Assessing Impacts on Ktunaxa Nation Cultural Resources from Ecological Restoration Timber Thinning and Prescribed Burning in the Rocky Mountain Trench, Southeastern British Columbia

By

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Bachelor of Environmental Studies, University of Waterloo 1979

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Abstract

Timber harvest and prescribed burning in the Rocky Mountain Trench in southeastern British Columbia are part of long-term ecological restoration in the forest and grassland ecosystems of the region. Conducted in the traditional territory of the Ktunaxa Nation, this restoration work has the potential to impact Ktunaxa precontact archaeological sites around kettle lakes in the Trench. The focus of this research project is the integration of cultural information into ecosystem restoration decision-making processes. Detailed inventory of archaeological sites was completed using standard archaeological site inventory procedures; this inventory information served as the baseline data prior to monitoring of timber harvest activities around the cultural sites, carried out under prescribed winter conditions of frozen ground and snow cover. Surface soil disturbance surveys were completed around the sites following the timber harvest activities, to assess impacts to Ktunaxa archaeological sites. Management recommendations are advanced pertaining to reduction of impacts of timber harvest equipment and prescribed fire on cultural sites. These include timber harvest only under prescribed winter conditions, use of low impact harvest equipment, exclusion of equipment from ecologically and culturally sensitive sites, and training of field staff in identification and protection of cultural sites. Ktunaxa Nation natural resources staff must be involved in all aspects of ecological restoration planning – including initial archaeological impact assessments, determining what restoration activities take place around cultural sites, monitoring of timber thinning and prescribed burning processes and post-harvest and post-fire impact assessments – to fully protect cultural resource values. Ecological restoration activities will be complemented by the successful integration of Ktunaxa cultural information and values into restoration practices.

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CHAPTER ONE

Introduction

1.1 The Context for Ecological Restoration Research

> Modern forest restoration continues a long pattern of human environmental manipulation. Although restoration, as practiced today, focuses primarily on enhancing 'natural ' ecosystem processes, it can also simultaneously benefit and enhance cultural resources. Restoration plans that specifically integrate cultural concerns and objectives in their design demonstrate a concern with maintaining ecosystems in their broadest sense.
>
> - Fairley 2003. *Ecological Restoration of Southwestern Ponderosa Pine Forests*, Chap. 22, pg. 393.

Ecological restoration, as described by the Society for Ecological Restoration International, is "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability". Ecological restoration is defined as " the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER 2004).

In the setting of this research – the dry interior forests and grasslands of southeastern British Columbia – the natural ecosystem has become degraded through a number of key human activities. Fire was a natural recurring phenomenon in these forested ecosystems (Walstad *et.al.* 1990), the most prevalent major disturbance process on the landscape prior to European settlement (Gruell 1983). Lightning-caused fires were typically middle-to-late summer events, and aboriginal-caused fires were deliberately set in the spring and fall (Barrett and Arno 1982). These fires maintained a relatively open forest structure with an abundant understory of grass species.

Settlement by Europeans brought about cultural changes that reduced the incidence and size of wildfires. The breaking up of fuel continuity by livestock grazing and cultivation, coupled with fire suppression and elimination of aboriginal burning were major factors (Gruell 1983). Active fire suppression beginning in the 1930's was designed to protect the forest for timber companies and the grasslands for ranchers (Smith 2000), resulting in few stand-maintaining fires and a changed forest ecosystem and grassland structure. Many small diameter shade-tolerant species now cover the forest floor and many sun-tolerant species have invaded open grasslands.

Restoration of these forests focuses on reintroducing fires and re-establishing natural ecosystem patterns, processes and structures (Friederici 2003). Hand-in-hand with ecological restoration should be a process of cultural restoration – the concomitant recovery of indigenous management practices, including support for the cultural survival of indigenous peoples and their traditional ecological knowledge. Truly successful ecological restoration would see these cultural practices and ecological processes as mutually reinforcing (SER 2004, Higgs 2003).

Why should cultural history and practice matter to ecological restorationists? One of the primary tasks of ecological restoration is to gain an understanding of past conditions on the landscape (ie.) a reference ecosystem, in order to re-establish the historical processes and components needed to repair damaged or degraded ecosystems (Wagner *et.al.* 2000). Knowledge of past cultural history, practices and their impacts on the landscape is critical to understanding reference ecosystems and their historical range of variation (Egan and Howell 2001). Involvement of restorationists in discovery of the past will serve several key purposes:

- Help locate the restorationist in the 'complementary opposition' of culture and nature;
- Provide a deeper sense of personal, professional and bioregional identity; and,
- Serve as a guide for present and future action (Egan and Howell 2001).

The historical interrelationships between humans and their environment can be read in the landscape in a number of ways, and are encapsulated in the study of historical ecology - the study of past ecosystems by charting the changes in landscape over time (Crumley 1994). Archaeologists, who employ both the natural and physical sciences (biology, geology, chemistry) and the humanities (history, linguistics, philosophy) in their studies, are especially well suited to undertake this type of work and to contribute to long-term ecological restoration research. Archaeology offers the spatial and temporal breadth required for long-term ecological analysis (Crumley 1994). Hence the integration of archaeological and cultural information into ecological restoration will enhance this already multi-disciplinary practice.

Archaeological sites and historic structures are threatened by many of the same forces affecting natural ecosystems – high intensity wildfires, long-term climate change, erosion and deposition processes, and infrequent weather events. But they are equally threatened by resource extraction and resource management practices carried out in the name of ecological restoration. These practices can include:

- Prescribed thinning activities, such as operating heavy machinery, skidding logs, piling slash, and building of roads and log landings;
- Prescribed fires and fire-control measures, such as digging fire lines, clearing staging areas, burn mop-up, rehabilitating burn areas and burning slash piles;
- Research activities such as digging soil test pits, fencing, establishing test plots, and installing monitoring equipment; and
- Removal of invasive species through tilling or replanting, scarification of soils and mechanical site preparation (Fairley 2003).

Each of these activities has the potential to disturb the surface and subsurface soil horizons and damage cultural resource sites and values. Unlike animal habitat, fisheries, timber or water quality values, archaeological sites are finite, non-renewable resources that cannot be restored - nor can damage to them be repaired (Foster 2002). These sites include prehistoric aboriginal village and campsites, petroglyphs, pictographs, midden deposits, human burials, caves, hunting blinds, bedrock acorn milling stations, and other types of features. It is very difficult to quantify the value of archaeological and cultural sites; investigation of these sites is the primary source of information about the peoples who occupied the Pacific Northwest for the past 12,000 years (Foster 1995).

The impacts of ecological restoration work on cultural sites, values and resources have been scarcely investigated in the Province of British Columbia. It is incumbent on resource managers to recognize cultural resource sites and values as part of current ecological restoration practices. This purpose of this thesis is to investigate the potential for integration of cultural resource information of the Ktunaxa Nation of southeastern British Columbia into ecological restoration work (prescribed timber thinning and prescribed burning) being carried out in the Rocky Mountain Trench.

1.2 The Cultural Setting of Research

The Ktunaxa Nation is a culturally and linguistically unique tribal group that have lived in their traditional territory of the East and West Kootenays, southern Alberta and northern Montana and Idaho for an unknown period of time in the post-glacial period (Smith 1984). The center of their land occupancy is the Kootenay River drainage in the Rocky Mountain Trench (**Figure 1**). The Upper Ktunaxa sub-group of the larger Nation inhabited the Trench from Tobacco Plains in the south to Golden in the north, as well as the Rockies and eastern Purcell Mountains. They followed a nomadic seasonal subsistence pattern based on natural resources as distinct as the buffalo herds on the Great Plains near the eastern slopes of the Rockies, and the salmon runs up the Columbia River to its headwaters in the Trench. Many of the food plants and roots that sustained the Ktunaxa peoples are concentrated in the grasslands and adjacent mountains of the Trench too. The major ethnographic works completed on the Ktunaxa people were by Schaeffer (1940) and Turney-High (1941); Smith (1984) produced the most recent synthesis of cultural information.

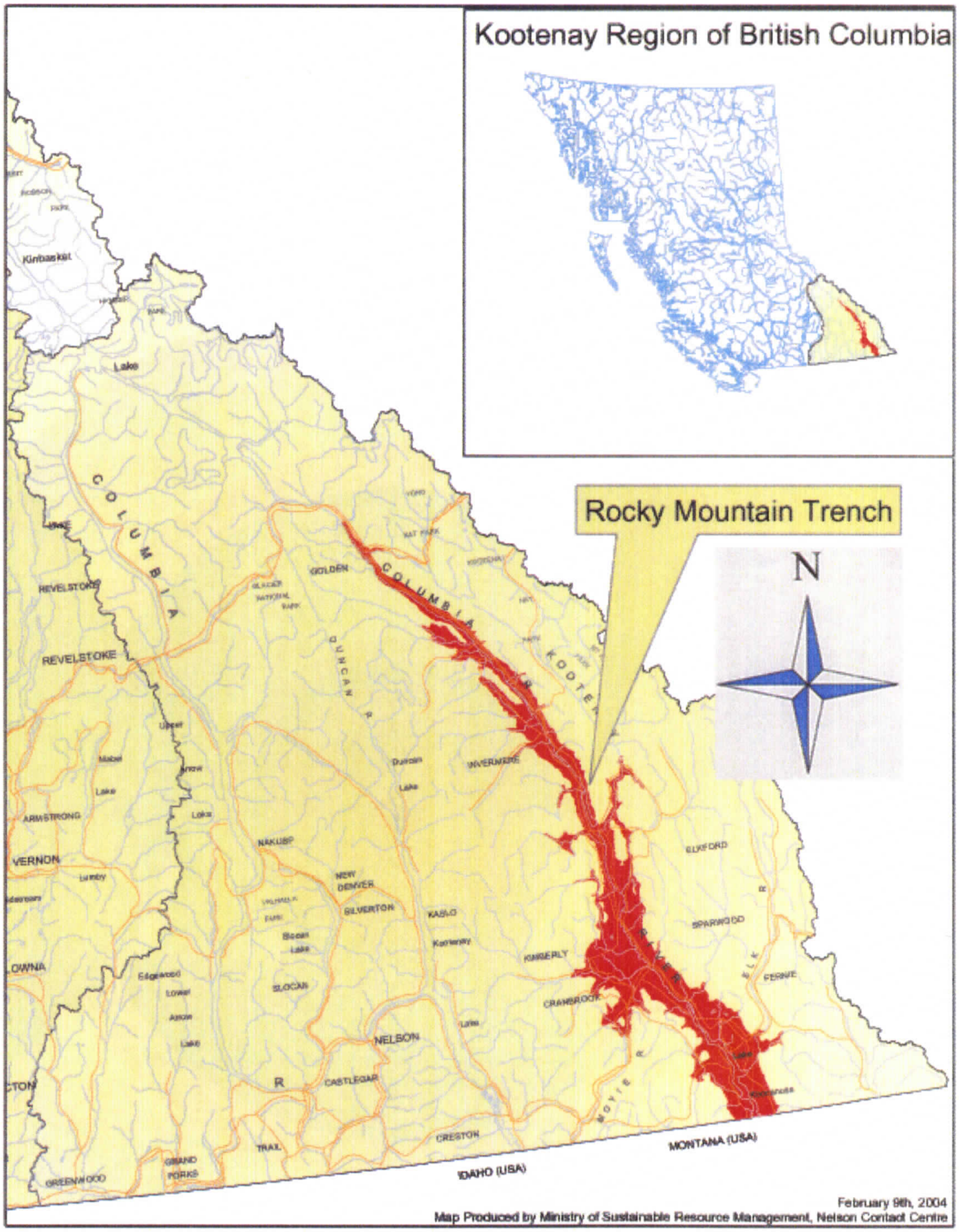

Figure 1: Rocky Mountain Trench in British Columbia (Scale – 1:2,000,000)

The location and scheduling of abundance and ripening of a broad range of animal and plant resources determined the Upper Ktunaxa seasonal subsistence pattern.

Large ungulates, particularly deer and elk, were hunted singly with bows and traps and in communal hunts, mostly in spring and fall. From late spring through early fall, other small game, fish, waterfowl and plant foods such as bitterroot (*Lewisia rediviva*) and berries were acquired by different family task groups. Cooking by stone boiling was the preferred method for preparing food for immediate consumption, except for roots and berries such as camas (*Camassia spp.*) and bitterroot, which were baked in earth ovens (Choquette 1999).

Around 4000-5000 years ago, the climate of the East Kootenays became notably cooler (Hebda 1995), and the higher mountain orientation of the Upper Ktunaxa people gave way to a more intensive focus on the resources of the valley bottom of the Trench. Rivers, ponds and sloughs would have increased in size, and evidence from archaeological sites dating between 5000 and 2500 B.P. indicates that fishing, plant gathering and taking of waterfowl became more important. The shores of the numerous small kettle lakes that dot the floor of the Rocky Mountain Trench became typical locations for campsites (Choquette 1999).

Choquette (1975) has named this cultural association with the landscape the 'Kettle Lake Complex'. Numerous archaeological artifacts occur around many of the small lakes in the Trench north and south of Cranbrook (Munson 2004). Patterns of lithic material associated with these campsites and their use between 5000 and 2500 B.P. show a preference for microcrystalline tourmalinite (having a crystalline structure visible only under a microscope); the quarry source(s) for this tourmalinite have never been positively identified locally (W. Choquette, *pers.comm.*, 2006) Deer bone is a characteristic constituent of faunal assemblages and fire-broken rock is much more common than previously found, often occurring in concentrations.

During the last 2500 years, there was a significant shift in the type of lithic material used, toward cryptocrystalline stone (having a crystalline structure too fine to be seen even under a microscope) from two local sources: Top-of-the-World quarry in the nearby Canadian Rockies and the Madison formation in northwestern Montana. Both of these quarries contain cryptocrystalline chert (Wood *et.al.* 2002a, Kooyman 2000). Lithic material of high quality, such as Top-of-the-World chert, became part of Interior Columbia Plateau intra-tribal trade and exchange for stone tool manufacturing (Richards and Rousseau 1987). Artifacts from my research sites are mainly of the earlier period of 5000-2500 years ago, and are made from tourmalinite and not chert; the former lithic material is harder than chert and more resistant to heat (Choquette, *pers.comm.*, 2006)

During the last 2500 years, some significant but gradual shifts in Upper Ktunaxa settlement pattern, subsistence base, tool technology and lithic material use are apparent. In the southern Rocky Mountain Trench, these changes were associated with increased exploitation of grazing ungulates: deer continued to be important, but herd grazers such as elk, sheep and bison increase in the bone samples of the past two millennia. The more-or-less continuous utilization of the upper Columbia Valley by hunting groups from early post-glacial time onward likely reflects the pre-contact heritage of the present day Ktunaxa Nation people (Choquette 1999).

With stone quarry sources of argillite, tourmalinite, chert and quartzite in their traditional territory, the Ktunaxa developed a high level of stone tool workmanship (Munson 2002). Remains from these quarries - the lithic artifacts and tools themselves - are now the basis of extensive archaeological study in relation to movement of the Ktunaxa people and their archaeological material throughout the traditional territory. Archaeologist Wayne Choquette has worked with the Ktunaxa and their cultural resources for over 30 years, including the first recording of archaeological sites in the study area (Choquette 1971, 1975); he developed a system of Archaeological Potential Modeling (APM), which is used to predict the likely location of Ktunaxa archaeological sites, sites facing potential damage during development activities (Choquette 1999).

There are a number of key physical site attributes that are used in the archaeological potential mapping process. These include landforms, soils, sediment type, paleo-hydrology, and occurrence of previously recorded sites, solar aspect, natural resource availability, elevation, and proximity to water bodies among others. These landscape attributes or archaeological predictors are mapped from air photo analysis, ranked into areas of High, Medium, Low and Unknown Archaeological Potential, and then digitized onto maps using GIS technology. The mapping results are selectively ground-truthed to determine the accuracy of the predictive model in locating archaeological sites (Choquette 1999).

The main application of APM has been the determination of the locations to conduct Archaeological Impact Assessments (AIA's) in areas of the traditional territory slated for timber harvest, mining development, or highway and subdivision projects. The information generated by archaeologists through AIA's is used to provide developers with recommendations on how and where to proceed with resource extraction activities in relation to areas of cultural or archaeological concerns. AIA results can also contribute to testing the accuracy of the site model. The Rocky Mountain Forest District (RMFD) in Cranbrook has concentrated efforts to map their District - which falls mainly in the Rocky Mountain Trench and the southern Purcell Mountains - using the Archaeological Potential Mapping at a Landscape Unit level.

1.3 Ecological Restoration Activities in the Rocky Mountain Trench

The RMFD is actively involved in another current resource management initiative in the same areas of High Archaeological Potential (HAP) - grassland and open forest ecological restoration in the Rocky Mountain Trench. The Trench has historically been an ecosystem with open grasslands and scattered stands of Ponderosa Pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*), an ecosystem characterized by frequent stand-maintaining fires every 15-20 years (Braumandl and Curran 1992). Over 250,000 ha. of the Trench are in the NDT4 ecological zone (Natural Disturbance Type), which require these fires to remove small conifer ingrowth, rejuvenate grassland species, and keep the open grassland structure. Since the 1930's, fire protection crews have attacked and suppressed wildfires with the intention of protecting trees for the timber mills, and protecting valley homes and properties. The result has been a major change in forest and vegetation structure in the Trench ecosystem. Conifers have grown into forest stands and encroached onto grasslands at a rate of 3,000 ha. per year. Taylor *et.al.* (1998) examined changes in forest cover over 40-year period (1952-1992) in the TaTa Creek watershed, which contains the westerly research sites in my study area. Using historical and contemporary air photo analysis, they found a 50% reduction in grassland and open forest crown closure classes over the past 40 years, while the area of closed and dense forest classes doubled in size. The result has been a reduction in grassland value as ungulate habitat, an increase in the risk of major wildfires due to fuel buildup, and production of poor quality timber with limited growth potential in choked stands of small diameter trees.

Interagency plans are now being implemented to actively restore the historic open forest and open grassland ecosystem structure, through timber thinning and prescribed burning of ingrown forest stands. These treatments are followed by longer term Stand Management Plans and Silviculture Prescriptions, which emphasize return of grassland species and more open grown conifers. Both the ungulates and forest companies are anticipated to benefit from this ecological restoration activity. The restoration of Trench grasslands also has important implications in ethnobotany – in the restoration of plant species used by the Ktunaxa peoples for sustenance, such as bitterroot (*Lewisia rediviva*), and desert parsley (*Lomatium macrocarpum*). Grassland restoration should aid in rejuvenating growth of these important fire-dependent species.

Timber harvest and prescribed burning activities are barely able to keep up with the current rates of forest ingrowth and grassland conifer encroachment on thousands of hectares of NDT4 lands requiring restoration each year (Taylor *et.al.* 1998). RMFD is pursuing prescribed thinning and burning projects in areas along the Premier Ridge and around the kettle lakes in the Trench (**Figure 3** below), areas of exceptional ungulate winter range, which have been ranked as having High Archaeological Potential and known high archaeological site densities (Choquette 1999). Preliminary multi-attribute evaluation of landscape-level fuel management to reduce wildfire risk has been completed for the Premier-Diorite forest management landscape unit (Ohlson *et.al.* in press), the results of which support this proactive ecological restoration work. The challenge undertaken in this research is to protect the cultural resources and heritage of the Ktunaxa people, while at the same time meeting the forest, range and ecological restoration management goals of the respective stakeholders.

1.4 Description of the Study Area

The project area is located in the Rocky Mountain Trench, south of Premier Lake and north and west of the Village of Wasa Lake in the Kootenay Region of southeastern British Columbia. The study area falls within the Interior Douglas-fir (**IDFdm2**) biogeoclimatic zone, characterized by hot, very dry summers, and cool winters with light snowfall (Braumandl and Curran 1992). Zonal vegetation consists of predominately Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*) and Ponderosa pine (*Pinus ponderosa*) forests (**Figure 2**), with an understory shrub layer of Rocky Mountain juniper (*Juniperus scopulorum*), soopolallie (*Shepherdia canadensis*), Saskatoon (*Amelanchier alnifolia*) and snowberry (*Symphoricarpos albus*), and pinegrass (*Calamagrostis rubescens*) in the herb layer (Braumandl and Curran 1992, Meidinger and Pojar 1991).

The IDFdm2 climate (Interior Douglas fir Dry-Mild) of the Rocky Mountain Trench is continental in character, with the main controlling factor being the rainshadow created in the lee of topographic barriers (the Coast, Cascade, Columbia mountains) to the Pacific easterly flowing air. Mean annual temperature is 1.6 – 9.5°C. The average temperature is below O°C for 2-5 months of the year, and above 10°C for 3-5 months. Mean annual precipitation ranges from 300 to 750mm; 20-50% of the precipitation falls as snow. The majority of rainfall occurs in the late spring, early summer and late fall periods, and growing season moisture deficits are common (Meidinger and Pojar 1991).

Figure 2: Research Control Site (DlPw-024) and dry kettle lake feature

The Rocky Mountain Trench is a broad flat glacial plain bounded by the Rocky Mountains to the east and the Purcell Mountains to the west (Ryder 1981). Glacial and fluvial deposits cover the floor of the steep-sided, depressional Trench, dissected by glaciofluvial channels and scattered kettle lakes. Much of the Trench floor also contains stratified glaciolacustrine sediments and an extensive glacial outwash plain, known locally as the 'Skookumchuck Prairie', just north of the project area (Choquette 1999, Meidinger and Pojar 1991). Evidence has been noted of at least three major ice advances in the glacial period of the last few million years (Ryder 1981), when large lakes were ponded against the sides of a large trunk glacier that occupied the floor of the Rocky Mountain Trench and the lower slopes of adjacent side valleys. A considerable thickness of stratified silt, sand and gravel was deposited within these glacial lakes, which forms the soils of the project area (Choquette 1999).

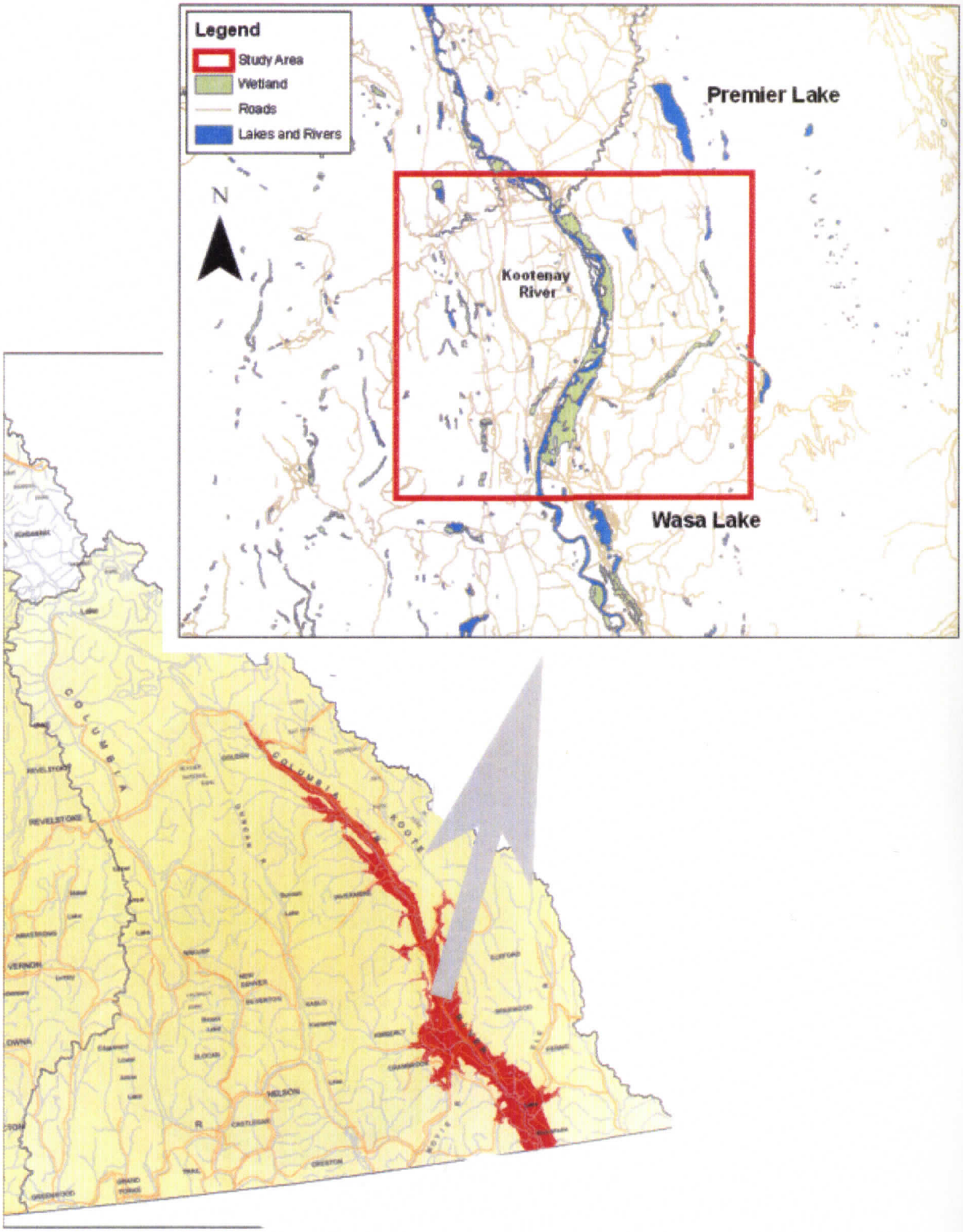

Figure 3: Research Study Area, Rocky Mountain Trench, Southeastern BC (Inset Map derived from TRIM files, scale approximately 1:250,000)

1.5 Project Rationale

One of the biggest threats to the physical integrity of known and unidentified archaeological sites is the damage done to the sites in the wake of fighting wildfires. Wildfires and fire suppression can have a severe impact on a unique resource found on the forest floor – archaeological and historical sites (Foster 1995). The awareness of the importance of protecting archaeological and cultural resources during the suppression of wildfires and during prescribed burning activities has only emerged recently in resource management practices in BC; prior to this research, this awareness was due to efforts by staff at the former Invermere Forest District office in the Ktunaxa Nation territory. Ecological restoration projects involving pre-burn timber treatments and prescribed burning are ongoing in the area around the kettle lakes research sites. The management of forestlands in the East Kootenays in areas of high density of archaeological sites (or areas of HAP) has been problematic for government regulatory agencies, the Ktunaxa Nation and archaeologists. Site avoidance or exclusion of the archaeological site(s) from proposed forestry development by redefinition of block boundaries, or inclusion of sites into wildlife tree patches or riparian zones, have been the preferred management options.

Many of the areas of HAP have been set aside from timber harvest and prescribed burning due to lack of clear management recommendations, leaving them vulnerable to wildfire and fire fighting activities. For example, an archaeological site in the study area was damaged by fire protection activities in 1998 (Choquette, *pers. comm.*, 2000). Again during the summer of 2000, the driest on record since 1985, use of equipment during fire response activities in the Premier Ridge area damaged an archaeological site in an area of HAP. In the heat of fire fighting, the last thing on the mind of machine operators is protecting archaeological sites.

1.6 Project Objectives

This research aims to reduce or eliminate further archaeological site damage by investigating a process of proactive site management, designed to achieve the protection of cultural sites, the reduction of fire hazard and accomplishment of ecological restoration goals. This research focuses on a study of disturbance by timber harvesting and restoration practices on archaeological resources. Results of the study will illuminate the nature of the impacts of harvesting and post-harvesting activities and under what conditions such impacts occur. Originally, the research project had five broad objectives for the Ktunaxa Nation and I:

- **Objective 1: To combine Ktunaxa Nation cultural resource information and scientific silviculture information in an ecological restoration application;**
- **Objective 2: To involve the Ktunaxa Nation in proactive archaeological site management;**
- **Objective 3: To monitor ecological restoration activities (prescribed forest thinning and prescribed burning) to determine their impacts on archaeological sites;**
- **Objective 4: To design a process of proactive archaeological site management procedures to reduce these potential impacts, to be used at the operational level by foresters, contractors and equipment operators;**
- **Objective 5: To assist in Rocky Mountain Trench ecological restoration efforts through interagency cooperation.**

This thesis focuses on **Objectives 3** and **4**, the study of impacts from forest thinning and prescribed burning activities, and development of an archaeological site management system to reduce impacts. This includes an analysis of climate data and climate change impacts, and literature review under **Objective 3**. **Objective 2** will be briefly discussed to set the context for current archaeological site management in British Columbia. However, an in-depth analysis of the current state of archaeological management in BC is not intended. **Objectives 1** and **5** are broader research questions and beyond the specific scope of this thesis, but remain important to the Ktunaxa Nation.

CHAPTER TWO

Impacts of Ecological Restoration Activities on Cultural Resources

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2.1 Formation Processes of the Archaeological Record

Cultural artifacts are objects produced or shaped by human craftsmanship. All artifacts begin as materials procured from the natural environment, which are then modified by additive (mixing of materials) or reduction (breaking down of materials) processes. Archaeologists have long operated under the assumptions that past human activities are reflected in the patterned distribution of artifacts found above or below the ground surface. Of special interest to archaeologists is the systematic (or social / behavioural) context of artifacts recovered from the archaeological (natural environmental) context (Schiffer 1987).

The term 'in-situ' is often used to describe the 'natural or original position' that artifacts are found in when recovered. This original 'find-spot' of an artifact is also referred to as its provenience- the last place of repose of an artifact before being found and returned to its systematic context (Schiffer 1987). However, because cultural and environmental processes move all artifacts around to some degree during their life history, the 'find-spot' of an artifact may not be the original position in which it entered the archaeological context; the likelihood of finding completely undisturbed artifact distributions is slim (Wood and Johnson 1978, Schiffer 1987).

2.2 Natural Disturbance Processes on Cultural Sites

There is a wide range of natural or environmental formation processes that act on both individual artifacts and on archaeological distributions or deposits at an archaeological site. Chemical, physical and biological agents produce different impacts and rates or cycles of deterioration of the original artifacts and/or sites. In the physical soil matrix where artifacts are found, there is a diverse range of soil mixing, or pedoturbation processes, that occur naturally at a cultural site, including the following:

- Faunalturbation (animal burrowing);
- Floralturbation (root growth, tree fall, etc.);
- Cryoturbation (freezing and thawing);
- Graviturbation (mass wasting and soil creep);
- Argilliturbation (soil swelling and shrinking);
- Aeroturbation (gas, air, wind effects);
- Hydroturbation (water effects);
- Crystaloturbation (growth and wasting of salts);
- Seismiturbation (earth movements) (Wood and Johnson 1978, Schiffer 1987).

The most common processes seen at cultural sites in the project area are faunal or burrowing activity, tree fall, root dislodgement, and freeze-thaw disturbances. The net result in terms of impacts to archaeological materials and features are the movement downward of artifacts; concentration of artifacts at depth; re-orientation of artifacts or archaeological features within soil layers; upward thrusting of soil layers; horizontal, vertical displacement and downslope displacement of artifacts (Wood and Johnson 1978). From a research perspective, a spurious artifact assemblage results, and may lead researchers to conclude that vertical movement of artifacts and other debris in their sedimentary matrices after deposition is more common than most archaeologists previously suspected (Gifford-Gonzalez *et.al.* 1985). Most archaeologists now recognize that assessing the influence of various site-formation processes is a prerequisite to inferences about human behaviour from spatial patterning in archaeological materials (Gifford-Gonzalez *et.al.* 1985, Schiffer 1987).

2.3 Human-induced Disturbance Processes on Cultural Sites

The manner is which societies retain artifacts in their systematic context through re-use, and discharge materials into the environment after use, through depositional processes, determines the actual characteristics of the archaeological record. Cultural formation processes include re-use, cultural deposition, reclamation / transformation and disturbance processes of both artifacts and artifact distributions in sites. In prehistoric lithic quarries and stone tool workshop sites, for example, there may be virtually no re-use; lithic flake tools can be manufactured, used and discarded in a matter of minutes! These quarries or workshop sites may actually be secondary refuse sites for discarded artifacts; later, reclamation of artifacts may occur through surface collecting or subsurface 'pot-hunting' of artifacts (Schiffer 1987).

Archaeologists have long recognized that agricultural activities such as plowing disturb the archaeological record of a site (Frink 1984). Research into the field of "plow-zone" archaeology falls into four general areas of inquiry: (1) vertical displacement of artifacts; (2) horizontal displacement of artifacts; (3) plow breaking of artifacts and (4) interpretation of surface collections obtained from plowed fields (Frink 1984).

The same equipment used in agriculture practices can be used in forest restoration processes, for site preparation for replanting of trees (Gallagher 1978, Haase 1983). DeBloois *et.al.* (1974) studied the impacts of chaining used to uproot pinyon-pine-juniper roots in Utah. Flint debitage was 'surface-planted', and caterpillar tractors with chains were the subject equipment; they found that 53% of artifacts near tree roots, 72% of artifacts in caterpillar tracks and 82% of artifacts in the caterpillar turn zone were buried or destroyed following the tree uprooting activity. A sample of 12 depressions caused by tree uprooting had a mean diameter of 11.7m and an average depth of 50cm, for a disturbance volume of 5.85m3. It was estimated that when trees were located less than 15m apart, tree root dislodgement would disturb all areas to a minimum depth of 50cm.

One common forest management site disturbance process is scarification – mixing of the soil surface, which contains conifer seeds, with underlying mineral soil. In a similar manner, a forest soil can be scarified prior to actual tree seedling planting. Gallagher (1978) recreated artifact assemblages in a forest soil setting in southern Idaho and monitored impacts of slash piling and site scarification. Severe to heavy cultural site impacts resulted from this practice if stumps were abundant and slopes were >5%; severe impacts were defined as mixing of soil horizons over a wide area, including vertical and horizontal soil movement to considerable depth. Heavy to moderate cultural site impacts resulted from scarification with few stumps present, and slopes >5%; heavy impacts were defined as mixing of soil strata over a wide area, with vertical movement not greater than 30cm. He concluded that scarification affected cultural resources to a minimum depth of 15cm (Gallagher 1978).

Haase (1983) recommended a series of mitigative steps to minimize chaining impacts to archaeological sites, including pre-work assessment of the site by an interdisciplinary team; complete inventory of site characteristics, including archaeological values; development of an on-site plan to accomplish forest management objectives and protect archaeological resources; marking of boundaries for known archaeological sites; and archaeological on-site monitoring during the scarification process, to ensure protection of marked sites, and cessation of work should new sites be uncovered. The most susceptible sites to disturbance – small and shallow archaeological sites with fragile artifact assemblages – needed be avoided altogether.

In development of the ***Forest Practices Code*** in BC, substantial research went into understanding the impacts of timber harvesting activities on soils, in relation to such issues as soil compaction (Butt and Rollerson 1988; Utzig and Thompson 1992), soil disturbance (Curran and Thompson 1991; Curran 1999) and site degradation (Lewis and Carr 1989). This work culminated in the *Forest Practices Code* Guidebook for Soil Conservation Surveys (Province of British Columbia 2001). The key concerns in all of this research were whether or not the area or site was left in a favourable or unfavourable state for future growing of trees. Although some of the measurements of soil disturbance have applicability to archaeological sites (soil displacement, soil erosion), little work has been done in BC in relation to the integrity and context of archaeological sites as a main criterion for studying soil disturbance.

In the USA, research was done on the impacts of logging around archaeological sites on snow and frozen ground (Philipek 1985). He monitored winter logging with snow cover of 45-60cm, and temperature ranges (night-day) of –6.6°C to 7.2°C. Trees were felled by hand and removed by rubber-tired skidders. On logged research plots, horizontal displacement of artifacts ranged from 2 – 79cm, with a mean lateral movement of 15cm. However, on nearby control sites, artifact movement ranged from 3 – 57cm, with a mean lateral movement of 15.9cm. Factors attributed to this movement on control sites over a season were cattle trampling, frost heave actions, rodent activity, erosion, wildlife grazing and treefall. He recommended a minimum snow cover of 50cm and temperatures below 0°C to ensure minimum artifact disturbance during harvesting.

Several seminal studies have been completed on the direct impacts of tree falling and timber yarding (transport of trees from fall site to landings on skid trails) in the United States. The studies examined alternatives to the "flag and avoid" management practice of setting protective zones around archaeological sites during timber harvest to avoid damage to them. The most well documented study took place in the Eldorado National Forest in California (Jackson 1994), and was summarized in video (USDA-FS/Biosystems Analysis 1994).

Jackson (1994) cites earlier unpublished work from Oregon and Washington. A 1982 study by Bryant (n.d.) measured the effects of different types of log yarding operations on small lithic scatters and on overall archaeological site integrity. Replicate artifacts were placed in the ground on a timber block, and subjected to different timber yarding equipment, on different slopes and soils. Results showed that the greatest damage to artifacts was in high lead logging (where harvested trees are swung through the cutblock on a cable system) with tractor yarding on < 30% slopes; the greatest displacement of artifacts took place due to high lead cable logging on > 30% slopes. Over 10% of artifacts were not recovered after timber harvest, and 20% were displaced to some degree. The author concluded that there is no blanket rule that can be applied regarding acceptability of any particular level of disturbance on cultural sites, because each site is unique in conditions and significance.

Another study from the Six Rivers National Forest in Oregon placed replicate artifacts in a grid pattern (both surface and subsurface) and subjected them to different yarding and skidding practices and timber falling. The results showed minimum artifact breakage or displacement from use of rubber-tired skidders and maximum impact from crawler tractor use (Jackson 1994). This study led to research in the Eldorado National Forest, to assess whether timber harvest impacts could be kept to a minimum level that did not harm archaeological research values on site.

Replicate artifacts were laid out in a grid pattern around trees to be felled, on the surface and up to 10cm below surface, and on skid trails and landings. Jump scars from felled trees hitting the ground ranged in size from 60-90cm, and had an average depth of 20cm. Scars from trunk felling had an average depth of 13cm, and branch penetration ranged up to 60cm. Timber yarding impacts included soil compression, soil churning to 5cm, compaction, and loader pincer penetration into artifact scatters. Helicopter yarding of trees produced lift scars, which averaged 1.98m in length, 1.4m in width and 0.15-0.25m in depth. Displacement of artifacts was greatest when logs were suspended from one end and skidded to the landing: maximum displacement of projectile points horizontally was 7m, and vertically was 10cm; maximum displacement of pestle artefacts was 1.45m, and to a depth of 5cm. Artifact breakage occurred on less than 1% of specimens, with the greatest breakage occurring when the branches of felled trees penetrated the ground surface (Jackson 1994).

In British Columbia, there is no record of use of replicate artifacts to assess the impacts of timber harvest on cultural sites. In the course of archaeological inventory work, most artifacts encountered on the surface or in subsurface testing are collected and sent to the Royal BC Museum as a policy of research protocol (D. Hutchcroft, *pers. comm.*, 2005).

Forestry impact analysis in Alberta and British Columbia by Gibson (2003) has produced a classification system for cultural resource impacts due to different timber harvesting processes. His **Cultural Resource Impact Classification System (CRICS)** for Alberta forestry is based on predicting forestry impacts when:

- The nature, significance and distribution of archaeological resources is known;
- The form of industrial forest activities are identified and characterized; and
- The relationships between forestry activities and archaeological resources are understood.

Site disturbance under the CRICS is defined as the alteration of an archaeological site in **any** manner from its natural state. The CRICS process codifies the potential of site disturbance, and then timber harvest activities can be adjusted according to site and soil conditions to minimize cultural site impacts. Timber harvest impacts are broken into different categories of activities related to: construction of transportation systems for harvest and hauling; timber harvesting; and silviculture practices. Each activity is viewed as resulting in a different range of impacts. The CRICS classification range is as follows:

Table 1: Cultural Resource Impact Classification System (Gibson 2003)

Class	**Name of Class**	**Impact Summary**
0	No Impact	No physical disturbance of either surface organic or subsurface mineral soil (Ah horizon)
1	Incidental Contact	Impact to organic soil, but no disturbance subsurface
2	Incidental Impact	Removal of organic soil, exposure of mineral soil
3	Regular Impact	Exposure and disturbance of mineral layer, movement of artifacts
4	Severe Impact	Removal of organic soil layer, modification of mineral soil layer
5	Total Impact	Removal of part or all of known archaeological site context (organic and mineral soil layers)

Gibson (2003) concludes that the activities related to timber harvesting itself produce the least amount of ground disturbance of the three main activities. Construction of access and transport infrastructure and the loading of wood at landings were the most destructive to archaeological sites. This is an important conclusion for the forest industry, because timber harvesting affects the largest **area** of forest and has the least flexibility for relocation of activities without knowing where heritage resources are located. The CRICS system will be used to closely examine the impacts of both timber harvest and road infrastructure activities on my research sites in **Section 5.3.2**.

