health issues locally, which may require targeted action under some circumstances, c) invasive species - control of invasive species within or adjacent to the park boundary is a critical feature of maintaining ecological values of forested ecosystems within this park.

Level of threat = high. Value = high.

#	Question	Monitoring actions?	Links to Management Action
1	Identify locations of remaining old forest within the park. Links to caribou habitat questions below.	Map old growth remaining in different ecosystems. Map based assessment, with flight for clarification. Identify possible threats based on existing mountain bike trails, access roads etc.	Inventory project. Allows remaining old forest values to be identified in order that key areas are protected in future disturbance situations. Also allows conflicts with other values (particularly recreation / caribou) to be identified.
2	What is the predicted Mountain Pine Beetle susceptibility of stands in the park?	Complete mapping based on forest cover attributes (based on available data – see detailed plan).	Would provide information on potential future mortality risk due to dead pine stands. May require some localised thinning to reduce fuel levels, in some areas in future.
3	What level of actual mortality currently exists in Anderson and Lasca Creeks?	Field project to ground truth localised results from the susceptibility mapping, to determine current risk of fire in the interface – would complete for current levels and ground truth map for future levels.	Would provide an assessment of if, or when future management action may be appropriate.
4	What level of threat is posed by the spruce bark beetle, to existing spruce old growth, and particularly caribou habitat? Complete susceptibility mapping for spruce bark beetle, in relation to other values in ESSF. See links to restoration monitoring required for spruce beetle.	Survey segments of lightly burnt areas in ESSF to confirm the presence and incidence of spruce bark beetle in the park and potentially around the periphery of the park.	Is questionable whether any action would be appropriate, irrespective of threat. However, Susceptibility mapping would be useful in the longer term as a basis for understanding potential threats to caribou habitat and potential losses due to fire in future.
5	What is the predicted susceptibility of stands in the park to Douglas fir Beetle?	Complete mapping from existing MoF data.	Would provide information on potential future mortality risk due to dead fir stands. May require some localised thinning to reduce fuel levels, in some areas in future.

#	Question	Monitoring actions?	Links to Management Action
6	What is the abundance and distribution of invasive species within the park?	Establish permanent sample plots to identify species establishment, distribution, abundance and potential control strategies.	Baseline data required to understand extent of future changes, and to link to potential restoration actions.

Wildlife Habitat

Mountain caribou

Maintaining remaining mountain caribou habitat is a key function of the West Arm Park.

Caribou habitat has been significantly impacted outside the park by forest harvesting. Maintaining any existing habitat within the park should be a key goal.

Level of threat = high. Value = high.

#	Question	Monitoring actions?	Links to management action
7	What areas of caribou habitat remain in the park? (see also #'s 16, 25, 26 relating to restoration issues and caribou).	Identify remaining caribou habitat to ensure future disturbances do not negatively impact these key areas.	Inventory project of remaining caribou habitat. Provides basic information to guide access and future natural disturbance management.
8	How important was the habitat in West Arm Park? Does loss of this area require other areas to be set-aside?	To our knowledge, no assessment of habitat required to maintain caribou populations has ever been undertaken. However, the loss of a large area of caribou habitat may be extremely significant for this species (esp. since it was an area where harvest and snowmobiles were banned).	Links to question of whether additional area needs to be set-aside in order to maintain caribou populations.

Grizzly bear

Providing grizzly bear habitat is a key function of the West Arm Park, in an area where the bear population is isolated and at risk. The 2003 Kutetl fire likely had a positive short-term impact on grizzly bear forage availability. Long-term habitat suitability may have been reduced by the fire if longer term habitat values such as wetland food sources were negatively impacted.

Future increases in recreational access to the park may result in significant negative impacts on grizzly bear habitat suitability.

Level of threat = high. Value = high.

#	Question	Monitoring actions?	Links to Management Action
9	Where are areas of highest habitat suitability for grizzly bear? How do these coincide with current or proposed recreational uses?	Inventory current and predicted future habitat suitability. Inventory current and predicted future recreational use. Assess for conflicts.	Leads directly to recreational disturbance management plan.

Hydrology and soils

Hydrology impacts many other values, including watershed condition, fisheries values, water resources available for humans, etc. Vegetation and soil response to the fire plays an important role in understanding the impacts and recovery potential of hydrology values.

Threats include negative impacts caused by potential management of future natural disturbances and so it would be appropriate to gather baseline data to understand any future impacts. However, given the probability of disturbances outside the range of natural variability, this section receives a lower priority overall.

Level of threat = medium . Value = high

#	Question	Monitoring actions?	Links to Management Action
10	Describe baseline hydrology data for one or two major systems.	Install monitoring stations on Kutetl Creek to provide baseline information	Provides baseline data necessary for understanding impacts of future disturbances.

Social Values

Nelson water supply

West Arm Park provides the primary water supply for the City of Nelson, and various adjacent communities and private land homes.

Threats include primary negative impacts caused by potential management of future natural disturbances. This area is not a direct responsibility of West Arm Park but ensuring cooperation with surrounding communities is important.

Level of threat = medium-low. Value = high.

See question 10, for suggested baseline data monitoring.

Recreational Values

Recreation values could be impacted by future disturbances. However, they are also likely themselves to be considered a threat to other ecological values provided by the Park.

Value = medium. Level of threat = medium.

#	Question	Monitoring actions?	Potential Restoration or Management Action
11	Quantify extent of recreational use of the park, by season and area.	Summarise use of different areas (primarily mountain bikers and back-country skiers), by a) direct use questionnaires (on entering the park), and / or b) by systematic counting of cars/ bikers.	Provides managers with baseline data for making access management decisions in future. May be important for understanding potential conflicts between recreation and wildlife habitat (caribou and grizzly bear in particular).

Interface Values

The 'interface' of the park includes all the areas (urban, rural, recreation, other) surrounding the park that can have both positive and negative impacts on park values.

Level of threat = low (caused by the park)[2]. Value = high

#	Question	Monitoring actions?	Potential Restoration or Management Action
12	How familiar are homeowners with the Fire-smart program? To what extent has the Fire-smart program been implemented within the immediate interface?	Interview homeowners regarding familiarity with fire-smart program and principles. Monitor compliance with Fire-Smart program, throughout the interface zone.	Since this is recommended as the first line of defense, for both private and parks property, it is important to understand how comprehensively the program has been presented and adopted. Unless it is reasonably well adopted, there will be no point moving to the secondary level of management – within the meso-interface (see Question 13). This area is outside the jurisdiction of Parks, but we suggest that collaboration between the City, Regional Districts and Parks may be helpful at this time.
13	Within the mesointerface (0.5km from the boundary), how extensive are fuel loadings and fire threats caused by topography etc.? See links to questions 2,3,4,5.	Assess state of forest adjacent to immediate boundary, in terms of fire threat.	Relates to longer term management objectives, since management of this area requires initial management of immediate interface.
14	How does a prescription for fuel management fit with an ecologically relevant prescription?	If question 12 is adequate, and 13 is undertaken then in the longer term an assessment of conflicts between fire management and ecological goals is needed.	Links to longer term management action.

Recommendations on Ranked Projects

The following questions rank highest based on value, threat, and potential cost.

#	Question	Rationale
1	Identify locations of remaining old forest within the park. Potentially links to caribou habitat questions below.	Value – high Threat – high Cost – medium
2	What is the predicted susceptibility of stands in the park for Mountain Pine Beetle?	Value – high Threat – medium Cost – low
7	What areas of caribou habitat remain in the park? Combined with question #1.	Value – high Threat – high Cost – medium
8	How important was the caribou habitat in West Arm Park? Does loss of this area require other	Value – high

[2] Note, this refers to threats 'to the interface values', since the threat is considered to mostly come from the interface and 'threaten' park values.

#	Question	Rationale
	areas to be set-aside?	Threat – high Cost – high
11	Quantify extent of recreational use of the park, by season and area.	Value – high Threat – medium / low? Cost – low
12	To what extent has the Fire-smart program been implemented within the immediate interface? Although this question is outside Parks' direct mandate, it may significantly impact the park in future. Collaborative action may raise awareness locally, and reduce the risk to the Park in future.	Value – high Threat – medium? Cost – low

Workplans for the above questions are outlined in Appendix 1, with the exception of question 8 and question 12.

Question 8 is an important one for Parks managers and land managers across the region. However, to our knowledge a large project is ongoing to try to understand habitat use and population regulation of caribou in the different herds (K. Jardine MSRM), and it is likely beyond the capacity and scope of the West Arm Park managers to lead the way in answering this question. We suggest that understanding the value of remaining habitat in the Park will fill an information gap that will allow others to address this broader question. However, we also left this question in the priority list because it is the key question relating to how parks and other land use managers manage and restore remaining caribou habitat for this herd.

Question 12 is important for the region in general, however is outside the direct mandate of Parks, since it involves management issues outside the park boundary. We prioritise this question because it is relevant both to the potential future of West Arm Park (since a fire outside the boundaries may affect values within the park) and to surrounding communities and rural areas. We recommend that park staff engage in ongoing dialogue with municipalities and regional districts as opportunity arises in relation to the FireSmart program.

Section 3: The 2003 Kutetl Fire

The following section focuses on the 2003 Kutetl fire, and assesses known and potential impacts of both the fire and fire-fighting activities. Monitoring requirements, restoration actions and lessons learned are highlighted.

Site-Specific Impacts of the Fire

The 2003 Kutetl fire attained a maximum fire size of 7,916 ha and burned significant portions of the Kutetl, upper Midge, upper Lasca and upper Five Mile Creek drainage basins (**Figures 1 and 3**). Fire severity was extremely variable, ranging from high intensity running crown fire to low intensity ground fire (R. Noble, pers. comm.). A preliminary fire severity map has been completed for West Arm Provincial Park, using satellite imagery and air photo interpretation (Figure 1). This will help define the extent and distribution of fire impacts and field verification of mapping products will be required (G. Utzig, pers. comm.).

To date, there have been no post-fire field investigations undertaken to evaluate the potential ecological impacts of the Kutetl fire (with the exception of a preliminary overview assessment of post-fire rehabilitation efforts completed in 2003 and 2004 by the Ministry of Forests).

Old-growth values within the park were impacted, though the general values of those areas were not inventoried pre-fire, so they cannot be quantified.

