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Research Links

A Forum for Natural, Cultural and Social Studies

Tree-Ring Dating of Historic Log Structures in the National Parks of the Canadian Rockies

Figures 1 and 2. Glacier Lake Cabin, (left), and Mistaya River Cabin (right), both in Banff National Park. Photos: Karen Brelsford

Karen Brelsford

Throughout the late nineteenth and early twentieth centuries, the Canadian Rocky Mountains attracted a variety of people of different cultural backgrounds. This is apparent within the National Parks, where they have left their imprint on the landscape in the form of abandoned log cabins, teepees, and wooden coffin-like crib burial sites. Although these log structures form an essential heritage element of the mountain parks, time and increasing use of this landscape is threatening their existence. To ensure that historical information is not lost, Parks Canada and the University of Victoria Tree-Ring Laboratory (UVTRL) are working collaboratively to create an inventory of tree-ring dated structures in Jasper, Banff, and Kootenay National Parks. This paper will describe an application of dendrochronology and will highlight the results for two log structures. The results of this research are designed to contribute to the documentation of Canadian Rocky Mountain history and should assist Parks Canada in their attempt to preserve, manage and interpret the heritage resources of this area.

Since 1999, Parks Canada and the UVTRL have located and tree-ring dated log structures. During the summers of 2001 and 2002, 25 log cabins, crib burial sites and a single teepee were sampled in Jasper, Banff, and Kootenay National Parks. Tree-ring samples were taken from the structures and construction dates for each structure were determined using dendrochronology. This paper presents the findings of those investigations at Glacier Lake Cabin (Figure 1) and Mistaya River Cabin (Figure 2).

This research is a part of a larger architectural inventory currently being compiled as a component of my graduate studies. The intention is to document the age, builder(s), function(s), and architectural form of log structures in Jasper, Banff, and Kootenay National Parks. Over recent decades Parks staff have worked to document these structures and interpret their historical context. However, many of these structures remain undocumented. This project intends to shed light on the context of these structures through tree-ring analysis and in turn promote a better understanding of settlement

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Research Links is a publication that highlights research from the natural, cultural and social sciences, and is published by the Western Canada Service Centre (Calgary). Deadlines for submissions to future issues are:

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FRANCOPHONES

Le texte de cette publication est offert en français. Vous pouvez l'obtenir en écrivant à l'adresse à la page 24.

RESEARCH LINKS ONLINE

Previous issues of *Research Links* are available in PDF format from the National Library of Canada: Publications@nlc-blnc.ca, on the WCSC Intranet or by contacting us at: Research.Links@pc.gc.ca

Editorial

My brief tenure as a member of the *Research Links* editorial board has transformed my preconceived notion of this publication's mandate. Coming from a cultural resources perspective, my assumption had always been that Research Links was heavily weighted in favour of ecosystem issues – an appropriate leaning, given Parks Canada's mandate. Happily, the range of articles submitted for publication has disproved this narrow viewpoint.

The current issue aptly demonstrates this publication's commitment to balanced coverage of research from the natural, cultural and social sciences. The juncture of scientific method and cultural knowledge is explored in Karen Brelsford's article on the use of dendrochronology, a tree ring dating technique, to establish construction dates for log structures in the mountain parks. Brelsford's research represents another step in moving beyond mere inventories of cultural resources to increasing the body of historical knowledge and more importantly our ability to effectively manage and interpret these threatened heritage resources. Gwyn Langemann and Rena Varsakis' article on the Cougar Street midden in Banff shows how excavating a site can give rise to more complex issues that involve both natural and heritage resources. This archaeological research sheds light on artefacts that increase our knowledge of the townsite's past, but also offer practical help on thorny questions of contaminated site clean-up, and potential park liability in such situations.

Trevor McFayden's discussion and evaluation of the Athabaska Glacier Safety Signage project will also remind readers of the links between natural and social science research. This study of patterns of human use in a potentially hazardous natural environment increases our understanding of public safety perceptions among visitors and as a result improves our management of public safety issues.

Other articles focus on the effect of human intervention in the supposedly natural world. The potential for genetic change in black bears due to human fragmentation of previously contiguous natural landscape is discussed in Colin Kristian Reynolds' article. A.P. Clevenger's article summarizes 5 years of research and monitoring on highway-influenced wildlife mortality and the effectiveness of Parks Canada's mitigation efforts along the Trans-Canada Highway in Banff National Park. His work is all the more timely given the G-8 legacy project underway – a wildlife crossing near Canmore.