2.4 Fire Effects on Cultural Resources

2.4.1 Fire Ecology in Forested Ecosystems

Understanding fire effects on cultural sites and heritage resources involves piecing together a jigsaw puzzle of complexities. It requires knowledge of the dynamics of fire behaviour, soils, vegetation, site formation processes and post-depositional site effects (Timmons, 1996). Wildfire was a natural part of Pacific Northwest and Interior ecosystems before the 20th century. Fires occurring at the hand of humans and from natural processes are a part of the Northern Rockies ecosystem (Barrett and Arno 1982). It is assumed that past historical fires have burned over most prehistoric archaeological sites in forested environments (Jackson 1997).

Over the past century, land use and management practices changed fire regimes, particularly in dry, low-elevation forests that were historically dominated by large, widely spaced Ponderosa pines (Rapp 2002). Modern fire suppression and fire management strategies have had a profound effect on natural fire frequency, fire intensity and the extent of occurrence of wildfires (Walstad *et.al.* 1990, Keane *et.al.* 2002). Now these forests are threatened by high intensity, widespread wildfires that consume most fuels built up following decades of fire suppression activities, instead of low intensity surface fires which have more limited effects on cultural sites and heritage resources.

Information about the effects of fire on cultural resources in Douglas fir/Ponderosa pine forest components is sparse. Fire intensities and the severity of effects depend upon factors such as surface woody and forest floor fuel load, fuel and soil moisture, topography, and weather factors, specifically wind and precipitation (DeBano *et.al.* 1998). Environmental characteristics within different habitats are quite diverse, making it difficult, if not impossible, to apply fire effects information among different ecosystems (Timmons 1996). Nonetheless, current research is starting to provide some understanding of the relationship between fire and archaeology.

Fire effects can vary in their severity (depth of forest floor consumption and heat penetration in the mineral soil), intensity (rate of energy released by the fire front), and their rate of spread (speed of movement of the heading fire). The impact of fire on forest soils (which may contain cultural resources) depends mainly on the depth of forest floor consumed relative to the pre-burn depth; that is influenced by soil bulk density, moisture content at different depths in the forest floor, and the resulting heat penetration. High surface woody fuel load can increase the forest floor consumption by providing downward heat flush to maintain the combustion zone in the organic matter (Hawkes 1993).

Different types of fires will have different effects, which will vary between ground fires (flameless fires which smoulder in surface organic matter and dead and dry roots), surface fires (fires which burn through litter, herb and shrub layers) and crown fires (fires that burn through tree crowns) (Kimmins 1997). Heat is transferred downward into mineral soil during a fire mainly through the process of convection; downward heat movement in the soil raises its temperature (Hartford and Frandsen 1992). Temperatures at the flame front of a fire can reach 1400°C; temperatures at the combustion zone can vary between 1000-1200°C for short periods, while temperatures of glowing burn material at or below the surface can reach 400-760°C (DeBano *et.al.* 1998).

Soil properties themselves change with fire heating: living soil organisms are killed at temperatures as low as 60°C; complete soil dehydration occurs ~ 220°C; soil combustion of organic matter (including organic artifacts) occurs from 220-460°C; soil heating beyond 460°C causes soil structural breakdown and thermal alteration of inorganic material (DeBano *et.al.* 1998). Soil temperatures are difficult to quantify for different fire severities: heating of soils is site-specific, depending on soil texture, depth and soil moisture content. In forest ecosystems, such factors as microrelief, wind speed and direction, soil and fuel moisture content and type, quantity and spatial distribution of fuel load will produce a variable fire severity pattern (DeBano *et.al.* 1998).

Few studies have been carried out during wildfires to determine the temperatures reached at the forest floor, where cultural resources are found. One study during a wildfire at Yosemite National Park found that soil temperatures could exceed 931°C (2001°F) in the upper 8cm of soil during the burn (Jackson 1997). Grassland surface fire temperatures were recorded at 95-720°C, while temperatures reached at depths of 3-4cm were only 50-80°C (DeBano *et.al.* 1998). Studies of soil temperatures during prescribed or controlled burns are more available: a Jack Pine forest prescribed burn in Minnesota reached temperatures at the forest floor and mineral soil interface > 800°C for 1 minute, > 500°C for 9 minutes, and >300°C for 17 minutes. At a depth of 5-8cm below surface, at the organic-mineral interface, the same fire reached temperatures of 300°C for 14 minutes and 50°C for 72 minutes (Ahlgren 1970). Studies in Australia of slash burning showed temperatures of 1000°C at the forest floor and 100°C at a depth of 5-10cm below the forest floor (Humphreys and Lambert 1965). Forest floor surface temperatures reportedly reached 1751°C during controlled burns in forests in Yosemite National Park (Jackson 1997).

Taylor (1995) studied fire behaviour using thermologgers during prescribed burns in the Rocky Mountain Trench north and south of my research sites. At the Findlay Creek burn north of Skookumchuck, maximum above-forest floor surface temperatures reached were 663°C for a brief period; temperatures of 203°C were attained at the forest floor surface. At a prescribed burn at Picture Valley south of Wasa Lake, temperatures of 873°C, 597°C and 360°C were recorded at 5cm above the litter surface, at the litter surface, and at 1cm below the litter surface respectively. Despite high tree stem densities at these sites (6000-10,000 stems/ha), and surface woody fuel load, fire residence times and duration at the litter surface was short, and heat penetration into the mineral soil was shallow.

Hartford and Frandsen (1992) reported maximum temperatures reached at the litter surface, within the duff and at the duff and mineral soil interface, using fires in slash piles in Idaho and Montana. These results show a wide variation of temperatures reached, mainly dependent upon soil moisture content (**Table 2**).

Table 2: Post-burn analysis at Idaho and Montana plots (Hartford and Frandsen 1992)

	Plot 1 (slash fire)	**Plot 2 (slash fire)**	**Plot 3 (surface fire)**
Duff consumed	5cm	5cm	6.5cm
Maximum temp's			
- Litter surface	690°C	460°C	300°C
- Duff layer	625°C	400°C	515°C
- Soil surface	< 80°C	80°C	400°C
Duration of temp's > 100°C in duff	1 hr.	2.5 hrs.	16+ hrs.

In a long-term study of the impacts of fire on Long Mesa in Mesa Verde National Park, Colorado, Eininger (1990) developed a table illustrating temperatures reached at different levels of fire intensity and severity for southwestern Ponderosa pine ecosystems (**Table 3**). The fire temperature range was calculated in earlier fire studies by Chandler *et.al.* 1983).

Table 3: Fire intensity estimates – Mesa Verde National Park (Eininger 1990)

Type of Burn	Temp's at 1-2cm	Temp's at 5cm	Fire temp. Range
Light fire (low intensity)	100°C		100-250°C
Moderate fire intensity	200-300°C	40-50°C	300-400°C
Severe fire (high intensity)	350-450°C	100°C	500-750°C

2.4.2 Fire Effects on Artifacts

What is the impact of such temperatures reached during fires on different types of cultural resources? The damage to artifacts will depend on the type of materials present, their location (surface/subsurface) and the fire intensity, duration and severity (DeBano *et.al.* 1998). The artifacts in question at the Rocky Mountain research sites are mainly made of tourmalinite or cryptocrystalline chert. Laboratory tests on stone artifacts found that the critical threshold temperatures that could produce thermal alteration of chert were in a range from 350- 450°C. In excess of these temperatures, artifacts showed water loss, development of friability, discoloration and change in form (Purdy and Brooks 1971, Mandeville 1973, Crabtree 1975, Purdy 1975, Bleed and Meier 1980, Bennett and Kunzman 1985, Dunnell *et.al.* 1994, Smith 1999, Cooper 2002).

Boras (1991) analyzed the physical effects of heating on tourmalinite samples from three quarries in southeastern BC near the research sites (though of different sources than the materials in these sites). The tourmalinite exhibited no change in lustre or texture, no significant weight loss, and no colour change until temperatures exceeded 600°C. Samples kiln-heated to more than 400°C were easier to flake, but became brittle after reaching temperatures of 800°C. This suggests the possibility of prehistoric heat treatment of tourmalinite being advantageous to Ktunaxa toolmakers, but no evidence of such heat treatment has been found in quarry samples (W. Choquette, *pers.comm.*, 2006).

Long fire durations, smouldering litter and coarse woody debris, and thick forest floor duff layers produce extensive subsurface heating, which can be potentially damaging to surface and subsurface artifacts. Direct fire effects include complete combustion (wood materials), structural changes, melting, spalling and fracturing, changes in chemical composition and physical re-arrangement of materials. Indirect post-fire effects include overland flow and erosion of sites, tree fall, compaction of materials by fire-fighting equipment, looting of exposed artifacts, discoloration by fire retardants and damage by post-fire site rehabilitation (DeBano *et.al.* 1998).

Very few controlled experiments of fire effects on heritage resources have been completed; most studies have been done after the fire burned (Jackson 1997). One of the first studies of this type followed the La Mesa fire of 1977 in Bandelier National Monument, New Mexico. Traylor *et.al.* (1990) studied both direct fire impacts and impacts of fire suppression equipment and methods, and of post-fire rehabilitation. Of 99 cultural sites surveyed for direct fire damage, 58 had burn effects. Estimates of fire temperatures were as follows: for lightly burned areas – temperature range of 100-300°C; for moderately burned areas – temperature range of 300-500°C; and for severely burned areas – temperatures up to 800°C. Areas where tree roots burned in the subsurface could produce temperatures of 1500°C for long periods.

The largest surface impacts were on building stones made from adobe (mud and straw): spalling, fire cracking, color changes and interior deterioration occurred. Post-fire tree fall and soil erosion from precipitation were major sources of damage to cultural resources. As regards artifacts, only surface deposits were affected, with a black sooting and pitch residue appearing from smoke and burning. No visible soil alteration took place below 5cm, and no visible effects were found on subsurface artifacts in terms of colour or structure (Traylor *et.al.* 1990).

Of greater importance were the human impacts of fire suppression and site rehabilitation. Of 100 cultural sites surveyed, 44 exhibited fire suppression damage, with the most common impacts being the actual destruction of architectural structures (pueblo walls, etc.) and displacement and destruction of surface and subsurface artifacts by ground disturbing activities. Construction of catlines and fireguards by bulldozers caused the most damage. Exposure of artifacts by burning of cover vegetation also led to site looting. Post-fire management recommendations included on-site monitoring of heavy equipment activities by archaeologists during the fire suppression and post-fire rehabilitation phases of wildfires (Traylor *et.al.* 1990).

Such management recommendations were in place during the Long Mesa wildfire in 1989 in Mesa Verde National Park, CO. Eininger (1990) reported on the post-fire evaluation of impacts to cultural resources: 188 cultural sites were evaluated – 49 suffered no visible damage, while 139 had fire damage; of these 139 sites, 36 had high damage rating, 32 had moderate damage rating and 71 showed a low damage rating. Temperatures reached during the fire were estimated and are displayed in **Table 3** above. Only two sites were damaged due to fire suppression activities.

Heat impacts on surface lithic artifacts (cherts, claystones) included discoloration due to soot blackening and black residue resulting from burnt pine pitch; there was some evidence of artifact cracking, shattering, and lustre changes, with minor potlidding (breaking off of rounded surface piece). None of the surface alterations by fire were severe enough to interfere with the lithic attribute analysis or functional interpretation, but fire's effects on other diagnostic analysis methods (such as Carbon-14 analysis, thermoluminescence, archaeomagnetic dating, or dendrochronology) varied depending on artifact material and fire intensity effects (Traylor *et.al.* 1990). Post-fire recommendations included careful monitoring of potential site erosion areas.

Berg (2003) summarized post-fire impacts of the 2002 Pines fire in southern California. Of 48 sites examined post-fire by California Department of Forestry archaeologists, 8 suffered fire damage, 16 had impacts from bulldozer construction of fire lines, and 24 escaped with no damage. Damage to lithic artifacts included sooting and discoloration, pot-lidding from excessive fire temperatures, displacement and damage by equipment during fire suppression, post-fire tree fall displacement, and displacement due to later on-site erosion following loss of vegetation.

In post-fire studies of the Henry Fire on Holiday Mesa in New Mexico, Lentz *et.al.* (1996a) found that even under light burning conditions, the integrity of cultural resources within the burn area was significantly altered, and substantial effects were present at moderate and high fire intensities. Analysis of 125 lithic artifacts showed the most common effects to be adhesion of organic deposits, lustre changes and heavy sooting. Thirty four percent of artifacts were affected to some degree by burning: lightly burned sites showed minimal effects unless heavy coarse woody debris (trunks/roots) were present; moderately burned sites had appreciable damage (especially on surface artifacts) and heavily burned sites had severe fire effects on all artifacts. The most intensely charred artifacts were those found under burned trunks or roots, exposed to long-lasting, slow-burning and hot fires. They concluded that subsurface alterations to artifacts could occur under certain conditions, to a depth of at least 20cm. Fuel loading was identified as an important cause of damage to artifacts. (Cartledge 1996, Lentz *et.al.* 1996a, Spoerl 1996). The direct effects of fire on artifact materials are summarized in **Figure 4**, from DeBano *et.al.* (1998).

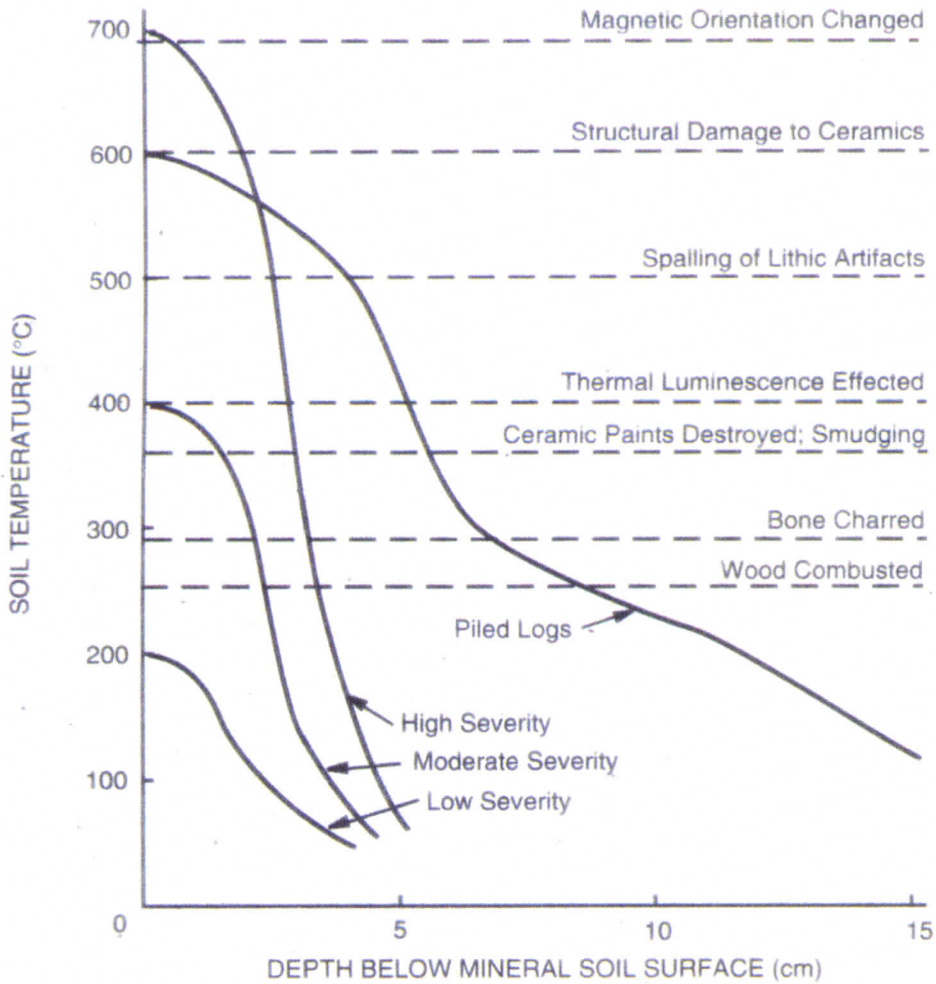


Figure 4: Temperatures, fire severities and soil depths at which archaeological interpretations of buried artifact materials are likely to be damaged (DeBano *et.al.* 1998).

2.5 Summary of Potential Impacts to Cultural Sites

Artifacts and artifact associations at sites all reflect traces of the human and natural activities that transform them over time. These transformations affect the different 'dimensions of variability' of artifacts, which can be used to illustrate or measure the transformation processes themselves. Schiffer (1987) defined these dimensions as:

(i) Formal dimension – measurable physio-chemical qualities such as shape, size, colour, cut, hardness, chemical composition, etc.;

(ii) Spatial dimension - location of an artifact (or site) or its provenience;

(iii) Frequency dimension – number of occurrences of a particular type of artifact;

(iv) Relational dimension – patterns of re-occurrence of artifacts, or associations between artifacts.

Site formation and disturbance processes are the major determinant of the relational dimensions of artifacts. Artifacts displaced by earth-moving processes can often contribute to archaeological deposits that exhibit 'reverse stratification' – previously deposited objects of an earlier period of manufacture and use are brought up and deposited above later-manufactured artifacts or objects. This fact reveals the importance of investigating relatively intact 'archaeological features' at sites, rather than individual artifacts, features such as fire hearths (**Figure 57**) in my research area. A feature can be visible on the surface or completely buried subsurface, and subject to the same disturbance processes as artifacts, the difference being that artifacts can be moved and not damaged (retaining their formal dimension), whereas movement of a feature destroys its archaeological interpretive value (Q. Mackie, *pers.comm.*, 2005).

Another important archaeological distinction is between primary and secondary deposition or context: artifacts in primary context have experienced many minor environmental disturbances over time but with overall artifact movements being small on a regional scale; artifacts in secondary context would have the original deposit of archaeological materials re-deposited by environmental processes (Schiffer 1987). It is difficult to determine whether artifacts at a site are in primary or secondary context without the presence of archaeological features that are still intact, due to the wide range of environmental processes that could have affected a site over time. Measurements of impact (measurable change in a characteristic or property of an archaeological site) may be restricted to measurements of formal and spatial dimension without features being present (Wildesen 1982).

In conclusion, the most severe impacts of ecological restoration activities on cultural sites are likely to result from use of heavy equipment for:

- Tree uprooting during site preparation for replanting (DeBloois *et.al.* 1974);
- Site scarfication during site preparation for replanting (Gallagher 1978, Haase 1983);
- High lead logging and rubber tired tractor log yarding (Jackson 1994);
- Log skidding on skid trails (Jackson 1994);
- Construction of timber block access roads and log landings (Gibson 2003);
- Prescribed burning preparation or wildfire protection activities (DeBano *et.al.* 1998).

The use of heavy equipment on sensitive soils, and/or during conditions when sensitive soils are most vulnerable to surface disturbance (wet or unfrozen conditions) will result in the most surface and subsurface disturbance to cultural sites. This disturbance can have direct impact on the measurable formal and spatial dimensions of variability or attributes of artifacts, and on the association or pattern of artifacts and features within cultural sites.

Because fires have historically burned over most forested ecosystems of the interior Pacific Northwest, the direct effects of fire on cultural sites and artifacts have been felt in the past. Following the period of active fire suppression since the 1930's in these ecosystems, direct fire effects are likely to have been more severe due to buildup of fuel load and increased fire intensity during wildfires (Traylor *et.al.* 1990, Lentz *et. al.* 1996a). The most severe fire impacts to artifacts result from long-term burning of tree roots and trunks over top of archaeological sites (DeBano *et.al.* 1998). Fire impacts to cultural sites are compounded by damage due to fire suppression activities and equipment, post-fire site rehabilitation, post-fire site erosion and tree fall (Berg 2003).

It should also be noted that the cultural sites of the Kettle Lake Complex have occasional assemblages of deer bone and more frequent occurrence of fire broken rock at the prehistoric camps. Though not strictly defined as 'artifacts' per se, both bone and fire broken rock are indications of past cultural activities. Bone is subject to a wide range of environmental transformation processes: fossilization, leaching of minerals, dissolution by soil acidic elements, weathering and exposure to sunlight if on the surface, freeze-thaw cycles, water and animal transport, animal gnawing, and more recently, damage from equipment and surface collection (Schiffer 1987). As noted in **Figure 4**, bone is charred at a relatively low temperature (< 300°C) and would be burned in a hot fire.

The field of paleoethnobotany – the study of interrelationships between human populations and the plant world seen through the archaeological record (Pearsall 1989) – is linking the work of archaeologists and botanists. Analysis of archaeological plant remains such as pollen grains, phytoliths (plant silica), wood charcoal and plant seeds can shed light on past human activities on the landscape. The material from which pollen walls are made of is one of the most resistant plant products in nature, and is especially well-preserved in acidic, podzolic forest soils where soil mixing organisms (such as earthworms) are largely absent (Dimbleby 1985). These are the soil characteristics found at these research sites, and though pollen analysis was not done, pollen could have served as an environmental marker, especially to identify old land surfaces and buried soils encountered in excavation pits. However, intensive forest fires burning below the forest floor, and use of ground-disturbing equipment to fight such fires disrupts a potentially valuable pollen or wood charcoal record at these research sites. The use of palynology – the study of pollen and spores, the biology of their production and distribution and their relationship to the reconstruction of past vegetation patterns, climate and cultural activities- is becoming more common in interdisciplinary work between archaeologists and other natural systems specialists (Pearsall 1989, Allen *et.al.* 1999).

CHAPTER THREE

Approach and Methods

3.1 Project Approach

The research inventory and evaluation of five (5) archaeological sites in the Wolf Creek/Premier Ridge area and two (2) archaeological sites in the Reed Lakes area is built on theoretical modeling developed for Archaeological Potential Mapping by Choquette (1999), Ktunaxa Nation traditional use and oral histories, and earlier archaeological information gathered at these sites (Choquette 1975, Choquette and Sauer 1998, Campbell 1999, Brandzin 2000).

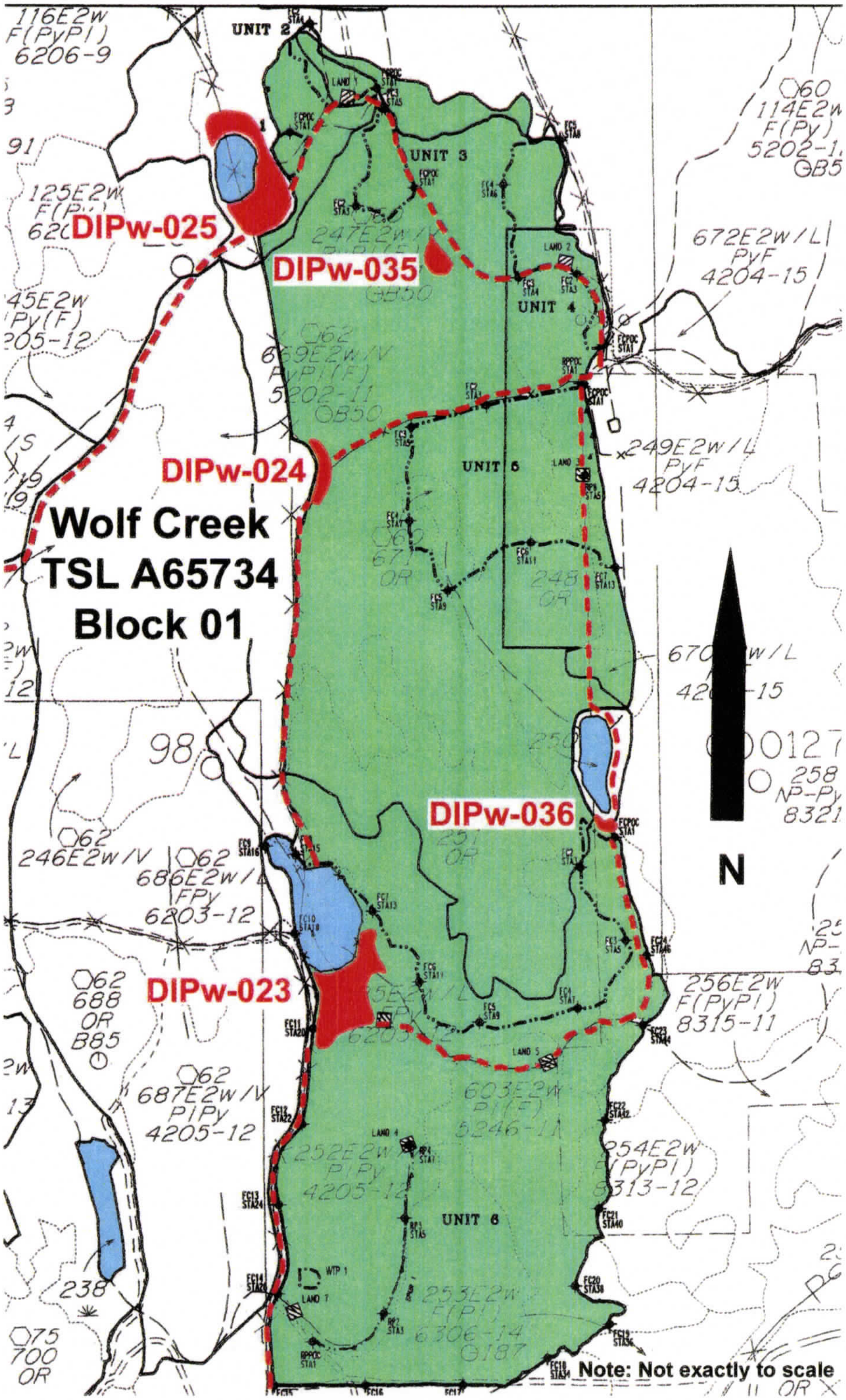
Choquette (1971, 1975) first conducted archaeological fieldwork in this area in the early and mid 1970's. Archaeological sites were recorded adjacent to a number of small pothole or kettle lakes and dry sloughs found in the bottom of the Trench. Site files are on record with the BC Archaeological Branch in Victoria (Choquette 1975). At the time, there was no requirement for shovel testing or excavation to determine the surficial or subsurface extent of these archaeological sites. Sites were simply recorded on the basis of surface discovery of archaeological materials or visible features.

As part of the Premier Ridge Ecosystem Restoration Plan for the Trench, then Invermere Forest District (IFD) prepared timber harvest plans for TSL Q43102 - Block 6 (now renumbered **TSL A65734 – Block 1**) in the late 1990's (**Figure 5**). The overall objective was to remove merchantable lodgepole pine (Pl) prior to ecosystem restoration by burning (H. Mitchell, *pers. comm.*, 2001). In the course of conducting AIA's prior to timber harvest, four new archaeological sites were located (Choquette and Sauer, 1998). Prior to the AIA work in 1998, Block 6 of the IFD Small Business Forest Enterprise Program already had five previously recorded sites in the vicinity. At that time, the archaeologists proposed the recommendation that "no further development can occur within this block until this archaeological survey work is concluded to the satisfaction of the Archaeology Branch" (Choquette and Sauer, 1998).

In the spring of 1999, the Archaeological Overview Assessment (AOA) of Landscape Unit 4, Invermere Forest District, was completed (Choquette, 1999). This work covered the area of Block 6, and indicated that much of the block was ranked as an area of High Archaeological Potential. IFD staff and archaeologists working for Eaglevision Geomatics and Archaeology Ltd. (Ktunaxa Nation archaeological consulting company) have advanced different management recommendations since that time, including the following:

- Conduct an AIA for the entire area of TSL A43102 Block 6, prior to timber harvest and prescribed burning;
- Conduct an AIA in areas subject to direct impacts of the timber harvest such as: all existing roads to be upgraded, all proposed skid routes and all fire guards;
- Conduct prescribed burning only, and conduct an AIA only in areas of fireguards, and roads to be upgraded prior to burning.

All of Block 1, TSL A65734 of the Small Business Program of IFD had been set aside from timber harvest and follow-up ecological restoration because of the concentration of archaeological sites. To move past a management impasse, and following a field reconnaissance of these archaeological sites in Block 1 in July of 2001, the principal researcher and the archaeologists selected a number of sites, which would be targeted for restoration timber harvest, as follows: **DlPw – 023; DlPw – 024; DlPw – 025; DlPw – 035; DlPw – 036**. All of these sites are associated with small kettle lakebeds. These sites would be the subjects of detailed archaeological fieldwork, to determine their surficial and subsurface extent prior to any timber harvest. Two additional sites were selected later in the operating area of Tembec Inc. (Canal Flats Division) near Reed Lakes – **DkPw-012** and **DkPw-013** (**Figure 6**) – timber blocks CP 176, Blocks 004 and 005. By involving both the Ministry of Forests Small Business Forest Enterprise Program and Tembec Inc., the possibility was opened for greater collaboration with both government and industry on the field research.



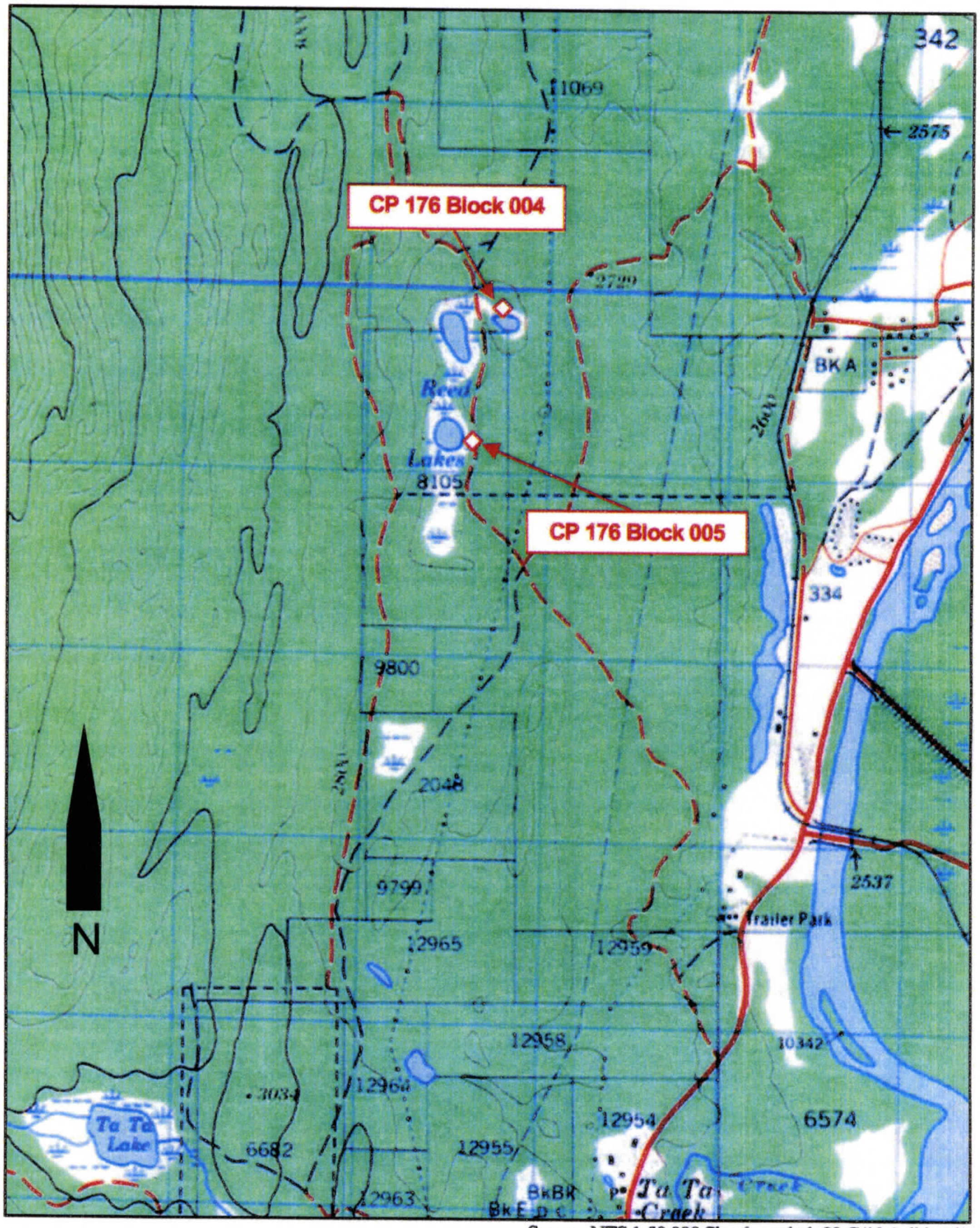
Scale Approximately 1:15,000

Figure 5: TSL A65734 – Block 1, Wolf Creek

The BC Archaeological Planning and Assessment Branch was consulted about this research, and they were supportive of the knowledge that could be gained by monitoring restoration and timber treatments around archaeological sites. Applied archaeological and cultural resource management of this kind is not common with the Branch; the majority of their work consists of review of AIA reports (D. Hutchcroft, R. Kenny, *pers. comm.*, 2001). A Heritage Inspection Permit was required under the *Heritage Conservation Act*, to conduct the detailed research and inventory investigations of the archaeological sites chosen in the study area. This permit (2001 – 325) was applied for and obtained in September 2001 (Wood, 2001). It describes the field methodology for conducting the archaeological inventory work in the study area. A Site Alteration Permit was subsequently applied for and issued to monitor the impacts of timber harvest around the sites after their inventory.

3.2 Traditional Use Research

The Ktunaxa Kinbasket Tribal Council (KKTC) conducted an extensive Traditional Use Study in the late 1990's, over their entire traditional territory of the East and West Kootenays. In August of 2001, a meeting was held with the Ktunaxa Kinbasket Elders Working Group to discuss this proposed research, and to suggest a field trip to the study area. In early September, eight Elders, six youth, KKTC staff and Ministry of Forests staff, plus project archaeologists and I, conducted a field trip to the north end of the study area. Field staff and I made presentations regarding previous archaeological work, ecological restoration plans and research objectives. Additional traditional use and Ktunaxa place name information was collected in the field; however, because of concerns for confidentiality of traditional use information, this information is not included in this research.



Source: NTS 1:50,000 Skookumchuk 82 G/13 (edition 3)

Figure 6: Timber Blocks at research sites near Reed Lakes, Rocky Mountain Trench

The Ktunaxa people still use the project area in a traditional manner, much as it was used when the known archaeological sites were created: for hunting and camping around the small kettle lakes in the bottom of the Rocky Mountain Trench. Ktunaxa people were less able to use the study area during the years following the creation of Indian Reserves in the Rocky Mountain Trench; Indian agents greatly restricted Ktunaxa movement from the Reserves for hunting and gathering purposes. These lakes are now being used less by wildlife, especially as a result of recent droughts and lake evaporation. Reduced grassland habitat for ungulates due to forest ingrowth has lowered the wildlife habitat capability of the area.

3.3 Archaeological Field Inventory [1]

Prior to field investigations, a review of the available heritage inspection reports and BC Archaeological Site Inventory records was made to ascertain the locations of other previously recorded archaeological sites in the general region (Choquette 1971, 1975). Field inventory methodology followed the British Columbia Archaeological Inventory Guidelines (Province of BC 1992, 1998a, 2000), and all work was conducted under the terms of a BC Archaeology Branch Heritage Inspection Permit. Field inventory was completed during the 2001 and 2002 field seasons.

Field investigations consisted of a combination of intensive on-foot visual surface inspections, subsurface shovel test units, and judgmentally-selected evaluative test excavation unit locations within the identified site areas for the purpose of meeting or exceeding the stated objectives of the research permit, including locating, recording and evaluating densities and distributions of archaeological materials, overall site significance levels and assessing proposed impact levels.

3.3.1 Systematic surface survey methods

[1] The description of field methodology for archaeological inventory is taken from the research inventory reports (Wood *et.al.* 2002a, 2002b) submitted to the BC Archaeology Branch and co-authored by me.

The general areas noted in previous archaeological site forms from Choquette (1975) were assessed using systematic foot survey traverses, with crew members spaced between 5-7m apart depending on local topography and surface visibility of archaeological features. This allowed for 100 % coverage within the identified site areas. Traverses were periodically paused to allow for supplemental examination of higher potential micro-topographical features within or immediately adjacent to the site areas. Visual inspection included the examination of available exposures such as unvegetated patches of ground, road surfaces, ditch cuts and back slope cuts, tree throws and adjacent roads and/or truck trail and cattle and game trails. All identified archaeological materials (i.e. single occurrences or concentrations) or other culturally significant resources were plotted on maps at a scale of approximately 1in: 20-50m.

3.3.2 Subsurface testing design and methods

Survey coverage included intensive visual inspections of the ground surface and was supplemented by the excavation of selected sites using shovel tests. The intensity of subsurface testing varied according to the archaeological site potential/significance observed within the examined site areas. For both surface and subsurface sites, shovel test units were placed at pre-determined intervals in each cardinal direction from each positive shovel test, surface artifact or feature encountered. The shovel test interval was determined based on the density of artifacts, landform size and configuration, or other considerations, such as landform features present.

Shovel tests were tightly placed at intervals ranging between 5-7m, depending on ground surface exposure, subsurface exposure (in road cutbanks) and size of landform features or other considerations. Shovel test intervals were spaced at less than 5m when surface visibility was considered poor and subsurface and general topographic conditions were considered highly suitable for occurrence of subsurface archaeological materials, in order to fully assess the sites vertical and horizontal dimensions. Shovel testing was continued until two consecutive negative shovel tests (i.e. no archaeological materials present) were found or the limit of the landform was reached (**Figure 7).**

Figure 7: Archaeologist Barry Wood and Eaglevision field technician Vern Patrick begin a shovel test unit

Shovel tests measured 40cm by 40cm and were excavated to sterile strata (**Figure 8**), subject to subsurface constraints such as hardpan layers. All back dirt was screened using a ca. 6mm mesh. General stratigraphic descriptions were recorded for all site areas tested. All archaeological materials encountered in shovel tests were recorded as to context (i.e. depth below surface & relevant stratigraphic information) location, artifact and material type as well as basic metric data. No charcoal or sediment samples were collected for analysis.

All observed artifacts in disturbed areas and those excavated from shovel tests and evaluative test units were collected because: (1) artifacts were deemed to be in immediate and ongoing danger of being impacted and more detailed recovery programs were not judged to be warranted; (2) they were exceptionally significant; and (3) Archaeology Branch permits require artifact recovery and submission to a repository - usually the Royal British Columbia Museum (**Figure 9**).

Figure 8: Shovel test unit at Site DlPw-036 reaches sterile gravel level

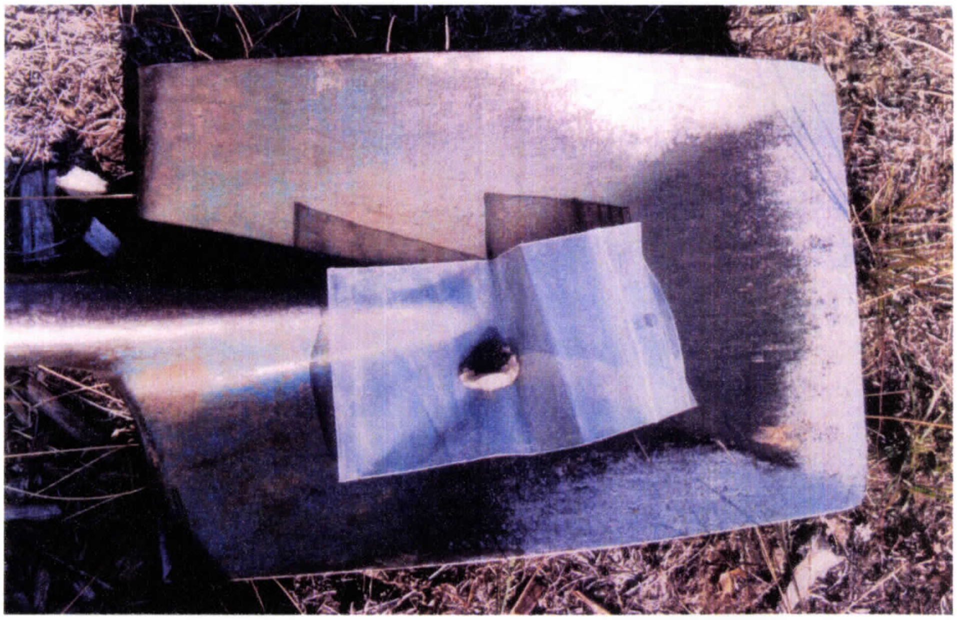


Figure 9: Small chert scraper found at site DlPw-025

Survey coverage and the approximate location of positive archaeological shovel testing were mapped onto large-scale maps using GPS readings and compass-and-pace. The general location and number of subsurface tests were indicated on survey coverage maps. All observed and collected archaeological materials were mapped and their location indicated on survey coverage maps.