A recent habitat mountain caribou suitability mapping analysis was completed by the Columbia Basin Fish & Wildlife Compensation Program based on data supplied by Tim Layser of the US Forest Service. This analysis estimated that of 9,489 ha of suitable caribou habitat (classified as either early winter, early & late winter, or late winter habitat only) present within the boundaries of West Arm Provincial Park, 3,805 ha (or 40.1% of the total suitable habitat) were burnt as a direct result of the Kutetl fire (John Krebs, unpublished data; **Figure 6**). Within the Kutetl drainage in particular, most of the areas with highest caribou use (based on radio-telemetry data) on gently-sloped southwest aspects were burned during the fire (Christian Schadendorf, pers. comm.).

Other potential though unknown impacts of the fire include increased potential for run-off, peak flows, erosion, sedimentation and potential degradation to water quality and aquatic habitats. Invasive species movements into burnt or rehabilitated areas may also be anticipated.

Context: Are fires and forest health issues in West Arm Park natural?

Understanding whether or not a fire or disturbance event is a 'natural' phenomenon helps to determine what actions may be appropriate in terms of restoration or prevention. Determining the naturalness of a single event requires an understanding of the larger ecosystem processes that typically occur in that ecosystem, and how trends in processes occur through time. Note that this first question does not automatically lead to the conclusion that if something is natural it should also be allowed to run its course. Many additional considerations, such as size of park, values present, and greater park ecosystem context are also key to the decision.

As outlined above, the Kutetl fire was a medium to large-sized fire of variable severity. A detailed understanding of whether the Kutetl fire was within the range of natural variability would require extensive details about the fire and about natural disturbances in the region. Alternatively, as an initial assessment, we can ask whether there is evidence that the fire was likely promoted by **conditions outside the range of natural variability**. Fire parameters are largely a result of local climatic conditions combined with local site conditions (particularly fuel loads and local weather). Year 2003 was a warmer and drier year than average. It is possible that climate change is causing a steady trend towards warmer and drier weather, and from this perspective, increasing fire frequencies may not be natural. However, there appears to be no reason for assuming the fire itself was not natural. Forests within the fire area are themselves not obviously in an 'unnatural' state – the area does not appear to have been extensively impacted by the fires of the early 1900s except perhaps the north facing slopes of the park which were not included within the fire boundary. Fuel loads were therefore likely to be within natural levels and the fire also started 'naturally' as a result of lightning strikes (though if man-

made it does not prove that the fire itself was outside RONV). However, it appears, given this evidence that the fire itself can be classified as 'natural'. Impacts of the fire therefore are also 'natural' and would not be the subject of restoration activities unless they were associated with other values as outlined above.

Impacts of Fire-Fighting Activities on Ecosystem Components

Fire-fighting activities aimed at mitigating the devastating impacts of wildfire can result in environmental impacts (review in Robichaud et al. 2000; Ingalsbee 2004). For example, the construction of fireguards, trails, roads, helicopter pads and staging areas involves impacting and removing trees and vegetation. Tree felling to create fire breaks creates new fuel hazards by leaving post-fire "windthrows" of downed woody debris. Additional impacts include soil displacement, compaction, erosion, debris flows and avalanching; degradation of water quality; reduction of visual quality; altered wildlife movements and reduced habitat quality (particularly for forest interior-dependent species sensitive to fragmentation and edge effects)**.** Fire retardant applied to riparian areas in concentrated doses can directly harm fish and lead to algal blooms that kill fish over time. When left on the ground, the fertilizer in retardant can stimulate the growth of invasive weeds that can enter remote sites from seeds transported inadvertently by suppression crews and their equipment. Furthermore, vegetation removal and soil disturbance associated with wildfire and suppression activities can create ideal conditions for the establishment and spread of invasive weeds.

Site-specific Impacts of Kutetl Fire-Fighting Activities

In conjunction with the Kutetl fire, a number of structures were built and activities undertaken. Fire-fighting activities and post-fire rehabilitation efforts focused on four main areas: Five Mile Creek, Lasca Creek, Kutetl/Midge Creeks and Whitewater Ski Area. Activities pertaining to these areas are briefly summarized below with reference to **Figure 3**.

Five Mile Creek (adapted from Wallace 2003 and Nicol 2003)

From the existing Five Mile Creek road, a fire road was built beginning at the City of Nelson water intake (km 6 from the start of Svoboda Road) and extending to km 12.6. This road paralleled Five Mile Creek on relatively moderate terrain and was driveable to km 12. Three fords were built across Five Mile Creek (km 6, km 9.5, and 50 m beyond km 12). The last crossing (machine only) was built to access heli pad #3 and to construct a fireguard 0.6 km beyond the pad.

From km 8.4 on the Five Mile Road, a trail was constructed up the Ferguson drainage for 6.8 km to heli pad #13. Terrain was generally moderate with few sections over 50% sideslope. This machine only trail had foot/ATV access for 4.5 km and the last 2.2 km section to the heli pad was located on flat terrain along the ridge top, with minimal disturbance to the site.

A 2.4 ha staging/landing area ("Hanes Landing" or "ballpark area" located at km 7) with adjacent helipad (not shown on Figure 43) was cleared during construction within the Park boundary.

The trees felled for road, trail, fireguard and helicopter pad construction were later skidded to landings/pads and piled for removal. The access road, trail, helipad and landing were later rehabilitated by machine-pulling back all sidecast material, decompacting, dispersing debris and log accumulations, and re-contouring the road and parts of the landings. The entire length of the road/trail was hand-seeded with a winter rye grass mix and construction fabric and culverts were removed. During rehabilitation, a problematic 400 m steep pitch with sandy eroding banks (km 6.3 - 6.6 and km 7.2 - 7.3) was stabilized with logs embedded horizontally in the sand.

Lasca Creek (adapted from Nicol 2003)

The Lasca Creek road (initially built to km 8 and then permanently deactivated) was reconstructed in the same location to about 9.5 km. A wide right-of-way (ROW) was logged from the end of the original road to Strickland Creek (a 2.5 km distance). ROW wood was skidded and decked in two landing locations (a lower landing at the start of new road construction and an upper landing at the end of the new road). A 2 km forwarding trail was built from the upper landing to heli pad A at Strickland Creek and timber was piled and removed from both landings.

Lasca Creek rehabilitation involved full de-construction of the forwarding trail and road system by machine-pulling back all sidecast material, decompacting the road and trail surface areas, reestablishing and armouring natural drainage channels, removing drainage structures, scattering debris over disturbed areas, and then grass seeding. Construction fabric and culverts were removed.

Some concerns have been raised regarding high water tables, surface flows and erosion at two locations (km 1.9 and 4) along the Lasca Creek Road following heavy winter rains in late January of 2005 (Doug Nicol, pers. comm.). These locations are along the newly de-activated section of the road, and flights over the area in February 2005 did not detect any debris flows but did confirm high water tables and surface flows. Additional follow-up will be required in these areas during spring 2005 to ensure proper drainage control, evaluate stability of fill slopes, and assess re-vegetation effectiveness.

Kutetl/Midge Creeks (adapted from Perdue 2003)

The Kutetl/Midge confluence area was accessible via an existing Darkwoods private forestry road originating from the Ymir Creek Valley. Small sections of this road required widening to provide access for fire suppression activities and a 210 m fire trail ("south cat guard") was constructed from the end of an existing cutblock access road (Figure 3). This 20-30% grade trail crosses Kutetl Creek and ends at the park boundary.

Rehabilitation of the south cat guard involved pulling back piled CWD and placing it on the trail, removing fill from and armoring cross ditches, and seeding all exposed mineral soil with a suitable erosion control mixture.

Whitewater Ski Resort

A fire access trail was constructed from the Silver King chairlift to the park boundary (estimated distance of 1.4 km).

Portions of this trail were rehabilitated, involving pulling back of fill material and recontouring, scattering of CWD across the surface, and seeding of exposed mineral soil with a suitable erosion control mixture. Rocky moss-covered areas along the exposed ridgeline were not rehabilitated (R. Noble, pers. comm.).

Summary of fire-fighting impacts: An estimated 22.6 km of roads, trails and fireguards were constructed or re-constructed in conjunction with the Kutetl fire, all of which were rehabilitated in 2003 and 2004. It has been noted that these areas appear to have been rehabilitated to high standards, and based on known information, these areas provide little potential for impacts (G. Utzig pers. comm.), except possibly as a result of invasive species.

An additional 36 helicopter pads were built (Figure 3) and a rough estimate of 100 logging truck loads of mixed timber were felled and removed from the Lasca and Five Mile drainages (R. Noble, pers. comm.). These areas have the potential to impact water sources, and create hazard in relation to some forest health agents.

An unknown quantity of fire retardant was applied aerially to suppress the fire – impacts of this appeared minimal initially (no known impacts on water supply; Peter Hartridge, pers. comm.),).

No special weed management precautions were taken to clean equipment during fire road/trail construction and post-fire rehabilitation (R. Noble, pers. comm.), which may create a significant threat in relation to future movement of invasive species into the park. Seed mixes used were comprised of rye grass or erosion control mixes that were not certified 100% weed free (V. Miller, pers. comm.).

Potential Monitoring and Restoration Actions

Some questions are the same as those in relation to future natural disturbance management. Where this is the case, the overlap is identified.

Forested Ecosystems

Known impacts include direct loss of old growth and caribou habitat from the fire. Potential impacts include invasive species, from both the fire and fire-fighting activities.

Overall Impact – high.