We hope you enjoy the range of articles and perspectives presented in this issue.

Katharine Kinnear, Cultural resource Services, Parks Canada WCSC, Calgary. katharine.kinnear@pc.gc.ca

Errata...

In the side bar on page 11 of *Research Links* 11[1] (Spring 2003), we inadvertently omitted equations 1 and 2 from Mark Hebblewhite's article, "Elk Population Dynamics Following Wolf Recolonization of the Bow Valley of Banff National Park." The side bar, titled "Fitting Population Modeles to Elk Population Counts," Should have listed the General Linear Model (GLM) equations as they appear below:

" ...We then fit elk population data to this set of candidate models using the following GLM of elk population growth rate over time:

$$r_t = \ln\left(\frac{N_{t+1}}{N_t}\right) = \beta_0 + \beta_1 X_1(t) + \beta_2 X_2(t) + \dots + \beta_m X_m(t) + \varepsilon$$

(equation 1) where r_t = elk population growth rate, N is population size at time t, N_{t+1} is the size at time t+1 and $\beta_1 X_1 \dots \beta_m X_m$ are the linear combination of independent variables where β_1 is the coefficient of independent variable X_1...

We graphically assessed model fit by comparing predicted to observed population size in each zone. Modeling elk populations in this fashion allows for the estimation of carrying capacity for models that include elk density as an independent variable, by rewriting equation 1 as a form of the logistic growth equation:

$$N_{t+1} = N(t) e^{(\beta_0 + \beta_1 X_1(t) + \dots \beta_m X_m(t))}$$

(equation 2) and solving under average conditions for $\beta_1 \dots \beta_m$ using starting N_t."

We apologise for any confusion our readers experienced as a result of this error.

WHO WAS JIMMY SIMPSON?

Justin James McCarthy Simpson, commonly referred to as Jimmy Simpson, emigrated from England to Canada in 1896. After dabbling in a multitude of employment opportunities, from CPR construction in Banff National Park to seal hunting off the coasts of California and Vancouver Island, Simpson settled in the Canadian Rockies. Here he began a career as a trapper and guide outfitter. His career as a guide and outfitter proliferated well into the mid 1900s, culminating with the successful Num-Ti-Jah Lodge at Bow Lake, BNP. However, Simpson's first major guiding experience began with Tom Wilson of Banff in 1898. Simpson quickly became familiar with the areas surrounding the North Saskatchewan River, including Wilcox Pass near the Columbia Icefield, the Alexandra and Mistaya Rivers, and areas south into Lake Louise and the Banff townsite. Simpson was also introduced to many noteworthy alpine explorers, including Reverend James Outram who participated in the first ascents of 10 major peaks in the Rockies, and Mary Schaffer, one of the principal non-native female explorers of the Rockies known for producing the first map of Maligne Lake, JNP in 1911 (Hart 1991).

Simpson was noted to scout out good cabin locations while he was guiding, and sometimes built tiny, flat-roofed structures (barely large enough for a grown man to crawl into for a night's sleep), while his charges were off hunting. He would return to the spot later for his own recreation!

Tree-Ring Dating Historic Log Structures

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history in the National Parks of the Canadian Rockies.

METHODS

SITE DESCRIPTIONS

Glacier Lake Cabin

The Glacier Lake Cabin is located approximately 7.5 km SW of Highway 93 and the Saskatchewan River Crossing, at the north end of Glacier Lake. The cabin is situated in a forest dominated by Engelmann spruce, lodgepole pine and subalpine fir trees. The cabin is approximately 3.4 m long, 2.6 m wide, and 2.2 m high (Figure 3), and consists of both lodgepole pine and subalpine fir log beams connected by saddle and notch joinery. The SE facing wall (side C) contains a single doorway offset towards corner C/D and the SW facing wall (side D) includes one centrally located window. A small log table is attached to the exterior of the SE facing wall (side C) and a neighbouring tree. The majority of logs exhibit attached bark and axe marks – mainly evident at the corners. Overall there appears to be minimal decay. The interior of the cabin includes three main structural crossbeams running the length of the roof. A bed platform consisting of a log frame and wood panel runs the width of side A. Above the bed, a wire cable suspends a foam mattress. A raised cupboard is attached to side B at corner A/B and a small shelf is attached to side D under the central window. Nails, presumably functioning as hangers, frame the top of doorway.