Archaeological site boundaries were determined using a combination of the results of surface inspection and shovel testing. Where surface materials or features are present, surface inspection was used to assist in determining site boundaries and then confirmed using shovel tests. For sites with only subsurface materials, shovel tests and the examination of subsurface exposures were used to determine site boundaries.

Evaluative excavations of larger size were considered necessary to obtain additional information about individual site integrity, stratigraphy and depth of archaeological deposits at three of the sites (i.e. **DlPw-023, 025 & 036**). Evaluative excavation holes measured 50cm x 100cm in dimension and were excavated to basal, non-archaeological deposit (i.e. till, outwash or glaciolacustrine silt) in 5cm levels (**Figure 10**). Initially, given the research focus of these investigations it was expected that at least one evaluative excavation unit per archaeological site would be required in order to properly assess site significance. Although outlined in the permit application this was not deemed essential at two sites (**DlPw-024** and **DlPw-035**) due to compressed stratigraphy, low artifact frequencies, low significance levels and other physical or time constraints.

All matrixes removed from evaluative test units were screened through a ca. 6mm mesh (**Figure 11**). Profile drawings of stratigraphy and features exposed in the walls were prepared, and photographs taken where conditions allowed. Artifacts found in evaluative tests were treated like those found in shovel tests. That is, they were collected for subsequent cataloguing, identification and analysis and additional notations were made significant to this research (i.e. surface and/or subsurface contexts including depths below surface) (**Figure 12**).

Figure 10: Archaeologist Barry Wood cleaning Evaluative Test Unit at Site DlPw-036

Figure 11: Test Unit soil screened through 6mm mesh screen

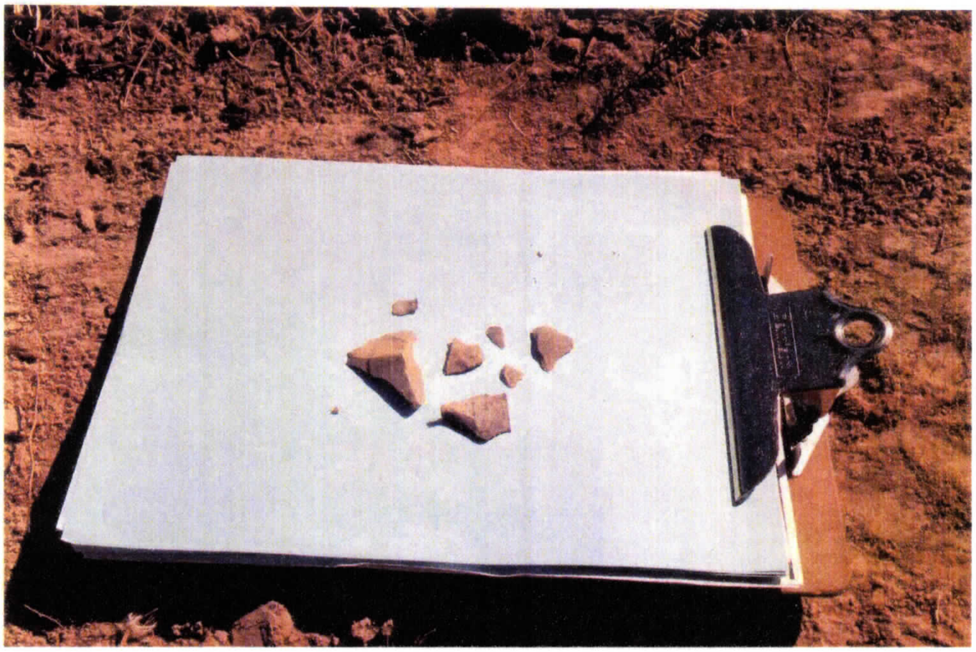


Figure 12: Example of artifacts recovered from site DlPw-023

3.3.3 Data retrieval methods

All archaeological sites were recorded in field notes, photographed, and mapped by pace, compass and hand-held GPS. Site datums, in the spatially more complex sites were established and existing site inventory forms were updated. The locations of individual shovel tests within and adjacent to site areas were mapped, and positive result tests distinguished from negative. The location of all investigated sites were indicated on NTS maps at the largest scale practicable (approximately 1: 10,000).

Artifacts were generally collected because: (1) they were in immediate danger of being impacted, especially on and adjacent to existing truck trails, in cattle wallows and cattle/game trails and where more detailed recovery programs were not judged to be warranted; (2) the artifacts were exceptionally significant, as in the case of formed tools; and (3) damage to the sites were likely to be unavoidable by resource extraction activities. In addition it was deemed desirable, if possible, to collect a meaningful enough sample size to allow for future lithic analysis and interpretation.

3.4 Survey of Ecological Restoration Timber Treatments

Several different ecological restoration timber treatments are utilized in the Rocky Mountain Trench as methods to restore stand structure and species composition and to reduce fuel loads prior to restoration burning. Treatments include the following:

- Hand falling, piling and burning
- Falling and hauling to 'cast-iron sloop' for burning
- Low impact feller-buncher and forwarder equipment
- Conventional feller-buncher and skidder equipment

The field sites where each of these timber treatment methods were being used were visited in the winters of 2002 and 2003, to conduct visual inspections of the potential for surface and subsurface disturbance by different timber treatments. Photographs and field notes were taken to record equipment activities and impacts to the ground surface of the operating sites.

Final research observations focused due to time constraints on potential disturbance caused by the most common timber treatment in the Rocky Mountain Trench – use of conventional feller-buncher equipment (**Figure 13**). Standard operating procedures for timber harvest with this equipment, in areas of HAP and soil sensitivity, require that resource extraction only proceed under winter conditions, with recommended minimum depths of frozen ground (7. 5cm) and with snow cover of 30 cm. or more (S. Brookes, *pers. comm.*, 2001, Curran 1999).

Figure 13: Tree de-limber equipment adjacent to log pile at Site DlPw-023

3.5 Pre-Harvest Soil Disturbance Analysis

An initial analysis of soil hazard assessment was made using soils information from the research area, and application of the Hazard Assessment Keys (BC MoF/MoE 1995). **Section 4.1** of the Results section shows a summary of this analysis.

3.6 Monitoring of Timber Harvest Treatments

The BC Archaeology Branch approved Site Alteration Permits in 2002. Approvals for timber harvest and field monitoring were in place late in the winter of 2002-03; however, suitable winter conditions did not occur for the harvest to proceed. During timber harvest in the winter of 2004, Ktunaxa field technician John Nicholas was on site, photo-recording the harvest activities, on prescribed winter conditions of frozen ground and snow cover, and monitoring any soil and surface/subsurface disturbance impacts. Ktunaxa field staff had the authority to shut down or move harvest activities away from any areas where surface disturbance resulted in the uncovering of artifacts. In the winter/spring of 2005, John Nicholas was on site with a field archaeologist – Ian Tomasie – of Eaglevision Archaeology and Geomatics Ltd., again monitoring timber harvest and field conditions.

3.7 Soil Disturbance Surveys Post-Harvest

Following the winter timber harvests of 2004 and 2005, I completed soil disturbance surveys for timber harvest blocks and road systems used to access timber harvesting areas. Methodology for these surveys is described in the **Soil Conservation Surveys Guidebook** (Province of BC 2001). Surveys methods for timber blocks and roads are described below:

3.7.1 Transect method for timber blocks of 10 ha. or smaller.

A field transect method was used, whereby a series of parallel transects was established within the survey area, with survey points for soil disturbance at defined intervals along each transect. For each of six archaeological research sites, a section of the timber block covering the site was surveyed as follows:

- The survey area was walked by foot traverse to determine the main orientation of soil disturbance (direction of equipment movement), if any;
- The survey transect orientation was established to cross the direction of major disturbance orientation at right angles on the archaeological site area;
- A survey baseline was established from which survey transects were run parallel to each other across the survey area;
- Survey transects were spaced 5m apart;
- Survey transect length varied between 75-100m depending on the size of the timber block, or ran from baseline to the edge of the timber block boundary;
- A Point of Commencement (POC) for the survey baseline was chosen at a fixed landscape feature (tree, stump, road crossing, etc.);

- From the point of commencement (POC) on the baseline, the survey line was run at a 90° angle across the survey area measuring distance using a hip chain (**Figure14**)
- At each 5m point on the transect line, presence (and type) or absence of soil disturbance at the survey point was recorded on field sheets;
- At each survey point, soil compaction, soil disturbance > 5cm, tree root disturbance, deep gouging or scalping and presence of tree slash was recorded; (**Figure 15**)

Locations of soil disturbance surveys are shown on the respective maps of each research site in **Chapter 4**.

Figure 14: Hip chain stretched out for Soil Disturbance Survey of Site DkPw-012

Figure 15: Logging slash left on timber block at Site DkPw-013

3.7.2 Survey method for access roads

A road survey was conducted on access roads where known road construction or upgrading had caused surface impact on the archaeological research sites. In the spring of 2004, road surveys were conducted on the new access road to the log landing and on the upgraded access road at site **DkPw-013**, and on the access road at site **DlPw-023**. In the spring of 2005, a detailed road survey was conducted on the access road at site **DlPw-025**.

A section of original road surface was normally the POC to act as a control point. Starting at the POC, a hip chain was extended the length of the disturbed section of road surface. The width of the road right of way in horizontal distance was measured at fixed intervals (5 – 50m), including the width of sidecast road material, the running surface and ditches. The depth of ditches or road cuts was measured at the same fixed intervals as the distance from ditch or road cut bottom to the top of the adjacent road material (**Figure 16**). Archaeological artifacts encountered on the disturbed surface were counted but left in place.

Locations of access road soil disturbance surveys are shown on the respective maps of individual research sites in **Chapter 4.**

Figure 16: MoF Soils Technician Simon Brooks measuring depth of ditch cut at Site DkPw-013

3.8 Photopoint Monitoring

Effective documentation of changes in resource values over time in field studies can be achieved with accurate repeat photography. Photopoints are landscape or feature photographs retaken in the same spot over a number of years, each photo filling the same frame so that differences between years can be compared (Elzinga *et.al.* 2001). Permanent photopoints were established at three locations in each of the archaeological research sites, to appraise changes in vegetation cover and surface conditions following timber harvest and/or road work at the sites. Locations are shown on the respective maps of individual research sites in **Chapter 4**. The most important criterion for repeat photography success is maintaining the same photo point over the period of monitoring; for this reason, camera location and photopoint require permanent markers (Hall, 2002). Camera locations and photopoint marker locations were marked with wooden survey stakes; photos were recorded in summer and winter conditions prior to timber harvest, and in spring conditions following the timber harvest activity (**Figure 17**). Photopoint shots are included in **Appendix 2**.

Figure 17: Example of Photopoint shot at Site DkPw-013, looking east

3.9 Additional Field inventories

Ecological site descriptions and vegetation plot surveys (10m x 10m plots) were completed for each research site, using methods and field forms from the **Field Manual for Describing Terrestrial Ecosystems** (Province of BC 1998b). To determine whether resource development activities will have any impact on the wetlands in the adjacent kettle lakes, field surveys of **Proper Functioning Condition** (PFC) were completed for each kettle lake, using methods developed by the US Department of the Interior Bureau of Land Management (USDI 1999). These additional field inventory data (vegetation and PFC conditions) are not directly pertinent to the objectives of this research on impacts of timber harvest and prescribed burning, and are not included in the analysis. However, the data collected will provide base line ecological information for potential future studies in the same areas.

CHAPTER FOUR`

Results

4.1 Introduction

The results chapter includes the following information:

- A pre-harvest site and soil condition analysis (**Sec. 4.2**);
- Archaeological inventory results from seven research sites (**Sec. 4.3**);
- Review of ecological restoration techniques used in the Trench (**Sec. 4.4**);
- Soil disturbance survey results from seven research sites (**Sec. 4.5**);
- Analysis of significance of Ktunaxa Nation cultural sites (**Sec. 4.6**).

4.2 Pre-Harvest Soil Disturbance Analysis

The analysis of soil hazard assessment using soils information from the research area, and application of the Hazard Assessment Keys (BC MoF/MoE 1995) is shown below.

Table 4: Preharvest Site Condition Information (generalized conditions at (7) research sites)

Site Factor	Site Conditions
Climatic information	
• BEC subzone/variant	IDFdm2
• Seasonal occurrence of:	
- dry soil > 15-30cm deep	Yes
- compressible snow > 1 m deep	Rare
- frozen ground > 15-30cm deep	Occasional
Slope information	
• Slope gradient	0 – 5%
• Slope length/uniformity	Short / uniform
• Slope continuity	No – discontinuous
• Slope instability indicators	No
Site hydrology	
• Gully spacing	No gullies
• Water course spacing	No watercourses
• Soil moisture regime	Xeric-subhygric
• Seepage	No

Soil information	
• **Forest floor depth/ prominent horizon**	**0 - 5cm / B horizon**
• **Ah horizon depth**	**< 5cm**
• **Soil texture/change @ depth**	**Si (1-5cm) / SiL (5-7cm) / SiC (7-15cm)**
• **Coarse fragment content**	**< 5% - 20%**
• **Depth to carbonates**	**N.A.**
• **Depth to bedrock**	**N.A.**
• **Depth to unfavourable subsoil**	**30 – 60cm (dense clays, gravels)**
• **Depth to water restricting layer**	**60 – 90cm**

Table 5: Soil Compaction and Puddling Hazard Key for Research Area

Site Factor	**Classification of Site**	**Point Rating**
Soil texture (0 – 30cm)	**SiL / Si / L**	**Very High**
Moisture regime	**Xeric – subhygric**	**Very High (clayey)**
Coarse fragments	**< 70%**	**Very High (as per texture)**

Table 6: Soil Displacement Hazard Key for Research Area

Site Factor	**Classification of Site**	**Point Rating**
Slope gradient	**0 – 5%**	**1**
Terrain feature	**Hummocky terrains**	**2**
Subsoil conditions (depth to unfavourable subsoil)	**30 – 60cm**	**8**
Point Total / Hazard Rating		**11 - Moderate**

Table 7: Forest Floor Displacement Hazard Key for Research Area

Site Factor	**Classification of Site**	**Point Rating**
Forest floor (LFH/Ah)	**< 6 cm/ < 1cm**	**12**
Dominant soil matrix (top 30cm)	**Medium**	**2**
Depth to unfavourable subsoil	**30 – 60cm**	**2**
Slope	**< 30%**	**0**
Point Total / Hazard Rating		**16 – High**

Table 8: Surface Soil Erosion Hazard Key for Research Area

Site Factor	Classification of Site	Point Rating
Climate (precipitation)	**IDFdm2 – low**	**2**
Topography (slope %)	**0 – 10%**	**1**
Slope length/uniformity	**Short / uniform**	**4**
Depth to water restricting layer (cm)	**30 – 60cm (clay layers)**	**3**
Surface soil detachability (0-15cm)	**Si / SiL – very high**	**8**
Surface coarse fragments (0-15cm)	**< 16% – high**	**4**
Subsoil permeability	**Clay texture layers**	**4**
Point Total / Hazard Rating		**26 - High**

The Hazard Assessment Keys for site sensitivity to disturbance can be summarized as follows:

- Soil Compaction and Puddling Hazard: Very High
- Soil Displacement Hazard: Moderate
- Forest Floor Displacement Hazard: High
- Surface Soil Erosion Hazard: High

Given the Very High, High and Moderate assessment ratings, the best recommendation for the research area sites was to proceed with timber harvesting activities in the winter, on frozen ground and with snow cover. This is standard operating procedure for the Rocky Mountain Forest District in the Rocky Mountain Trench on such soils (S. Brookes, *pers. comm.*). Curran (1999) has reviewed to some extent the question of how much frozen ground or snow is sufficient to allow timber operators to proceed. For example, the following criteria could be used:

Frozen soils:

A soil is considered to be frozen if, using an average of at least (5) readings:

- The frost depth is 7.5cm or greater, and the underlying unfrozen soil is not wetter than the "how wet is too wet criteria" (Curran 1999);

Snow covered soils:

A soil is considered to be snow covered if, from at least (5) readings, the following criteria are met:

- Wet or near wet compressible snow (makes snowball):
    - Boot compression test > 30cm or snowpack > 60 cm
- Dry fresh or granular snow (does not make snowball):
    - Boot compression test > 50cm or snowpack > 80 cm
- Frozen crusty snow (possible to walk on top of snow)
    - Jump compression test > 20cm or snowpack > 40 cm

The snow pack and frozen conditions in the Rocky Mountain Trench vary greatly from one year to the next, making it necessary for flexible operating conditions that can be applied at different times during the winter. Snow and frozen ground conditions were measured prior to the start of resource management activities at the study sites.

4.3 Archaeological Inventory [2]

Site DlPw-023

DlPw-023 (**Figure 18**) was initially recorded by Choquette (1975) as a temporary (hunting) campsite extending north/south for 500m on the east side of a small kettle lake 0.65 km south of Alkali Lake and 5.2km east of the Kootenay River. Choquette originally records "most flakage found in disturbed areas of fan - likely buried components." He further records "fire broken rock, chipped stone artifacts, burnt and butchered bone frag [ments]." No shovel tests were undertaken at that time, with visibility enhanced by disturbance from cattle, vehicular traffic and natural erosion processes.

The site (as presently observed) is situated within a series of terraces and colluvial aprons on the east and south sides of a kettle pond on the Rocky Mountain Trench till plain, approximately 2.5km due east of the Kootenay River and 2km due north of Wolf Creek. It occurs 860m above sea level (asl) and approximately 7-15m above the visible high water mark around the small kettle lake (**Figure 19**)

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[2] The description of the results of project archaeological inventory is taken from the research inventory reports (Wood *et.al.* 2002a, 2002b) submitted to the BC Archaeology Branch and co-authored by me.

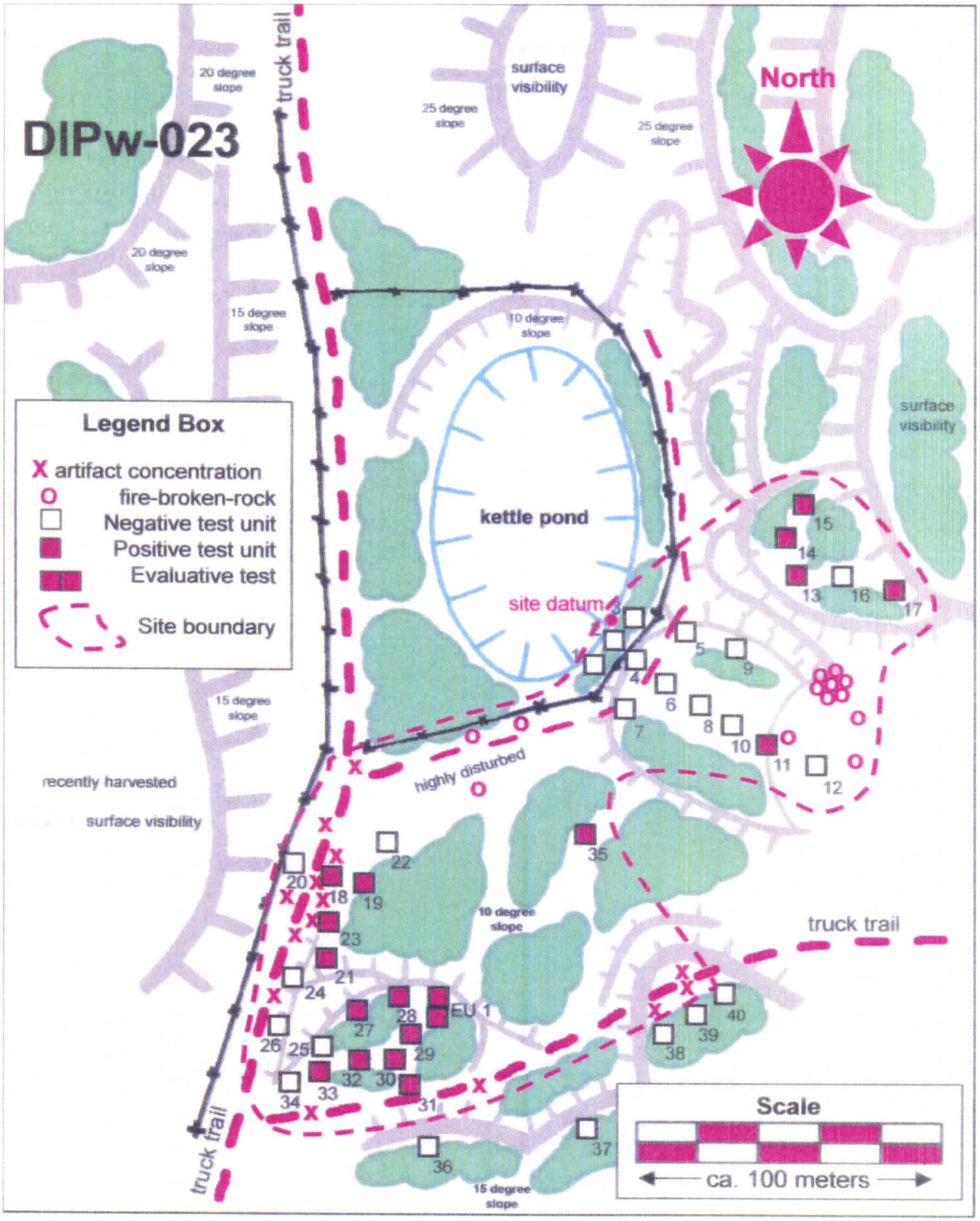

Figure 18: DlPw-023 Site Diagram (Wood *et. al.* 2002a)

Figure 19: Looking south to site DlPw-023 from north end of kettle lake feature

When the site was originally recorded, Choquette noted prominent surface exposures due in large part to disturbed/deflated areas and limited plant cover. During the recent investigations it was observed by Choquette (1975) that there was considerably less surface visibility as a result of the now relatively thick ground cover of grasses, and with truck traffic no longer permitted through the general area because of construction of a fence.

The intensive visual surface examination of the site involved tightly spaced foot traverses beginning at the site datum on the southeast side of the kettle lake, and included areas east, south and north for distances of more than 250 meters. The west side was less intensively examined due to the 15-20° rocky slopes and high levels of disturbance resulting from recent harvest and silviculture treatments.

Artifact concentrations were observed southwest and south of the kettle lake on the Forest Service Road (**Figure 20**). A total of 149 artifacts were collected directly from the road surface, mostly from the area around TU18. Artifact concentrations were tied back to the established site datum by GPS. The only other areas that had excellent surface exposure were on a high bench to the north and northeast of the kettle pond. All other areas exhibited rocky surfaces, or slopes with heavy vegetation ground cover. Artifacts were recorded at distances of up to 200m south of the datum.

Shovel Tests units 1 to 12, at the southeast corner of the kettle lake (**Figure 18**), produced one unit (TU11) that was positive; numerous scattered pieces of fire-broken-rock were also observed on the surface. Test units 13 to 17, undertaken on a bench to the north, produced four more positive results but few artifacts (TU13 to 15 & 17).

Figure 20: Surface inventory southwest of Site DlPw-023 on Forest Service Road, looking north

The area immediately south of the kettle lake had been heavily disturbed by truck traffic with the ground surface appearing rough, as it had been most likely subjected to some sort of reclamation. Several pieces of fire-broken-rock were observed near the newly placed fence line and on the old truck trail.

Based on the observation of tourmalinite flakes on the truck trail 130m southwest of the kettle lake, an intensive visual examination and shovel testing was initiated (**Figure 20**). Test units 18 to 26, excavated either on the truck trail or immediately adjacent to it in undisturbed areas, produced three tests units that were positive (TU18, 21 & 23), producing hundreds of reduction flakes and a complete middle period projectile point (**Figure 21**).

Figure 21: Partial projectile point recovered on road, Site DlPw-023

Test units 27 to 34, south along and adjacent to the truck trail, focused on a large level area, with four units (TU24, 25, 26 & 34), producing no archaeological material. Examinations south and east along the truck trail surface recovered three additional flakes. The observed artifacts resulted in the placement of additional test units (TU36 to 40), all of which produced negative results. A total of 40 test units were excavated with 14 positive and 26 negative being recorded. Eight hundred and eight lithic artifacts were recovered from the test units with 676 coming from TU18.

One evaluative test unit (EU) was excavated approximately 160m south-southwest of the datum. It was 5m northwest of shovel TU28 and undertaken in an area where considerable stratigraphic depth and surface integrity was observed. **Table 9** presents matrix descriptions, depths and cultural associations from EU1. Excavation of the 50 x 100cm evaluative unit in 5cm arbitrary levels resulted in the recovery of fifteen artifacts from between 0-25cm below surface (cm bs).

Table 9: DlPw- 023 Evaluative Unit Stratigraphic Associations

Level	Cultural	Depth (cm bs)	Matrix Description
1	Yes	1- 3	**IAh** & duff with thin ash
	Yes	3 -15	**IBm** gravelly clay loam (10YR3/6) wet
2	Yes	15 25	**IIAhb** Gravelly loam with calcareous nodules (10YR3/4) wet
	Yes	25-30	**IICcab** C cab calcareous gravely clay (1.5Y7/3) wet
2	Yes	>30	**D** Unweathered gravel with calcareous encrustation

The overall site area is calculated at approximately 45,000m2 (300m NE/SW x 150m NW/SE). The site extends from a small level terrace remnant east of the kettle pond to a similar terrace feature 300m southwest. Numerous low-angle ephemeral runoff channels and low to moderate angle colluvial aprons cross the site area. A total of 990 artifacts were recovered from the surface (n=149), test units (n=808) and the evaluative test (n=15). The majority was recovered from the road surface in heavily disturbed areas, in particular around TU18.

Site DlPw-024 (Control Site)

DlPw-024 was initially recorded by Choquette (1975) as a "crescentic shaped, 300m north-south by 100m east-west temporary (hunting) campsite. Choquette originally recorded fire-broken-rock, butchered and burnt bone fragments, chipped stone debitage and tools and two hearth features on an alluvial fan and disintegration moraine on the north and east sides of a small kettle lake approximately 2.25km east of the Kootenay River. He further records "definite clustering of cultural material" and the "site may contain significant buried cultural deposits" and "some disturbance by vehicle cattle traffic and natural erosion."

The site as presently observed is situated on a series of terraces and colluvial fans adjacent to a small kettle pond in outwash deposits on the Rocky Mountain Trench till plain approximately 4.25km due east of the Kootenay River and 3.5km due north of Wolf Creek at an elevation of 896m asl (**Figure 22, Figure 23).**

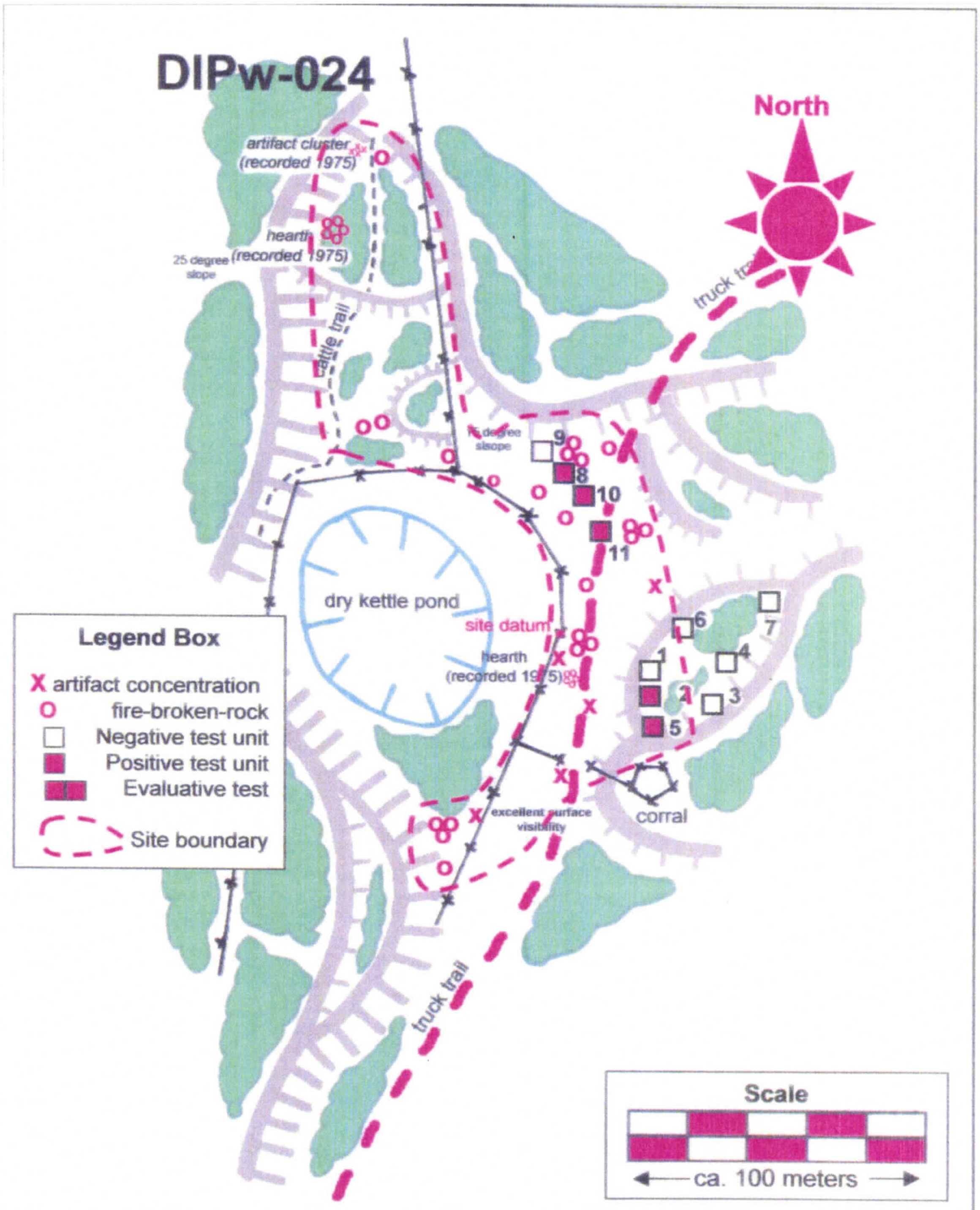

Figure 22: DIPw-024 Site Diagram (Wood *et.al.* 2002a)

Figure 23: Looking northeast across kettle lake feature at Site DlPw-024 to Rocky Mountains

The area north of the kettle pond where Choquette had previously recorded an artifact cluster and hearth was carefully examined. A deeply incised cattle trail was inspected for a length of more than 100m, as were several unvegetated areas. No signs of the recorded features were visible, but three pieces of fire-broken-rock were observed immediately north of the fence. The entire west side of the kettle pond is characterized by steep, (c. 25° slope) rocky slopes considered to have low potential to contain archaeological materials.

Intensive visual inspections of the areas around the kettle pond noted numerous pieces of fire-broken-rock and several lithic flakes; four subsurface test units were initiated on a small level bench southeast of the dry kettle pond. In test units 1 to 7, designed to effectively cover the small level area, two test units were positive (TU2 & 5) (**Figure 22**).

Figure 24: Ktunaxa Elder Leo Williams and Archaeologist Barry Wood at Site DlPw-024

Numerous pieces of partially buried fire-broken-rock were observed northeast of the kettle pond; excavation of four more shovel test units (TU9 to 11) produced three (TU8, 10 & 11) with positive but meagre results. A total of 11 test units were excavated, with five being positive, and 29 artifacts recovered from test units at depths of up to 30cm bs, while only four were recovered from the surface. A general stratigraphic description is provided in **Table 10**.

Table 10: DlPw-024 General Stratigraphic Associations

Level	Cultural	Depth (cm bs)	Matrix description
1	No	0- 3	Litter mat
2	Yes	3 - 7	**IAh** Light gray fine silt/clay
3	Yes	7 -13	**IC** Silty clay
4	Yes	13 - 15	**IIAh** buried
5	Yes	15 - 25	**IIC** Unweathered sand & gravel
6	No	> 25	**D** Unweathered gravels

No evaluative tests were excavated due to the good to excellent surface and subsurface visibility, low artifact densities and mostly unfavourable and/or compressed stratigraphy deemed to have low potential to contain archaeological materials.

The overall site area is calculated at approximately 3,250m2 (130m n/s x 25m e/w). The site is situated on a series of small nearly level terraces and colluvial fans in outwash deposits. A total of 33 artifacts were recovered, including four from the surface and 29 from test units.

This site was utilized as the control site for research purposes, as no timber harvest was to be conducted within the defined site area.

Site DlPw-025

DlPw-025 was originally recorded by Choquette (1975) as a crescentic-shaped, 300m north-south by 100m east-west temporary (hunting) campsite/workshop on a terraced alluvial fan or disintegration moraine feature on the north, east and south sides of a small kettle lake approximately 2km east of the Kootenay River. He further recorded fire-broken-rock, a large quantity of flakes (scattered and in clusters) and scattered tools. He noted some disturbance by cattle and campers and natural erosion (**Figure 25**).

Figure 25: Archaeological field staff conducting inventory on northwest side of Site DlPw-025

The site as presently observed consists of numerous lithic artifacts and fire-broken-rock observed on the surface, especially northwest and southwest of the kettle pond, approximately 2km due east of the Kootenay River and 4km due north of Wolf Creek at an elevation of 896m asl. It is situated an estimated 7-11m above the high water mark of the nearby kettle lake (**Figures 26).**

The intensive visual inspection of the area around the kettle lake took advantage of the numerous deeply incised cattle trails, existing truck trail and bare unvegetated patches of ground. Sparse vegetation/ground cover and numerous cattle trails aided visual inspection of the surface. Lithic artifacts and fire-broken-rock were observed on the northwest side of the kettle pond where the site datum was established (**Figure 26**).

Numerous artifacts (n=171) were collected from the surface due to the high archaeological visibility conditions and ongoing disturbance (i.e. truck trails and cattle trails/wallows). Shovel Test Units 1 to 4, initiated northwest of the kettle lake in an area thought to possess several favourable attributes (i.e. south aspect, well-drained, good view) and numerous the artifacts on the surface, produced three positive test units (TU1, 2 & 3) and many artifacts (n=57) at depths up to 30 cm bs.

An area south of the kettle lake had numerous artifacts on the surface and a potential for intact buried subsurface archaeological materials. Initially, much archaeological material was observed in the deeply incised cattle trail, wallows and truck trail, and collected for later analysis (**Figure 27, Figure 28).**

In Test Units 5 to 13, excavated on a small level landform with poor surface visibility due to pine needles and a thick vegetation cover, only TU11 failed to produce archaeological materials in this area.

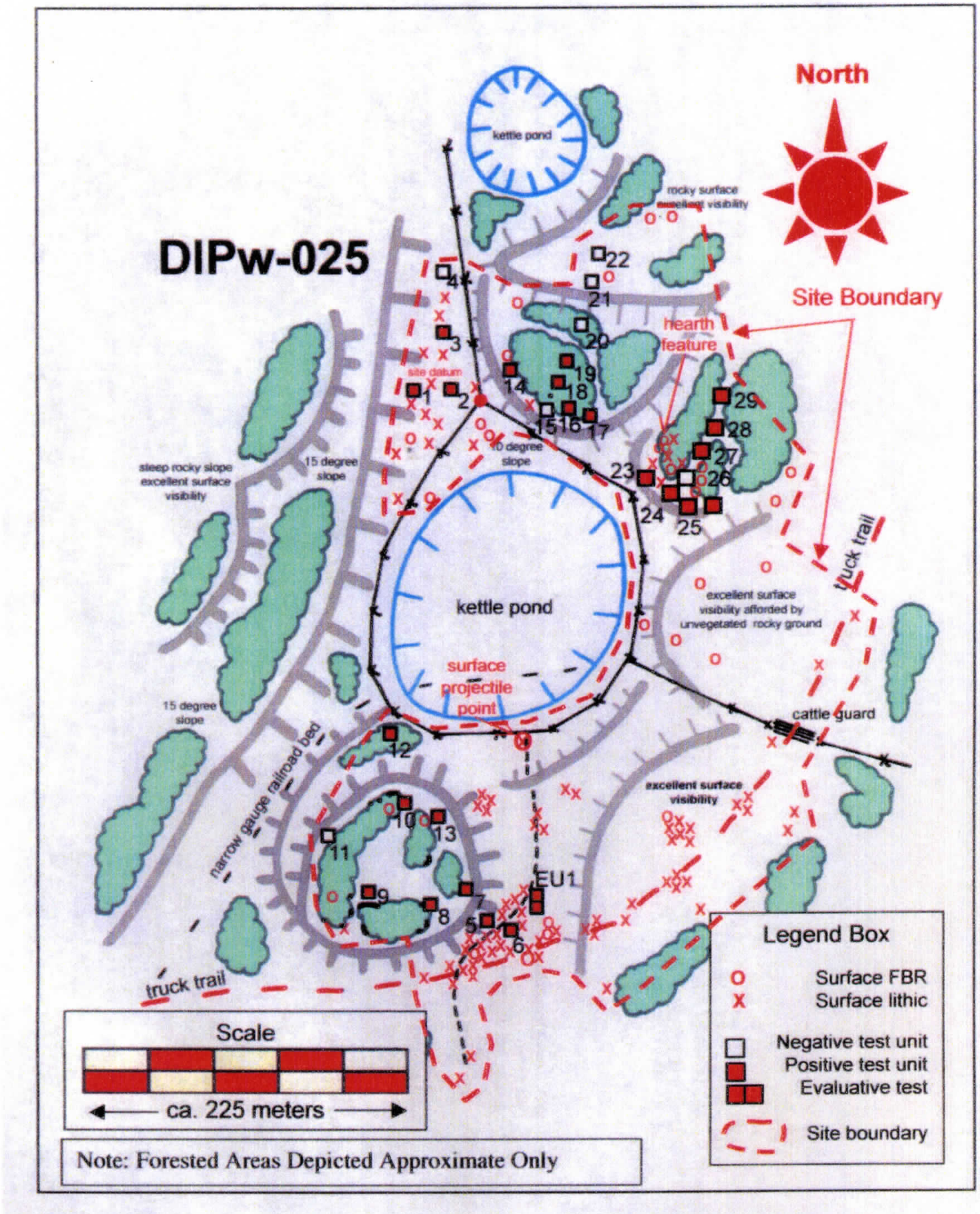

Figure 26: DIPw-025 Site Diagram (Wood *et. al.* 2002a)

Figure 27: Archaeological inventory on small knoll at south end of Site DlPw-025, looking northwest

Areas immediately south of the kettle pond were sparsely vegetated and provided excellent surface visibility. Archaeological materials (i.e. lithic reduction flakes) and fire-broken-rock were observed and flakes were collected to avoid further disturbance.

Figure 28: Tourmalinite lithic reduction flakes recovered from cattle wallow at Site DlPw-025

The final area tested was a large level terrace immediately north of the kettle pond. A dense stand of mature ponderosa pine trees covers the site. The ground surface is covered with a thick layer of pine needles, effectively limiting surface visibility. Favourable physical site attributes (i.e. south aspect, level & well drained) resulted in eight shovel test holes (TU14 to 22), with four of them (TU16, 17, 18 & 19) producing positive but meagre results. When surface visibility greatly increased due to the absence of trees and the ground surface became obviously much more rocky and less desirable, no further shovel testing was conducted. In total, 125 artifacts were recovered from the test units at depths up to 40cm below surface.