Agent: fire and fire-fighting activities

#	Question	Monitoring actions?	Links to Management Action
15	What are the vegetation recovery patterns and rates, in relation to fire severity? Potentially links to invasive species, caribou and grizzly bear forage questions below.	Establish permanent sample plots. Stratify by burn severity, and monitor recovery rate of understory	Research Focus. Will allow knowledge of impacts of fire severity on vegetation and recovery trajectories to be increased in these ecosystems. Links to understanding needs for restoration. A relatively long-term project.
16	What are the stand structure recovery patterns and rates, in relation to fire severity? Potentially links to caribou habitat questions. This is a subset of #15, but focusing specifically on stand structure only.	Establish permanent sample plots. Stratify by burn severity and monitor a) impacts and b) recovery on stand structures (trees, wildlife trees, downed woody debris). Could focus on impacts, or on values remaining post-fire.	Research Focus. Will allow knowledge of impacts of fire severity on vegetation and recovery trajectories to be increased in these ecosystems. Links to understanding of how fires impact habitat values for a variety of species.
17	Are there specific sources of woody substrate that promote forest health problems?	Identify problem areas where log piles at landings, etc. need to be removed immediately.	**Restoration Action needed immediately.** Action differs in relation to species. Spruce piles can be burned, peeled, or flown out.
18	In addition to 17, are lightly burnt areas a potential source for spruce beetle outbreaks? See workplan outlined for #4 to assess susceptibility mapping.	Survey segments of lightly burnt areas in ESSF to confirm the presence and incidence of spruce bark beetle in the park and potentially around the periphery of the park.	Provides an understanding of how spruce bark beetle outbreaks may influence caribou habitat quality.
19	What is the abundance and distribution of invasive species within the park? How does this relate to fire severity?	Monitor any establishment / movement of invasive species throughout park in relation to burn severity. Establish permanent sample plots to identify species establishment and potential control strategies.	Leads directly to potential restoration activities.
20	Has disturbance due to fire-fighting actions resulted in movement of invasive species into the area?	Monitor movement of invasive species along access roads, on landings, trails, etc.. Monitoring should focus on species composition and abundance in relation to disturbance.	Known restoration action required immediately. Action includes assessment of mechanical, biological or hand-pulling control methods.
21	Has seeding associated with trails, roads, landings, heli pads, etc. been successful? [Was there a requirement of parks to use 100% certified weed-free seed mixes?]	Monitor these areas for seed coverage, presence of invasive, or non-appropriate species, and evidence of erosion.	Links to future restoration activities, and to general policies within parks?

Riparian Ecosystems

Impact: assumed to be low

Agent: fire

#	Question	Monitoring actions?	Links to Management Action
22	A stand-replacing fire occurred in the park. Did riparian areas burn with a lower frequency than upland areas? What aspects of the riparian were responsible for any difference (size, slope, aspect, species composition, etc.).	Require immediate monitoring of riparian areas to determine level of impacts compared to upland sites. Could be based on a GIS mapping exercise, combined with fire severity mapping.	Research and statistical analysis project. Contributes to broader science of how fires affect ecosystem components.
23	Has the fire altered riparian streamside vegetation to significantly change stream temperatures?	Initial action could be based on GIS/ airphoto / remote sensing interpretation to determine changes in riparian vegetation. This could be followed by further work tracking forest succession and riparian recovery. Stream temperature monitoring.	Re-vegetation and reforestation of riparian areas.
24	Has the fire altered riparian streamside vegetation to significantly change litterfall inputs?	Initial action could be based on GIS/ airphoto / remote sensing interpretation to determine changes in riparian vegetation. This could be followed by further work tracking forest succession and riparian recovery. Aquatic ecosystem monitoring – litterfall and invertebrate populations.	Re-vegetation and reforestation of riparian areas.

Wildlife Habitat

Mountain caribou

Maintaining mountain caribou habitat is a key function of the West Arm Park. The 2003 Kutetl fire had a negative impact on caribou habitat values, but the extent of impacts are unknown. Concerns are high because caribou habitat outside park is significantly impacted by forestry activities and other disturbances such as snowmobiling, back-country tenures, etc.

Impacts = high. Agent = fire

#	Question	Monitoring actions?	Links to Management Action
25	What are the impacts of the Kutetl fire on caribou habitat? How do effects vary with fire severity? Is summarised as part of Question #7	Establish sampling plots in known prior caribou habitat, stratified by burn severity. Collect full sample of data on known attributes affecting caribou habitat quality.	Research project. Links to understanding how the fire impacted caribou habitat. May identify specific needs for restoration.
26	Was lichen availability impacted by the fire?	Focused version of question 17 to ensure lichen availability is assessed.	Potentially re-inoculate lichen, if possible? Follow up further – some evidence it

#	Question	Monitoring actions?	Links to Management Action
			may be possible.
27	How might caribou movement be influenced by the fire (and other factors)?	Map known, or potential trails, plus areas considered likely impassable to caribou (e.g., large areas of 'pick-up sticks). Overlay with known remaining habitat and identify potential movement conflicts for this species.	Potential restoration actions to ensure movement possible. May relate to need for recreation / access management.

Grizzly Bear

Providing grizzly bear habitat is a key function of the West Arm Park. The 2003 Kutetl fire likely had a positive short-term impact on grizzly bear forage availability.

Impacts = possibly positive, though potential for negative impacts in relation to access / recreational management.

Agent: fire and recreation activity

#	Question	Monitoring actions?	Potential Restoration or Management Action
28	How is short-term forage for grizzly bear influenced by the fire?	Most evidence suggests short-term food supplies will be increased as a result of the fire – avalanche chute vegetation, plus berry levels will likely be more prevalent post-fire. However, in areas of high fire severity, there may be a significant timelag in response. Monitor habitat values for GB in short-term to understand potential for supporting more bears in this area.	Links to habitat values for GB. Also links to potential needs for recreation management.
29	How are long-term food supplies impacted by fire?	Food supplies such as wetland associated vegetation types may have been negatively impacted.	

Hydrology and Soils

Hydrology impacts many other values, including watershed condition, fisheries values, water resources available for humans, etc. The recovery of vegetation and soils after fire plays an important role in understanding the impacts and recovery potential of hydrology values. Answering these broad questions in relation to hydrology and aquatic values would be a first step, before continuing on to more specific questions about 'downstream' values (e.g., fisheries, water supplies, etc).

Impacts = overall thought to be low as a direct result of the fire and fire-fighting activities. However, further exploration of potential areas of impact would be useful.

Sediment and Channel Stability

#	Question	Monitoring actions?	Links to Management Action
30	Has the fire resulted in areas with a significant potential for waterborne surface erosion?	How much of the fire area has moderate or high surface erosion potential? How much of that area was significantly impacted by the fire (i.e., loss of surface	Seeding of ground cover. If necessary, installation of erosion control structures to control rilling

#	Question	Monitoring actions?	Links to Management Action
		organic layers)? Initial action could be based on GIS/ airphoto interpretation, followed by field surveys.	(bio-engineering?)
31	Has the fire resulted in areas with a significant potential for landslide initiation?	How much of the fire area has moderate or high landslide potential? How much of that area was significantly impacted by the fire (i.e., increased soil moisture/seepage and/or loss of stabilizing tree roots)? Initial action could be based on GIS/ airphoto interpretation, followed by field surveys.	Re-vegetation and/or reforestation of key landslide initiation zones.
32	Have the fire-fighting actions resulted in potential sediment sources (waterborne surface erosion and/or landsliding)?	Assessments of fire roads, fire guards and heli-pads for sediment source areas or potential landslide initiation areas. Initial action could be based on review of existing construction and rehabilitation reports and airphoto interpretation, followed by aerial and/or ground surveys.	Seeding of ground cover. If necessary, installation of erosion control structures to control rilling and/or reduce landslide potential (bio-engineering?)
33	Are there areas where fire impacts have the potential to affect stream channel stability (mainly due to loss of trees in riparian areas – e.g., rooting on streambanks and long-term loss of large woody debris)?	How much riparian habitat was impacted by the fire? Are the impacted areas located along stream channel reaches with potential channel stability issues? Initial action could be based on GIS/ airphoto interpretation, followed by field surveys.	If necessary, installation and/or removal of in-channel structures to increase channel stability (bio-engineering – large woody debris manipulation?) Reforestation of riparian areas.
34	Is there likely to be increased sedimentation to streams and other aquatic ecosystems?	Ground and/or aerial surveys of sediment source areas to determine whether sediment is being delivered to aquatic features. Initial action could be based on GIS/ airphoto interpretation, but will also likely require ground surveys. Sediment monitoring of streams.	If necessary, installation of erosion control structures to control and/or mitigate sediment delivery (bio-engineering?) - and treatment of sediment sources as indicated above.

Flow Regimes – Watershed Cover

#	Question	Monitoring actions?	Links to Management Action
35	Has the fire changed forest cover sufficiently that it will likely result in detectable changes in stream flow?	Initial action could be based on GIS/ airphoto / remote sensing interpretation to determine changes in ECA. This could be followed by further work tracking forest succession and hydrologic recovery.	Reforestation of areas that contribute to reducing peak flows.

#	Question	Monitoring actions?	Links to Management Action
		Stream flow monitoring.	
36	How effective was seeding in dealing with erosion control. Seeding was used only locally on trails / roads/ landings. But broad effectiveness in these ecosystems could be assessed.		May link to future decisions to use similar types of seeding, or to use seeding more broadly if required to stabilise areas that are severely burned.
37	Are there areas within the burn that would benefit from some form of restoration / erosion control? Are those areas linked to high values (fisheries/ water sources?)	From results of above 23,24,25 are there areas that would require some restoration actions.	May identify potential areas of concern for restoration action.

Social Values

Nelson water supply

The 2003 fire likely had short-term immediate impacts on water quality directly after first rains, and data are unavailable to determine whether there were any significant long-term impacts. However, if events occurred which resulted in significant changes to hydrology there could potentially be longer term impacts on quantity, quality or timing of flows. All of which could impact consumption values for the City of Nelson.

However, the amount of area burned in Five Mile and its location is such that we would expect no short or long term detectable changes (G. Utzig pers. comm.).

#	Question	Monitoring actions?	Links to Management Action
38	Was short-term water quality impacted by the fire (direct / indirect impacts?)	Short-term impacts of the fire may have occurred during the first rains following the fire. No monitoring would detect any effects today.	NA
39	Is long-term water quality potentially impacted by the fire?	No detailed long-term monitoring is ongoing for the City of Nelson, so baseline data are lacking.	Parks could potentially collaborate with the City of Nelson (and possibly Harrop, who do have baseline data collection). However, this is likely to be outside the mandate of parks and would most appropriately be initiated by the external group (e.g., City of Nelson). Some monitoring has already occurred undertaken by a private landowner (on Strickland Creek) – where local needs arise a collaborative effort between MoF, MWLAP is likely most appropriate.
40	Are there potential future impacts associated with failures in current infrastructure?	Identify potential hydrologic failure areas, associated with water supply for Nelson, Harrop, private land, or general water resources along West Arm. This question takes a broader view of the same issue as #39	There appears to be little need for this at this time, due to relatively low impact of Kutetl fire on relevant areas.