One 50cm x 100cm evaluative test unit was excavated at 5cm depth intervals, 3m northeast of TU6 and approximately 300m south of the datum, in an area where considerable stratigraphic depth and surface integrity was observed. The evaluative test unit recovered 491 artifacts from between the surface and 50cm depth. The majority of artifacts (n=382 or 77%) occurred in the 10-20cm interval. A general stratigraphic description is provided in **Table 11**.

Table 11 DlPw-025 Evaluative Unit Stratigraphic Associations

Level	Cultural	Depth (cm bs)	Matrix Description
1	Yes	0 - 4	**IC** loamy silt (10YR3/3) wet
2	Yes	4 - 6	Charcoal rich layer in silt (10YR2/2) wet
3	Yes	6 -13	**IIC** clayey silt (10YR4/4) wet
4	Yes	13 - 29	**IIIAhb** buried A (10YR5/2) wet
5	Yes	29 - 40	**IIICcab** with calcareous nodules (10YR6/2) wet
6	Yes	40 - 49	**IV** Ahb loamy silt (10YR5/2) wet
7	Yes	49 - 60	**D** Laminar calcareous clay (2.5Y6/2) wet

The occurrence of a medium size side-notch projectile point base and the general setting suggest that the lower archaeological assemblage (13 - 29cm below surface) belongs to the Kettle Lake Complex (ca. 5000 to 2500 years before present) (Choquette 1999).

The horseshoe-shaped site area is calculated at approximately 300,000m2 (600m n/s x 500m e/w) and encircles the north, east and south sides of a small kettle lake. A total of 787 artifacts were collected from the site. This included 171 from the surface, 125 from test units and 491 from one evaluative test.

The site area has been moderately to heavily disturbed by past construction of a narrow gauge railroad, use of the minimally improved truck trail and by cattle trails and wallows.

Site DlPw-035

An Eagle Vision Geomatics & Archaeology Ltd. field crew originally recorded site **DlPw-035** in 1998 while conducting an archaeological impact assessment for the Ministry of Forests Invermere District (Choquette and Sauer 1998). It was recorded as a subsurface lithic scatter on a small terrace, with a southwest exposure overlooking a kettle pond (**Figure 29, Figure 30).**

Subsurface shovel test units (TU1 to 18) were excavated in 1998 but site dimensions were not determined pending further funding from the Ministry of Forests. Significant artifacts were observed, including "one crude biface fragment [and] two utilized flakes with retouch/use wear."

The site is presently recorded as occurring on a terrace on the northwest side of a small kettle lake on the Rocky Mountain Trench till plain approximately 3km due east of the Kootenay River and 3.5km due north of Wolf Creek. The elevation is 904m asl and an estimated 7-11m above the visible high water mark of the nearby kettle lake.

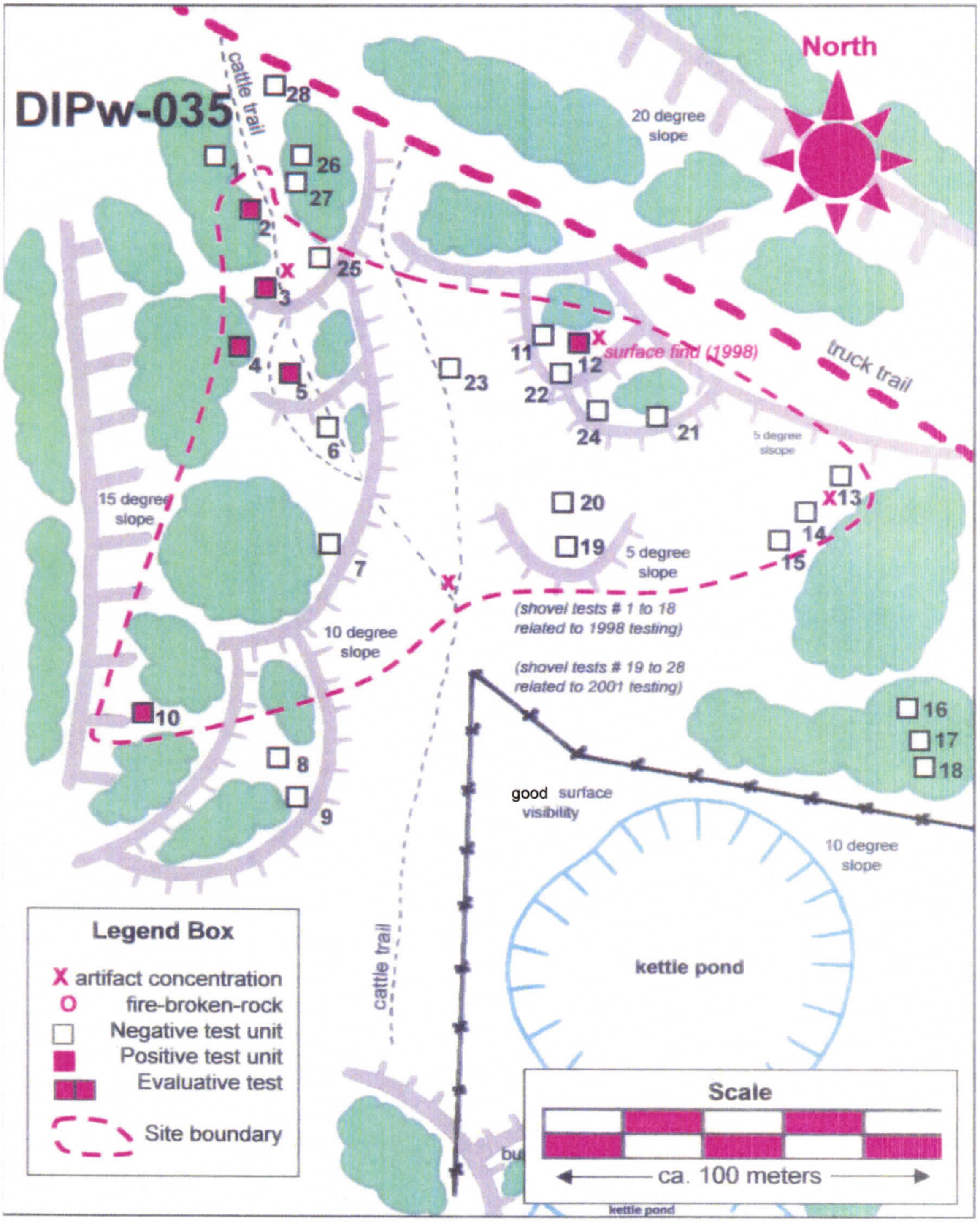

Figure 29 DIPw-035 Site Diagram (Wood *et.al.* 2002a)

Figure 30: Looking south from Site DlPw-035 to kettle lake feature

Initial field investigations focused on the level areas, numerous deeply incised cattle trails and the nearby truck trail. Two artifacts were recovered from the cattle trail. The area has also been impacted by past construction of a narrow gauge railroad, the bed of which now forms portions of the truck trail.

Shovel tests 1 to 18 were excavated in 1998 and are included on the site map for reference purposes. Shovel Test Units 19 to 24 were located north of the kettle pond on small level areas deemed to have archaeological potential, in an attempt to fill in some of the apparent gaps in the previous shovel-testing program. Test Units 25 to 28, placed northwest of the kettle pond in an area where one lithic artifact was previously recovered from the surface and testing, resulted in four positive tests (TU2 to 5). None of the current tests (TU19 to 28) resulted in the recovery of archaeological materials, nor was subsurface stratigraphy favourable to presence of artifacts. **Table 12** provides a generalized stratigraphic description.

Table 12 DlPw-035 General Stratigraphic Associations

Level	Cultural	Depth	Matrix Description
1	Yes	0 -3	Litter mat
2	No	3 -18	Fine gray silts with round to subangular cobbles
3	No	> 18	Very rocky

The overall site area is calculated at approximately 21,875m2 (175m n/s x 125m e/w). The site is situated on a small level terrace remnant on the north and northwest side of the kettle pond. Numerous low-angle, ancient, ephemeral run-off channels and low to moderate angle colluvial aprons cross the site area.

No evaluative tests were excavated due to unfavourable stratigraphy deemed to have low potential to contain archaeological materials.

Site DlPw-036

An Eagle Vision Geomatics & Archaeology Ltd. field crew originally recorded site **DlPw-036** in 1998 while conducting an Archaeological Impact Assessment for the Ministry of Forest, IFD (Choquette and Sauer 1998).

The site as presently observed is situated in a linear east-west trending swale south of a gravel ridge on the south side of an unnamed kettle lake on the Rocky Mountain Trench till plain approximately 3km due east of the Kootenay River and 2km due north of Wolf Creek at an elevation of 919m asl (**Figure 31, Figure 32)**

Figure 31: Looking south across kettle lake feature to Site DlPw-036

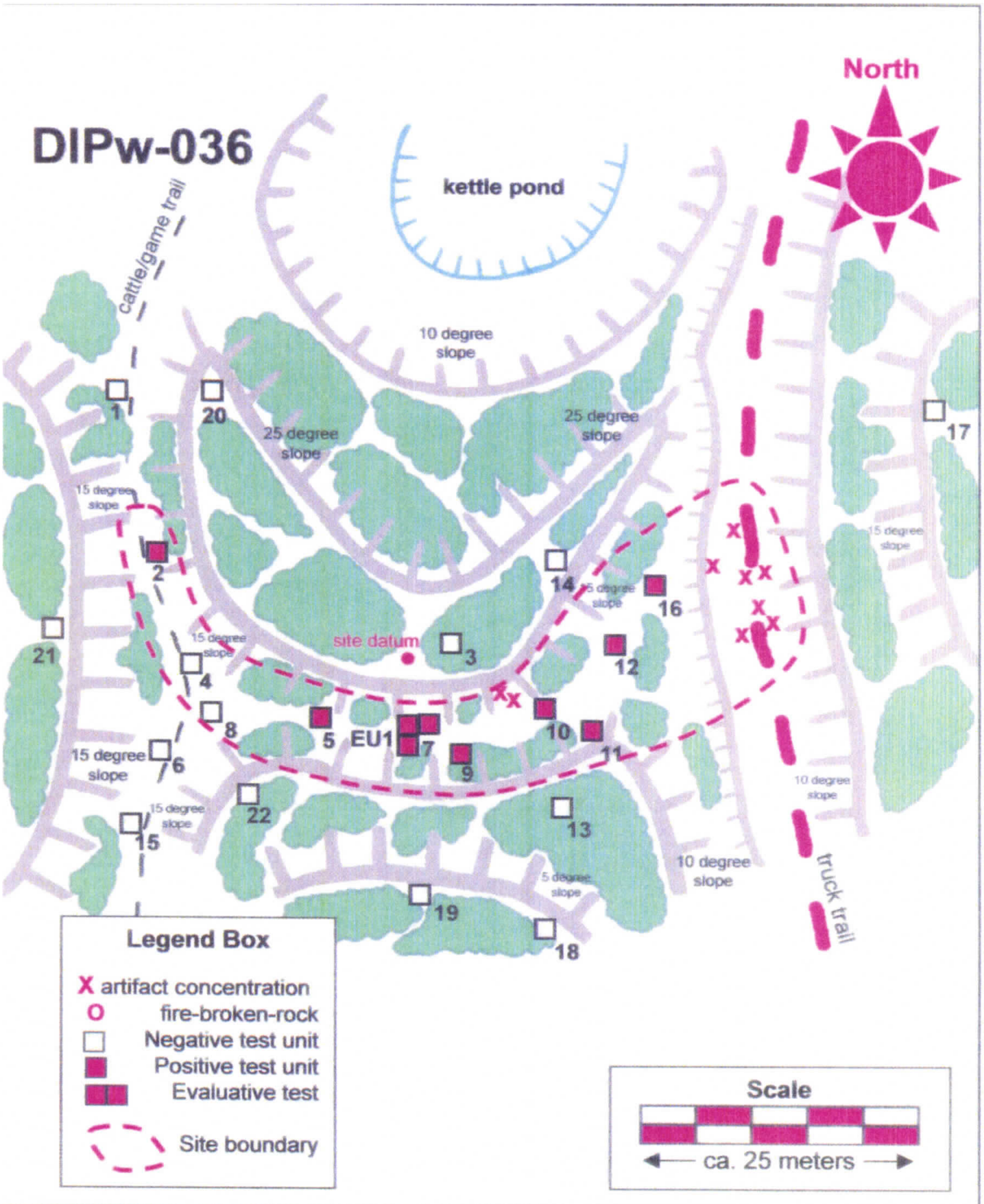

Figure 32: DlPw-036 Site Diagram (Wood *et.al.* 2002a)

An intensive visual inspection of the area around the kettle lake took advantage of the numerous deeply incised cattle trails, existing truck trail and unvegetated patches of ground. Heavy vegetation/ground cover inhibited visual inspection of the poorly drained surface in the wooded areas. The few cattle trails and adjacent truck trail to the east did, however, provide excellent surface visibility. Lithic artifacts (n = 9) were observed and collected with seven collected from the truck trail and two (2) from a tree throw hole northwest of TU10.

Shovel test units 1, 2 and 4, excavated southwest of the kettle lake in the bottom of a shallow draw in a depositional setting, produced one positive test unit (TU2) and a single artifact from between 30-40cm bs. Test Unit 3, on top of a gravel ridge (i.e. esker) yielded no artifacts and further confirmed the lack of any sedimentary deposits (i.e. was in a zone of erosion) on the high linear ridges as was suspected through visual examination of exposures.

The next area tested included a relatively deep swale below the site datum where seven test units (TU5, 7, 9, 10, 11, 12 & 16) all resulted in positive results. TU8, 11 & 12 accounted for over 150 artifacts recovered from depths up to 40cm bs with TU16 artifacts (n = 25) coming from depths up to 60cm bs. **(Figure 33)**

Figure 33: Archaeologist Barry Wood and Ktunaxa technician Zane Gravelle at Site DlPw-036

Test units (TU13, 15, 17, 18, 19 & 21) were selectively located on terrace margins, swales and physiographic high spots, and all produced negative results. Several game trails, examined to take advantage of the bare ground surface and tree throws, showed no artifacts.

One 50cm x 100cm evaluative test unit was excavated to a depth of 45cm bs, directly north and adjacent to TU7, approximately 7m south of the datum in an area where considerable stratigraphic depth and surface integrity was previously observed. A total of 264 artifacts were recovered in the intervals between the surface and 30cm bs, of which 175 or 66% came from between 10-20cm below the surface (**Table 13**).

Table 13 DlPw-036 Evaluative Unit Stratigraphic Associations

Level	Cultural	Depth (cm bs)	Matrix Description
1	No	0 -1	Litter mat
	No	1 - 2	**IAe** Silty ash/tephra
	Yes	2 - 7	**IBm** fine silty clay (2.5Y4/4) wet
	Yes	7 - 15	**IBt** clay loam
	Yes	15 - 23	**IC** Clay loam
2	Yes	23 - 38	**IIAhb, IICca** buried soil organics & calcareous nodules lower (10YR4/3) wet
	Yes	38 - 45	**IIC** Lacustrine clay oxidized mottled to top of gravels (5Y5/6) wet
3	No	45 - 52	**IIIAhb** Sand & gravel with loam (10YR 4/4) wet

The overall site area is calculated at approximately 1,500m2 (100m n/s x 15m e/w). Of considerable significance were the presence of multiple buried soils and complex stratigraphy, plus the recovery of two middle period projectile points (i.e. Kettle Lake Complex) (**Figure 34**) and observation of a heavy charcoal stain at 17cm bs in the east half of the evaluative unit. The projectile points were recovered from depths between 10-30 cm bs. The charcoal stain appears to be from a hearth, but no hearth rocks were observed. The stain was encountered in the south portion of the east half of the EU, with substantial portions remaining intact upon completion of the EU. Staining was restricted to the portions of the EU, as no additional evidence from any other tests was observed. A total of 460 artifacts were collected from the site with nine from the surface, 187 from test units and 264 from the evaluative test.

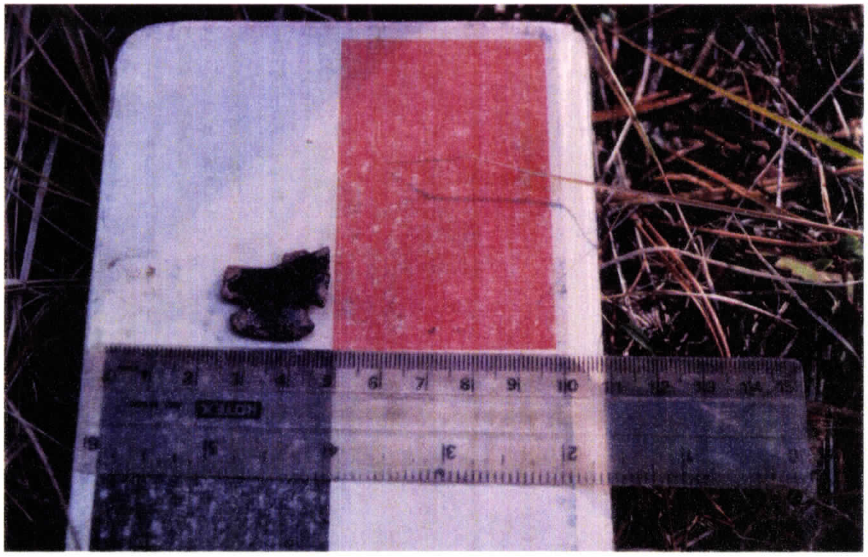

Figure 34: Projectile point recovered at 10cm level at Site DlPw-036

Site DkPw-012

Choquette (1971) originally recorded **DkPw-012** as a temporary campsite on an alluvial fan on the north side of the northeastern-most Reed Lake (**Figure 35**), approximately 3km west of the Kootenay River. It was recognized on the basis of the observation of surface lithic flakes. Choquette further indicates disturbance as being related to an existing "vehicle track" and "cow paths."

The site was later revisited by Brandzin (2000) and assigned temporary number of Ages 2000-1 while conducting an AIA for Tembec Canal Flats Woodlands (i.e. CP176 Block 004). They further noted the "...site is most closely associated with the northeastern of the three Reed Lakes" and "...is a large surface/subsurface lithic site that extends both south and west of the CP 176 Block 004 boundaries (**Figure 36).**

Figure 35: Looking south from Site DkPw-012 to northeastern Reed Lake (badly damaged by ATV's)

Field activities associated with these investigations (Wood *et.al.* 2002b) consisted of tightly spaced foot traverses, focusing initially on the level open prairie-like area between the proposed cut block and the kettle lake. Existing deeply incised truck road(s), numerous cattle trails and wallows and bare unvegetated patches of ground were carefully examined. Because of the fact that the block's eastern portion had been previously intensively shovel-tested, a shovel test program was initiated only in the remaining western portion (**Figure 36**).

The collection of surface (n=4) and subsurface lithic artifacts (10-20cm bs n=7 & 20-30cm bs n=6) included lithic reduction flakes and a core fragment of dark chert (n=1), mudstone (n=5), tourmalinite (n=9), basalt (n=1) and quartzite (n=1). Stratigraphic descriptions are included below in **Table 14** (Brandzin 2000).

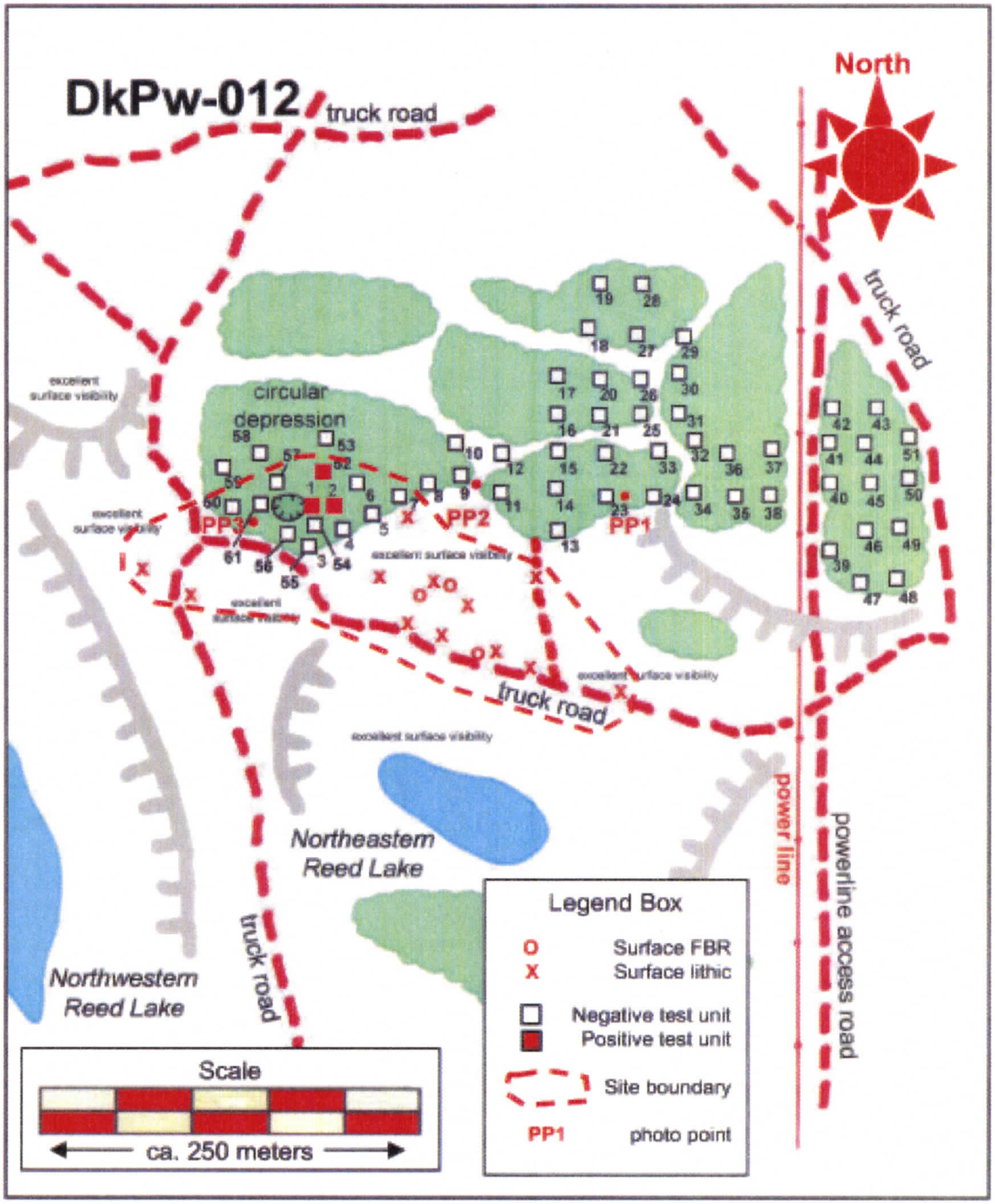

Figure 36: DkPw-012 Site Diagram (Wood *et.al.* 2002b)

Table 14 DkPw-012 General Stratigraphic Associations

Level	Cultural	Depth (cm bs)	Matrix Description
1	No	0 -3	Black-brown humic with powdery silt
2	Yes	3 - 7	Light gray-brown powdery silt
3	Yes	7 - 18	Transition between B & C
4	Yes	18 - 38	Golden brown fine silt with small clay inclusion
	No	38 - 51	Compact gray-white clay-silt

Ten additional shovel tests, placed adjacent to a circular depression on the west side of the timber block, produced only one positive result. One tourmalinite lithic reduction flake was recovered from 28cm bs with the test unit (TU1) terminated at 43cm bs. Subsurface stratigraphy was similar to that observed by Brandzin.

The overall site area is calculated at approximately 48,750m2 (150m n/s x 325m e/w). A total of 25 artifacts were collected from the site, with twelve from the surface and thirteen from test units. Cattle (i.e. trails & wallows) and the continued use of the nearby truck road(s) are currently impacting the site.

No evaluative tests were conducted due to low artifact recoveries and the unfavourable stratigraphic resolution, deemed to have low potential to contain significant archaeological materials.

Site DkPw-013

Choquette (1971) originally recorded **DkPw-013** as a hunting site on a flat bench on the east side and above the most southwestern of the three Reed Lakes. It was recorded on the basis of the observation of lithic material, most notably a "a fragmentary biface of fine grained blue-green tourmalinite." (**Figure 37**).

The site was later revisited by Brandzin (2000) as requested by Tembec Canal Flats in advance of a proposed forest harvest plan (i.e. CP 176 Block 005). Brandzin (2000) recorded the "recovery area as located in the central section of Block 5 CP 176 on the block boundary."

They further note, "The known site area is large and located approximately 90m east and overlooking the most southerly Reed Lake." They observed numerous lithic artifacts on the truck road and generally high disturbance levels of the light sandy silts typical in the region. Only a representative sample of the observed assemblage was collected including "a few flakes, a preform and a biface knife-like tool."

Figure 37: Looking west from Site DkPw-013 to Middle Reed Lake

Selected areas were intensively shovel tested, with only one test hole yielding positive results (**Figure 38**). Additional testing was suspended at the proponent's request before the site's vertical and horizontal dimensions were fully identified. Stratigraphic descriptions are included below in **Table 15** (Brandzin 2000).

Table 15 DkPw-013 General Stratigraphic Associations

Level	Cultural	Depth	Matrix Description
1	No	0 -11	Black-brown humic with powdery silt
2	No	11 - 19	Light gray-brown powdery silt
3	Yes	19 - 25	Transition between B & C
4	No	25 - 50	Golden brown fine silt with small clay inclusion

Field inspection in 2002 initially focused on the 1500M of the north/south truck road on the block's western perimeter. The truck road is at times deeply incised into the fine aeolian silts and sands, providing excellent surface and subsurface exposure to depths greater than 50cm bs in some areas. Numerous lithic reduction flakes and tool fragments were observed on the roadbed and exposed roadside edge face.

Foot traverses later included variably spaced transects through the block's interior and eastern portions, following cattle trails, a fence line and lengthy portions of the adjacent power line right-of-way. Rodent mounds afforded good to excellent subsurface visibility, as did tree throws. The terrain conditions consist of generally level to gently rolling terraces with a few isolated knolls.

Shovel testing was initiated from a proposed short road and landing adjacent the truck road where numerous surface artifacts had been observed/collected. The high archaeological potential of the area prompted testing in the block's southern portion below the truck road and north of the terrace/bench margin and block boundary. Testing was designed to ascertain if the archaeological site continued to the block's southern limits. Testing was also conducted on several small sandy knolls in the block's central interior.

Four (4) additional tests, conducted adjacent to the previous one conducted by Brandzin (2000), recovered one artifact from 43cm bs in TU76. The overall site area is calculated at approximately 150,000m2 (1000m n/s x 150m e/w). A total of 123 artifacts were collected from the site with thirty-nine from the surface, and eighty-four from test units. Cattle (i.e. trails & wallows) and the continued use of the nearby truck road(s) continue to impact the site.

No evaluative tests were conducted due to comparatively low artifact recoveries and unfavourable, stratigraphic resolution, deemed to have low potential to contain significant archaeological materials.

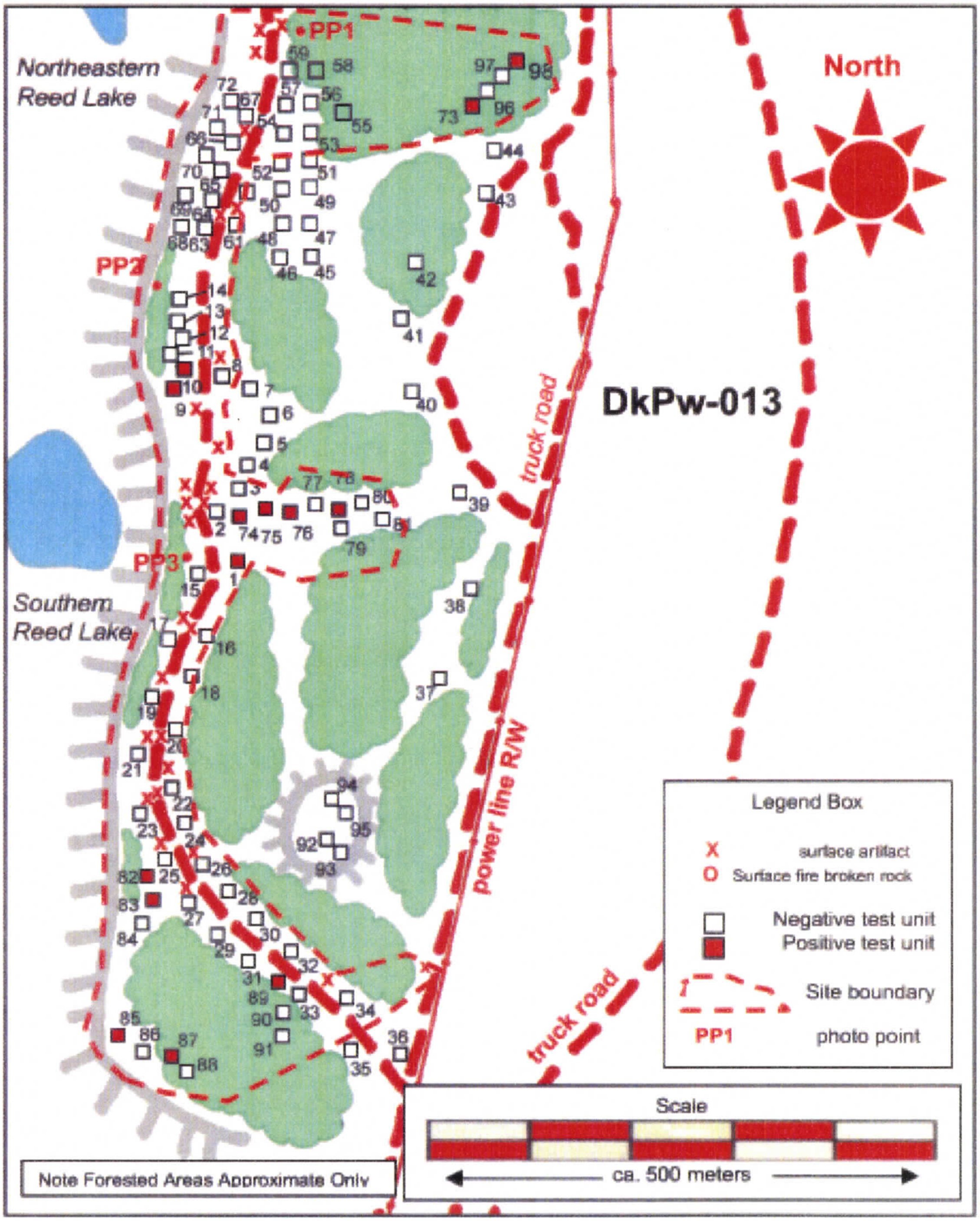

Figure 38: DkPw-013 Site Diagram (Wood *et.al.* 2002b)

Summary of Archaeological Inventory

Table 16 shows the results of shovel testing and artifact recovery at all sites.

Table 16: Summary of Archaeological Artifact Recovery at all Sites

Site	DlPw-023	DlPw-024	DlPw-025	DlPw-035	DlPw-036	DkPw-012	DkPw-013
Surface	826	4	170	2	8	11	39
0-10 cm	83	16	406	25	104	7	36
10-20	56	11	322	13	241	6	32
20-30	6	1	208	1	55	0	14
30-40	4	0	80	0	17	0	1
40-50		0	25	0	0	1	1
50-60 cm		0	1	0	0	0	0
Total # of Artifacts	**975**	**32**	**1631**	**41**	**425**	**25**	**123**

Figure 39 shows graphically the stratigraphic distribution of the artifacts at depth.

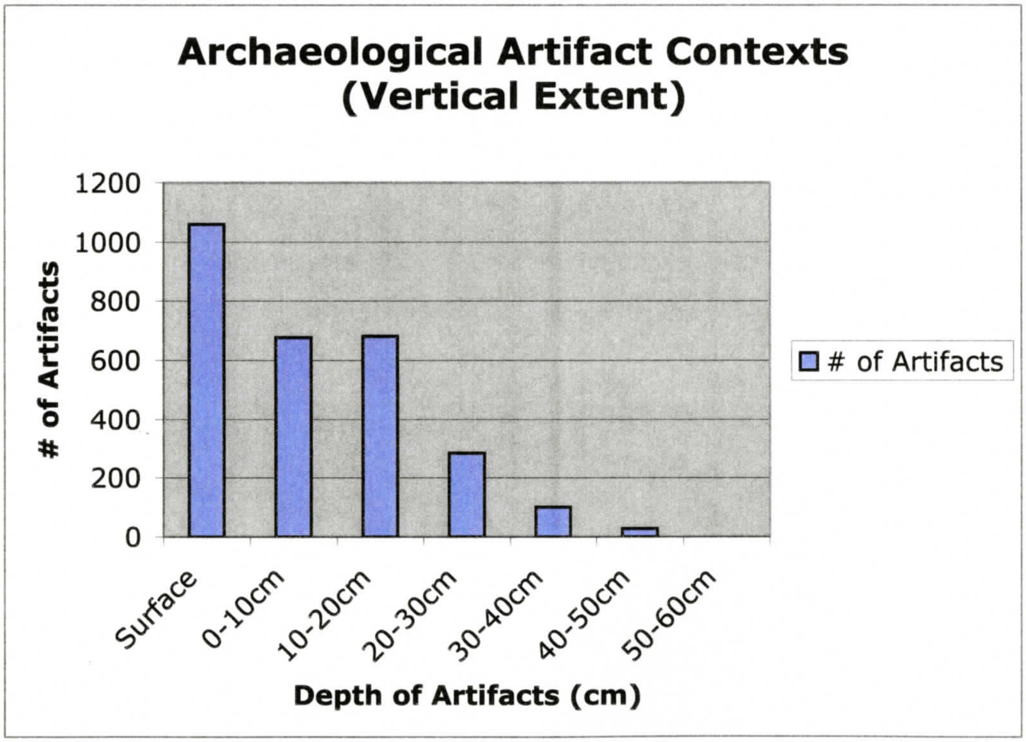

Figure 39: Stratigraphic Distribution of Recovered Archaeological Artifacts, all Sites

Most artifacts (85%) were found on the surface or in the top 20cm of soil, making this surface zone highly vulnerable to disturbance from ecological restoration and other activities. As noted in **Section 2.4** however, some of these surface and near-surface artifacts may have been disturbed by previous human-induced disturbance activities (logging, railway tie cutting, etc.) and are now in secondary context. The presence of the hearth feature at **DlPw-025** is the clearest indication of primary context material. Buried soils were also found in a number of excavation units.

4.4 Ecological Restoration Timber Treatment Reconnaissance

In the winters of 2002 and 2003, visual inspections were made of the current timber harvest methods used in ecological restoration prescriptions in the Rocky Mountain Trench. The intention of the inspections was to assess the potential for surface and subsurface disturbance by different equipment and methods. Timber harvest treatments visited in the field included the following examples:

- Hand falling, piling and burning
- Falling and hauling to 'cast-iron sloop' for burning
- Low impact feller-buncher and forwarder equipment
- Conventional feller-buncher and skidder equipment

4.4.1 Hand falling, piling and burning

A timber treatment contract was carried out at Alkali Lake, a kettle lake that has similar characteristics to the kettle lake research sites, and is similarly bordered by an archaeological site. Small diameter Douglas fir trees were fallen by hand (**Figure 40**), and piled for later burning. Work was carried out on frozen ground, with < 5cm of snow cover as shown in the photo. In general, surface disturbance was very limited in the harvest phase. Slash piles are left to dry for more than a year; some minor soil heating (<5cm depth) occurs where the slash piles are later burned during prescribed burning.

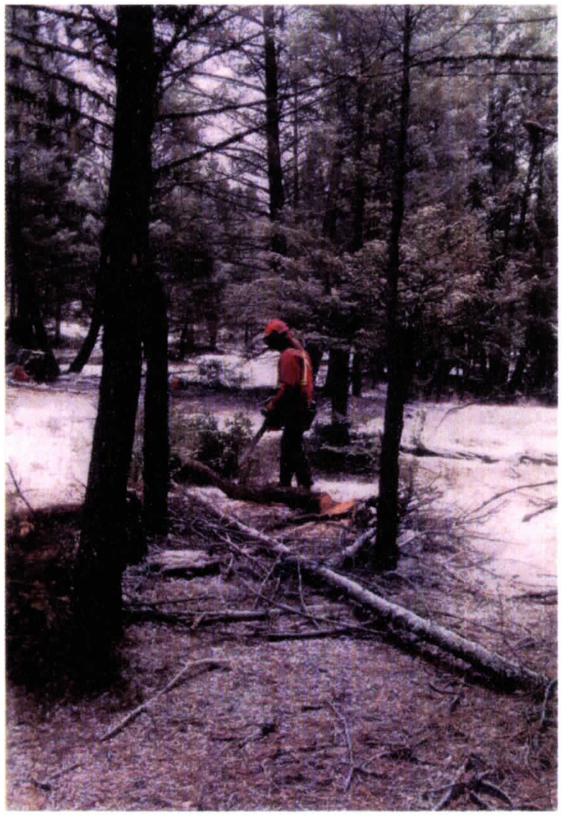

Figure 40: Hand falling of timber at Alkali Lake

4.4.2 Falling and hauling to 'cast-iron sloop' for burning

Some small contractors use a large cast-iron 'sloop' or basin for burning green slash left from timber treatments. A sloop is a large (5m x 10m x 1m) shallow barrel to which small caterpillar tractors or front-end loaders bring tree slash for burning. The resulting soil and surface disturbance includes:

- The movement of tree slash by small tractors off side slopes (**Figure 41**) causing subsurface disturbance to a depth of 5-10cm;
- The regular machine traffic coming and going from the sloop (**Figure 42**) producing subsurface disturbance of 5-10cm, and extensive surface compaction;
- The soil heating and burning under the sloop when slash is burned at high temperatures producing the possibility of altering cultural artifacts (**Figure 43**). (Normally the sloop is not placed in an area of High Archaeological Potential during the timber treatment).

Only two of these units are in operation, with irregular scheduling, thus making it difficult to conduct more detailed study of the amount of surface disturbance. Should use of this equipment become more common, an assessment should be done of their disturbance impacts.

Figure 41: Surface disturbance from caterpillar activity on side slope, Stoddard Creek

Figure 42: Front-end loader moving tree slash to sloop for burning at Stoddard Creek

Figure 43: Remains of slash burning at Stoddard Creek

4.4.3 Low impact feller-buncher and forwarder equipment

A trend gaining acceptance in the forest industry is use of low-impact rubber-tired timber harvesting equipment – both feller-bunchers and tree forwarders. This equipment is especially suited to harvest sites on soils sensitive to machine traffic, or with potential for surface disturbance under marginally suitable climatic conditions. Examples of this timber harvest equipment are shown in **Figures 44** and **45** from an operation in the upper part of the Rocky Mountain Trench east of Radium Hot Springs. Normally this equipment operates on snow cover and frozen ground. For added surface protection, a bed of green branch slash is laid down for the machines. However, surface disturbance of 5-10cm in depth can result from crushing and compaction of tree slash and branch tips into soil surface.

The few harvesters of this type are steadily in demand for harvest contracts, and it is hoped that their usefulness and popularity will lead more contractors to buy them in the future. They do however cost more than conventional timber harvest equipment.

Figure 44: Low impact feller buncher at work near Kootenay National Park

Figure 45: Skid trail with bed of green slash for low impact harvesting equipment

4.4.4 Conventional feller-buncher and skidder equipment

Feller-buncher and skidder timber harvest is the most commonly used in the BC Interior. Feller-bunchers have the potential for greatest surface disturbance because of their weight, metal tracks and jerky turning patterns. Repeated machine traffic by skidders, especially around log landings and at slash piles, has the potential to cause the following disturbance:

- Surface compaction at log landings and on skid roads;
- Subsurface disturbance to 10-20cm bs at log landings and on skid roads if winter conditions are not present or weakly developed;
- Subsurface disturbance to 10-50cm bs if tree roots are dislodged in the process of cutting timber.