Recreational Values

Recreational values were impacted by the fire, likely both positively and negatively. The actual fire area likely has lower recreational values in the short-term. However, recreational values may be increased if access is promoted by fire access routes (note potential conflict with maintaining other values such as caribou habitat and grizzly bear habitat in good condition).

#	Question	Monitoring actions?	Potential Restoration or Management Action
41	Have access opportunities increased as a result of the fire? Link to Caribou #1, 7, 25, 26, 27; GB #28; recreation #11. Not directly relevant to natural disturbance monitoring, but very important to values within the park, and particularly linked to potential changes in both mountain caribou and grizzly bear habitat as a result of the fire.	Monitor recreational trails and numbers of visitors.	Potential need to close some areas due to conflict with limited areas of caribou habitat. Increase in food supply for grizzly bears may result in need for access management from safety perspective.

Recommended Restoration and Monitoring – summary

The following questions have been identified as priorities from the preceding lists, based on the level of the value impacted, the perceived level of impact and the cost to address the question.

#	Question	Rationale
20	Has disturbance due to fire-fighting actions resulted in movement of invasive species into area?	Value = high Impact = potentially high Cost = medium
25	What are the impacts of the Kutetl fire on caribou habitat? How do effects vary with fire severity?	Value = high Impact = high Cost = medium
26	Was lichen availability impacted by the fire?	Value = high Impact = potentially high Cost = medium
30	Has the fire resulted in areas with a significant potential for waterborne surface erosion?	Value = high Impact = potentially high Cost = low / medium
31	Has the fire resulted in areas with a significant potential for landslide initiation?	
32	Have the fire-fighting actions resulted in potential sediment sources (waterborne surface erosion and/or landsliding)?	
33	Are there areas where fire impacts have the potential to affect stream channel stability (mainly due to loss of trees in riparian areas – e.g., rooting on streambanks and long-term loss of large woody debris)?	
34	Is there likely to be increased sedimentation to streams and other aquatic ecosystems? Undertake initial GIS work to determine potential.	

Workplans for the questions above are outlined in Appendix 1. In some cases (# 25, 26) the workplan was combined with the previous set of broader questions dealing with future natural disturbance management. The workplan for questions 30, 31, 32, 33 and 34 is more generalised, because a wide variety of questions could be asked using this technique, and the specifics will depend on funding availability.

Section 4: Detailed Recommendations

Monitoring for Natural Disturbance Management

In order to make decisions regarding natural disturbance management within parks, an assessment of values in relation to the broader ecosystem context is required. Such analysis allows an understanding of whether a 'protection against disturbance' strategy or whether allowing natural disturbance processes to continue is most appropriate. In this project, the values provided by West Park are summarised and assessed in relation to the broader ecosystem context.

From an ecological perspective, Mountain Caribou habitat within the park is an outstanding value that should be maintained as a first priority of the park, due to the international significance of the herd, the declining population status, the irreplaceability of the habitat (at least in the short-term) and the threats acting on caribou habitat outside the Protected Area. A significant area of caribou habitat was burned in the 2003 Kutetl fire and efforts to protect remaining habitat should be paramount. The current remaining locations and quality of caribou habitat within the park is unknown, and our primary recommendation is that a detailed assessment and mapping of remaining habitat is undertaken. With this information at land, future management decisions can take into account this habitat in a spatially-explicit fashion. Relevant disturbances include fires, forest health disturbances (direct impact from spruce bark beetles, and potential losses from fire associated with mountain pine beetle), and potential impacts from recreation activities.

We reviewed the major forest health agents found within West Arm Park. There is significant beetle activity within the park, particularly of Mountain Pine Beetle and Spruce Bark Beetle within susceptible stands. However, there is no evidence to suggest that this activity is non-natural (except perhaps within the context of climate change). Management of forest health agents is therefore unnecessary from an ecological perspective. However, the linkages between mountain pine beetle and fire probability are largely unknown, though the potential for increased fire severity in heavily impacted high density pine stands is likely. Although we do not recommend any short-term beetle management we do suggest finalising the mountain pine beetle susceptibility mapping. This is a relatively small project, based on existing inventory, and will provide important background to assess future threats to caribou habitat within the park. In addition, expert opinion identifies that management actions will not influence beetle abundance and distribution in surrounding areas because the level of pine beetle infestation throughout the larger area is extensive. Beetle management to maintain external timber values is therefore not recommended as a productive strategy within the Park.

Spruce bark beetle is a forest health agent that has the potential to negatively impact high value mountain caribou habitat directly. We recommend undertaking susceptibility mapping for this species, to understand potential threats.

From a social perspective the West Arm Park provides significant water resources to adjacent rural areas and the City of Nelson. These values are potentially threatened by natural disturbances, particularly fire, if a significant fire and / or fire-fighting activity occurred in the relevant drainages. Efforts to maintain natural forest cover in these drainages would be appropriate at least in the short-term. The potential contradiction between suppression of fires in the park leading to higher long-term fire risk is a concern in these ecosystems, but less so than in drier ecosystem types that burn more frequently, and is also reduced because of the north-facing aspects of most of these watersheds.

Expert opinion (Don Mortimer, pers. comm.) has concluded that the primary threat of fire in this local area comes from the surrounding rural and urban settings. Although Parks is clearly not responsible for managing this potential threat from outside the Park, a collaborative approach to management of the threat could be a useful Park role. We do not recommend that Parks undertake any monitoring programs in relation to water quality because a) they are not responsible for the quality of the resource and b) because gathering adequate baseline data would be a costly process with little benefit gained by the park itself.

Many other values were identified in West Arm Park, but most were not considered to be 'irreplaceable'. That is, for most other values, although future disturbances may locally impact the

value, this likely would not offset the value of allowing natural disturbance processes to continue unabated.

In Summary

Natural disturbances with the potential to impact Mountain Caribou habitat should be controlled where feasible. To understand the potential impacts of management decisions on caribou, the extent and quality of remaining habitat should be assessed and mapped.

Although largely not a direct threat to caribou habitat, the predicted extensive impact of mountain pine beetle on stands in the park may result in higher probability of fire in future. This cycle is likely within the range of natural variability, however fire also has the potential to significantly impact caribou habitat in future. We do not recommend direct action on mountain pine beetle stands, because this will likely not reduce the spread of this species either within or outside of the Park. However, we do recommend that existing data are used to map susceptibility of the park to MPB. Having this information to hand will aid future management action in relation to fire threats.

Spruce bark beetle does have the potential to impact caribou habitat in future. We recommend using existing data to map spruce beetle susceptibility, which may be useful in future to inform management actions.

Monitoring and Activities for Restoration in Relation to the Kutetl Fire

The Kutetl fire burned approximately 8000ha within the Park boundaries in 2003. There is no evidence to suggest that the fire was a 'non-natural' event, or that is was exacerbated by unnatural conditions (except perhaps climate change). As a result, general restoration of the broad fire area is not necessary or appropriate using an ecological rationale. Fairly extensive fire-fighting activities were undertaken as a result of the fire, but based on existing information, these infrastructure (road/ trails/ helipads) created to fight the fire appear to have been appropriately rehabilitated immediately after the fire, and additional work appears unnecessary at this time.

However, soil disturbance and vegetation clearing associated with infrastructure has resulted in the potential for increased movement of invasive species into the park boundaries. We recommend initiating a monitoring program for invasive plant species in relation to constructed roads, trails and landings. Wilderness values of the park increase the priority to prevent invasion by non-native species.

The cutting and leaving of wood adjacent to the trails and helipads also has the potential to exacerbate forest health issues. We recommend an immediate removal / treatment of any spruce that was cut adjacent to infrastructures. Spruce is of particular issue because spruce bark beetle has the potential to negatively impact caribou habitat over the long-term. Spruce beetle may fly annually or every two years, so an immediate removal of this potential substrate should be an immediate priority in the park.

A project to map burn severity in the park has been undertaken (Utzig 2005). This mapping exercise provides a unique opportunity to use GIS to undertake a series of exploratory analyses to summarise the effects of the fire on different ecological values. We identify a number of values that could be explored using this new overlay.

In addition, we identified a suite of other potential inventory or monitoring projects for the West Arm Park that would provide information on the effects of the Kutetl fire. These additional projects focus either on more generalised research into fire effects on ecosystems, or on lower priority values. If additional funding were available, these monitoring projects could provide useful information that would expand our knowledge on fire and ecosystems in general, or on specific values impacted within the park.

In Summary:

Activities associated with fire-fighting appear to have been mitigated immediately, and to a high standard. With a limited budget, we do not recommend on-going monitoring in relation to these potential threats.

Removal of any remaining fallen spruce adjacent to infrastructure is an immediate restoration need.

A monitoring program to collect baseline data on invasive species movement into the park will provide key baseline information to support appropriate invasive species management if necessary in future. Soil disturbance associated with fire-fighting infrastructure development, coupled with the fire itself likely results in high potential for the establishment of invasives. Early detection and intervention of invasive species may be crucial to prevent extensive invasion of the park.

A project to map burn severity in the park has been undertaken. This mapping exercise provides a unique opportunity to relatively easily explore the potential impacts of the fire on ecological functioning. A number of examples are presented in the recommendations.

Additional Monitoring and Actions

Recreation

Recreation activities were not a primary focus of this contract, however they were mentioned in the original request for proposals, in relation to potential impacts of the fire on recreational activities within the park. Recreation is a key value provided by West Arm Park, and primary recreation values appear not to have been impacted by the Kutetl fire. However recreation also has the potential to be in conflict with some other key values of the park, in particular caribou and grizzly bear habitat suitability, and potentially also water values. We raise this issue in particular because there may be an interaction between the impacts of the fire directly on those values, and recreation that is relevant to future management of the park. In particular, because an extensive area of caribou habitat has already been lost within the park, ensuring that remaining areas fulfill their potential to provide undisturbed caribou habitat is paramount. The extent of recreation use within the park is largely undocumented, and we would recommend that baseline data be gathered to understand recreational use, particularly mountain biking and back-country skiing. This information would provide important baseline data to support future management decisions in relation to caribou habitat and to managing recreation activities.