Normally, log landings are not placed in areas of HAP during timber harvest. **Figures 46 and 47** show typical timber harvest operations at a site near Radium Hot Springs in Kootenay National Park. This equipment was used for timber harvest on all the research sites, and is the type of equipment most closely examined in this study.

Figure 46: Conventional Feller Bunchers at work near Radium Hot Springs, 2001

Figure 47: Surface disturbance at log pile from feller-buncher equipment, Radium Hot Springs, 2001

4.5 Post-Harvest Soil Disturbance Surveys (SDS's)

4.5.1 Soil disturbance surveys on timber blocks

Table 17 summarizes the site conditions, climatic conditions, timing of harvest and timing of Soil Disturbance Survey for each of the research sites. For all SDS's on timber blocks, survey transects were placed 5m apart, and survey points on each transect were spaced at 5m intervals. All Points of Commencement of SDS's were recorded with a GPS unit.

Table 17: Site Conditions During Timber Harvest at all Research Sites

Site	**Harvest Period**	**Soil Disturbance Survey**	**Snow Cover Present**	**Temperatures Present**	**Frost Depth**
DlPw-023	Feb 2004	April 2004	20-30 cm	(- 5) to (-10) °C	15 cm
DlPw-024	Control Site				
DlPw-025	March 2005	April 2005	< 5 cm	(-3) to (+ 6) ° C	10 cm
DlPw-035	Feb 2005	April 2005	< 5 cm	(-3) to (+3) ° C	10 cm
DlPw-036	Feb 2004	April 2004	20-30 cm	(-5) to (-10) ° C	15 cm
DkPw-012	Feb 2004	April 2004	20-30 cm	(-5) to (-10) ° C	15 cm
DkPw-013	Feb 2004	April 2004	20-30 cm	(-5) to (-10) ° C	15 cm

Soil disturbance was recorded according to the following values on each survey block in **Table 18**:

Table 18: Disturbance Values used for Soil Disturbance Surveys

Disturbance value	Interpretation
0	No surface impact
1	Minor surface disturbance < 5cm depth below surface
2	Surface disturbance > 5cm depth below surface
3	Skid trail compaction
4	Slash on surface
5	Area outside timber block boundary

Site DlPw-023

Figure 48 shows the timber harvest conditions and equipment being utilized on the timber block. **Figure 49** shows the conditions of the ground surface in April on a skid trail.

Figure 48: Tree de-limber operating at Site DlPw-023 in winter of 2004

Figure 49: Skid trail on edge of Site DlPw-023 in spring of 2004

The SDS baseline was placed along the Forest Service Road (FSR) southwest of the kettle lake. The Point of Commencement (POC) for the survey was 53m north of the intersection of the west side FSR with a spur road heading northeast (**Figure 51**), and transects ran east from the FSR at an angle of 70ºE, for a total of 400 survey points on Unit 6 of the timber cutblock. The results of the SDS for **DlPw-023** are shown in **Figure 50**. A separate survey was completed for surface disturbance of the west side FSR (see **Section 4.5.2**)

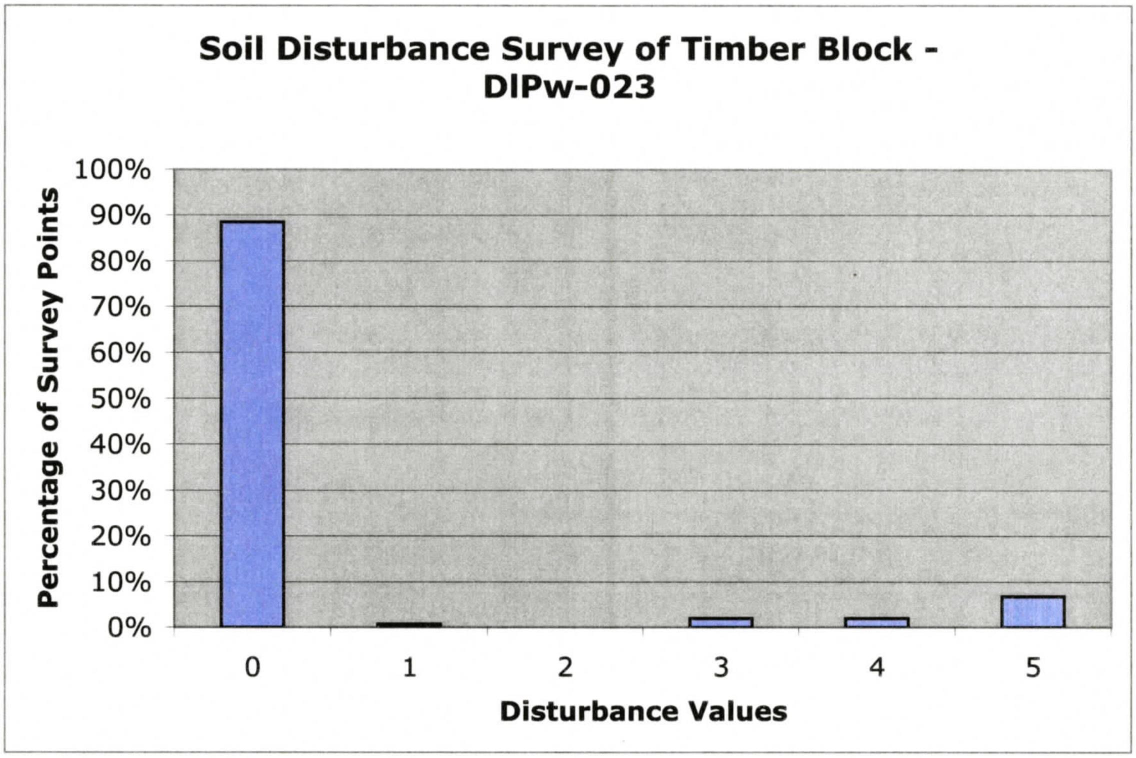

Figure 50: Summary of Soil Disturbance Survey at Site DlPw-023 (see Table 18 for disturbance values)

Almost 90% of the timber block surveyed had no surface disturbance, with minor incidence of surface disturbance < 5cm, and compaction on timber skid trails. Visual survey of the ground surface during the SDS encountered six lithic artifacts: one large stone artifact on a skid trail in the center of the survey area (**Figure 53**), three small olive-coloured tourmalinite artifacts north of a slash pile on the edge of the site, and two small darker-coloured tourmalinite artifacts in the same area. Artifacts were not collected, as the Archaeology Branch permit did not allow for surface collection without an archaeologist on site.

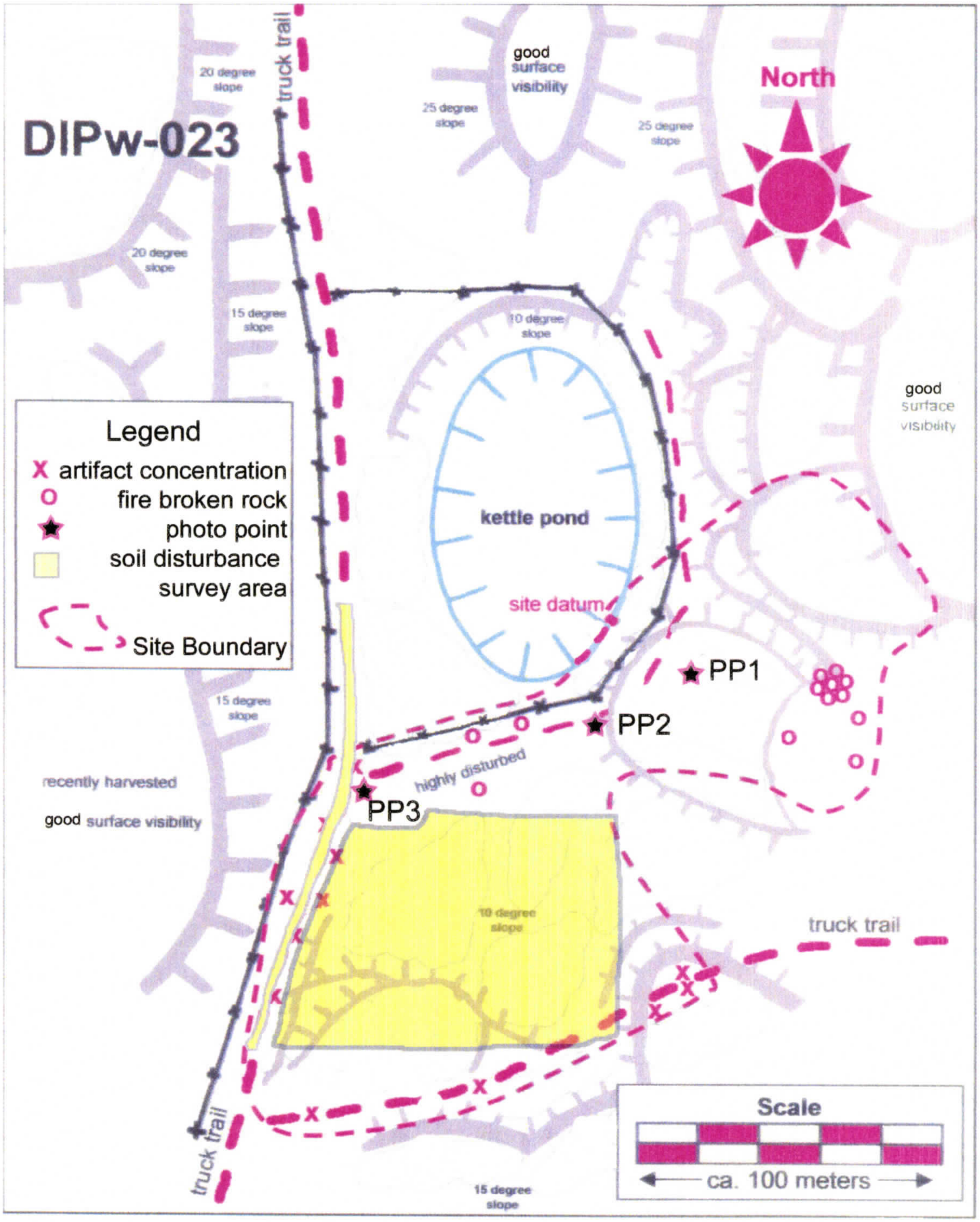

Figure 51: Soil Disturbance Survey Area at Site DlPw-023 (Spring 2004)

Figure 52: Field biologist Peter Davidson marking the baseline for SDS at Site DlPw-023

Figure 53: Stone tool (?) found on skid trail of Site DlPw-023

Site DlPw-025

The SDS baseline was placed along the FSR running at an angle of 10°E and adjacent to the timber block, and east of the kettle lake. The POC for the survey was at a stump adjacent to the Timber Block boundary on the edge of the FSR (**Figure 54 and Figure 55**).

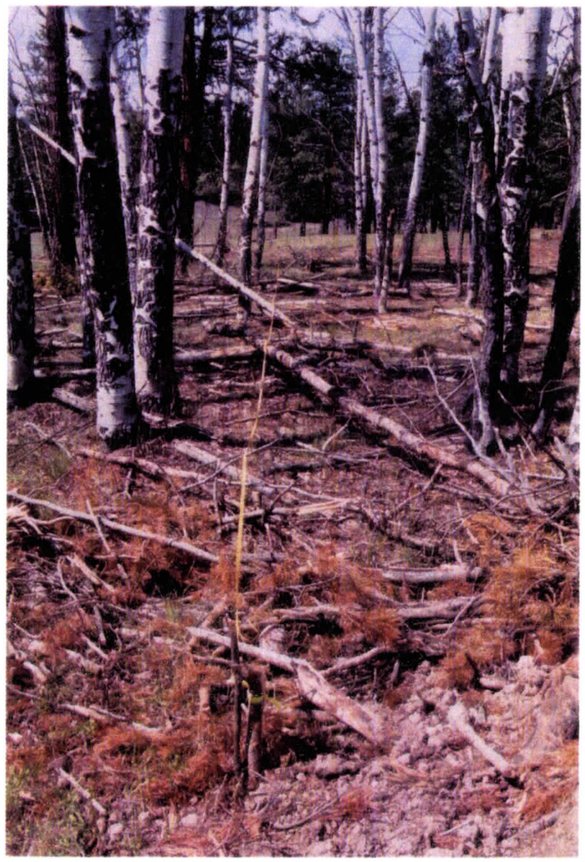

Figure 54: Soil Disturbance Survey line through timber cutblock at Site DlPw-025

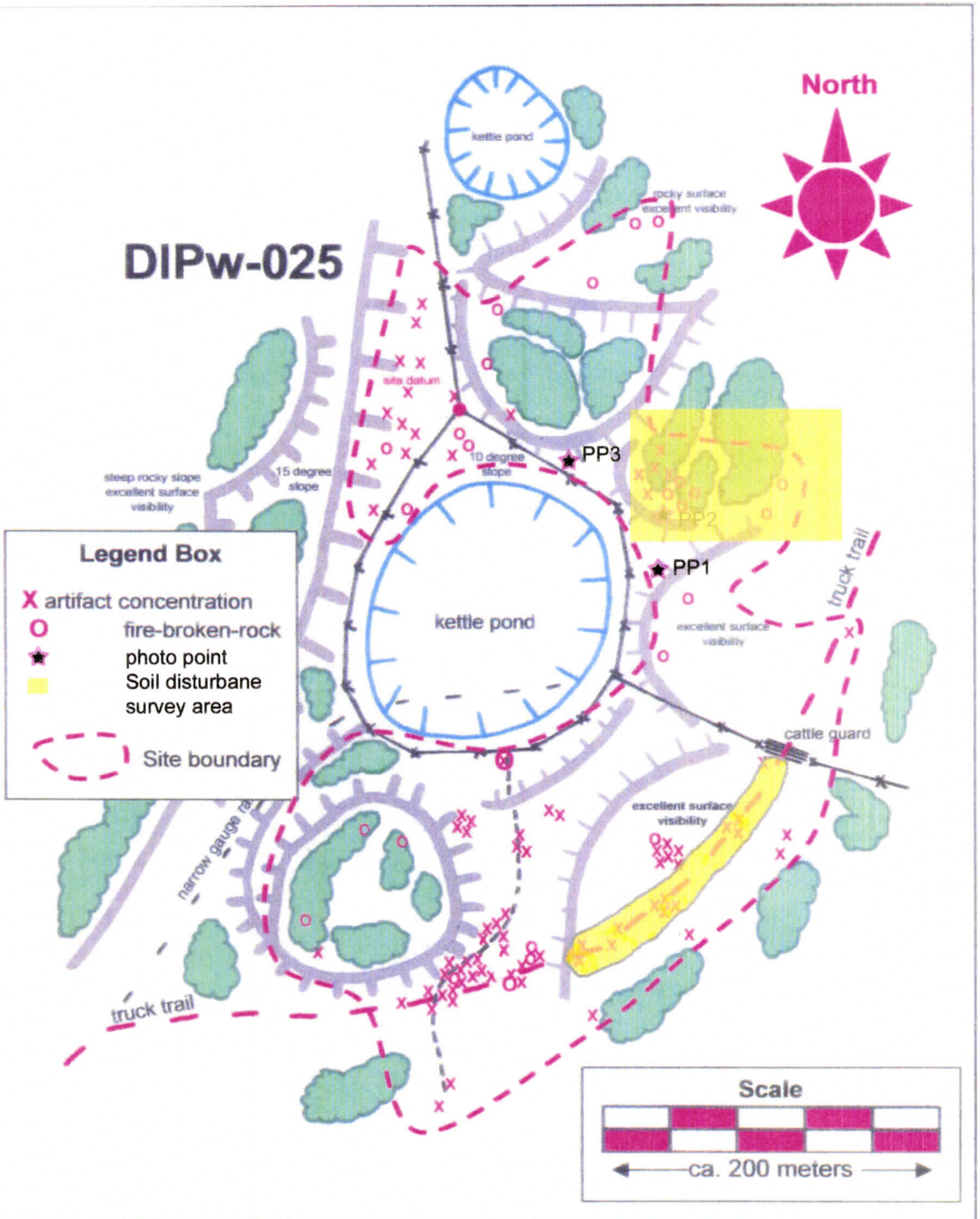

Figure 55: Soil Disturbance Survey Area at Site DIPw-025 (Spring 2005)

SDS transects ran west from the FSR at an angle of 280°W, for a total of 135 survey points in Unit 1 of the timber cutblock. This was a small timber block, bounded on the east side by the FSR and on the west side by a range fence, so the SDS was less than the standard size. The results of the SDS are shown in **Figure 56.** In addition to the SDS, a separate survey was completed for surface disturbance of the FSR south of the timber cutblock (see **Section 4.5.2).**

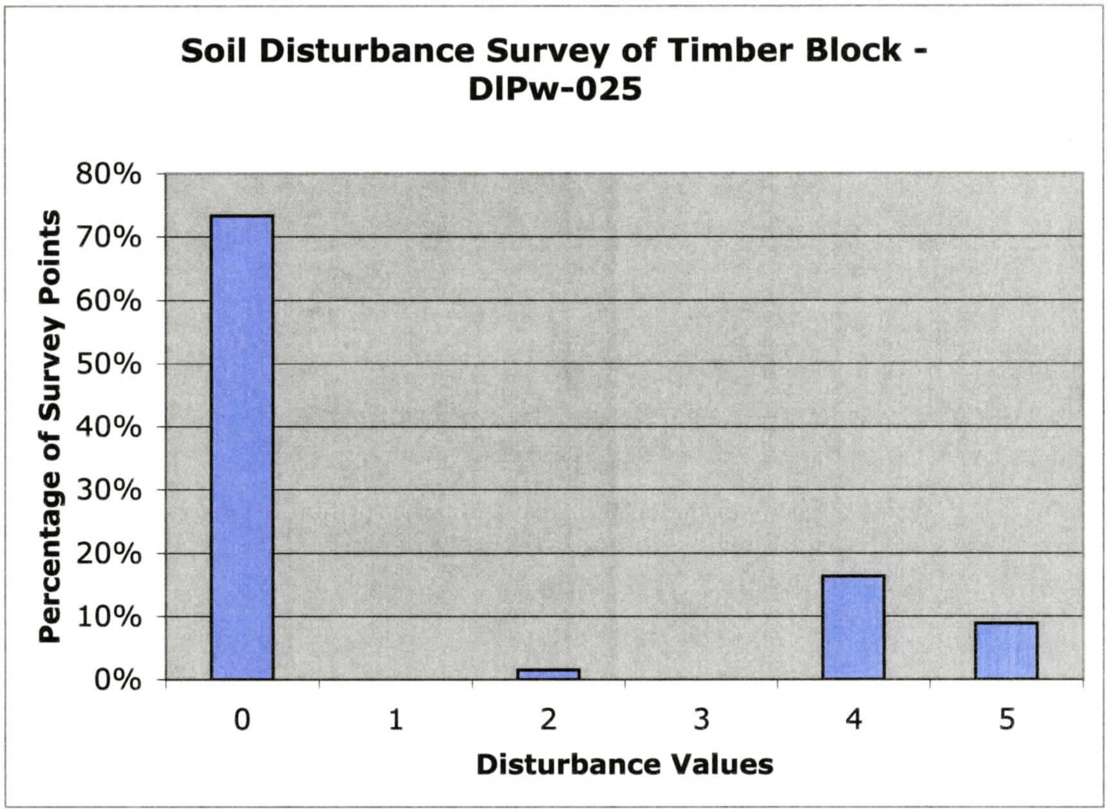

Figure 56: Summary of Soil Disturbance Survey at Site DlPw-025 (see Table 18 for disturbance values)

About 73% of the timber block had no surface disturbance. The main disturbance value observed was the presence of logging slash left on the surface following harvest. Despite marginal winter conditions, little surface disturbance resulted from harvest of this small timber block. No artifacts were encountered on the ground surface through visual inspection during the course of the SDS. A small hearth feature located in the center of the cutblock was flagged off to alert equipment operators and was not disturbed during the timber harvest (**Figure 57**). This is the only diagnostic intact feature on the surface of all of the research sites, and a valuable indicator of archaeological material in primary context.

Figure 57: Small hearth feature in center of timber cutblock at Site DlPw-025

Site DlPw-035

Figure 58 shows the ground conditions during timber harvest in the spring of 2005. The SDS baseline was placed 20m west of the Forest Service Road (FSR) and north of the kettle lake, and the baseline ran northwest at an angle of 330°NW. The Point of Commencement (POC) for the survey was at the southeast timber block boundary of Unit 2, (**Figure 60**). Transects ran west from the FSR at an angle of 90°E, for a total of 133 survey points on Unit 2 of the timber cutblock. The results of the SDS for **DlPw-023** are shown in **Figure 59.** This was a small timber block, the majority of which was outside the boundary of the archaeological site, so the SDS was smaller than standard size.

Figure 58: Limited snow cover and frozen ground conditions at Site DlPw-035, winter of 2005

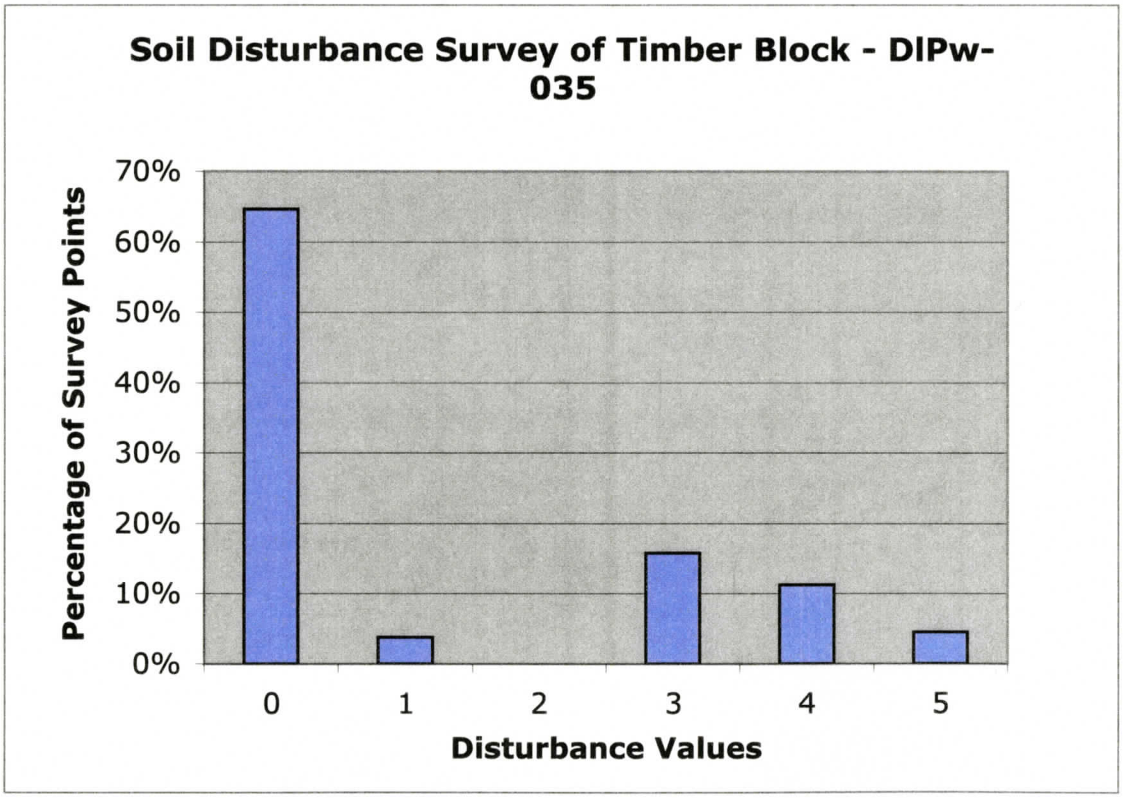

Figure 59: Summary of Soil Disturbance Survey at Site DlPw-035 (see Table 18 for disturbance values)

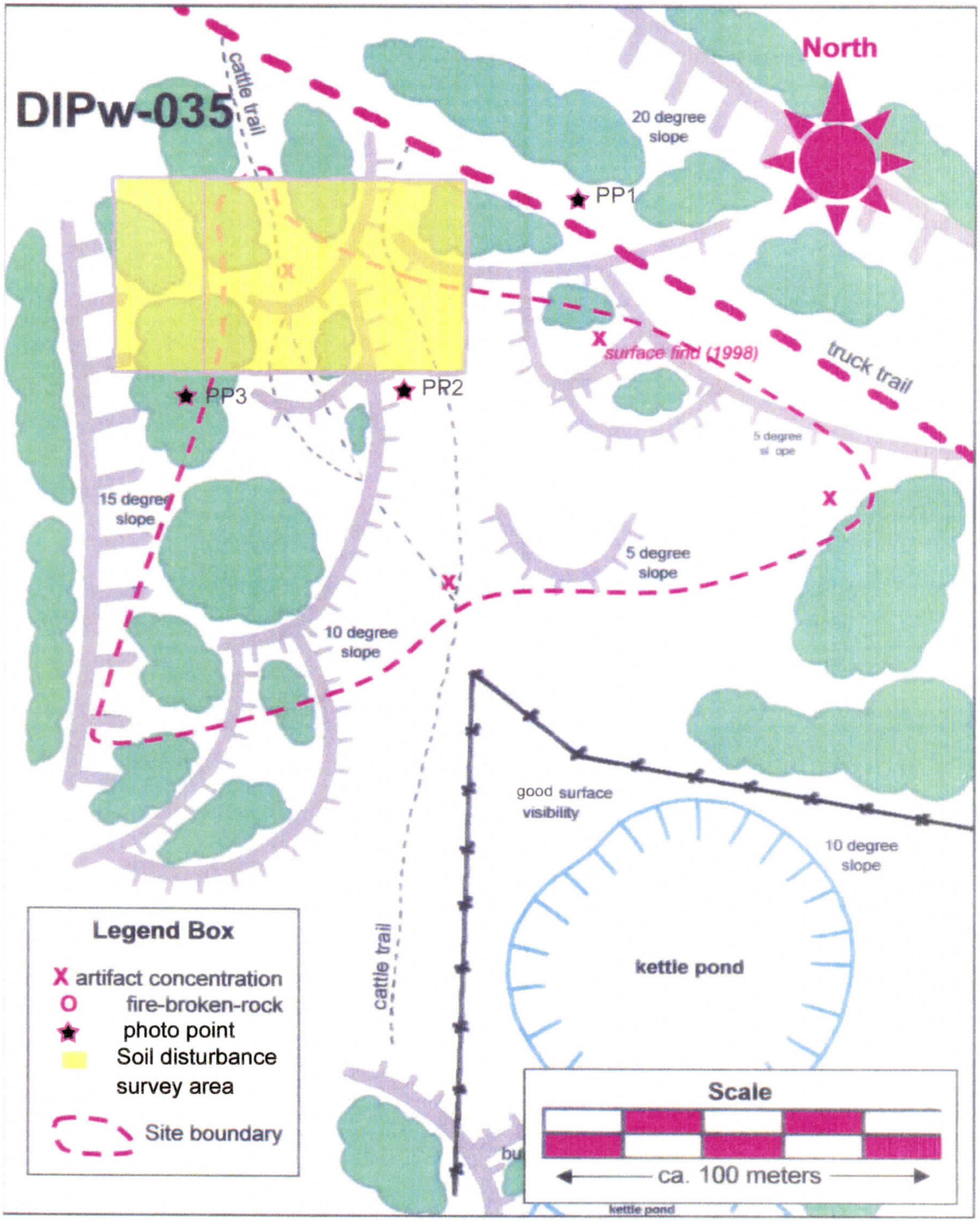

Figure 60: Soil Disturbance Survey Area at Site DIPw-035 (Spring 2005)

Sixty-five percent of the timber block had no surface disturbance; a large skid trail (**Figure 61**) in the center of the SDS accounted for most of the site disturbance by compacting the soil; at the edge of the SDS, log skidding over a small knoll produced minor surface disturbance to a depth of 5cm. No surface artifacts were encountered during the visual inspection of the timber block during the SDS.

Figure 61: Skid trail in center of SDS area at Site DlPw-035

Site DlPw-036.

Figure 62 shows the conditions of the ground surface in April of 2004 on the timber block. The SDS baseline was placed along the Forest Service Road (FSR) southeast of the kettle lake. The Point of Commencement (POC) for the survey was at Photopoint Monitoring Point #1, adjacent to the FSR (**Figure 64**). Transects ran west from the FSR at an angle of 250°SW, for a total of 160 survey points on Unit 3 of the timber cutblock. The results of the SDS for **DlPw-036** are shown in **Figure 63.**

Figure 62: Laying out SDS chain on Site DlPw-036, April 2004

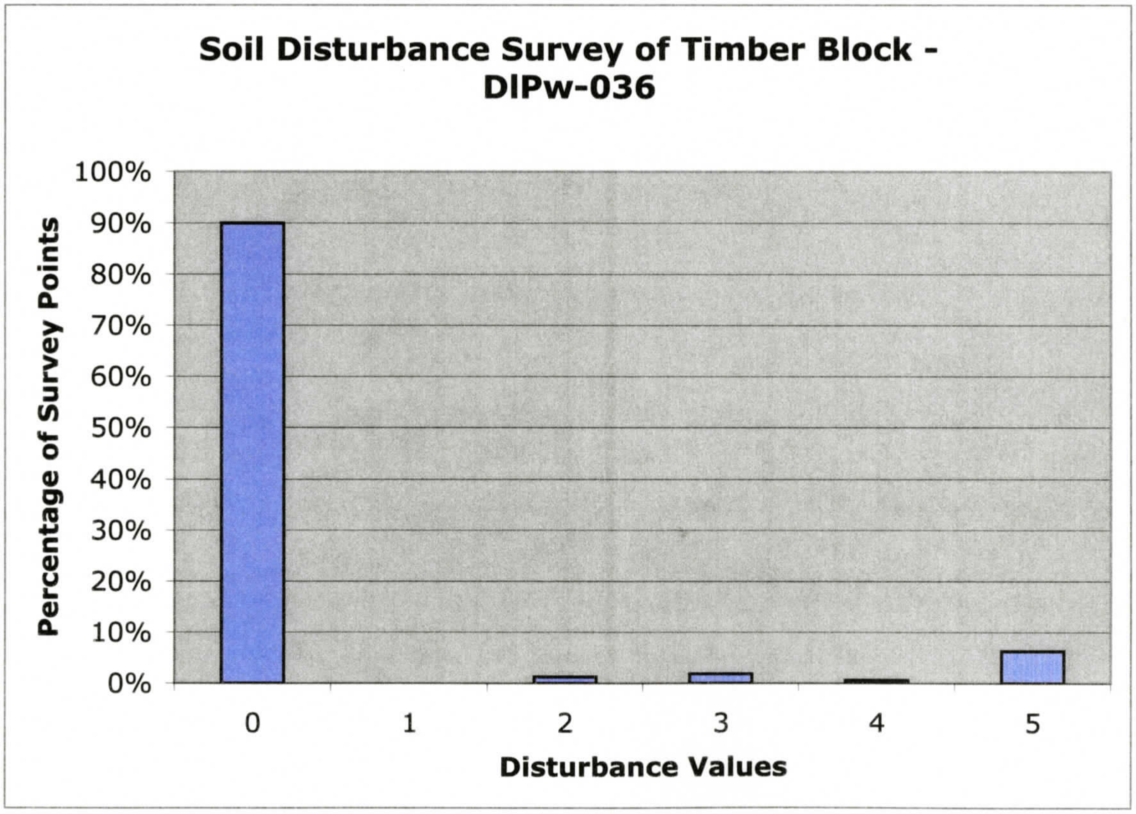

Figure 63: Summary of Soil Disturbance Survey at Site DlPw-036 (see Table 18 for disturbance values)

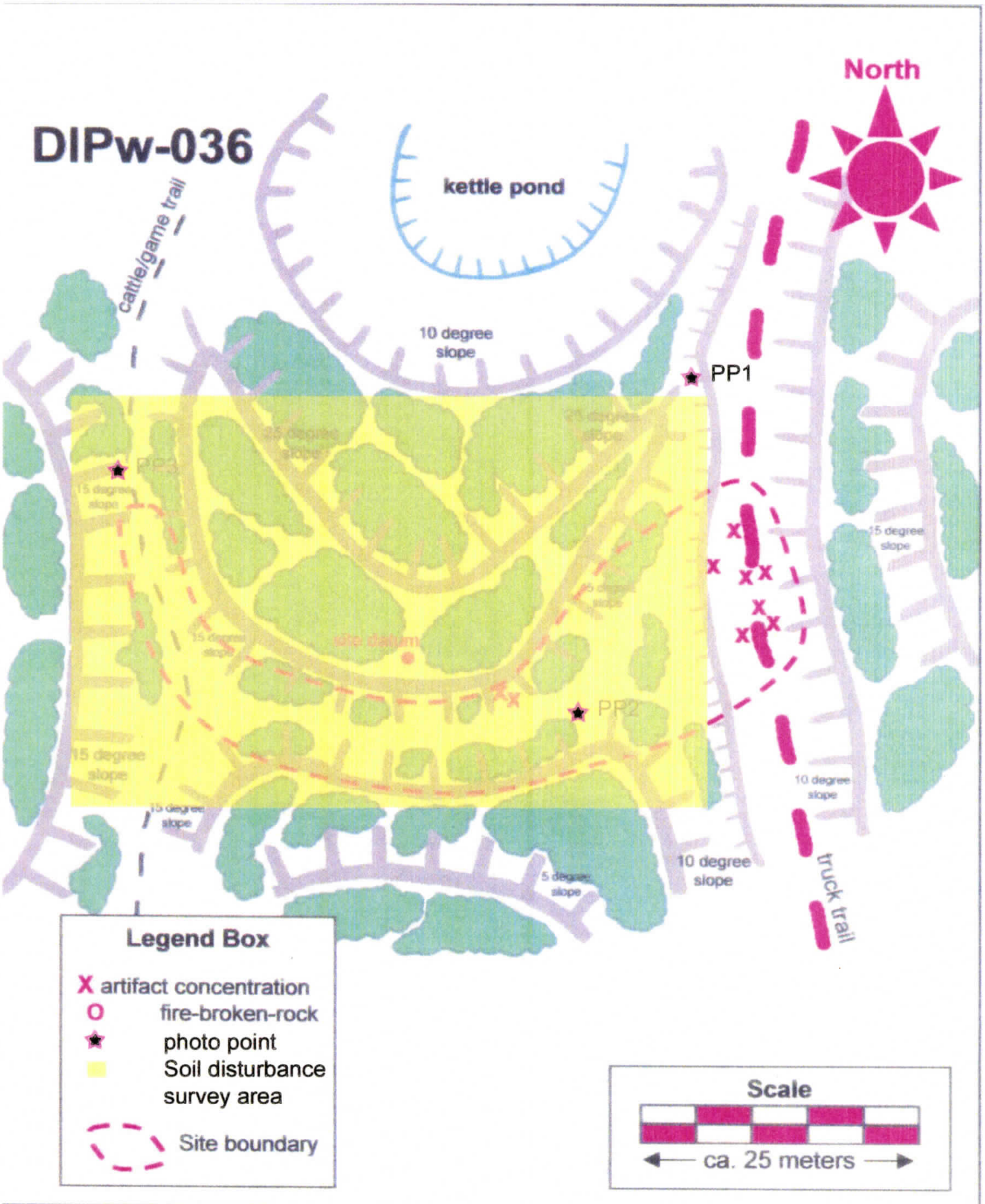

Figure 64: Soil Disturbance Survey Area at Site DlPw-036 (Spring 2004)

Though 90% of the timber block surveyed had no surface disturbance, there was a large machine gouge from a timber skidder on the surface that the SDS did not register (**Figure 65**). The gouge exceeded 20cm in depth in places, and such disturbance would cause serious impact to surface or buried cultural deposits. No artifacts were encountered on the ground surface through visual inspection during the course of the SDS.

Figure 65: Deep gouge from skidder at Site DlPw-036, spring of 2004

Site DkPw-012

Figure 66 shows the conditions of the ground surface in April on the timber block. The SDS baseline was placed perpendicular to the Forest Service Road (FSR) running northwest of the kettle lake. The baseline heading was 50°NE. The Point of Commencement (POC) for the survey was near Photopoint Monitoring Point #3, at an old stump adjacent to the FSR (**Figure 67 and Figure 69**). Transects ran west from the FSR at an angle of 320°NW, for a total of 288 survey points on CP **Unit 004** of the timber cutblock. The results of the SDS for **DkPw-012** are shown in **Figure 68.**

Figure 66: Ground conditions following timber harvest on Site DkPw-012, spring of 2004

Figure 67: Point of Commencement of baseline for SDS at Site DkPw-012, spring of 2004

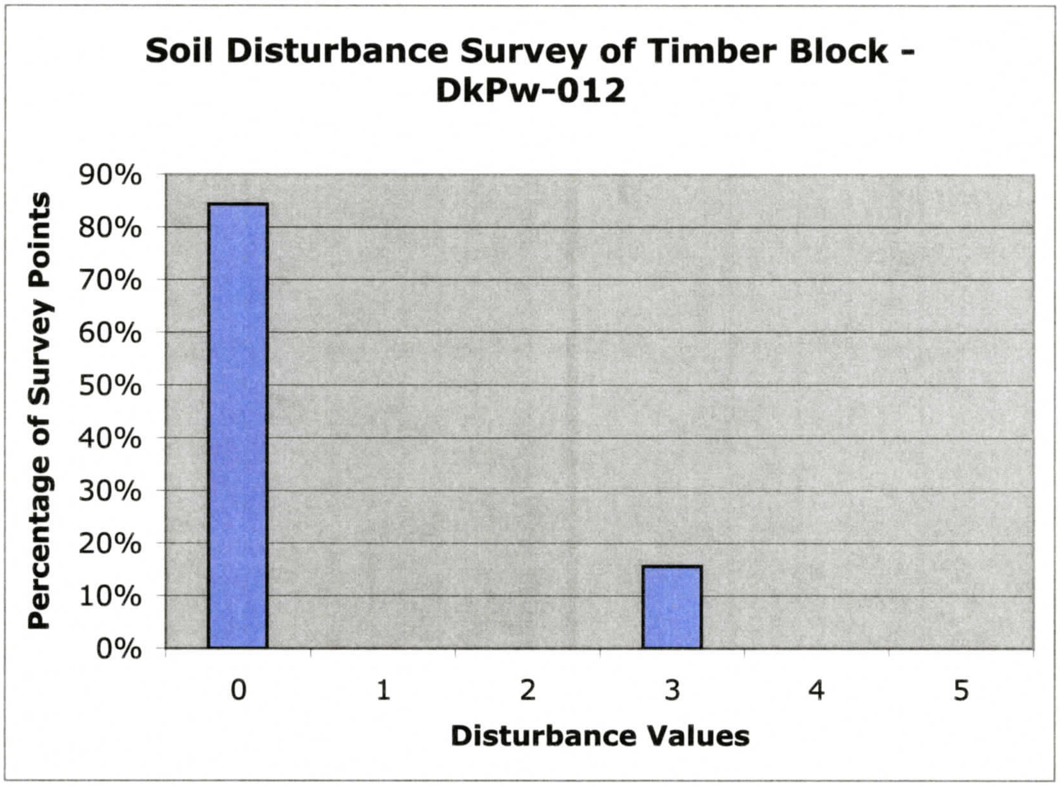

Figure 68: Summary of Soil Disturbance Survey at Site DkPw-012 (see Table 18 for disturbance values)

Eighty-five percent of the cutblock had an undisturbed surface, with the major disturbance being skid trail compaction on a side slope on the northeast side of the survey area. No disturbance took place in the circular depression at the southeast corner of the cutblock. No artifacts were encountered on the ground surface through visual inspection during the course of the SDS.

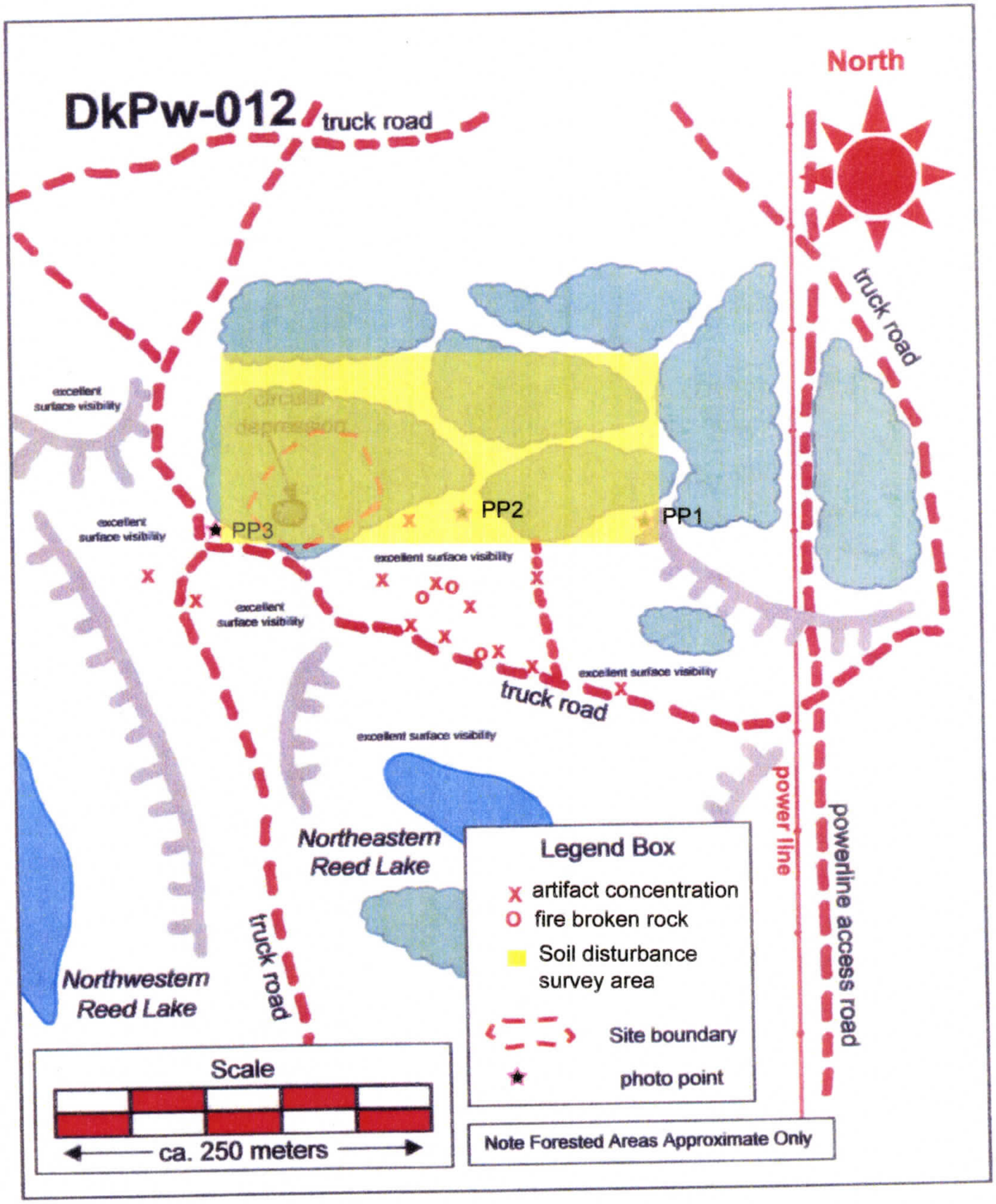

Figure 69: Soil Disturbance Survey Area at Site DkPw-012 (Spring 2004)

Site DkPw-013

The SDS baseline was placed parallel to the upgraded Forest Service Road (FSR) running east of the kettle lake, with the baseline along the bearing of 180°S. The Point of Commencement (POC) for the survey was at a stump 10m south from the intersection of the main FSR and a spur road running to the log landing, opposite Photopoint Monitoring Point #3, (**Figure 70**).

Figure 70: Point of Commencement of SDS for Site DkPw-013, spring of 2004

Survey transects ran east from the FSR at an angle of 90°E, for a total of 400 survey points on CP **Unit 005** of the timber cutblock (**Figure 71**). The results of the SDS for **DkPw-013** are shown in **Figure 72.** A separate survey was completed for surface disturbance of the east side FSR (see **Section 4.5.2).**

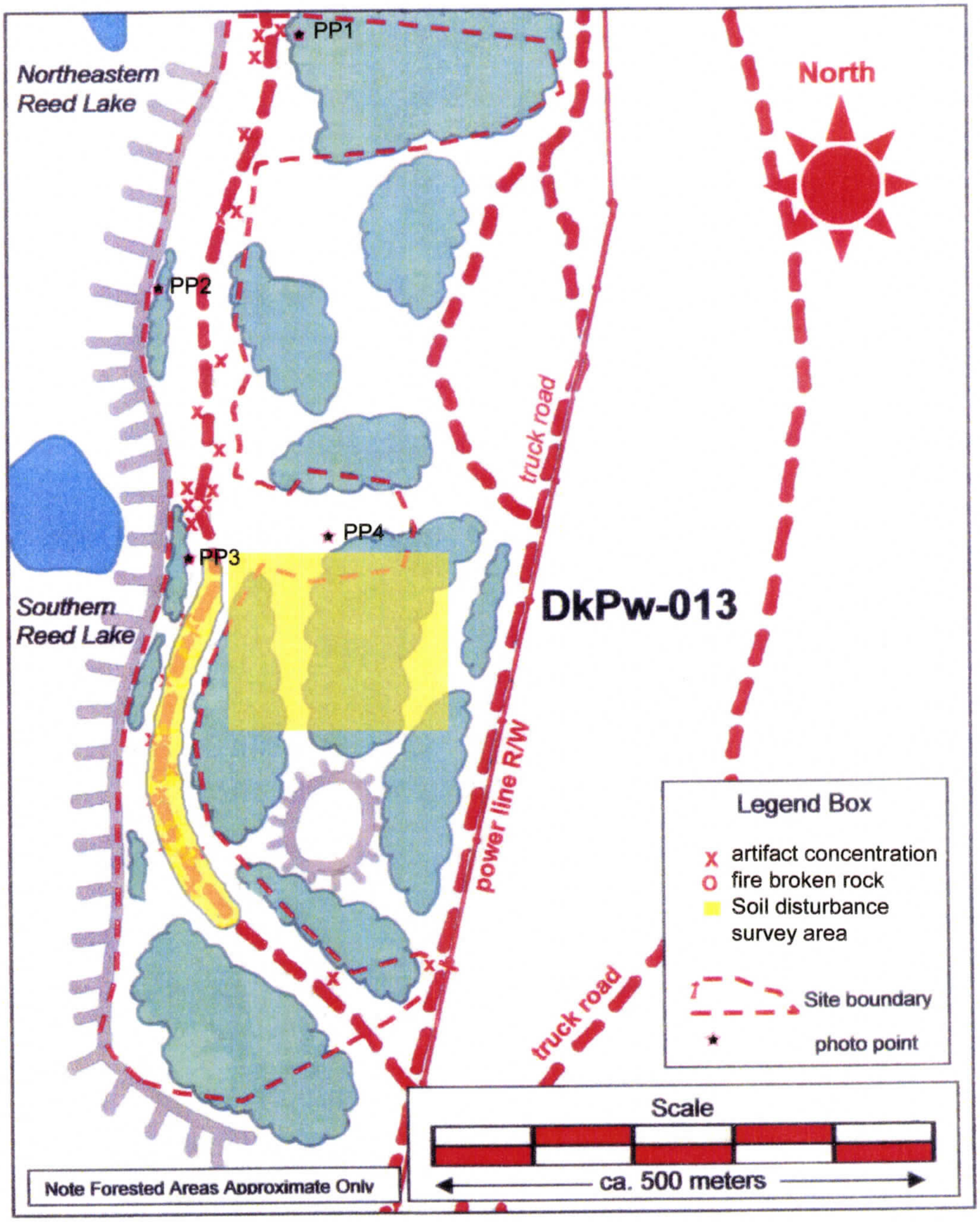

Figure 71: Soil Disturbance Survey Area at Site DkPw-013 (Spring 2004)

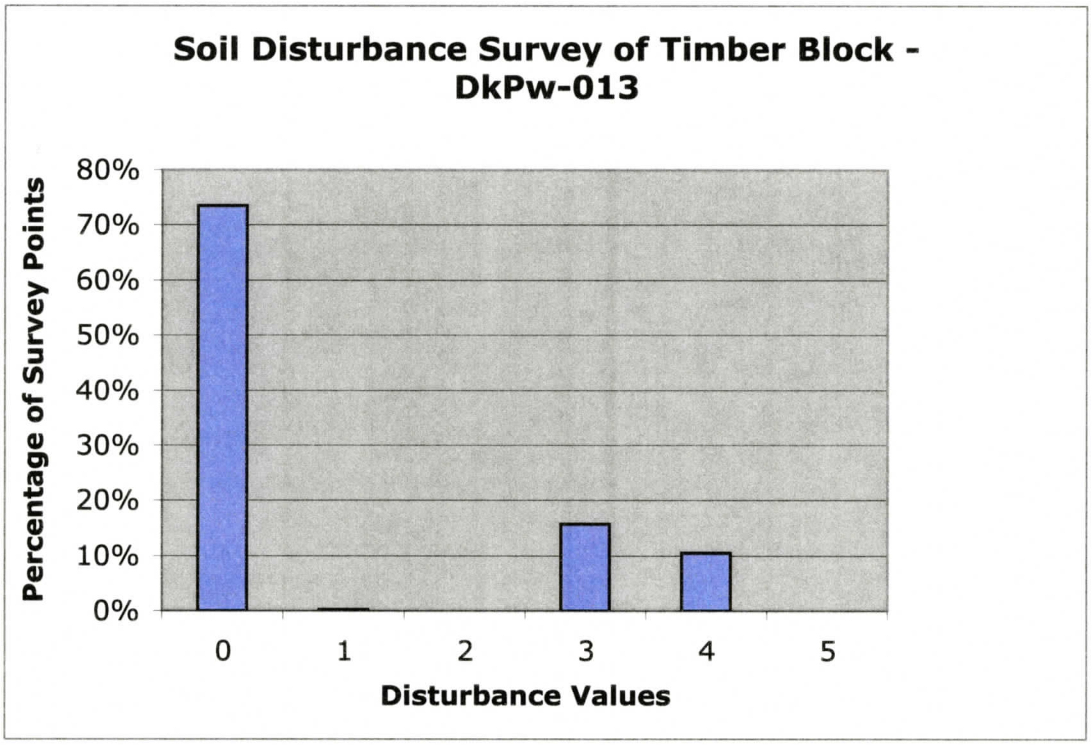

Figure 72: Summary of Soil Disturbance Survey at Site DkPw-013 (see Table 18 for disturbance values)

Again, under ideal winter conditions, soil surface disturbance on the cutblock was at a minimum; almost 75% of the SDS area experienced no surface disturbance, with skid trail compaction and timber slash being the two main disturbances recorded (**Figure 73**) No artifacts were encountered on the ground through visual inspection during the course of the SDS. The majority of survey effort was concentrated on the area of road upgrade adjacent to the timber block.

Figure 73: Skid trail on timber block at Site DkPw-013, spring of 2004

Table 19 summarizes soil disturbance impacts for all timber blocks.

Table 19: Summary of Impacts of Timber Harvest at Research Sites

	Timber Harvest Activities		
Research Site	**Type of Impact**	**Extent of Impact (% Soil disturbance in SDS area)**	**Duration of Impact**
DlPw-023	Minor surface disturbance (<5cm), compaction	10 %	Temporary
DlPw-024	Control Site	Control Site	Control Site
DlPw-025	Minor surface disturbance (>5cm), logging slash	23%	Temporary (except for root throw)
DlPw-035	Minor surface disturbance (<5cm), compaction	35%	Temporary
DlPw-036	Minor surface disturbance (>5cm)	10%	Temporary (except for machine gouge)
DkPw-012	Soil compaction	15%	Temporary
DkPw-013	Soil compaction, logging slash	25%	Temporary

4.5.2 Access road soil disturbance survey

Site DkPw-013

The Forest Service Road running parallel to middle Reed Lakes and through archaeological site **DkPw-013** was upgraded prior to timber harvest in the winter of 2004. The upgrade was undertaken and completed under the terms of a Road Permit issued by the Ministry of Forests, but this permit required no consultation with the Ktunaxa Kinbasket Treaty Council (KKTC), and the resulting disturbance to the site almost brought my project research to a complete halt. The Site Alteration Permit from the Archaeology Branch did not stipulate any road upgrade either. Many artifacts were turned up during the road upgrade, and the site disturbed to depths of 0.9m. Following some tense discussion about these actions, which involved the timber licencee, Tembec Inc., the Ministry of Forests, KKTC and consulting archaeologists, it was decided that timber harvest would proceed, as winter conditions were appropriate for the harvest.

The SDS of the road upgrade and spur road to the new log landing were completed in the spring of 2004. A small SDS was completed for the access spur road; the POC of the survey was the intersection of the spur road with the edge of the log landing, to the east of the kettle lake. **Figure 74** shows the condition of the access road. At 0-50-100m intervals, the road width was measured, as well as the depth of subsurface cut of the roadbed and ditch.

Figure 74: Conditions left on access road following timber harvest at Site DkPw-013

As this was a new access road to the log landing, there was no control site for pre-disturbance comparison. The new access road ranged from 9-16m wide at one survey point, including overburden on the east side, road running surface, ditch and overburden on the west side. Ditch depth ranged from 0.3-0.7m, and overburden covering the archaeological site had a depth of 0.2m at several survey points. The construction of even this short access road in the midst of an archaeological site of HAP, with known concentrations of lithic artifacts on the surface of the existing FSR and near the surface of the rest of the site, would be expected to cause major negative impacts to the stratigraphic integrity of site **DkPw-013**. However, no surface artifacts were encountered through visual inspection during the course of the SDS. Any artifacts present may have been turned over and buried in the road overburden, or the location of the log landing may have been east of the boundary of the archaeological site.

For the larger road upgrade SDS, the POC for the survey was at a control point on the existing road surface, 10m north of the intersection of the access spur road with the main road. (**Figure 75**) The SDS proceeded south, with survey points measured every 50m south for a distance of 400m. The road width was measured, as well as the depth of subsurface cut of the roadbed and ditch.

Figure 75: Condition of Forest Service Road before upgrade at Site DkPw-013

The upgrade of the FSR without any notice to KKTC staff caused significant damage to the stratigraphic and cultural integrity of site **DkPw-013**. **Figures 77, 78 and 79** show some of the damage: uprooting of countless trees with stumps left on the surface; ditch depths ranging from 0.5m down to as much as 0.9m at one survey point; the mean increase in ditch depth from the control point was 0.57m, with a standard deviation of 0.23m. Overburden left on top of the surface on the west side of the road ranged from 5.6-9.5m in width, with a depth of 0.2-0.3m. The road surface increased from an average width of 2.5m of running surface with no ditch or overburden, to a width ranging from 12.7m to 18.9m. The mean increase in road width from the control point was 13.86m, with a standard deviation of 1.89m. No estimate was made of the actual volume of soil material displaced within the boundaries of the archaeological site, much of it to depths far exceeding the critical threshold of 20cm for the upper sensitive soil layers. Results for the SDS are shown in **Figure 76.**

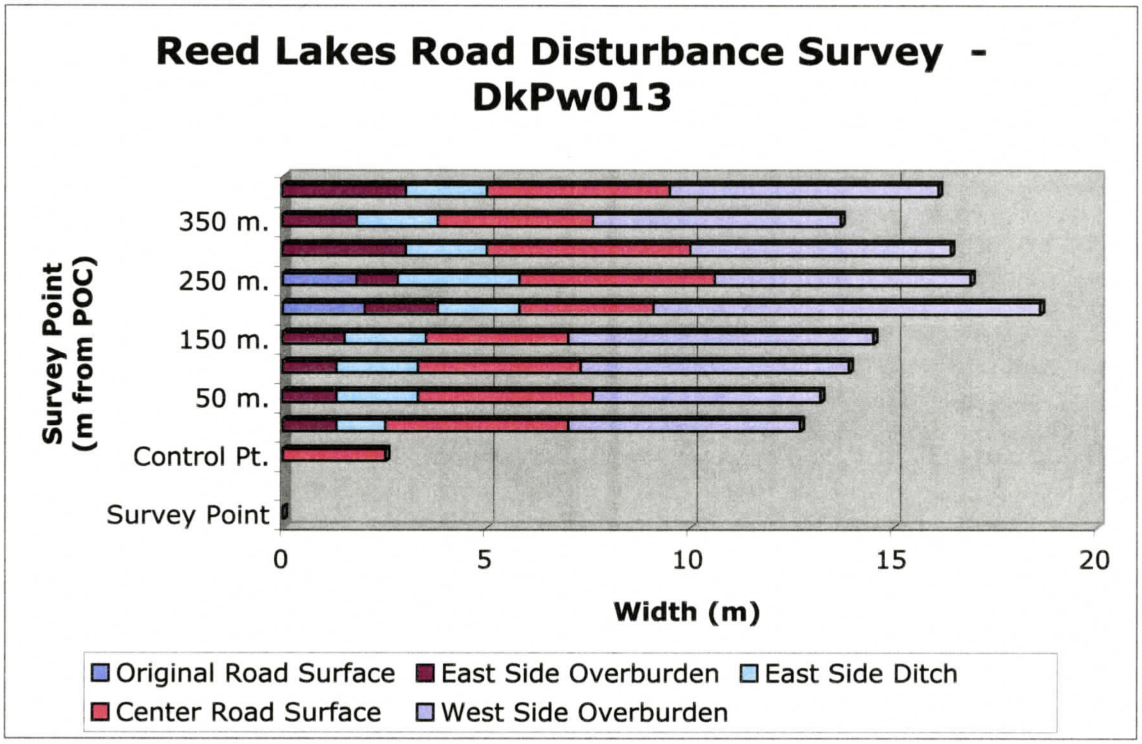

Figure 76: Summary of surface disturbance at Site DkPw-013

Forty lithic artifacts were found on the surface of the road, in the ditch and on top of the overburden during the course of the SDS (**Figure 80**). These artifacts were left in place and not collected, as the Archaeology Branch permit did not allow for surface collection without an archaeologist being present.

Figure 77: Condition of upgraded timber haul road bisecting Site DkPw-013, looking south

Figure 78: Large expanse of overburden on west side of upgraded FSR, looking north

Figure 79: Ministry of Forests Soils Technician Simon Brooks assisting with SDS measurements

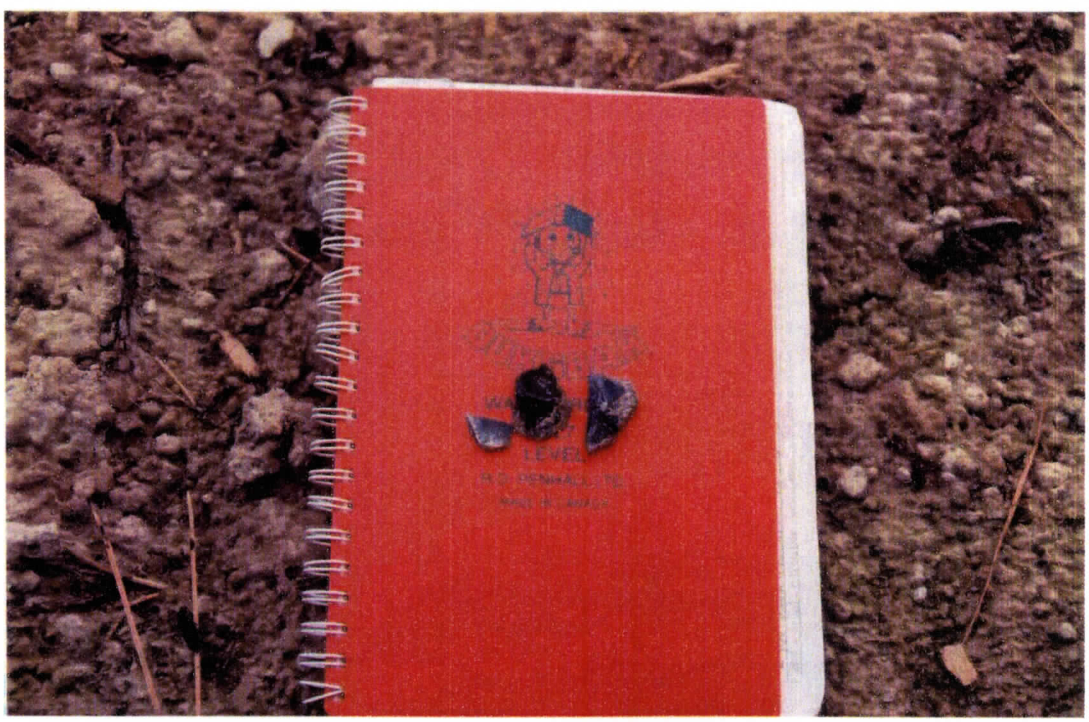

Figure 80: Lithic artifacts found on road surface of upgraded FSR at Site DkPw-013

Site DlPw-023

In the spring of 2004, the Ministry of Forests scraped the surface of the FSR west of the kettle lake, running through archaeological site **DlPw-023**. This work was done to uncover mineral soil and prepare the FSR to serve as a fireguard for a prescribed burn taking place on the adjacent timber block to the west. The KKTC was not consulted about this activity, nor did the Site Alteration Permit cover this activity. Surface disturbance resulted from this action. A SDS was completed on the road upgrade in the spring of 2004 following the prescribed burn.

POC for the SDS was at a control point on the existing road 50m north of a gate in the range fence on the FSR, adjacent to the kettle lake. **Figure 81** shows the surface disturbance following road scraping.

Figure 81: Surface disturbance from road blading at Site DlPw-023, looking north

The SDS proceeded south, with survey points every 50m for a distance of 200m. The road width was measured, as well as the depth of subsurface cut of the roadbed. Note was made of the presence of surface artifacts uncovered during road upgrading. Results for the SDS are shown in **Figure 82.**

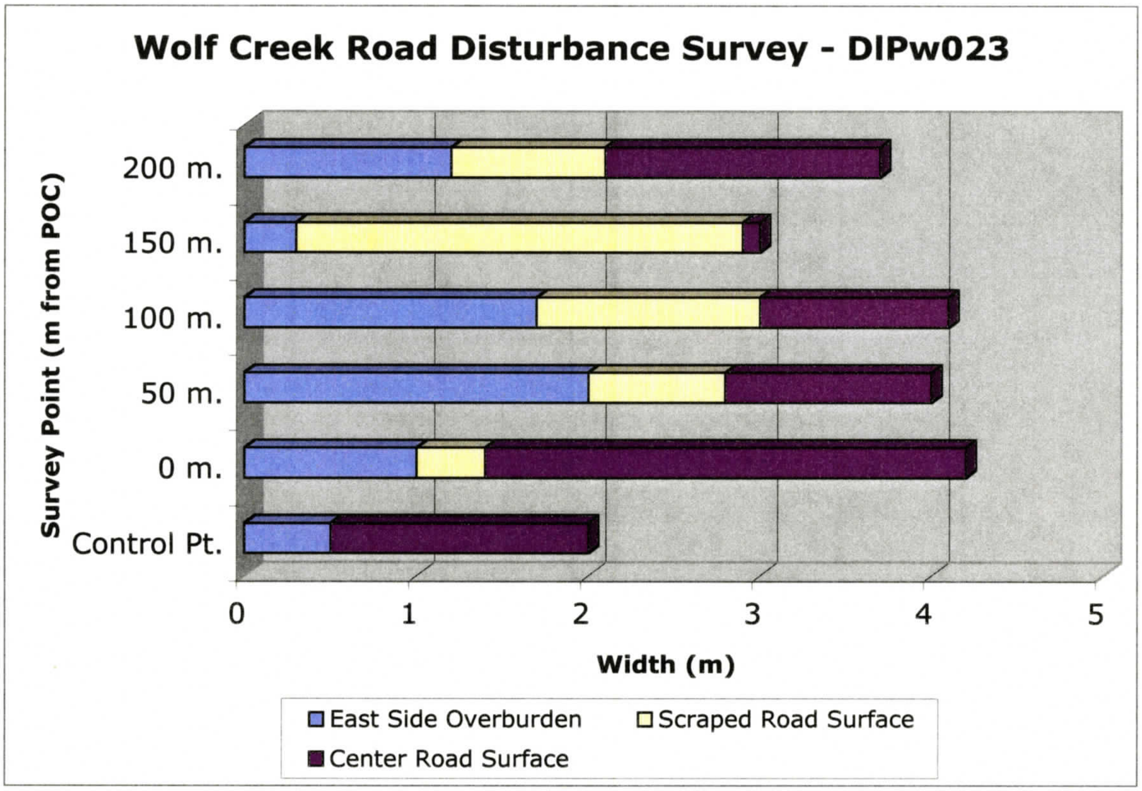

Figure 82: Summary of surface disturbance on road at Site DlPw-023

Road width increased with this disturbance from an average of 2m at the control point, to a width of 4m of disturbed surface area; mean width of disturbance was 3.8m, with a standard deviation of 0.48m. Mean depth of disturbance was 0.08m, with a standard deviation of 0.03m. Though this level of disturbance was minor compared to that at site **DkPw-013** at Reed Lakes, the disturbance did pass through a part of site **DlPw-023** with a high concentration of lithic artifacts at or near the surface of the FSR, southwest of the kettle lake. Twenty artifacts were found on the surface of the overburden material during the course of visual inspection as part of the SDS. (**Figure 83**). Additional surface disturbance took place to the same area in the spring of 2005, when the timber contractor working on Block 1, TSL A65734, Wolf Creek, took heavy timber harvest equipment over the site when daytime temperatures were above 0°C and no frost was present near the surface (**Figure 84).**

Figure 83: Lithic artifacts recovered on surface of overburden of FSR at Site DlPw-023

Figure 84: Surface disturbance from passage of timber harvest equipment, looking south to Site DlPw-023

Site DlPw-025

In the spring of 2005, following the timber harvest on Unit 1 of Block 1, TSL A65734, Wolf Creek, the timber contractor got the harvest equipment bogged down on the knoll of the FSR in the middle of site **DlPw-025**. No KKTC personnel were at the site at the time: the Site Alteration Permit covered KKTC site monitoring for timber harvest, but surface damage took place post-harvest. In the course of digging out the skidder a large amount of surface disturbance took place, from the knoll north to the cattleguard and range fence dividing site DlPw-025 (**Figure 55),** both on and adjacent to the existing FSR surface. I examined the site and completed a SDS for the road surface in April of 2005.

The POC for the survey was at a control point on the existing road surface, on top of the knoll south of the cattleguard. (**Figure 85**) The SDS proceeded north, with survey points measured every 5m for a distance of 65m. The road width was measured, as well as the width of roadbed and overburden material and the depth of subsurface cut of the roadbed and ditch. Note was made of the presence of surface artifacts uncovered during road upgrading. Results for the SDS are shown in **Figure 86.**

Figure 85: Point of Commencement of SDS on Forest Service Road at Site DlPw-025, looking north

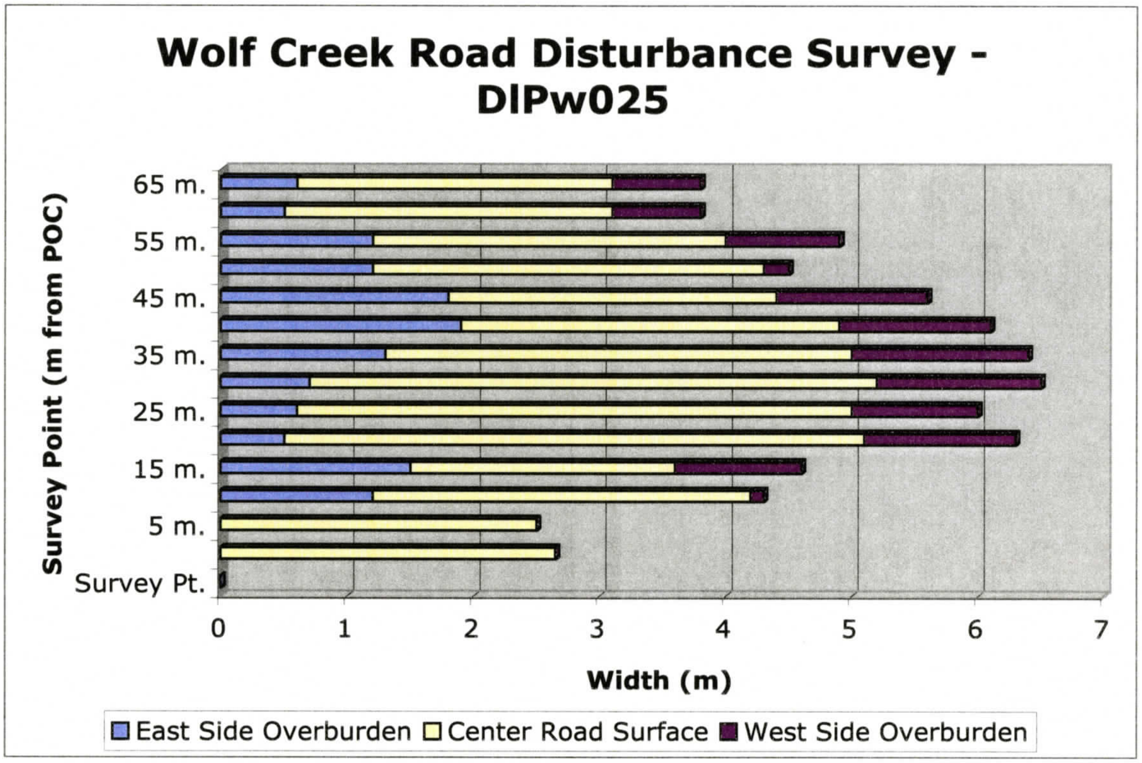

Figure 86: Summary of surface disturbance on road at site DlPw-025

Surface disturbance from the equipment increased the average road right-of-way width from a two-wheel track of 2.65m to a disturbed surface of up to 6.5m in width; mean disturbance width was 5.02m, with a standard deviation of 1.24m. Depth of disturbance in the roadbed ranged from 5cm to 30cm at one survey spot, far exceeding the threshold level of 20cm for sensitive soil vulnerability; mean depth of disturbance was 0.23m, with a standard deviation of 0.07m. The length of disturbed surface from POC to the cattleguard was 55m. Artifacts were encountered on the roadbed and overburden surface; additional artifacts had been collected previously by KKTC technicians examining the site (**Figure 87**).

Figure 87: Lithic artifacts recovered from the road surface at Site DlPw-025

Figure 88: Condition of road surface following disturbance, looking south to knoll

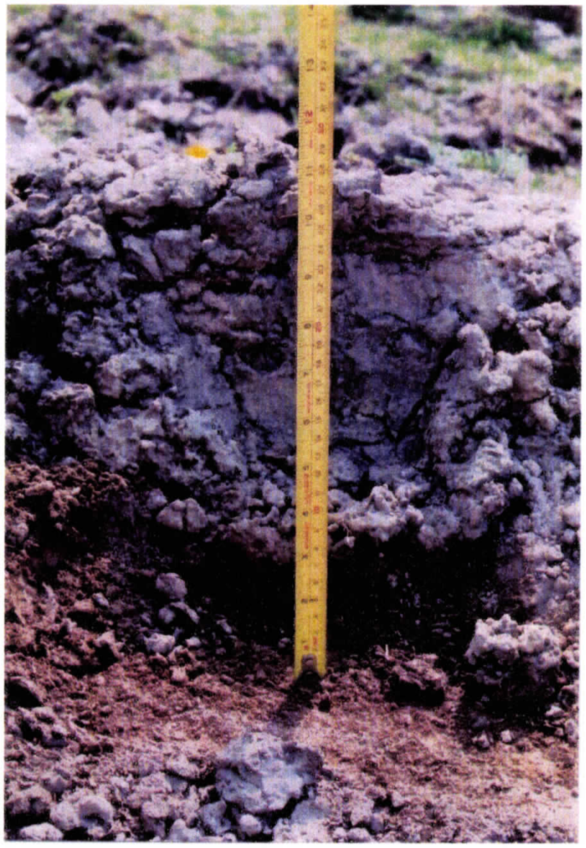

Figure 89: Depth of surface disturbance on road at Site DlPw-025

Table 20 summarizes impacts from road activities at three research sites.

Table 20: Summary of Impacts from Road Activities at Research Sites

Research Site	Type of Impact	Average Depth of Impact	Average Width of Impact	Range of Impact (width)	Length of Impact
DlPw-023	Scraping of road surface	0.08m /8cm Std. Dev.: 0.03m/3cm	3.8m/ 38cm Std. Dev.: 0.48m/48cm	2-4m	200m
DlPw-025	Interment by equipment and removal	0.23m/23cm Std. Dev.: 0.07m/7cm	5.02m/50cm Std. Dev.: 1.24m/124cm	2.65-6.5m	65m
DkPw-013	Removal of topsoil, soil displacement	0.57m/57cm Std. Dev.: 0.23m/23cm	13.86m/138cm Std. Dev.: 1.89m/189cm	2.5-18.9m	400m

4.6 Significance of Ktunaxa Nation Cultural Sites

Very few direct research – oriented archaeology projects are conducted in the province now outside of academic circles, because of the added time and expense involved in the methodical scientific approach. This research, via a more detailed site inventory than is normally conducted in the course of Archaeological Impact Assessments, produced a wealth of cultural information and an evaluation of cultural site significance that exceeds the information normally required through the BC Archaeology Branch permitting process. The significance of the archaeological sites investigated under this permit were determined using the criteria generated in the Archaeological Potential Modeling phase (Connery *et.al.* 1999, Choquette 1999) and the checklists of criteria for site evaluation in the *British Columbia Archaeological Impact Assessment Guidelines* (Province of BC 1998a). A format utilized by Messier & Eldridge (1997) addresses pre-contact sites.

Significance values are assigned based on a site containing one or several of the following attributes:

Scientific Significance is based on the potential of a site to contain evidence that could substantially increase our understanding of cultural history and processes, its ability to contribute to various scientific disciplines and its ability to contribute to furthering local and regional pre-contact history.

Public Significance is based on the potential of a site to be used by the public in an educational, interpretive or recreational capacity.

Ethnic Significance is determined under advisement by the Ktunaxa Nation and refers to the traditional, social or spiritual importance of a site. The Ktunaxa Nation considers all archaeological sites within their traditional territory to be of high ethnic significance.

Economic Significance refers to the potential financial benefits that could be derived from the general public's use of a site as an educational or recreational facility. A site's setting and ease of access figures prominently in this assignment but this is necessarily tied to other significance ratings.

Historic Significance refers to the possible association of the site with an important historic person or event.

An assessment of Scientific and Public significance is presented below in summary format for the sites being studied, from Wood *et. al.* (2002a, 2002b):

Table 21 Scientific and Public Significance Levels of Research Sites

Site	Scientific Ranking	Public Ranking
DlPw-023	Moderate	High
DlPw-024	Low	High
DlPw-025	Moderate	High
DlPw-035	Low	High
DlPw-036	Moderate-High	High
DkPw-012	Low	High
DkPw-013	Moderate	High

Scientific Ranking may be **Low** at **DlPw-024**, **DlPw-035** and **DkPw-012** simply because of the small number of artifacts recovered, and the nature of the artifacts themselves; Choquette (*pers.comm.*, 2006) rates the Scientific Ranking of sites **DlPw-025** and **DlPw-036** as **High** due to the presence of multiple buried soils, evidence of significant environmental change and associated artifact assemblages.

This ranking alone should not be the measure of the cultural significance of an archaeological site (Wickwire 1991). There are situations in which no level of a particular type of impact can be tolerated at a site, regardless of how mild. This is especially important given the determination of high ethnic significance by the Ktunaxa Nation for all their remaining archaeological sites. An estimated 40% of Ktunaxa Nation known cultural sites registered with the BC Archaeology Branch have been damaged or destroyed over the years (W. Choquette, *pers.comm.*, 2006); this may be only a small percentage of sites existing in the Ktunaxa Nation territory. No remaining known sites are considered expendable. Considering the repercussions to me when two of the seven research sites were significantly damaged by road activities, the construction of a replicate archaeological site upon which to study timber harvest impacts may have been a more prudent research decision in hindsight. Complete site avoidance may have been the best management option to recommend, rather than a Site Alteration Permit process that turned out to be ineffective in protecting site integrity.

Determining the significance of a site is not an easy task, as it requires careful assessment of the site's scientific research potential, condition, uniqueness, and other cultural values. In a protocol developed by the California Department of Forestry (Foster 2002), a significant archaeological or historical site is defined as:

> "A specific location which may contain artifacts or objects and where evidence clearly demonstrates a high probability that the site meets one or more of the following criteria:
>
> - Contains information needed to answer important scientific research questions (such as diagnostic artifact types);
> - Has a special and particular quality such as the oldest or most exceptional example of its type;
> - Is directly associated with a scientifically recognized important prehistoric or historic event or person;
> - Involves important research questions that historical research has shown can only be answered with archaeological methods, or
> - Has significant cultural or religious importance to tribal groups (Foster 2002).

If the California Department of Forestry Archaeology Program assesses a site as significant, that site must be protected through complete avoidance; a careful logging plan must also be developed for any work in the area surrounding the site, and the area to be protected should be clearly identified to all logging personnel (Foster 2002). Through studies of impacts, we may be able to distinguish those situations in which there are no effective site mitigation measures, and move to site conservation and avoidance as the appropriate management strategy (Wildesen 1982).

CHAPTER FIVE

Discussion and Recommendations

5.1 Introduction

In order to frame the conclusions of this project, the thesis objectives from **Section 1.5** are revisited. The thesis research, which focuses on **Objective 3** - assessment of impacts to cultural sites, and **Objective 4** - recommendations for cultural site management, also contributes toward a better understanding of **Objective 2** - the role of First Nations in archaeological site management in the province; comments are provided in **Section 5.4** on this issue.

5.2 Archaeological Site Disturbance

- **Objective 3: To assess whether ecological restoration activities (prescribed timber thinning and prescribed burning) could be carried out without impact around cultural sites**

5.2.1 Human-induced equipment impacts

"Any impact can be classified as to *type*, of which there are a relatively small number: burial, removal, transferal, and alteration comprise the major categories. A complete description of an impact on an archaeological site should include not only the characteristics just listed, but also an indication of the *amount* of change, its *extent* in three-dimensional space, its *duration* (temporary, permanent, or as measured in time), and something of its *characteristic behaviour* (rapidity of onset, potential reversibility, and possible synergistic action with other impacts). In addition, for purposes of designating appropriate measures to mitigate sites, it is helpful to know whether the specific actions were *intentional* or *unintentional*".

- Wildesen, 1982. The Study of Impacts on Archaeological Sites. In: *Advances in Archaeological Method and Theory,* Vol. 5, pg. 53.

Archaeological sites experience a range of impacts – both natural and human-induced – over the course of their existence. An *impact* is a *measurable change* in a characteristic or property of an archaeological site, as compared to some prior condition or characteristics of the site. Impacts are called *direct* if they are caused by an action and occur at the same time and place; impacts are *indirect* if they are caused by an action, but occur later in time or further removed in space (Wildesen 1982).

Impact types most commonly observed are site, feature or artifact alteration, artifact transfer and artifact removal. Alteration of artifact structure, (ie) physical damage, is less common than actual site and/or feature alteration, which result in damage to the context of the artifacts. Transfer and removal of artifacts, without alteration, also affects the integrity of the site, and the validity of many cultural inferences based on artifact location and descriptions. However, description and study of artifacts *per se* is not the sole purpose of archaeology – in the context of current cultural resource management and conservation, it is the *integrity* of the site – its potential for answering significant research questions, and its susceptibility to damage as the direct or indirect result of human activity – that are crucial for resource managers and decision makers (Wildesen 1982).