In Summary:

Recreational use of the park is currently relatively limited, but use has the potential to grow significantly over time. We recommend initiating an on-going long-term monitoring program to understand the number, distribution and seasonal variability in recreational use of the park.

This information will provide important background information to guide recreation management strategies in future. It will also provide important contextual information for understanding any current potential conflicts between remaining caribou habitat and recreation use (summer and winter).

Management of Interface Fire Threat and Hazard

Park managers are committed to engaging stakeholders in constructive dialogue on issues affecting fire management in wilderness areas. Park managers and stakeholders are specifically concerned with the following interface fire management issues:

- the risk of fire ignitions that endanger the wilderness value of the Park, and
- the risk of fire ignitions within the Park that may endanger interface values such as the City of Nelson and its water supply, resort areas (Whitewater) and adjacent rural and forest land (Harrop / Proctor, Darkwoods, etc.).

Mortimer (2001) outlined the threats and potential actions arising in relation to fire hazard in the urban/ rural interface of West Arm Park as part of a previous contract.. His report provides an overview of threats, fire conditions and potential prescriptions for different zones within the affected area. In this contract, we further clarify this issue and summarise the findings below:

Threats

In a summary of the threats, a number of different fire ignition hazards were identified. The highest ignition threat comes from within rural or urban property where the density of people and use is greatest. An unknown level of threat is found in West Arm Park, particularly in areas with relatively high recreational use. Finally, there is the risk of naturally ignited fires (from lightning strikes) occurring anywhere within the park and surrounding private or crown forests. When considering these different ignition sources under the prevailing weather conditions, Mortimer (2001) concludes that by far the greatest threat to the City of Nelson, surrounding rural areas, and the West Arm Park itself is for a fire to be ignited close to a dwelling, and then to spread rapidly to surrounding dwellings and into the adjacent forestland and Park.

Interface Fire Hazard Assessment and Mitigation

Dealing with these shared concerns requires implementation of interface fire protection initiatives that include:

Priority 1: Adopt FireSmart hazard reduction programs for interface values at risk.

Where high and extreme levels of fire hazard are assessed, hazard mitigation complying with FireSmart recommended guidelines should be implemented within 100 m of structural values that one is aiming to protect. Interfaces that have been managed using FireSmart principles are substantially less vulnerable to disastrous impacts from wildfire events and fire managers working adjacent to FireSmart interface areas can select suppression strategies that strive for attainment of overall fire management objectives as a priority, rather than solely being focused on value at risk protection.

Priority 2: Assessment of interface and urban areas for ignition risk stemming from long range spotting out of unmanaged fuel complexes within the Park.

Where reduction of fire hazard to urban values at risk from the long range spotting fire ignition process is required, landscape level hazard mitigation (fuel reduction treatments) are implemented within a strategically located zone up to 2 kilometres from the wildland urban interface boundary. This is a secondary priority – further reducing hazard to urban values at risk. Establish a series of fuel treatment units along the park interface with external values at risk. The purpose of these 'boundary units' is to assist with fire containment, providing fire managers with varying levels of confidence that fires burning within the boundary unit perimeter will not breach that perimeter under certain conditions. Wilderness land management is closely linked with fire as an ecological process and a wider range of natural and prescribed fire options can be explored where parks fire managers have planned containment and response strategies.

In Summary:

The primary fire risk stems from outside the Park boundaries. Park managers are therefore not responsible for or able to manage for this threat. However, park managers should continue functioning on regional interface steering teams and strive to implement or cooperate with FireSmart hazard reduction initiatives in areas within or adjacent Park jurisdiction.

In the longer term, once the FireSmart program has at least been partially undertaken in high hazard areas, park managers should consult with fire behaviour specialists to assess long-range spotting ignition risk to interface and urban values. Where the risk is significant, landscape level hazard reduction fuel treatments (featuring application of mechanical or prescribed fire treatments) may be appropriate over a longer timeframe.

Recommendation: Parks managers should develop a strategic plan incorporating proposed fuel treatment units with an implementation strategy linked with a pre-determined response strategy that ensures fire ignitions occurring within the fuel treatment units are subject to a full or modified suppression response in accordance with fire management objectives. Fuel reduction treatments proposed would be subject to an environmental assessment and stakeholder review process.

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Appendix 1: Workplans for immediate monitoring

Workplan #1: Mountain Caribou Habitat

1: Identify locations of remaining old forest within the park.

7: What areas of caribou habitat remain in the park?

25: What are the impacts of the Kutetl fire on caribou habitat?; How do effects vary with fire severity?

26: Was lichen availability impacted by the fire?

Overview: Understanding the value of remaining old growth forests for caribou habitat is a critical information gap for Parks managers. We recommend a workplan that focuses on identifying remaining old growth stands, and secondarily identifying their value as caribou habitat. This approach will allow an understanding of both current habitat suitability for caribou, and recovery potential (or capability). A two-pronged approach that combines air-photo interpretation with fieldwork is recommended.

Approach

The old-growthness and caribou habitat value of a particular stand will depend on two factors: a) the value of the stand prior to the fire and b) the burn severity within that stand.

This workplan involves a number of steps:

1. Use the GIS overlay of burn severities, in combination with best available forest cover mapping and airphotos to predict remaining old growth within the park, in different burn severity classes.
2. Use expert opinion (no habitat suitability models appear to be available for the South Selkirks) to predict areas that provide caribou habitat in different suitability classes. An option is to use the methodology provided by Kinley and Utzig (2001). This 'potential' map can then be ground truthed.
3. Ground sample across a subset of these sites to determine a) remaining structural attributes (i.e. 'old-growthness') and b) to identify caribou suitability (see below for detail).
4. Overlay new ground-truthed map with existing access points, recreation areas etc., to understand potential conflicts.
5. Overlay new ground-truthed map with susceptibility mapping (MPB and SBB) to understand potential threats from these sources.

Defining Old-Growth Forests

Old-growth can be described using a number of different approaches, and over the last 10 years various 'indices' of old-growthness have been developed which have categorised the types and abundances of different structural attributes found in old forests of different ages (e.g., Holt et al. 1999; Holt and Mackillop 2000). In this project, we are interested in whether sufficient attributes remain in the stand to classify it as old-growth after the burn has gone through the site. For this task, we recommend using the scorecards developed for local ecosystems (ICHmw2, ESSFwm), as a way to categorise the 'old-growthness' of the stand. These scorecards identify a range of attributes that classify old-growthness and could be used to rank stands in terms of their remaining attributes.

Caribou Habitat

Defining the suitability of any stand as mountain caribou habitat is a complex process because caribou use depends on attributes at multiple scales and across multiple seasons. Attributes relevant to the stand itself and attributes acting at small, medium and larger landscape level scales all can influence habitat use by caribou (Apps et al. 2000). A complex habitat suitability index is unavailable for caribou habitat in the Southern Selkirks (L. DeGroot, pers. comm), and we will therefore have to rely on expert opinion to identify suitable habitat at the stand level (see below).

Wildlife habitat ratings for mountain caribou are outlined in RISC (1999), but the provincial ratings are thought to provide a poor fit for caribou habitat in the Southern Selkirks (L. DeGroot, pers. comm.). A local habitat suitability index model for this area has not been built, and habitat suitability ratings for the Central Selkirks and further north are likely not suitable here either.

Broadly, stands provide caribou habitat values if they are old growth, or have old growth stand structures, if they provide food supplies (primarily lichen for winter habitat, and falsebox in other seasons), if they provide thermal cover, if they have moderate slopes or less, and if they provide a relatively open stand that allows good visibility. These attributes, combined with the old-growth index ratings will be used to identify the areas of highest, moderate and low suitable caribou habitat remaining. In addition, we will also look for evidence that stand structures may remain, but that caribou habitat values may have diminished as a result of burning of lichen in intermediately burnt areas. If this was the case, habitat recovery may be faster in these stands due to re-inocculation by lichen (either naturally, or through restoration).

Field Methods

- Line transects through stands
- Locate random plots and use 25m radius plot to measure
  - All OG attributes on scorecards (density large trees, snags, age of trees, age of oldest tree etc).
  - Additional attributes linked to caribou habitat quality (lichen loadings – Stevenson and Armleder 1998; slope, understory food potential, density of tall shrub cover as index of sightings).

Survey Effort

Habitat values will be measured in a range of sites and used to extrapolate to the broader area, using the burn severity map and original forest cover data. Determining how many stands can be sampled will be a combination of funds available, and amount of potential area that may be oldgrowth and caribou habitat (the greater the survey effort, the more accurate the final map product). A review of the fire severity map will provide some insight into this, once it is available. T

Project Deliverables

Deliverables should include:

- A map that shows remaining old growth forest, identified by different levels of burn severity
- A report that summarises how burn severity links to a) remaining old growth attributes (i.e. old-growthness of the stand) and b) remaining caribou habitat quality.
- A map that shows the projected values of all stands based on field samples.

Projected Costs

Task	Item	Days
1 and 2	Examination of available photos, burn severity mapping and forest cover to determine potential field sampling sites.	4d
3	Field based truthing of maps – collecting information on old growth values and caribou habitat values. Accuracy of the final map will depend on the number of days. Difficult to predict until potential sampling sites are known. Estimate includes report write-up.	10d
4 and 5	Create final map based on field verification, and overlay with other values (recreation trails / pine, etc.) to understand potential future threats	3 – 5d

Total		17d

References

Apps, C.D., B.N.McLellan, J.Flaa. 1999. Multivariate habitat modeling for Mountain Caribou in the Columbia Mountains, British Columbia. In L.M.Darling (Ed). Proceedings of a Conference on the Biology and Management of Species and Ecosystems at Risk, Kamloops BC.

Kinley, T. and G. Utzig. 2001. Proposed habitat management guidelines and habitat distribution for Mountain Caribou of the South Purcell Subpopulation. Prepared for LUCO, Province of BC, Victoria BC.

Holt, R.F. and D.J. Mackillop. 2000. An index of old-growthness for the ESSFwm: Nelson Forest Region. Prepared for the Inter-agency Management Committee.