One of the defining factors in the rating of High Archaeological Potential (HAP) is the soil type in which the cultural materials are found. The pre-contact cultural deposits occur in both surface and buried contexts at a range of depths. The location of cultural materials determines their susceptibility to surface and subsurface soil disturbance. A preliminary analysis of this site susceptibility was completed by Choquette and summarized in Munson (2002):

Table 22: Relationship between context of archaeological deposits and susceptibility to disturbance

SETTING	RELATED LANDFORMS	SUSCEPTIBILITY
Deflational	Gravel terrace, drumlin/esker (morainal ridge), knoll	Highly vulnerable
Slight burial (< 20cm)	Silt/sand terrace, colluvial/alluvial fan, colluvial apron	Highly vulnerable
Deep burial (> 20cm)	Silt/sand terrace, channel, draw, depression, fan toe, dune	Relatively secure

The archaeological sites in question are found on sand/silt terraces adjacent to the kettle lakes, making them highly vulnerable to disturbance. Soils are generally silty, consisting of a relatively poorly developed brunisol soil underlain by deposits of glacio/fluvial or glaciolacustrine origin at depths of 5-20cm (Middleton 2003).

Recommended winter conditions for timber harvest sites for High Archaeological Potential and sensitive soil conditions – snow cover of > 50cm and frost depth of > 7.5cm, were winter conditions that were utilized as field operational guidelines during the duration of the ***Forest Practices Code*** (1995-2002). Under the current management regime of the new ***Forest and Range Practices Act*** (2002), prescribed winter conditions do not determine whether winter timber harvest proceeds or not. Timber companies are given a target of soil disturbance levels, which should not be exceeded on a timber block. Harvest then proceeds, and Ministry of Forest field staff later do an inspection to determine if the target was met or exceeded. This new approach – the "results-based management" approach – leaves the methods used and the site conditions under which they are used open for wider interpretation in the course of timber harvest (H. Mitchell, *pers. comm.*, 2003). This management approach potentially places archaeological sites in more danger of disturbance during timber harvest, due to lack of prescribed winter conditions.

This research began with the hypothesis that the proposed ecological restoration activities of prescribed timber thinning could be carried out at the archaeological research sites under specific conditions – frozen ground and snow cover – with the result that there would be minimum disturbance to the integrity of the cultural sites. Following from Wildesen (1982), the summary tables of impacts to all the research sites from ecological restoration activities of timber harvest and road activities are repeated below:

Summary of Impacts of Timber Harvest at Research Sites

	Timber Harvest Activities		
Research Site	**Type of Impact**	**Extent of Impact (% soil disturbance in SDS area)**	**Duration of Impact**
DlPw-023	Minor surface disturbance (<5cm), compaction	10 %	Temporary
DlPw-024	Control Site	Control Site	Control Site
DlPw-025	Minor surface disturbance (>5cm), logging slash	23%	Temporary (except for root throw)
DlPw-035	Minor surface disturbance (<5cm), compaction	35%	Temporary
DlPw-036	Minor surface disturbance (>5cm)	10%	Temporary (except for machine gouge)
DkPw-012	Soil compaction	15%	Temporary
DkPw-013	Soil compaction, logging slash	25%	Temporary

Summary of Impacts from Road Activities at Research Sites

Research Site	**Type of Impact**	**Average Depth of Impact**	**Average Width of Impact**	**Range of Impact (width)**	**Length of Impact**
DlPw-023	Scraping of road surface	0.08m /8cm Std. Dev.: 0.03m/3cm	3.8m/ 38cm Std. Dev.: 0.48m/48cm	2-4m	200m
DlPw-025	Burial by equipment and removal	0.23m/23cm Std. Dev.: 0.07m/7cm	5.02m/50cm Std. Dev.: 1.24m/120cm	2.65-6.5m	65m
DkPw-013	Removal of topsoil, soil displacement	0.57m/57cm Std. Dev.: 0.23m/23cm	13.86m/138cm Std. Dev.: 1.89m/189cm	2.5-18.9m	400m

The impacts from timber harvest activities, despite exceeding 25% of the timber block in one instance (**DlPw-035**), were relatively minor (soil compaction, logging slash, etc). The activities did disturb the critical threshold of the upper 10cm of soil context; one machine gouge at site **DlPw-036**, and one tree stump uprooted at site **DlPw-025** were the major incursions into the substrate. The direct impacts from road infrastructure activities, on the other hand, have to be classified as major, exceeding the 20cm threshold in large sections of road at sites **DlPw-025** and **DkPw-013**. Under these circumstances, buried soils were also at risk. My research supports the conclusions from other sources, (Philipek 1985, Jackson 1994, Gibson 2003) that road construction and infrastructure activities associated with timber harvest can cause more surface and subsurface damage to archaeological sites and cultural resources than the actual harvest itself.

Literature review of BC Archaeology Branch permit reports in the Branch library shows little research on measurement of impacts to the province's archaeological sites caused by equipment; the majority of reports are Archaeological Impact Assessments of *potential* impacts posed by resource development, and a smaller sample of Site Alteration monitoring reports, mainly describing the recovery of artifacts during site alteration activities. A few exceptions were encountered: Dewhirst (1990) describes damage to a coastal shell midden site assessed in post-logging road construction – equipment had displaced the large midden in an area 5m wide, 21m long and to a depth of 25-50cm. Kinzie and Haggarty (1999) noted that previous logging damage at a North Coast shell midden site had disturbed the upper 30cm of soil, and that logging road construction had cut into the midden to a depth of 1m; tree skidding at the site had left U-shaped trenches 6m long in the midden material, and the upper 0.5 – 1m of midden deposit had been displaced.

In assessing the impact of proposed logging operations by TimberWest Forests Ltd. on the Chilcotin Plateau, Wilson and Smart (1994) made a telling observation:
"No documented studies have been undertaken in the interior of the province which document the integrity of archaeological deposits before and after harvesting".

Wilson and Smart (1994) went on to propose that such a study would be ideal for several closely-grouped logging blocks in the study area near Willan and Coyote Lakes, given that impact assessment information was now available. No record was found of such research being completed, or of any other such research taking place throughout the province.

To actually determine the nature of impacts and effects on archaeological sites, we need to know the nature of the archaeological site itself (through inventory), the specific local and/or regional archaeological management goals, and the purposes for which sites will be managed. Disturbance diminishes the site's value in proportion to the extent or disruptiveness of that disturbance with respect to one's research objectives (Wildesen 1982). Sadly, in response to this need to know, few archaeological sites in the province have inventories completed (except in the path of site destruction), local or regional management goals are not in place, and site avoidance is still the preferred management option.

5.2.2 Cultural Resources Impact Classification System (CRICS)

Site disturbance under the CRICS is defined as the alteration of an archaeological site in **any** manner from its natural state Gibson (2003). Timber harvest impacts are broken into different categories of activities related to: construction of transportation systems for harvest and hauling; timber harvesting; and silviculture practices; each activity produces different types of impacts. The CRICS classification is as follows:

Table 23: Cultural Resource Impact Classification System (Gibson 2003):

Class	Name of Class	Impact Summary
0	No Impact	No physical disturbance of either surface organic or subsurface mineral soil
1	Incidental Contact	Impact to organic soil, but no disturbance subsurface
2	Incidental Impact	Removal of organic soil, exposure of mineral soil
3	Regular Impact	Exposure and disturbance of mineral layer, movement of artifacts
4	Severe Impact	Removal of organic soil layer, modification of mineral soil layer
5	Total Impact	Removal of part or all of known archaeological site context (organic and mineral soil layers)

A schematic interpretation of the CRICS classification process is shown below (**Figure 90**);

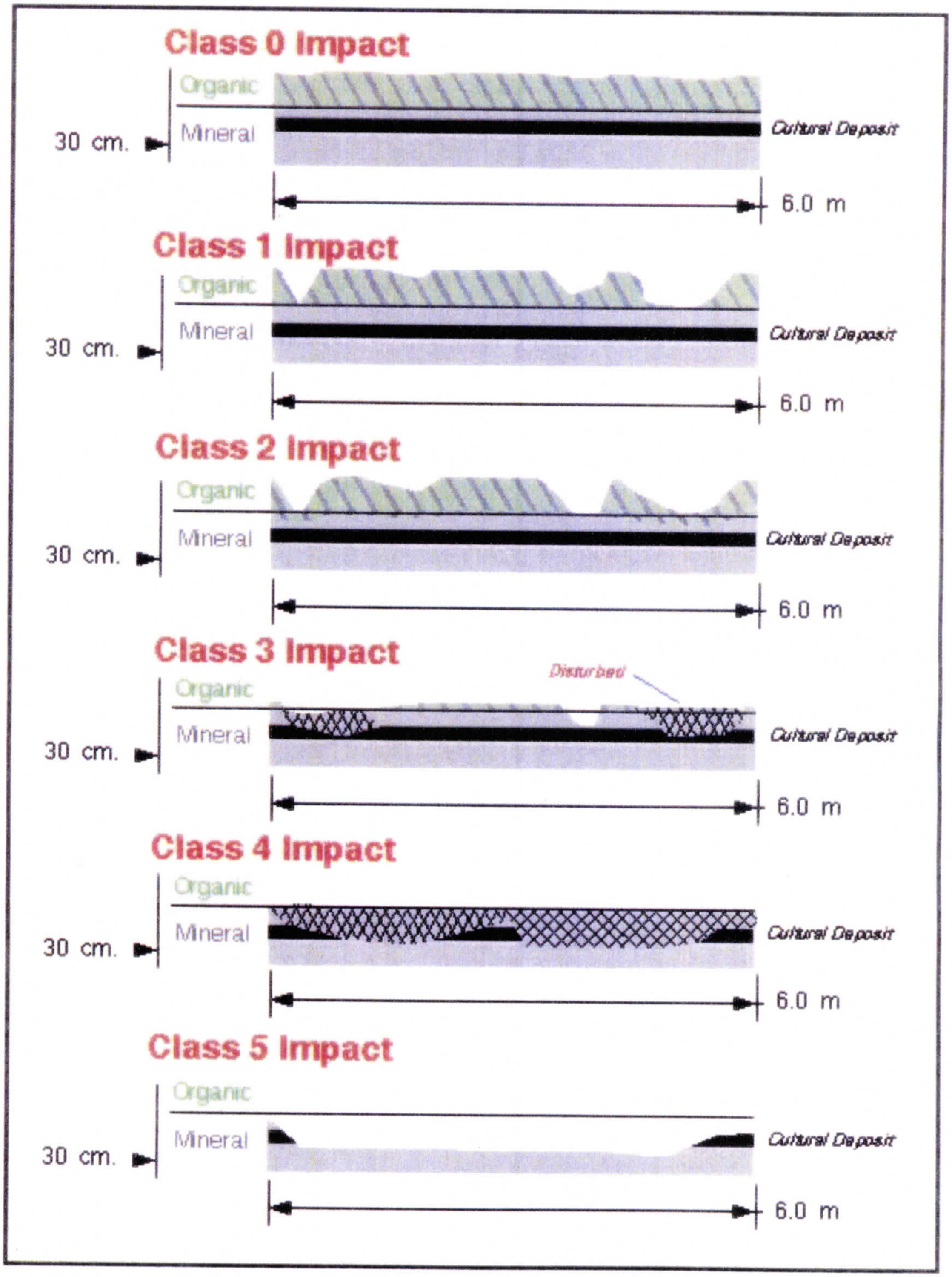

Figure 90: Summary of the Cultural Resource Impact Classification Scheme (Gibson 2003)

In **Figure 90**, organic forest soil horizons are defined as living and dead vegetation overlying the mineral constituent of the soil profile. In most archaeological contexts, only the most recent cultural material is found in the organic soil horizon. Materials found in the mineral soil are usually older in age and thus more relevant to heritage management concerns (Gibson 2003).

Gibson (2003) also developed a simple MS Excel program calculator to assess the impacts of different types of forestry operations under different operating conditions in Alberta. The calculator is based on application of eight basic operating condition variables that affect ground impacts: presence of installations; degree of slope; terrain conditions; organic overlay; soil consolidation; soil moisture; ground conditions (frozen or unfrozen); and snow cover. The CRICS system is used to quantify potential impacts on archaeological sites pre-harvest, based on expected ground impact. Applying the calculator to the Wolf Creek – Reed Lakes research sites results in the following predictions about impacts: the first example (**Figure 91**) shows the potential impacts with the recommended timber harvest conditions of snow cover >30cm and frozen ground (winter 2004); the second example (**Figure 92**) shows potential impacts under less than ideal conditions with < 30cm of snow and frozen ground (winter 2005); the last example (**Figure 93**) shows expected impacts with conditions least favourable for timber harvest with < 30cm of snow and no frozen ground (spring 2005 when road damage occurred). The Site Alteration Permit conditions were not adhered to under the last two scenarios.

Impact Variables

- [ ] Installations Required
- [ ] Slope > 20°
- [ ] Short Broken Terrain
- [x] <10 cm of Organics
- [ ] Loose Soil
- [ ] Wet Operating Conditions
- [x] Frozen Ground
- [x] >30 cm Snow Cover

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Heritage Impact Calculator

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Forestry Practice	CRICS
Class 1-3 Road	5
Class 4 Road	5
Class 5 Road	4
Class 5 Stumped Road	1
Unstumped Trail	0
Turnaround/Pull-Out	1
Stream Crossing	0
Borrow Pit	5
Operating Camp	5
Wood Landing	0
Wood Deck	0
Harvester	0
Low Impact FB	0
Regular FB	0
Hand Falling	0
Wheeled Grapple Skidder	1
Wheeled Line Skidder	1
Treaded Grapple Skidder	1

Forestry Practice	CRICS
Horse Skidder	0
Grapple Yarder	0
Forwarder	0
Horse Forwarder	0
Clambunk Forwarder	0
Hi-lead Skidding	1
But-top Loader	0
Treaded Delimber	0
Hand Planting	1
Disc Trenching	3
Tree Length Harvesting	1
Cut-To-Length Harvesting	0
Selective Harvesting	0
Commercial Thinning	0
Salvage Thinning	0
Wood Collection	0
Ground Preparation	3
Heavy Construction	5

Figure 91: Scenario 1: Cultural Resource Impacts with Most Favourable Winter Conditions Present

In **Scenario 1** (**Figure 91**), the key entries of note are **Class 1-4 Roads** and **Heavy Construction**: impacts of **Class 4** (severe impact) or **Class 5** (total impact) can be expected to occur with any road building activity. The results of road improvements on site **DkPw-013** fall into this category, and impact to the archaeological site was severe. Timber harvest activity such as commercial thinning that was conducted at the research sites in fact produced limited impact as expected - note the entries for **Harvester** and **Regular FB (Feller Buncher)** and use of the **Wheeled** or **Treaded Grapple Skidder**: **Class 0** (no impact) or **Class 1** (incidental contact). Use of various types of harvest equipment (grapple skidder or forwarder) did not increase the impact on the timber harvest cutblock under prescribed winter conditions.

Impact Variables

- [ ] Installations Required
- [ ] Slope > 20°
- [ ] Short Broken Terrain
- [x] <10 cm of Organics
- [ ] Loose Soil
- [ ] Wet Operating Conditions
- [x] Frozen Ground
- [ ] >30 cm Snow Cover

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Forestry Practice	CRICS
Class 1-3 Road	5
Class 4 Road	5
Class 5 Road	4
Class 5 Stumped Road	2
Unstumped Trail	1
Turnaround/Pull-Out	2
Stream Crossing	1
Borrow Pit	5
Operating Camp	5
Wood Landing	1
Wood Deck	1
Harvester	0
Low Impact FB	0
Regular FB	1
Hand Falling	0
Wheeled Grapple Skidder	2
Wheeled Line Skidder	2
Treaded Grapple Skidder	2

Forestry Practice	CRICS
Horse Skidder	1
Grapple Yarder	1
Forwarder	0
Horse Forwarder	0
Clambunk Forwarder	0
Hi-lead Skidding	2
But-top Loader	1
Treaded Delimber	1
Hand Planting	1
Disc Trenching	3
Tree Length Harvesting	2
Cut-To-Length Harvesting	0
Selective Harvesting	1
Commercial Thinning	0
Salvage Thinning	0
Wood Collection	1
Ground Preparation	3
Heavy Construction	5

Figure 92: Scenario 2: Cultural Resource Impacts with Frozen Ground Present

In **Scenario 2** (**Figure 92**), with < 30cm of snow and frozen ground, impacts from any road activity are predicted to remain high (**Class 4** or **Class 5**), and impacts from use of skidders (entries for **Grapple or Line Skidders**) would increase to **Class 2** (incidental impact). Soil disturbance surveys from the spring of 2005 do show a limited amount of skidder damage on the timber blocks, especially on exposed terrace slopes, when snow cover was minimal (at site **DlPw-035** for example). Skid trails show increased compaction, but this impact is not integrated with the impact calculator scenarios.

Impact Variables

- [ ] Installations Required
- [ ] Slope > 20°
- [ ] Short Broken Terrain
- [x] <10 cm of Organics
- [ ] Loose Soil
- [ ] Wet Operating Conditions
- [ ] Frozen Ground
- [ ] >30 cm Snow Cover

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Heritage Impact Calculator

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Forestry Practice	CRICS
Class 1-3 Road	5
Class 4 Road	5
Class 5 Road	4
Class 5 Stumped Road	3
Unstumped Trail	3
Turnaround/Pull-Out	4
Stream Crossing	3
Borrow Pit	5
Operating Camp	5
Wood Landing	3
Wood Deck	3
Harvester	1
Low Impact FB	1
Regular FB	3
Hand Falling	1
Wheeled Grapple Skidder	3
Wheeled Line Skidder	3
Treaded Grapple Skidder	3

Forestry Practice	CRICS
Horse Skidder	2
Grapple Yarder	2
Forwarder	1
Horse Forwarder	1
Clambunk Forwarder	1
Hi-lead Skidding	3
But-top Loader	3
Treaded Delimber	3
Hand Planting	1
Disc Trenching	4
Tree Length Harvesting	3
Cut-To-Length Harvesting	1
Selective Harvesting	3
Commercial Thinning	1
Salvage Thinning	1
Wood Collection	3
Ground Preparation	4
Heavy Construction	5

Figure 93: Scenario 3: Cultural Resource Impacts with Marginal Winter Conditions Present

In **Scenario 3** (**Figure 93**), with < 30cm of snow and no frozen ground, (conditions similar to the spring of 2005), impacts were predicted to increase as compared to the first two scenarios: entries for all equipment (ie) **Regular Feller Buncher** and all **Skidders** could produce impacts of **Class 3** (regular impacts). Use of **Wood Landings** or **Wood Decks** could produce **Class 3** impacts. Though timber cutblock impacts were minimal under these conditions in the spring of 2005 at sites **DlPw-025** and **DlPw-035**, impacts on the access road were as severe (**Class 4**) as predicted, when timber equipment was removed at a time when ground was not frozen, and subsurface cultural deposits were most vulnerable to disturbance.

For most practical application of the CRICS calculator, pre-harvest site conditions should be inserted into the Excel calculator, prior to any site disturbance from forestry activities, and the results used to predict impacts; follow-up monitoring of site disturbance post-harvest would then be done to compare results with predicted impacts. Given the success of the CRICS analysis in predicting impacts on sites, it could be a valuable and useful tool to target potential soil-disturbing activities pre-harvest, and to monitor these specific activities during harvest, (ie) use of particular types of equipment on particular landforms, in order to avoid impacts to cultural sites.

5.3 Archaeological Site Impacts from Prescribed Fire

There is potential for conflict between the goals of fire management and cultural protection programs, because fire itself may directly damage the cultural resources and fire suppression activities may do even greater damage than the fire. Cultural resources must be considered a fragile, non-renewable part of the environment for management purposes (Anderson 1985). We are eager to return the natural environment to a healthier condition through use of prescribed fire; however, the potential beneficial effects of fire must be weighed against other management considerations, such as potential losses of irreplaceable heritage resources (Cartledge 1996).

With the use of prescribed burning to reduce wildfire risk, it has been assumed that these fires were relatively "cool" burns, with little effect on cultural resources, other than on wood and organic materials (Jackson 1997). However, the actual effects of prescribed fire on various types of cultural materials is inadequately investigated and poorly understood (Lentz *et.al.* 1996a, 1996b). Bone, for example, which occurs in the project area, will char at temperatures slightly over 300°C (DeBano *et.al.* 1998). A controlled experiment on chert during a prescribed fire in California showed that damage to artifacts was slight when the fire burned very hot but quickly over the site, while chert artifacts were badly discolored when the fire burned slowly for long duration over the site. The results show that improperly conducted prescribed burns can also cause serious harm to cultural resources (Timmons 1996, Waechter 2003b).

Lentz *et.al.* (1996b) carried out experimental burning studies across both real and artificial cultural artifact collections, under different fuel loadings and within different fuel models, to try and establish thresholds of fire damage to archaeological materials. The results showed that lithic artifacts had signs of fire effects, at temperatures ranging from 593-816°C. Specifically, the chert artifacts suffered substantial sooting and adhesions at low temperatures, and spalling, oxidation and color alteration at higher temperatures. Lentz *et.al.* (1996b) concluded that under certain conditions, analytical information from ground stone artifacts could be substantially compromised by fire effects, even sooting and adhesions can have long-term detrimental effects which may not disappear with weathering. One of the most important conclusions was that it is not possible to distinguish deliberately heat-treated lithic materials from those that have been modified by fire long after their cultural use (Spoerl 1996).

In most cases, forest fires will not affect lithic material greater than 5-10cm. below the surface. The exception is burning of old tree stumps and roots in both high intensity wildfires and low intensity prescribed burning, which may impact buried cultural resources (Connor *et.al.* 1989). This impact can include the direct thermal alteration of artifacts found near the burning wood, or displacement of artifacts when stumps burn out and soil pits collapse (artifacts may have been displaced during root growth at any rate). Even in low intensity surface burns, temperatures up to 1500°C can be reached in burning roots (Timmons 1996).

Fire damage to cultural resources and sites can also occur when slash from logging and thinning has accumulated on the ground surface beyond levels that would occur naturally, leading to very severe fires with long residence time. Severe fires can also produce fire-cracked rock, which can later be falsely interpreted as having been produced by cultural processes (Q. Mackie, *pers.comm.*, 2005). Low fire intensities may not be a threat to certain kinds of cultural resources, but we know too little about the thresholds at which fire damage starts to occur to various archaeological materials (Cartledge 1996, Spoerl 1996). Archaeological sites that have not been exposed to fire in the last 60 to 100 years, due to fire suppression, are in the most peril (Smith 1999).

Section 2.4.2 summarized the likely impacts of fire operations on cultural materials and sites. In many cases, without proper coordinated planning between Fire Protection personnel and Archaeological Management personnel, the site preparation for prescribed burning, fire suppression activities themselves, or post-fire site rehabilitation produce more impacts on archaeological sites than the actual fire (Traylor *et.al.* 1990, Cartledge 1996, Spoerl 1996, Jackson 1997, DeBano *et. al.* 1998, Smith 1999).

5.3.1 Physical damage from fire operations

The results in my research area reveal several real negative impacts from prescribed burning: during fire preparation stage, and following the burn. The first example was discussed in **Chapter Four**, **Section 4.4.2**. Blading of a Forest Service Road at site **DlPw-023**, prior to conducting a prescribed burn in the spring of 2004, resulted in surface and subsurface damage to part of the archaeological site (**Figure 94**). Ministry of Forests Fire Protection personnel did not contact the Ktunaxa Kinbasket Tribal Council staff or myself prior to the road blading activity, although archaeologist Wayne Choquette reviewed the burn plans (P. Burke, *pers.comm.*, 2004). The subsequent site damage was detected the day after the prescribed burn took place.

Figure 94: Forest Service Road Bladed Prior to Prescribed Burn, DlPw-023, Spring of 2004

In the spring of 2005, a prescribed burn took place adjacent to the timber block containing sites **DkPw-012** and **DkPw-013**. Prescribed harvesting in 2002 had preceded this burn. **Figure 95** shows the surface impact of the prescribed burn, which was slight; **Figure 96** shows the hole created by a tree root burn, which exceeded 35cm (or 15 in.) in depth. Were archaeological artifacts present around such a tree stump, they would have experienced prolonged high temperatures and possible thermal alteration, followed by likely displacement when the tree root cavity collapses. However, not all tree stumps can be protected during prescribed burns, and the incidence of tree root burns that disturb artifact assemblages may be minor in comparison to other forms of site damage.

Figure 95: Ground Conditions Following Prescribed Burn in Research Area, Spring of 2005

Figure 96: Depth of Stump Burn Following Prescribed Burn, Spring of 2005

5.4 Recommendations for Managing Equipment Impacts

- **Objective 4: To provide archaeological site management recommendations, to be used at the operational level by foresters, contractors and equipment operators**

Literature review of a sample of reports on Archaeological Impact Assessments and Site Alteration Permits from the BC Archaeology Branch Library includes the following management recommendations to avoid impacts from timber harvesting:

- "Recommendations are made for avoidance of all sites where possible; where site avoidance is not possible, systematic data recovery (collection of recovered artifacts) is recommended" (Spafford *et.al.* 1994);
- "It is recommended that the few remaining intact midden deposits be capped with coarse sand" (Wilson 1988);
- "West Fraser Timber Company will avoid the buffered areas surrounding these archaeological sites during development by excluding the areas or dropping the plans for timber harvest in the entire development area" (Bereziuk 2000);
- "The preferred management recommendation is complete avoidance; should site avoidance not be possible, it is recommended that timber harvesting occur on frozen ground conditions" (Yip and Palmantier 1997);
- "Removal of all three features (culturally modified trees) in conflict with proposed road building is recommended under a Site Alteration Permit" (Simonsen 1997);
- "Avoidance with the establishment of a minimum 5 m buffer is recommended" (Campbell *et.al.* 1997);
- "Timber harvesting with a feller-buncher is allowed to take place within the flagged site perimeters provided that all heavy equipment remain outside the flagged boundary" (DePaoli 1997).

Winter logging will likely continue in Ktunaxa Nation territory for some time unless climate change dictates its end (Province of BC 2002a). The Ktunaxa Nation may follow the example of the Colville Confederated Tribes or the Spokane Indian Tribe in adjacent US jurisdictions, in actively pursuing ecological restoration through timber thinning and broadcast burning (Carrol *et.al.* 2004). If the Ktunaxa Nation takes an active role in such ecological restoration work, Ktunaxa Nation archaeological management staff must be involved in the following activities to protect Ktunaxa Nation cultural sites:

- **Completion of Archaeological Impact Assessments for all proposed timber harvest and prescribed burn plans, including road building and upgrading (currently done by Eaglevision Geomatics and Archaeology Limited);**
- **Completion of detailed Archaeological Inventory Assessments (similar to this research) to clearly define the boundaries of cultural sites prior to any ecological restoration activities;**
- **Application of the Cultural Resources Impact Classification System (CRICS) calculator to predict potential impacts of specific forestry activities on cultural sites;**
- **Site management determinations regarding whether any ecological restoration activity takes place on or adjacent to Ktunaxa Nation cultural sites, based on inventory information and prediction of potential impacts;**
- **Establishment of prescriptions for winter harvest conditions (snow cover, frozen ground, operating temperatures, etc.) to be adhered to should timber harvest be allowed to proceed (Curran 1999);**
- **Education of Ministry of Forests staff, timber contractors and equipment operators as to cautionary operating principles and practices when working around cultural sites (Foster 2002);**
- **Monitoring of timber harvest around all Ktunaxa Nation cultural sites, including road upgrading and construction of log landings;**
- **Post-harvest monitoring of impacts to cultural resources;**
- **Preparation of proper management measures to be taken post-harvest to prepare timber blocks for prescribed burning.**

While on site during monitoring of timber harvest, Ktunaxa archaeological management staff should have the authority to carry out the following site protection activities as required:

- **Establish a protective buffer zone around cultural sites in consultation with Ministry of Forests staff and timber contractors;**

- **Recommend avoidance of sites and any archaeological features completely when using feller-buncher and skidder equipment to minimize impacts from winter logging,**
- **Recommend use of a 'cut-to-length' harvesting system that processes trees in the woods, or a forwarding system rather than a log skidding system, by operating on slash pile mats (ERI 2003), if timber harvest around of cultural sites is allowed (though this increased fuel load could lead to more soil heating during burns);**
- **Apply strictly the criteria for winter logging from Curran (1999) and Philipek (1985), for example, operating only when temperatures are < 0°C during the day, and <-5°C the night prior to logging;**
- **Designate use of specific skid trails which avoid sensitive areas;**
- **Recommend movement to new skid trails if soil on existing trails becomes exposed;**
- **Recommend use of manual treatments such as hand felling of trees in ecologically and culturally sensitive areas (ERI 2003);**
- **Recommend burning of slash after timber thinning in areas where soil is already disturbed, or consider slash-burning alternatives such as chipping or transporting slash off sensitive sites (ERI 2003).**

As noted in the introduction to this thesis, forest restoration plans that successfully integrate protection of cultural resources (through application of these management measures) into design and activities for prescribed thinning and burning, will greatly minimize the impacts of these activities on archaeological and cultural values (Fairley 2003). Having Ktunaxa Nation technicians on site for monitoring of all restoration activities is the ideal management scenario. If, due to constraints on staff and resources, Ktunaxa staff is not available, the next best alternative is to initiate an archaeological training program for natural resource professionals involved in this work, with Ktunaxa staff and archaeologists leading the training. This training program could include archaeological site identification in Ktunaxa Nation territory, survey techniques and application of site protection measures (Foster and Betts 2004).

5.5 Recommendations for Prescribed Fire Management

Limiting or avoiding fire damage to cultural resources has become a critical part of fire management in the United States. On prescribed burns, studies are being carried out to design fire prescriptions that include specific measures in relation to fuel loads, fuel and soil moisture levels, and duff moisture and depth that will produce fires within ranges likely to protect cultural resources in Douglas fir/Ponderosa pine forest types (Timmons, 1996). Cultural resource protection for prescribed burning can now involve several phases: a review of existing cultural site records, traditional use and cultural site potential information; reconnaissance-level archaeological surveys to assess the likelihood of flammable properties; complete archaeological surveys of all areas near direct ground disturbance activities; and complete archaeological surveys where fires may exceed fire threshold and intensities and pose a threat to cultural resources (Spoerl 1996, DeBano *et.al.* 1998). The impact to cultural resources can be greatly reduced in prescribed fires by removing extraneous fuel loads from cultural site surfaces prior to burning, or by creating fire breaks that encircle cultural sites (Spoerl 1996).

As studies by Traylor *et.al.*(1990), Eininger (1990) and Foster and Betts (2004) have shown, the impacts of human activities during fire suppression can be more destructive on cultural resources than the effects of fire itself. This understanding has led to the development of detailed resource protection measures for cultural sites and resources in relation to fire management (USDA-FS 2004). Specific measures to protect cultural sites and resources during prescribed burns include:

- Fireline construction away from any known cultural sites;
- Use of rubber-tired or tracked equipment under prescribed measures with monitoring near cultural sites;
- Hand-clearing of excessive fuel build-up, including large logs, needles, duff and woody debris, from cultural sites prior to burning;
- Application of water on tree stumps following fire passage to immediately douse the fire, especially near cultural sites; and

- Pre-burning the site prior to the main prescribed fire under even cooler prescriptions than those called for in the burn plan (USDA-FS 2004, Smith 1999).

The best management practice to protect cultural resources during fires is to assign an archaeologist directly to the fire crew of both wildfires and prescribed burns. The archaeologist should know the characteristics of the archaeological sites in the fire zone, and provide technical advice on protecting and avoiding sensitive cultural areas (Traylor *et.al*, 1990, Waechter 2003c). When prescribed burning takes place around these research sites, the Ktunaxa Nation should ensure that the above management recommendations are applied, and that an on-site archaeologist is used during fires.

Indirect effects of the prescribed burn can take place **after** the fire itself, and can cause long-term negative impact on cultural sites and artifacts. These indirect effects include:

- Site deflation by wind and water erosion;
- Overland movement of artifacts through erosional processes;
- Fall of unstable trees weakened by fire, and uprooting of artifacts;
- Compaction or gouging of cultural sites by fire cleanup equipment;
- Collection of exposed artifacts by looters;
- Discoloration of artifacts by fire retardant chemicals;
- Impacts from post-fire site rehabilitation or preparation for seeding; and
- Disruption of cultural activities at sacred sites due to damage incurred (DeBano *et.al* 1998).

Post-fire monitoring of burn areas to identify areas of potential site erosion and archaeological material displacement is recommended (Traylor *et.al.* 1990), to locate artifacts exposed during a fire at unmapped sites. Such artifacts are vulnerable to site looting (Jackson 1997). Education of fire prevention and prescribed burn personnel is an effective means of reducing impacts – both direct and indirect – of fire on cultural sites. The California Department of Forestry (CDF) Archaeology Program commits a large percentage of its time and resources to the planning and delivery of an archaeological training program to three main groups of people: CDF staff with archaeological review responsibilities under the *California Environmental Quality Act*; private and state foresters and other resource professionals responsible for completing archaeological surveys, impact evaluations, and site recording under the Forest Practices Act rules; and CDF fire suppression personnel operating on wildfires and prescribed burns (Foster and Betts 2004). The CDF archaeological training program has been recognized as one of the most successful programs for stewardship of cultural resources in the country, and staffs from neighbouring states seek out this training as part of their professional development.

Excluding archaeological sites from prescribed burns (site avoidance strategy) can lead to looting of highly visible areas, and to future damage from wildfire, so allowing burns may be a more prudent management decision (Smith 1999). Allowing prescribed burns to run over archaeological sites provides the opportunity to evaluate fire effects and to plan mitigative measures (Smith 1999). The recognition that ecological restoration practices such as prescribed burning, if not carefully planned, executed and monitored, can and will have impacts on cultural resources, demonstrates that cultural resource values are finally being seriously recognized in some jurisdictions (Friederici, 2004).

5.6 First Nation Archaeological Site Management in British Columbia

- **Objective 2: To involve the Ktunaxa Nation in proactive archaeological site management**

"One reason that problems of traditional cultural properties persist is that....they continue to be thought of in the same way as archaeological sites or historic buildings – as 'neatly bounded places'. Many cultural resources managers are archaeologists, who are trained to deal with spots on the landscape, rather than the landscape itself. The artificial isolation of important places from the whole landscape of which they are an integral part often violates the very cultural principles that make certain places culturally significant in the first place. Not surprisingly, many tribal groups have great difficulty in dividing up the physical world in a way that is comfortable and convenient for cultural resources managers.

To alleviate this cultural divide, the people to whom traditional cultural properties hold cultural significance are generally the only people with the expertise to identify them, determine if and how they may be affected (by development) and determine whether or not treatment of the area is necessary, and recommend that treatment. And as adverse effects to most cultural properties can't be 'mitigated' in the same way as effects to archaeological sites or historic buildings can, so the treatment of cultural properties must be part of project design and planning, not something to be taken care of later."

- Downer and Roberts, Traditional Cultural Properties, Cultural Resources Management and Environmental Planning. In: *Cultural Resource Management* 16: 12-14.

"In the name of neutrality and fact-finding, one group (developers) treats culture as past, its remains dead and isolated artifacts; the other group (heritage specialists) treats culture, though changed, as present and ongoing, its meaning still evident in many sites in their living context".

- Wickwire, Ethnography and Archaeology as Ideology. In: *British Columbia Studies* 91/92: Autumn-Winter 1991-92, pp. 51-78.

5.6.1 Current state of BC archaeology site management

In British Columbia, the first legislation to recognize cultural resources was the *Historic Objects Preservation Act (RSBC 1948, Chapter 145).* In 1960, cultural sites were formally recognized in the *Archaeological and Historic Sites Protection Act (RSBC 1960, Chapter 15).* The *Heritage Conservation Act* (RSBC 1979, Chapter 165) replaced the earlier *Archaeological and Historic Sites Protection Act.* The HCA protects cultural heritage resources *in situ.* The Act prohibits the damage, desecration or alteration of Provincial heritage sites, Provincial heritage objects, burial places, aboriginal rock paintings or carvings, or sites of archaeological value that date prior to 1846 (date of signing of Oregon Territory Treaty in USA). Enabling legislation for the protection and conservation of British Columbia's archaeological resources was updated in 1996 (Province of British Columbia 1996).

The provisions of the Act apply whether archaeological sites are located on public or private land. Archaeological sites are protected through designation as "Provincial heritage sites", or through automatic protection by virtue of being of particular historic or archaeological value. Protected archaeological sites may not be destroyed, excavated or altered without a permit issued by the Minister or designate (Province of British

Columbia 1992). Part 2 of the Act empowers the Minister to order a "site survey" or "site investigation" if land scheduled for development contains or may contain an archaeological site which may be damaged or destroyed. The purpose of the site survey is to assess the archaeological significance of the land or property prior to development. However, recent changes in legislation in BC have placed the effectiveness of this Act in question in relation to resource extraction activities.

The BC Archaeology Branch administers sections of the *Heritage Conservation Act*. The role of the Branch is not to prohibit or impede land use or development, but rather to assist the BC Government in making decisions that will ensure optimal land use. When the benefits of a development project are sufficient to outweigh the benefits of archaeological preservation, the Branch's primary concern is to work with the project proponent to ensure that the project will be implemented with minimal loss to archaeological resource values (Province of BC 1992). However, the definition and nature of 'benefits' are seldom discussed with either the archaeological community or First Nations. The BC Archaeology Branch used to conduct salvage excavations of cultural sites prior to their destruction by development; however, due to lack of Archaeology Branch resources (human and financial), this responsibility now belongs to the developer (Dave Hutchcroft, *pers.comm.*, 2005)

Another major problem lies with the Archaeology Branch's site-specific/inventory approach as directed by the *Heritage Conservation Act*. A major weakness of this approach to heritage assessment is its reliance upon tangible physical remains, to the exclusion of all else, as indication of First Nations' use of an area proposed for development. Low archaeological visibility does not necessarily mean low archaeological significance. Making an inventory of the remnants of a dead and/or dying culture to fulfill the objectives of the formal guidelines of the Archaeology Branch, without any reference to living ethnographical interpretation of these remnants or to their larger environmental and cultural setting, does little service to cultural heritage in the province (Wickwire 1991).

The *Heritage Conservation Act* includes the provision for negotiating "Agreements with First Nations" (Province of BC 1996); in Section 4, the Province of BC may into formal agreements with First Nations with respect to conservation and protection of heritage sites and objects. Such agreements could also identify actions which would constitute a desecration of such sites or objects, or which would detract from their heritage value. To my knowledge, no such agreements have been negotiated under the terms of the new *Heritage Conservation Act* in the province.

Changes in legislation for forestry management have placed responsibility for protection of resources other than timber in the purview of the forestry companies themselves. The *Forest Practices Code 1998* was repealed by the recent BC Government, and its replacement is the *Forest and Range Practices Act 2002*; the new Act is no more specific than the following re the new Forest Stewardship Plans:

" A Forest Stewardship Plan must be consistent with (a) objectives set by government in relation to the following subject matter: (x) cultural heritage resources."

Forest licencees, archaeologists and First Nations now work more closely together on the AOA and AIA processes to protect cultural heritage resources, and the Ministry of Forests and Range and the BC Archaeology Branch's role have been greatly reduced. The new "results-based" management model has yet to be a proven method for protecting a range of natural and cultural values on the landscape. The present practice of sending Ministry of Forests Compliance and Enforcement staff into the field *after* timber harvest, to assess whether a timber licencee achieved the required results of a Timber Harvest Permit, will not bring back an archaeological site if it has been damaged during harvest activities. Without First Nation's monitoring of all timber harvest in the vicinity of their cultural sites, sites will end up being destroyed, and their irreplaceable values being lost.

The following objectives reflect archaeological resource management policy in British Columbia:

(a) To preserve representative samples (examples?) of the province's archaeological resources for the scientific and educational benefit of present and future generations;

(b) To ensure that development proponents consider archaeological resource values and concerns in the course of project planning; and

(c) To ensure where decisions are made to develop land, the proponents adopt one of the following actions:

- avoid archaeological sites wherever possible;
- implement measures which will mitigate project impacts on archaeological sites; and
- compensate British Columbia for unavoidable losses of significant archaeological sites (a rare event).