Holt, R.F, T. Braumandl and D.J. MacKillop. 1999. An index of old-growthness for the ICHdw and ICHmw2: Nelson Forest Region. Prepared for the Inter-agency Management Committee.

S.K. Stevenson, A.N. Lance, and H.M. Armleder. 1998. Estimating the Abundance of Arboreal Forage Lichens: User's Guide - A Guide for Users of Estimating the Abundance of Arboreal Forage Lichens, Land Management Handbook Field Guide Insert 7. Land Management Handbook 43. Available at: http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh43.htm

Workplan #2: Mountain Pine Beetle and Spruce Bark Beetle Susceptibility Mapping

2: What is the predicted susceptibility of stands in the park to Mountain Pine Beetle and Spruce Bark Beetle?

Overview: This project uses existing information to provide Parks with susceptibility mapping for the West Arm Park. Although we are not suggesting that parks pursue any options for managing either Mountain Pine Beetle or Spruce Bark Beetle at this time, this information may prove useful for understanding potential fire risk, or direct impacts on caribou habitat in future.

In addition, this project uses existing information and, in collaboration with Ministry of Forests, should allow this information to become available to Parks at no expense.

UPDATE: As this information was being finalised, we determined that in fact the Ministry of Forests has already mapped Mountain Pine Beetle hazard ratings for West Arm Park (Genevieve Lachance pers. comm.)). This was finalised from data in 2002 prior to the Kutetl fire. In order to update this map, a copy should be overlain with burn severity mapping to understand current hazard.

Approach

Susceptibility mapping would utilize the stand susceptibility for mountain pine beetle developed for the entire Nelson Forest Region in 2002. The latter is based on the Shore Safranyik Susceptibility and Risk Rating System (Duthie-Holt. 2003, Shore *et al*. 1992). The Susceptibility mapping would provide assistance in reviewing the predicted magnitude of pine mortality due to the mountain pine beetle outbreak. The extent of the potential mortality could be linked to fire risk and fire interface for the area.

In addition, a similar model is available for Spruce Bark Beetle, and similarly understanding hazard in relation to this species may provide important management information regarding mountain caribou habitat.

Methods

Susceptibility Mapping (MPB Example):

The pine susceptibility index equation below would be applied to existing data on forest cover to identify susceptibility of different stands within the park

Susceptibility (= Hazard): The inherent characteristics of a stand that affect its likelihood of attack and damage.

Beetle Pressure: The magnitude of a beetle population affecting a stand as determined by the number and proximity of infested trees.

Stand Risk: The short term expectation of tree mortality in a stand as a result of a bark beetle infestation.

Pine Susceptibility: The inherent characteristics of the pine component of a stand that affect its likelihood of attack and damage.

Pine Susceptibility Index (PSI) = 100.0/(1+EXP(-(P-22.7)/5.3)) x A x L x D

Where:

EXP = base of natural logarithms; P = Percentage of Susceptible Pine Basal Area; A = Age Factor; L = Location Factor; D = Density Factor; SSI = Stand Susceptibility Index (all of the above are defined in Shore and Safranyik 1992*).*

Updating Existing Mapping:

As outlined above, existing suitability mapping has been prepared through Ministry of Forests, but was created just prior to the 2003 fire. Overlaying the map with the burn severity map should be undertaken to update the map on forest cover remaining post-fire. This would be a simple GIS exercise.

Susceptibility Mapping (Spruce Bark Beetle):

High hazard stands have

- An average spruce diameter of 41cm DBH;
- Spruce volume exceeding 300m^3/ha;
- More than 65% spruce in well-drained creek bottoms.

In general, the order of hazard for spruce is:

- Stands in creek bottoms;
- Better stands of spruce on benches, slopes and high ridges;
- Poorer stands of spruce on benches, slopes and high ridges;
- Mixtures of spruce and lodgepole pine;
- Stands containing all immature spruce.

In the Forest Practices Code Bark Beetle Management Guidebook (http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/beetle/betletoc.htm) a ratings table is provided to help map susceptible stands using the following attributes:

Stand Hazard Rating = Sum of (BGC zone + site quality + % spruce + stand age + dbh)

Deliverable:

For MPB: Updated hazard map for West Arm Park that can be used to direct future natural disturbance management within the Park.

For Spruce Bark Beetle: A hazard map that can be used to assess potential future conflicts between remaining caribou habitat and areas of spruce. Ground-truthing may then be required to determine whether any management action is either necessary or feasible.

Projected Costs

We recommend that Parks collaborate with MoF to overlay map with burn severity mapping to provide a final map of remaining hazard within the park and adjacent forests. This would potentially provide management direction in future in the event of future natural disturbances (fire).

Workplan #3: Recreation Trends

11. Quantify the extent of recreational use of the park, by season and area.

Overview: This project is designed to provide Parks managers with an understanding of the scope and extent of recreational use in West Arm wilderness park. Recreational use is likely an expanding value within the park, and there are potential links to the value of habitat for disturbance intolerant species (caribou and grizzly bear in particular), invasive species, and potential for fire hazard within the broader interface zone. Two key types of recreational activities currently occurring in the West Arm Park include mountain biking and back-country ski touring. Each will require a different type of approach to provide baseline information on use.

Methods

Backcountry skiing: Two areas are of particular interest in relation to back-country skiing: a) Hummingbird Pass area which is accessed primarily from a parking lot along the Whitewater Road and b) Five Mile Basin and surrounding bowls which are accessed primarily from Whitewater Ski Hill itself.

Undertaking a preliminary inventory of the use of Hummingbird Pass can involve systematic surveys of the numbers of cars parked at the parking lot throughout the late fall, winter and spring months. This will provide only an index of use because a portion of these cars belong to people skiing on the 'backside' of Whitewater Ski Hill. A sign-up sheet at this location would provide a better indication on the level and specific areas of use, and could also provide a safety function.

Inventory of the use of Five-Mile Basin and environs could involve a sign-up sheet provided at the top of the Whitewater Silver King Chair (a sign-up board soliciting party/route information for safety purposes is currently posted within the Whitewater Ski Hill lodge, but a more visible location may be advantageous). These two pieces of information would provide a relative index of recreational use trends over time.

Collaboration: We suggest a collaboration with Whitewater Ski Hill staff to undertake 'counts' of cars on Whitewater road over time. These could be corroborated with the sign-in sheet for Hummingbird Pass Area to determine the reliability of each method.

Mountain Biking: The major mountain biking areas in the park are accessed from Svoboda Road above Nelson. Preliminary discussions with the bike community suggest relatively low use of these areas at this time, because it is necessary for bikers to ride a reasonable distance uphill to access the downhill trails (see attached map on page 22).

We suggest installation of a 'trip' counter just inside the park boundary to monitor bikers accessing the area. A 'time/ date' counter would be most useful because larger groups tend to access this area rather than single riders (D. Mackillop pers. comm.) Pat Wray, pers. comm..). Understanding when and how many people access the area at a time would be an important component of the monitoring.

Deliverables:

- Summary of the extent of use (number of people per day / week / month) and trends over time (years).
- Time of use (seasonal trends)
- Areas of Use (for backcountry skiing).

Workplan # 4: Invasive Species

20: Has disturbance due to fire-fighting actions resulted in movement of invasive species into area?

Overview: This project is intended to provide Parks managers with site-specific information relating to the occurrence of invasive species along access roads, trails and landings used or created to fight the Kutetl fire. The CPR line corridor within the park should be included in this assessment since it is an obvious vector for invasive species and a benchmark should be established for future comparisons. The inventory will lead to an ability to identify key species of concern, and implement relevant control strategies for these species in timely fashion.

In addition, researchers undertaking other monitoring / inventory work within the broader regions of the park should be requested to report any sightings of invasive species to parks staff, who could maintain a database of such sightings over time.

Methods: (based on an earlier workplan by Val Miller)

To optimize efficiency and accuracy of results, invasive species assessments must be timed to match each target species' bud to early bloom phenological stage. For the species most likely present in, or adjacent to West Arm Provincial Park (see Cranston et al. 2005), the assessment window is late May to mid-July, extending to late July at higher elevations. The methodology to complete the work should follow inventory protocols for invasive species using the single species approach. All roads, trails, landings, and areas adjacent to the CPR line should be carefully inspected by walking a systematic grid pattern and/or linear transect. When invasive species populations are identified, information on UTMs, slope, aspect, elevation, vegetation cover type, species, density, infestation size (m^2), average height of plants and phenological stage, and type of weed distribution should be recorded on standardized data sheets.

This information is required to assist in determining the best control strategy for the invasive species of concern.

When weed assessments are completed, a management and control strategy can be developed to address key areas. The specific control measure employed is determined based on each species population, distribution, mode of spread, likelihood of success, and suitability to the site. While some of this work can be accomplished concurrently with the population assessment, other work may require a two-phase approach. All control efforts will require an annual commitment for monitoring efficacy of treatments, and additional control activity. Adjacent land owners, particularly CPR and Darkwoods, should be encouraged to assist in implementing IAP management and control strategies. The requirement for long-term resource commitment to optimize treatment efficacy may be problematic.

In key areas of the park where invasive species are clearly a concern, it may be advisable to establish, and photo-monitor permanent photo-points to track the changes in invasive species abundance and cover over time, as control strategies are implemented. Protocols for establishing and monitoring permanent photo-points are described in Ministry of Forests (www.for.gov.bc.ca/hfp/range/manual) and Hall (2001). Photo-monitoring will also provide site-specific resources to promote public awareness and education in relation to this wilderness park.

Deliverables

- Brief report and database summarising invasive weed occurrence and distribution (by species) within selected areas of the park
- Control strategy and recommendations for areas of concern
- Implementation of control activities within key areas of concern

Potential Costs

Assessment and strategy development - $15,000 – $20,000 (depending on accessibility of the site).

Control activity - $5000 - $10,000 (depending on the extent of problem at sites assessed).

References

Cranston, R., D. Ralph, and B. Wikeem. 2005. Field guide to noxious and other selected weeds of British Columbia. Fifth Edition. BC Ministry of Agriculture, Food and Fisheries and BC Ministry of Forests.

Hall, F.C. 2001. Ground-based photographic monitoring. USDA Forest Serv. Gen. Tech. Rep. PNW-GTR-503, Pacific Northwest Research Station, Portland, OR. 340pp.