A separate protocol agreement signed between the BC Ministry of Forests and the BC Archaeology Branch (Klimko *et.al.* 1998) established a working relationship between these two agencies that required the completion of Archaeological Overview Assessments (AOA's) and Archaeological Impact Assessments (AIA's) in the Forest Development Plan process. In this manner, archaeological and cultural sites could be identified prior to ground disturbing activities related to timber harvest, and damage to these sites could be avoided.

In brief, the protocol stipulates that the Ministry of Forests initiates and funds AOA's not captured by other BC land management agencies; ensures forestry documents incorporate Archaeology Branch requirements; and informs licencees of the need for site-specific impact assessments. The Archaeology Branch sets the standards and policies for AOA's and AIA's and heritage permits; reviews reports; issues heritage permits; and provides advice on appropriate measures to manage impacts and protect archaeological sites (Klimko *et.al.* 1998).

Problems have arisen in relation to the working protocol, such as:

- No systematic review of AOA's is done by qualified archaeological personnel, leaving the archaeological potential mapping process vulnerable to criticism of being inadequate;
- The onus for consultation with First Nations falls onto the archaeological consultants and the forestry companies, devolving the responsibility from the BC Government;
- Reductions in staffing at the Archaeology Branch, Ministry of Forests and other BC Government land management agencies have increased workloads and reduced the effectiveness and timing of review of AIA reports (Klimko *et.al.* 1998).

The Archaeology Branch – Ministry of Forests protocol does not specifically address the management of cultural resources in relation to fire suppression or the conducting of prescribed burns. The damaging of a recorded archaeological site by Ministry of Forests Fire Protection staff in the course of fighting a wildfire in the Invermere Forest District in 1998 instigated this Master investigations (Munson 2004). The road blading incident that occurred at Site **DlPW-023** prior to the setting of a prescribed burn by the Rocky Mountain Forest District in the spring of 2004, indicated that progress was still needed in establishing a better working relationship between the government agencies, First Nations and timber companies in relation to fire planning and suppression activities. Lack of communication between the RMFD and KKTC staff prior to the road blading was evident, and this activity was not anticipated in the Site Alteration Permit for Site **DlPW-023**.

The Site Alteration Permit process can itself be faulted for lack of clear definition as to what constitutes an "alteration" that can be permitted around an archaeological site. The permit describing work at all research sites states: **"if possible, frozen ground and snow conditions will be utilized and monitored to ensure that harvest activities are carried out with minimal surface disturbance to archaeological sites"**. Such uncertainty, (ie) 'if possible', allows timber contractors to proceed under marginal conditions for winter harvest, which could pose a threat to the integrity of the sites.

The Road Permit process managed by the Ministry of Forests involves no First Nation consultation; the Permit states that **"an AIA has been carried out, and the road layout and design is consistent with the results of the AIA"**. To the contrary, neither in the AIA report nor in subsequent discussions between Tembec Inc. and the KKTC did the road upgrade ever get mentioned prior to work being done. Clearly, the damage to site **DkPw-013** could have been avoided during this project if the timber licencee Tembec Inc. had consulted with the Ktunaxa Kinbasket Tribal Council prior to sending a road contractor onto the site to upgrade the log haul road. The close cooperation developed during review of timber harvest plans for the project was severely compromised with the unilateral action on road upgrading.

Conflicts over culturally significant land are pervasive because resource management processes often ignore cultural values, often because these are difficult to incorporate within conventional modes of land management (Lewis and Sheppard 2002). Management has a very different meaning and context of interaction among indigenous peoples on the land in terms of their sustenance and their traditional indigenous sense (Armstrong 2002).

Staff reductions and increasing workloads have created the situation where Archaeology Branch project officers seldom get into the field to conduct on-site research or management of the cultural sites under their mandate. The Archaeology Branch project officers now review close to 500 permit reports annually; there is a significant shift from only processing AIA reports, to a 40% workload in review of Site Alteration reports (Dave Hutchcroft, *pers.comm.*, 2005) This change can be looked at as both positive and negative: positive in the sense that any alterations to cultural sites are now regularly monitored by archaeologists, and negative in the sense that more archaeological sites are being irreparably altered by development of many types in the province.

If there is little real communication among agencies except for the requirement to fulfill legal or legislative mandates, no significant progress on cultural site management and protection will occur. Many private lands with cultural and ceremonial sites are not accessible to First Nations in the province and elsewhere, and public lands with cultural sites of ceremonial or spiritual significance are now essential to cultural survival (Forsberg *et.al.* 1988). The US Forest Service recognizes the following needs in relation to US tribal groups, and the same could apply here in British Columbia:

- Need for consistent consultation policies and practices with tribal groups;
- Need to protect all known cultural sites from damage or vandalism;
- Need to integrate cultural information directly into land management planning;
- Need to respect and protect all tribal burial sites;
- Need to understand tribal values, practices and rights; and
- Need to shift the emphasis from managing material values to inclusion of socio-cultural values (Forsberg *et.al.* 1988).

Ultimately, (and regardless of legislation), archaeological research in Canada, and in many other jurisdictions, is influenced, sometimes driven, by political and legal agendas. (Klimko *et.al.* 1998), despite the ideal scenario that research be conducted free from such influences. The current funding process, whereby the developers or forest companies pay for AIA's prior to resource development, can create an alliance not favorable to cultural site protection: the financial bond between the consultant and the company leads to situations where those who depend on archaeological work become influenced by the goals of their "clients". We need to move beyond the mode of archaeology/anthropology as 'colonial facilitator' of development (Wickwire 1991).

The lack of integration of First Nation (BC) or tribal (US) cultural information into provincial, state or federal management systems means that cultural sites can be destroyed simply out of ignorance. Despite the current strong working relationship among the California Department of Forestry and Fire Protection – Archaeology Program, timber companies, Native tribes and private landowners, the impacts of resource development activities and fire suppression activities on cultural resources still occur (Waechter 2003a). Without a statewide information system in place, one that includes immediate electronic access to confidential information regarding the location of cultural sites, these sites can be destroyed by fire-fighting activities in an emergency (Waechter 2003a). This information system can only be established following the development of a relationship of trust between all the government agencies and tribal groups/First Nations involved in cultural resource protection. If one of the parties is not willing to make information available, or if the information does not come with the assurances that it will be used in a confidential manner, then cultural sites will be damaged or destroyed because of the ignorance of their existence.

5.6.2 Recommendations for First Nation management involvement

In this "brave new world" of resource development and management, it is my view that First Nations must get directly involved in stewardship and protection of their own cultural properties and resources. Neither the *Heritage Conservation Act* nor the *Forest and Range Practices Act 2002* is protecting archaeological sites from being damaged or destroyed. The Site Alteration Permit process and the Road Permit process, in both cases during my research, allowed major damage to archaeological sites to take place without consequence to the resource developers. Regarding the immediate research issues in Ktunaxa territory, if the Ktunaxa Nation is to be involved in ecological restoration and management, then I strongly recommend that the Nation's archaeological staff be involved in all phases of archaeological site management and protection of cultural values related to ecological restoration activities (timber harvest and prescribed burning), including the following:

- Archaeological Overview Assessments of the entire Ktunaxa Nation territory;
- Archaeological Impact Assessments for all proposed timber harvest and prescribed burn plans, including road building and upgrading;
- Archaeological Inventory Assessments (similar to this research) to clearly define the boundaries of cultural sites prior to any development;
- Decision-making authority regarding whether any ecological restoration activity takes place on or adjacent to Ktunaxa Nation cultural sites;

- Monitoring of timber harvest and prescribed burning activities around all Ktunaxa Nation cultural sites, including road construction and/or upgrading;
- Post-harvest and post-burn monitoring of impacts to cultural resources;
- Cultural site remediation if impacts and site disturbance occur.

Should First Nations choose to do so, their cultural resource information can be integrated into other resource management databases, to improve cultural site protection in relation to resource development or fire protection activities. Current Geographical Information Systems technology contains tools for presentation, analysis, consultation and decision-making regarding cultural properties (ESRI 2005). One technique that may prove valuable to overcome cultural differences in interpreting natural and cultural resource information is use of photo-realistic computer visualizations in GIS. Instead of using standard planimetric maps, First Nations communities are presented an assortment of landscape management scenarios in the form of three-dimensional scaled images, depicting the land as one would see if from the ground (Lewis and Sheppard 2004).

Regarding databases, the BC Archaeology Branch has recently updated its own database through use of the Heritage Resource Inventory Application (HRIA), an archaeological and heritage site management system designed to maintain data and produce maps and reports using a province-wide archaeological geodatabase (Province of BC 2005). This database is, however, access-restricted to Branch staff and consulting archaeologists working under permit to the Branch. The US National Parks Service and the Western Archaeological and Conservation Center have developed a GIS and database system that links all available archaeological site description data and graphics onto a unified desktop computer system (Baumann 1999). Only the development of a better relationship of trust among all resource management agencies, and the provision of sufficient resources for similar technology and programming will allow First Nations to integrate their own cultural resource information into such provincial or national systems.

Movement away from the piecemeal recording of 'sites' to a focus on a larger historical/cultural context for First Nations' heritage is essential; such an approach could incorporate ethnography as an integral part of the AIA process, and also as a method for assessing the larger cultural impacts of proposed developments on the communities whose cultural resources and lives will be affected by development (Wickwire 1991).

The cultural practices of Native Americans are reflected in the prehistorical patterns of ecosystems that Europeans found in 'pristine condition' when they came to the Pacific Northwest in the 1800's (Barrett and Arno 1982). Effective ecological restoration can take place in these ecosystems if certain prerequisites are met:

- An understanding that Native American traditional knowledge often aligns with and supports modern ecological restoration practices;
- An understanding that diverse communities share contiguous lands whose condition can safeguard or endanger the ecosystem health of whole regions; and
- A commitment to applying restoration treatments that honour the contributions and informed decisions of diverse peoples (Alcoze 2003).

It is time to renounce the myth of 'pristine condition', accept traditional practices that contribute to modern restoration applications, and to forge partnerships for ecological restoration that include native communities (Alcoze 2003).

5.7 The Age of Uncertainty

Many years of insistence on the need for ecological timber thinning and re-introduction of fire in the Rocky Mountain Trench by a diverse cross-section of agencies, local organizations and user groups has produced a cooperative management program for ecological restoration that is achieving some success, albeit against the continued backdrop of increased annual forest ingrowth and encroachment of forest onto the Trench grasslands. However, there are some newly emerging ecological restoration issues that agencies and residents must take into account if current restoration efforts are to continue to be successful: climate change, and ecological uncertainty.

5.7.1 Climate change

Long-term shifts in global climate likely are under way as a result of anthropogenic greenhouse gas emissions and resulting warming (IPCC 2001a), shifts that will alter the operating conditions favourable to winter logging in the research area. A comprehensive analysis of climate data documents an average global temperature increase of 0.6°C in the twentieth century (IPCC 2001a, Watson 2002). As a result of increased concentrations of CO2 and other greenhouse gases, models predict an increase of 1.4 to 5.8°C in mean annual temperature within the next century (Watson 2002).

Climate change information available from the Canadian Council of Ministers of the Environment (CCME 2003) reflects these predictions for southeastern BC: the average annual temperature has risen 1.5°C from 1900 to 1998, and while precipitation has increased 15-20% in the same time period, there is a 3-6% decrease in precipitation falling as snow from 1950 to 1998, reflecting higher winter or early spring temperatures. In these arid or semi-arid areas (ie) rangelands, dry forests/woodlands such as southeastern BC), impacts expected would be a rise in snow line in winter-spring, earlier snowmelt, more frequent rain-on-snow, possible reductions in summer streamflow and reduced summer soil moisture (IPCC 2001a, Province of BC 2002a).

Individual ecosystem response to climate change will depend on the climatic characteristics and sensitivity of constituent species, and key ecological factors such as fire and soil moisture. In BC, with its wide variety of Biogeoclimatic Zones, some general ecosystems trends should be expected:

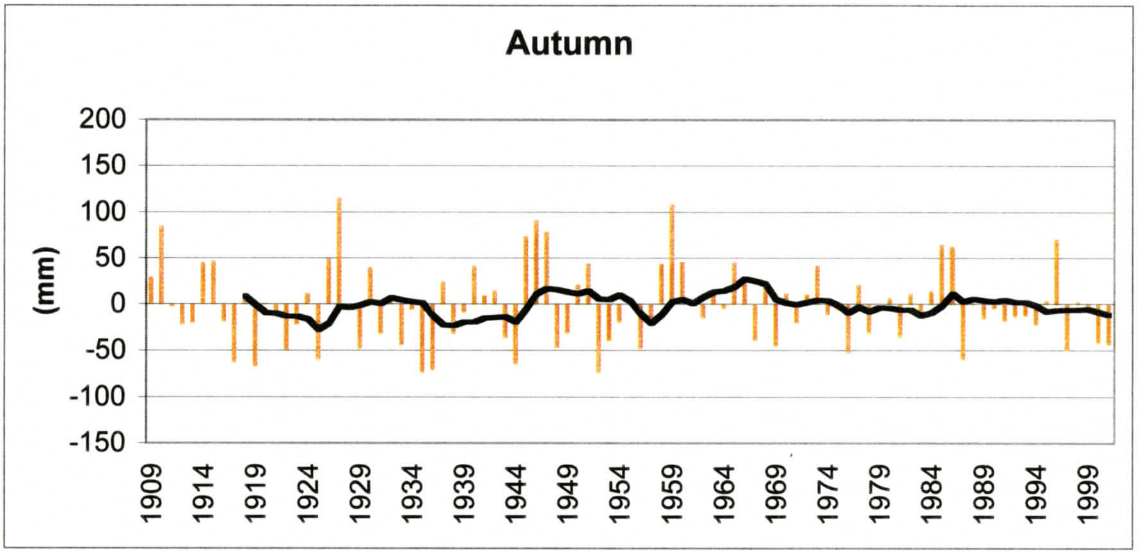
- Up-slope migration of tree lines and ecotones;
- Disappearance of forested ecosystems in regions of already warm, dry climate;
- Northward migration of some forest types in the BC interior;
- Replacement of biogeoclimatic zones by zones with no modern ecological analogues;
- Changes in disturbance regimes, (ie.) fire frequency, insect and disease outbreaks, windthrow (Hebda 1997, 1998).

Changes specific to the project area in southeastern BC include expansion of the Bunchgrass (BB) and Ponderosa Pine (PP) zones into what is now Interior Douglas Fir (IDF) zone in drier valley bottoms such as the Rocky Mountain Trench, and movement of Interior Douglas fir (*Pseudotsuga menziesii var. glauca*) upward to displace species in the Montane Spruce (MS) zone when moisture deficit becomes a controlling factor in tree distribution (Hebda 1997). Large tracts of interior forest could disappear as a result of this moisture deficit, especially drought-intolerant species such as Englemann spruce (*Picea englemannii*), Western hemlock (*Tsuga heterophylla*) and Western Redcedar (*Thuja plicata*) (Hebda 1994, 1997).

Climatic data from the Cranbrook Weather Station located 20km south of the research area in the past 90 years illustrate several important trends. For Cranbrook, the time series is 1909 to 2001. Each vertical bar is the seasonal departure for a given year from 1961-90 averages; the period 1961-90 is used for the so-called climate normals, which define the 30-year average climate and is used widely as a baseline in climate studies. If the vertical bar drops below the central zero mark, this represents a moisture decline in relation to the 30-year norm. Months represented include Autumn (Sept-Oct-Nov) and Winter (Dec-Jan-Feb), the critical months prior to and including the time period for winter logging, when snow is more likely than rain. In **Figure 97**, the decline in normal precipitation from the 30-year norm is especially evident in the period from 1984 to 2001 (IPCC 2001b), and this trend continued during the duration of the research.

Figure 98 shows the change in maximum daily temperature, again reflecting a general rise in temperatures during the late fall – early winter period of winter logging. During the winter months in the past 20 years (November – March) there has been an increase in maximum daily temperatures of 1-2°C. **Figure 99** shows a similar trend in minimum daily temperatures, which determine the amount of frost in the ground for winter logging.

In regions and in seasons where trends in both minimum and maximum temperatures were observed, minimum temperatures increased faster than maximum temperatures over the period of record. National trends indicate that minimum temperatures rose twice as fast as maximum temperatures from 1895 to 1991. The Intergovernmental Panel on Climate Change (IPCC) has concluded that the increase in minimum temperatures has lengthened the freeze-free season in mid-and-high latitude regions (Province of BC 2002a).



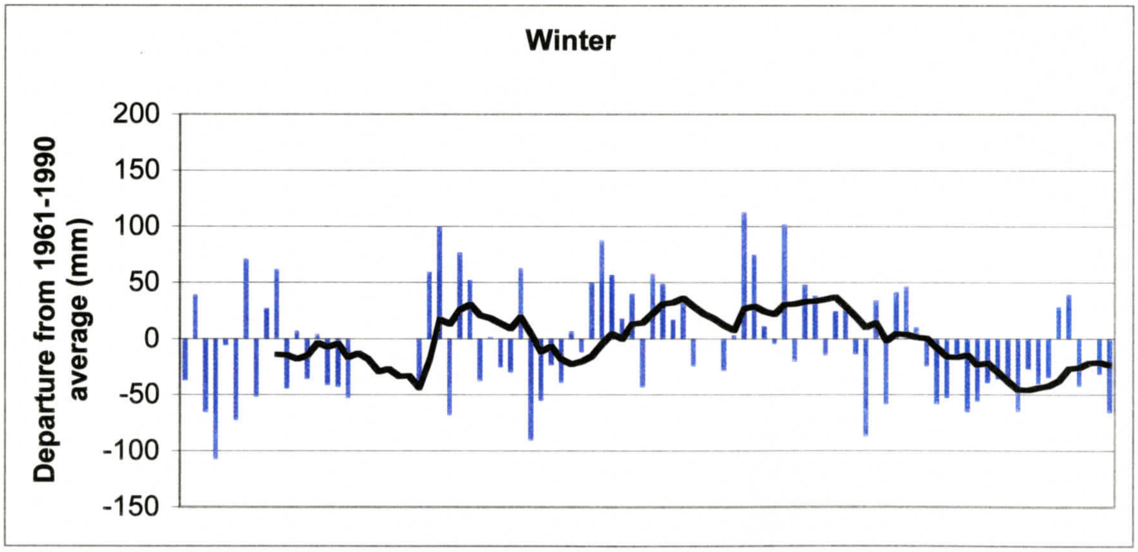
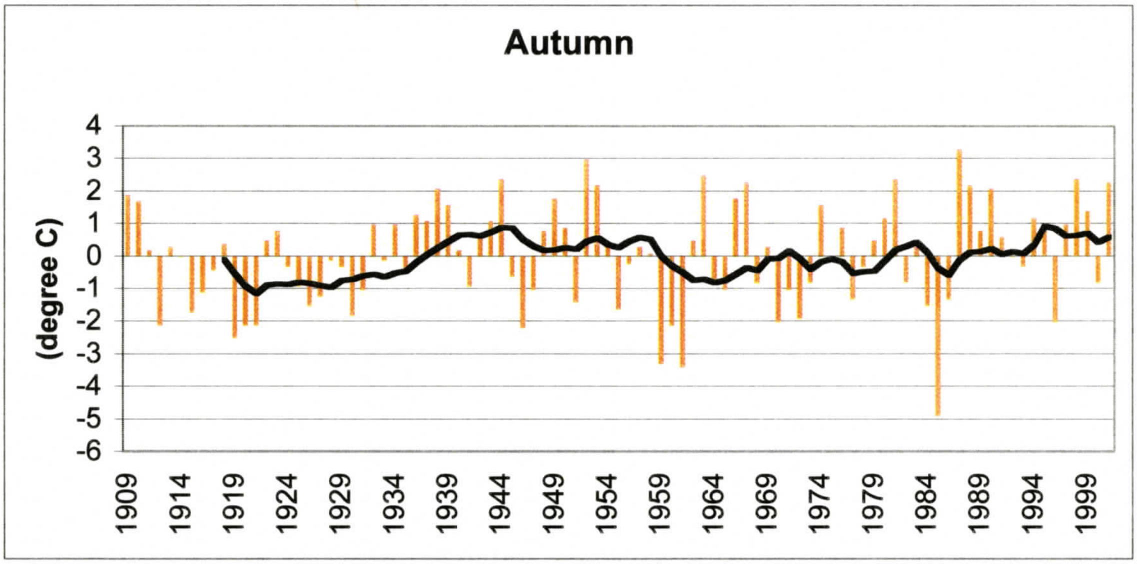


Figure 97: Climatic Records from Cranbrook Airport for Precipitation, 1909 – 2001 (IPCC 2001b)
(Note: the solid black line shows the 10-year running average precipitation)



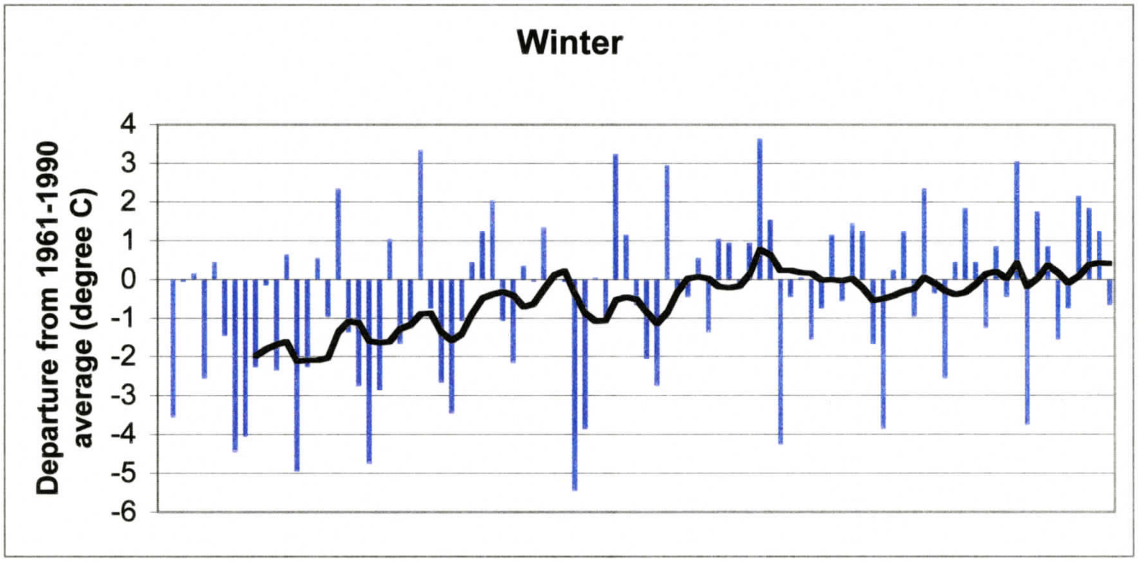
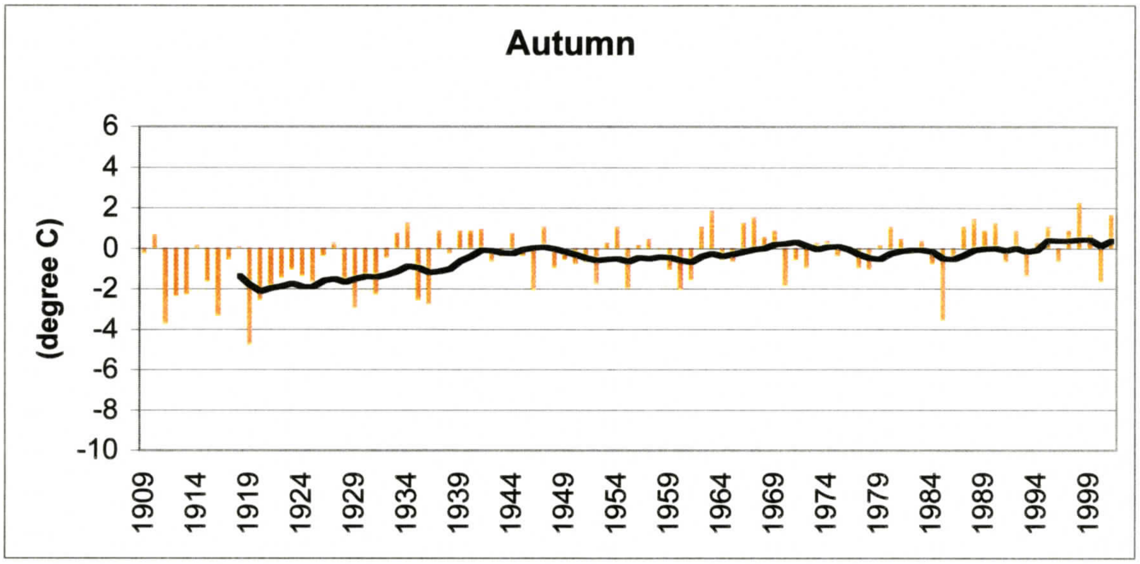


Figure 98: Climatic Records for Cranbrook Airport for Maximum Daily Temperature, 1909-2001 (IPCC 2001b)
(Note: the solid black line shows the 10-year running average maximum daily temperature)



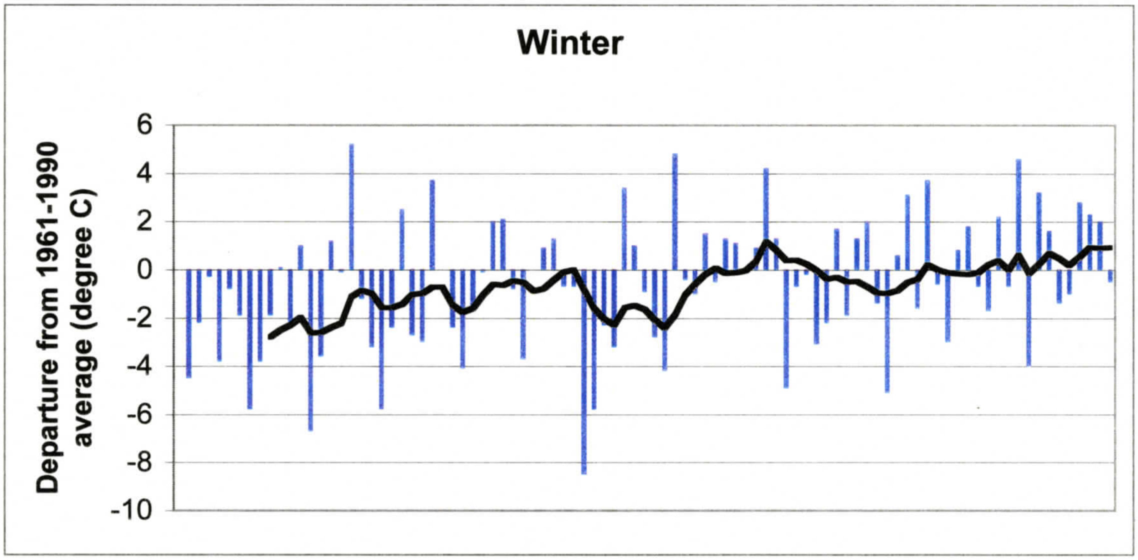


Figure 99: Climatic Trends for Cranbrook Airport for Minimum Daily Temperature, 1909-2001 (IPCC 2001b)
(Note: the solid black line shows the 10-year running average minimum daily temperature)

The lengthening of the freeze-free season translates into a shortening of the period of winter logging. The interval with suitable conditions for snow cover and frozen ground recommended to protect cultural sites is shorter. More logging will have to be carried out under less than ideal conditions and with more urgency, because there is less time available. Under conditions similar to those in March of 2005, when daily temperatures were above 0°C with little snow cover on or near archaeological sites **DkPw-025** and **DlPw-036**, increased ground disturbance around cultural sites must be expected.

One of the related side effects of warmer winter temperatures has been an increase in mountain pine beetle (*Dendroctonus ponderosae)* populations. While mountain pine beetle will attack most western pines, its primary host throughout most of its range is lodgepole pine (Province of BC 2002a). The ecological restoration work which is the focus of my research is a lodgepole-pine-only harvest of already-attacked pine, or pine in the age class vulnerable to pine beetle attack. Warmer winter temperatures would likely shift the northern boundary of the region suitable for mountain pine beetle a further 7° of latitude north, and may also allow the mountain pine beetle to extend its range upwards into high-elevation pine forests – for example, whitebark and limber pine forests of southeastern BC (Eng *et.al.* 2004). During the past few years of this research, entire mid-elevation watersheds and higher elevation pine species have already come under attack by pine beetle (M. Keefer, *pers.comm.*, 2005). Increasing pine species mortality has increased the harvest of larger timber harvest blocks in parts of the landscape that have yet to experience harvest. New logging road construction and increased ground disturbance is likely to occur in areas where archaeological sites are not yet well documented.

Large fires that consume entire stands of trees are certainly natural phenomena in parts of the Pacific Northwest in lodgepole pine forests (Friederici 2003). Altered fire disturbance regimes due to climate change (Hebda 1997, 1998) will bring increased frequency of severe fires, followed by post-fire salvage logging; this logging poses an additional threat to cultural resources, as it is often done with minimum environmental standards, and in a rush to recover wood fiber before it deteriorates. A debate is raging in the USA regarding the short and long-term environmental consequences of post-wildfire logging (Donato *et.al.* 2006). Post-wildfire studies completed in southwestern Oregon show that post-fire logging significantly increased both fine and coarse downed woody fuel loads, and increased short-term fire risk; a re-burn in logged stands would likely exhibit elevated rates of fire spread, fireline intensity and soil heating impacts (Donato *et.al.* 2006). The latter two impacts would likely affect surface and subsurface cultural artifacts, as does the increase in road network created to harvest the burned wood. The lowest risk fire strategy (and the strategy that would produce the least ground disturbance from road construction or skid trail use) may be to leave dead trees standing as long as possible, where they are less available to surface flames, allowing for aerial decay and slow, episodic input to surface fuel loads over decades (Donato *et.al.* 2006).

5.7.2 Ecological restoration and uncertainty

Science is the essential central prerequisite for ecological restoration – unless we understand the way in which ecosystems work and how their organisms interact with their environments, there can be no restoration worthy of the name.
- Perrow and Davy, *Handbook of Ecological Restoration, Volume 1, pg. xv.*

Strong scientific knowledge is critical to good restoration, but so is the knowledge of experience and tradition. Good ecological restoration is more than technical competence and efficiency, but also embraces a range of social, cultural, political, moral and aesthetic qualities that vary from place to place.
- Higgs, *Nature by Design, pg. 221.*

This research set out to collect baseline archaeological and ecological inventory information, which was used to assess impacts of development activities on cultural and ecological values. The results show that timber harvest can be carried out under prescribed conditions around cultural sites, and produce minimum surface or subsurface disturbance. However, giving respect to the principles of good ecological restoration, the Ktunaxa Nation world view cannot be cast aside when laid next to the scientific conclusions: strong cultural and moral arguments can be made for excluding Ktunaxa cultural sites from further restoration practices unless the Ktunaxa Nation determines otherwise.

Unfortunately, even the best restoration projects may have unforeseen outcomes. Some of these unforeseen results may offset any scientific or ecological benefits resulting from a restoration project (Bradshaw 2002). Unforeseen results are often described as 'uncertainties' (Jorgensen and Muller 2000). In this instance the unforeseen results did not stem from ecological but rather human uncertainty: lack of communication between human agencies and damage associated with road upgrading had serious consequences on cultural values, which overshadowed the scientific results of the research.

As every landscape is unique in terms of its biophysical characteristics and its pattern of human alteration, landscape-level restoration must be translated into site-specific recommendations which take into account the unique characteristics of the area being managed or restored (Hobbs 2002). Archaeological sites and cultural heritage are part of these unique characteristics. Steps must be taken to reduce the amount of uncertainly present in research applications, such as:

- Acquisition of accessible knowledge;
- Comparison of related cases;
- Reduction of stochasticity by repeated observations;
- Consideration of chaos; and
- Awareness of emergent properties (Breckling and Dong 2000).

Even with all this preparation, we are always left with a certain amount of irreducible uncertainty (especially of the human kind), which can unravel the best-intended research (Breckling and Dong 2000).

Despite these uncertainties, ecological restoration is now necessary, because the relationship between our human society and natural systems is not as mutualistic as it could be (Perrow and Davy 2002). A dysfunctional relationship between humans and the environment is the norm in today's society, and ecological restoration and rehabilitation are exceptions (to this dysfunction) (Cairns 2002). Implementing ecological restoration will be the "acid test" of human society's relationship with other species and the interdependent web of life that they collectively represent (Bradshaw 2002, Perrow and Davy 2002). The challenge will be huge, as changing climate and land uses by humans make the selection of an appropriate reference condition for restoration very problematic (Hebda 1999). Even if as a society we could agree that some previous reference condition was more desirable than the current one, there is considerable doubt that we have sufficient knowledge of how ecosystems function to get there. Ecological restoration must show that it is better than other options (ecosystem management, etc.) available to improve ecosystem health (Wagner *et.al.* 2000). What sets it apart from ecosystem management, in the eyes of restorationists, is that recovering the ecological integrity of a site requires using the techniques of re-establishing the composition, structure and disturbance regime of a historical or indigenous reference ecosystem (Bradshaw 1996).

5.8 Research Conclusions

The task of understanding the past and present human use of the landscape, in order to frame effective environmental and ecological restoration practices for the future is still in its infancy. The worth of ecological restoration will be adjudicated in historical, social, political, cultural, aesthetic, and moral contexts (Higgs 1997). Restoration entails difficult choices, but avoiding it should not be a choice. Not implementing restoration is an option, but not a wise one (Friederici 2003).

The term 'forest restoration' has been used to describe activities intended to recreate the forest structure and fire regimes that prevailed just prior to Euro-American settlement (Wagner *et.al.* 2000). Forest restoration is usually defined in terms of re-establishing *ecosystem* processes, implying that *human activities* have impaired natural functioning and that repairing the damage requires human intervention (Fairley 2003). However, the history of human interaction with the forest ecosystems of the Pacific Northwest has been long, varied and has produced many different outcomes; to fully understand this story, it is necessary to read the physical record of human interactions embedded in the land – the archaeological sites and associated human modifications and manipulations of the 'natural system' which result in 'cultural landscapes'. In these cultural landscapes, the individual human artifacts and activity areas are not as important as their relationships with and distribution across the land (Fairley 2003).

This research set out to study one small aspect of that relationship – whether current forest restoration practices of prescribed timber harvest (and secondarily, prescribed burning) could be carried out around the archaeological sites and in the cultural landscape of the Ktunaxa Nation in southeastern British Columbia. My conclusion is one of cautionary support for the continuation of ecological restoration practices in the research area: it appears that timber harvest and prescribed burning (with the notable exception of road activities), if carefully monitored and if carried out under controlled conditions, result in minimal disturbance to archaeological sites.

However, a strong proviso for this support is needed:

- Ktunaxa Nation natural resource staff and Elders themselves must determine whether any restoration activities are carried out around their archaeological sites and in their cultural landscapes;
- The possible impacts to archaeological sites and cultural landscapes from these restoration activities must be studied, understood and accepted by the Ktunaxa Nation if they agree to proceed with involvement in restoration work; and
- When those restoration activities proceed, Ktunaxa Nation natural resources staff must be involved in all aspects of ecological restoration work, from pre-harvest or pre-burn planning and site inventory, to on-site monitoring of activities, and to post-harvest and post-burn assessment of the impacts of these activities.

The role of fire will continue to change in the Rocky Mountain ecosystems if we continue to exclude fire from the landscape. It is not a question of 'if' a landscape will burn, but rather when will it burn, and how severe that fire will be (Keane *et.al.* 2002).

Restoration of some semblance of the historic fire regimes seems a critical step toward improving the health of these ecosystems. In most instances, the successful integration of cultural resource protection into ecological restoration plans involving prescribed thinning and/or burning can be accomplished with minimum outlay of additional funds, and minimal diminution of timber harvest yield. The only ongoing investment in cultural site protection is staff time expended by archaeologists, technicians and archaeologically-trained foresters that search for cultural sites and make management recommendations on the best way to protect them (Foster and Betts 2004). The protection of these cultural resources, which once gone, can never be replaced, is a responsibility that restoration practitioners should shoulder in concert with First Nations staff as ecological restoration continues in the Rocky Mountains.

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Appendix 1 – Personal Communication Contact List

Contact Name	Title	Organization
Brookes, Simon	District Earth Scientist	Rocky Mountain Forest District, Cranbrook, BC
Burke, Phil	Fire Protection Officer	Rocky Mountain Forest District, Cranbrook, BC
Choquette, Wayne	Consulting Archaeologist	Eaglevision Geomatics and Archaeology Ltd., Cranbrook, BC
Hutchcroft, Dave	Project Officer	BC Archaeology Branch, Victoria, BC
Keefer, Michael	Ethnobotanist	Kootenay Forest Innovation Society, Cranbrook, BC
Kenny, Ray	Permitting Officer	BC Archaeology Branch, Victoria, BC
Mackie, Quentin	Professor	Department of Anthropology, University of Victoria
Mitchell, Harry	Timber Sales Officer	BC Timber Sales, Rocky Mountain Forest District, Cranbrook, BC

Appendix 2 – Photopoint Monitoring Photos

Site DlPw-023 Wolf Creek

Photopoint # 1 – DlPw-023 Pre-Harvest June 2002

Photopoint # 1 – DlPw-023 Post-Harvest April 2004

Photopoint # 2 – DlPw-023 Pre-Harvest June 2002

Photopoint # 2 – DlPw-023 Post-Harvest April 2004

Photopoint # 3 – DlPw023 Pre-Harvest June 2002

Photopoint # 3 – DlPw-023 Post-Harvest April 2004

Site DlPw-024 (Control Site) Wolf Creek

Photopoint # 1 – DlPw-024 June 2003

Photopoint # 2 – DlPw-024 June 2003

Photopoint # 3 – DlPw-024 June 2003

Site DlPw-025 Wolf Creek

Photopoint # 1 – DlPw-025 Pre-Harvest May 2002

Photopoint # 1 – DlPw-025 Post-Harvest April 2005-08-30

Photopoint # 2 – DlPw-025 Pre-Harvest May 2002

Photopoint # 2 – DlPw-025 Post-Harvest April 2005

Photopoint # 3 – DlPw-025 Pre-Harvest May 2002

Photopoint # 3 – DlPw-025 Post-Harvest April 2005

Site DlPw-035 Wolf Creek

Photopoint # 1 – DlPw-035 Pre-Harvest June 2002

Photopoint # 1 – DlPw-035 Post-Harvest April 2005

Photopoint # 2 – DlPw-035 Pre-Harvest June 2002

Photopoint # 2 – DlPw-035 Post-Harvest April 2005

Photopoint # 3 – DlPw-035 Pre-Harvest June 2002

Photopoint # 3 – DlPw-035 Post-Harvest April 2005

Site DlPw-036 Wolf Creek

Photopoint # 1 – DlPw-036 Pre-Harvest August 2002

Photopoint # 1 – DlPw-036 Post-Harvest April 2004

Photopoint # 2 – DlPw-036 Pre-Harvest August 2002

Photopoint # 2 – DlPw-036 Post-Harvest April 2004

Photopoint # 3 – DlPw-036 Pre-Harvest August 2002

Photopoint # 3 – DlPw-036 Post-Harvest April 2004

Site DkPw-012 Reed Lakes

Photopoint # 1 – DkPw-012 Pre-Harvest June 2002

Photopoint # 1 – DkPw-012 Post-Harvest April 2004

Photopoint # 2 – DkPw-012 Pre-Harvest June 2002

Photopoint # 2 – DkPw-012 Post-Harvest April 2004

Photopoint # 3 – DkPw-012 Pre-Harvest June 2002

Photopoint # 3 – DkPw-012 Post-Harvest April 2004

Site DkPw-013 Reed Lakes

Photopoint # 1 – DkPw-013 Pre-Harvest June 2002

Photopoint # 1 – DkPw-013 Post-Harvest April 2004

Photopoint # 2 – DkPw-013 Pre-Harvest June 2002

Photopoint # 2 – DkPw-013 Post-Harvest April 2004

Photopoint # 3 – DkPw-013 Pre-Harvest June 2002

Photopoint # 3 – DkPw-013 Post-Harvest April 2004

Photopoint # 4 – DkPw-013 Pre-Harvest June 2003

Photopoint # 4 – DkPw-013 Post-Harvest April 2004