Workplan # 5: GIS analysis for selected impacts of fire

This workplan is suggested to take advantage of the Fire Severity Mapping completed by G. Utzig (2005). The Fire Severity map provides the basis for a wide variety of projects by providing a stratification tool for further work. In this workplan, we suggest some of the kinds of projects that could be undertaken based on the fire severity mapping. The questions identified below were identified in the report, although most did not appear to be high priority from the preliminary assessments we made. However, the kind of analysis suggested here would provide a more firm assessment of the potential for additional effects from the fire.

Example questions:

30: Has the fire resulted in areas with a significant potential for waterborne surface erosion?

31: Has the fire resulted in areas with a significant potential for landslide initiation?

32: Have the fire-fighting actions resulted in potential sediment sources (waterborne surface erosion and/or landsliding)?

33: Are there areas where fire impacts have the potential to affect stream channel stability (mainly due to loss of trees in riparian areas – e.g. rooting on streambanks and long-term loss of large woody debris)?

34: Is there likely to be increased sedimentation to streams and other aquatic ecosystems?

Overview: This project would utilise the newly available fire severity mapping to get a more detailed perspective on what some of the ecological impacts of the 2003 Kutetl fire may have been. A very large number of potential questions can be answered by using the severity mapping to overlay with different ecological components. This will provide guidance as to whether there may be additional impacts of the fire on different ecological components, and secondly, whether there is any additional need to undertake management actions in relation to the impacts. In addition, these projects can provide background information on general impacts of fire.

Approach

The project is primarily designed to take advantage of existing mapping held by MoF (most of which was in place prior to the designation of the park), such as terrain stability mapping (level D) and erosion mapping. For the riparian questions, new GIS maps would be created for this purpose. Each of the value maps would be overlain with the burn severity mapping to determine the extent of potential impacts. A specialist would be required to interpret the potential for damage or impacts of burn severity on the value in question, and may require additional photo-interpretation in some cases.

General Methods

E.G. 33: Are there areas where fire impacts have the potential to affect stream channel stability (mainly due to loss of trees in riparian areas – e.g. rooting on streambanks and long-term loss of large woody debris)?

A number of steps would be required to undertake this project:

1. Identify riparian habitat using airphoto interpretation, or a fixed buffer width on mapped streams.
2. Overlay with fire severity mapping and quantify extent of impact in different riparian zones.
3. Use the ground-truthing from the fire severity mapping to understand the implications of each burn severity category on loss of vegetation structure from riparian areas.
4. Use expert opinion to summarise potential impacts of such losses to instream and downstream values.

Costs

Costs would vary by the specific question, and the ease with which the base map could be generated or acquired from MoF. However, expected costs range between 3 – 10 days per question.

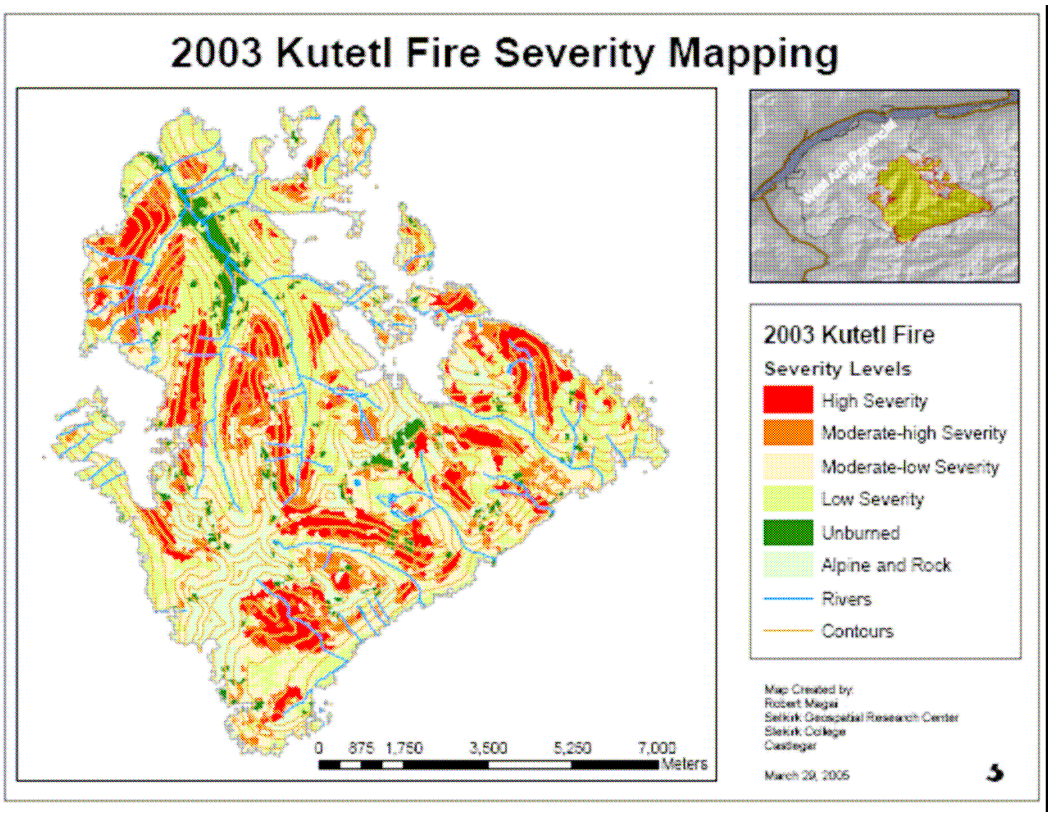

Figure 1. Preliminary Fire Severity Map (produced by G. Utzig).

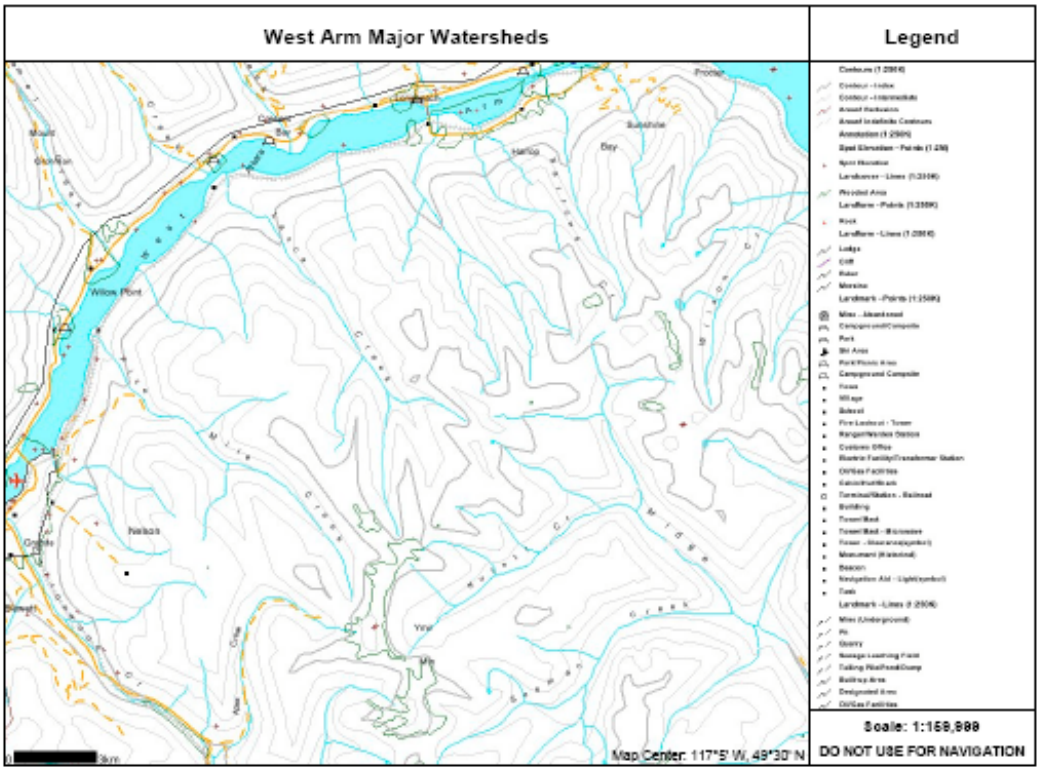

Figure 2. Major drainages of West Arm Provincial Park. Boundaries are not shown on this map, but the park consists of Five-mile, Lasca and Kutetl Creek major drainages.

Figure 3. Map of fire showing infrastructure and approximate final burn area (from MoF).

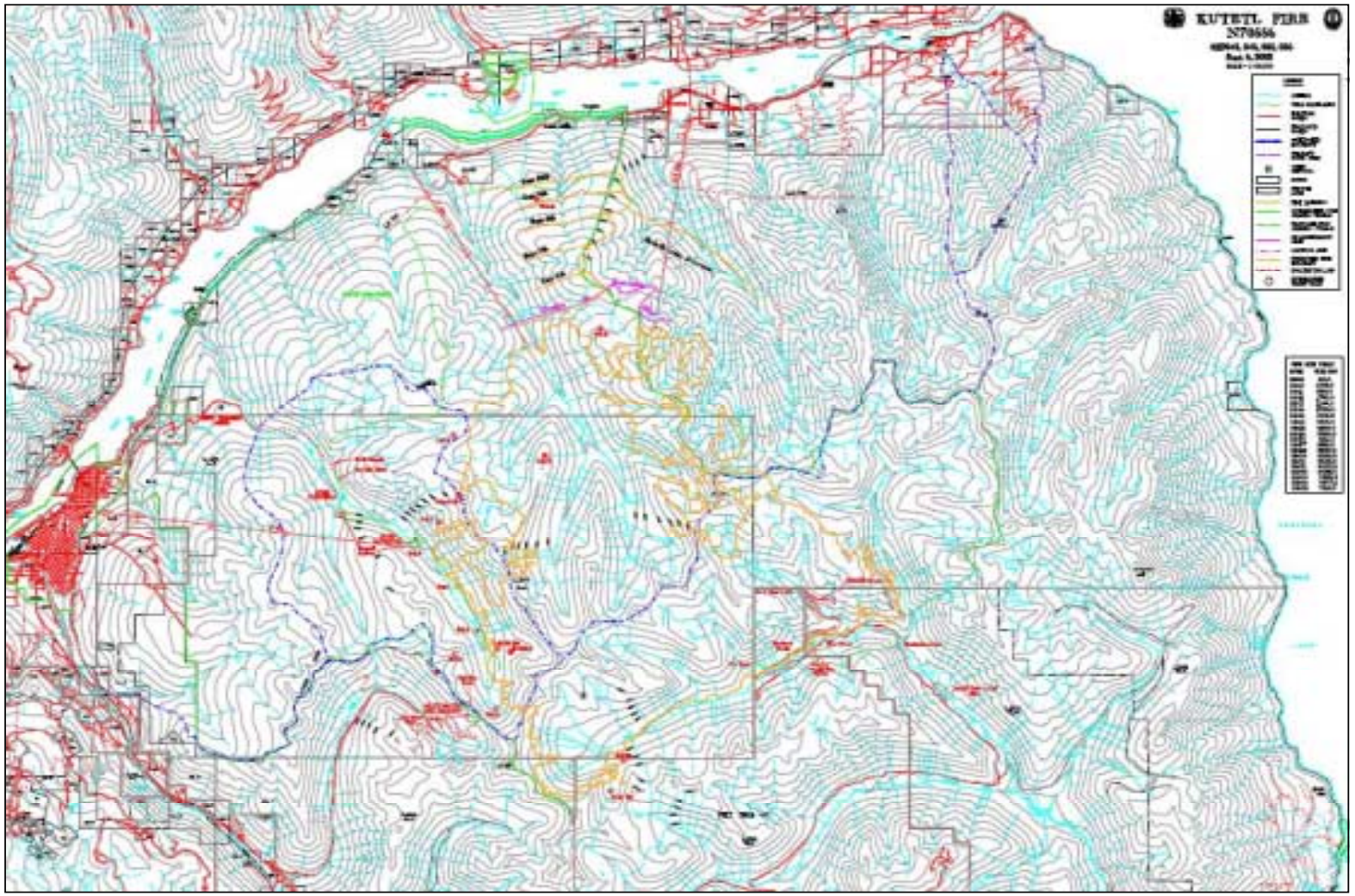

Figure 4. Mountain Pine Beetle incidence in BC based on spot data collected during aerial overview surveys (BC Ministry of Forests 2004).

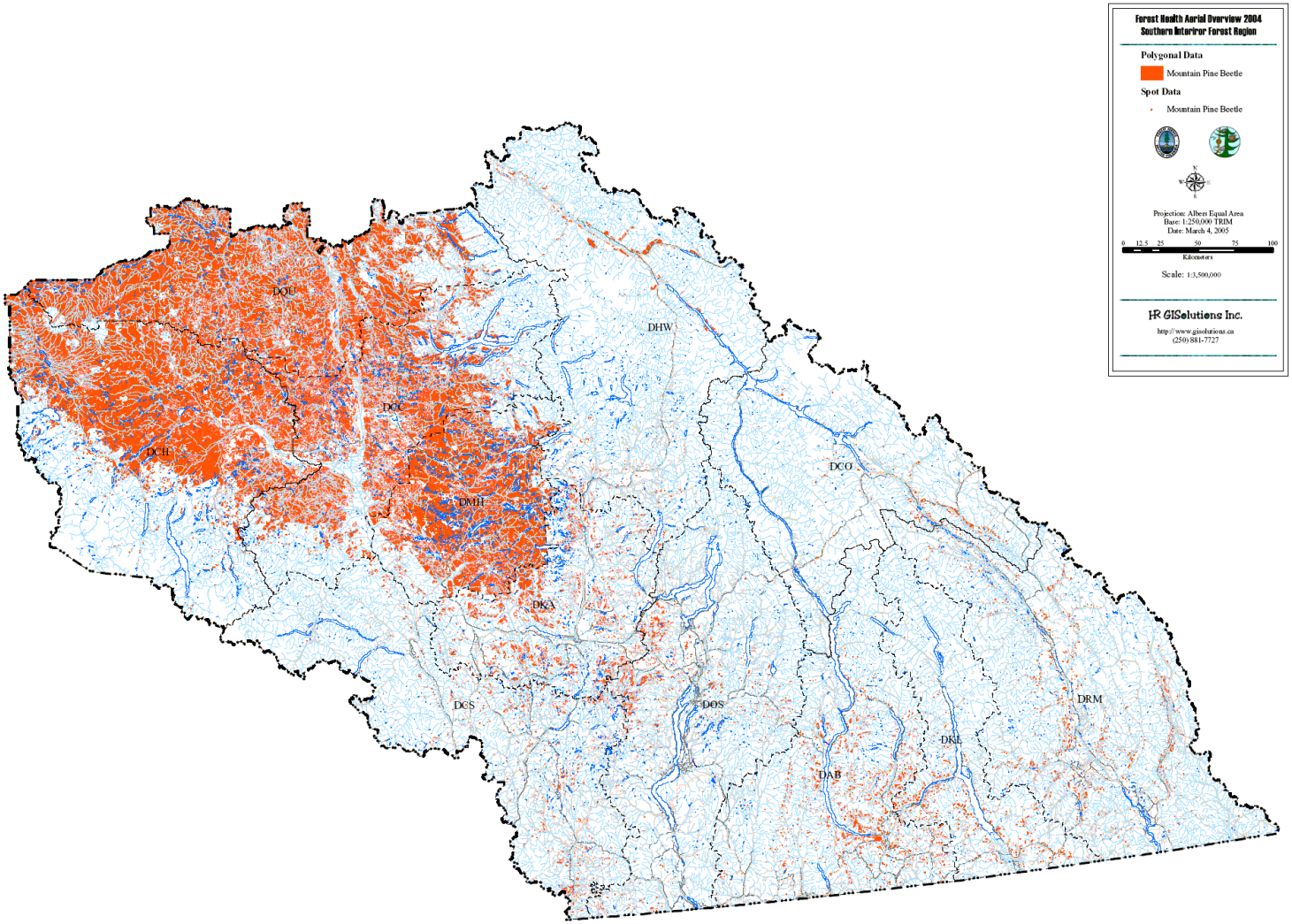

Figure 5. Telemetry locations and recovery area for South Selkirk Caribou (data supplied by L. DeGroot).

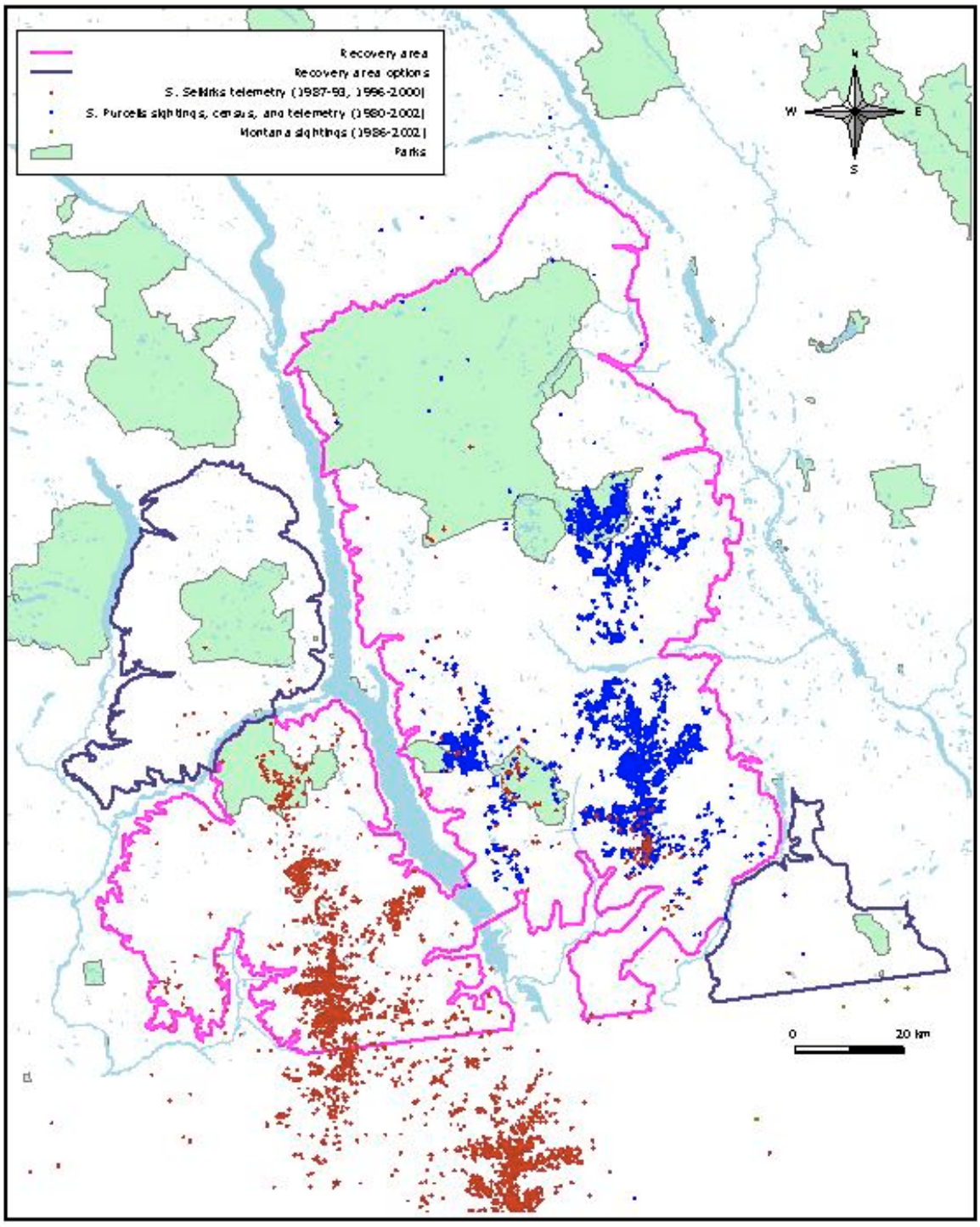

Figure 6. Availability of suitable habitat for the South Selkirk Caribou herd before and after the Kutetl fire (provided by John Krebs, CBFWCP with data from Tim Layser, US Forest Service).