The 1993-1994 Archaeological Resource Management Programme attributed the cabin's construction to Jimmy Simpson (Francis 1996). This credit was contested in a 1983 interview with Jimmy Simpson Jr. who stated the cabin was not a Simpson Cabin, as his father's cabin at Glacier Lake had a flat roof (Mellen and Lee 1983). However, the Glacier Lake Cabin roof was replaced in the 1960s by park warden Frank Lyster (Francis 1996) and may have originally been flat.

Mistaya River Cabin

The Mistaya River Cabin is located on the west bank of the Mistaya River, approximately 1 km south of its confluence with the North Saskatchewan River. The cabin is situated on the lowest river terrace in a forest dominated by young Engelmann spruce. The structure is approximately 4.5 m long, 4.2 m wide, and 1.2 m high (Figure 4). It has experienced significant decay and extensive vegetative encroachment. While the SW facing wall (side D) is standing, the remaining three walls and the roof are partially to completely collapsed. This appears to be the result of a deadfall laying in a NW – SE orientation. However, in a Parks report taken in 1983, before the presence of the deadfall, it was noted that the structure originally had a shed-type roof (Mellen *et al.* 1983). Construction techniques include saddle and big barn notching (Mellen *et al.* 1983). Some of the beams have been striped of their bark, as noted by axe marks, while the majority exhibit partial bark. Artifacts found in and around the structure include small round-headed nails, hole-in-top cans, sheet metal fragments, and a lantern base with the label "Simplex". Previously, Mellen *et al.* (1983) noted the presence of a cable crossing across the Mistaya River slightly north of the structure.

Parks Canada inventoried the site in 1983, 1996, and 2001. The 1996 and 2001 inventories state that the Saskatchewan Crossing warden Terry Damm believed the structure was built in the late 1940s by Arturo Letourneau. The cable crossing the Mistaya

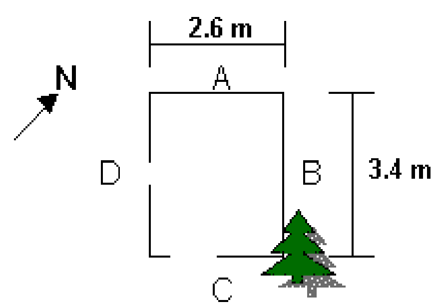

Figure 3. Glacier Lake Cabin dimensions and orientation.

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River was likely used for gravel access during the construction of the Icefield Parkway in the 1940s (Mickle and Wallace 1996; Langemann and Perry 2001). However, the 1983 and 2001 inventories indicate Jimmy Simpson may have built the structure for trapping purposes (Mellen 1983; Langemann and Perry 2001). The 2001 report states the cabin has the low, secretive appearance of a Simpson cabin and hypothesizes that Letourneau simply fixed up the structure in the 1940s during road construction (Langemann and Perry 2001). This conclusion is supported by a 1983 interview with Jimmy Simpson Jr., who identified the structure as one included in his father's hunting photo album that is labeled 1903 – 1914 (Mellen *et al.* 1983).

It is possible that Simpson built the Glacier Lake Cabin and the Mistaya River Cabin. However by determining the year of construction through dendrochronological dating we can narrow down the occupation period and with additional historical research determine if Simpson was trapping or outfitting in the area during that time.

DENDROCHRONOLOGY

Dendrochronology is a dating technique based on the recognition that trees in the mid and high latitudes grow annual rings that vary in size from year-to-year. These variations in ring widths are related to factors such as the age of the tree, climate, and individual or stand disturbance. For instance, favorable climatic conditions (ie. wet and warm) promote the growth of wide rings, while unfavorable conditions (ie. dry and cold) lead to the growth of narrow rings. These annual variations in tree-ring patterns can be matched between trees of the same species growing under similar climatic conditions (Baillie 1982). The procedure used to match these patterns is referred to as crossdating and enables both absolute and relative dating of tree-rings. Absolute dating occurs when two individual tree-ring sequences or chronologies (combined tree-ring patterns of multiple trees) are crossdated and the calendar date of the outermost ring of one of the samples is known. This allows for the identification of the calendar year each ring was formed. Relative dating occurs when the calendar dates for all samples are unknown or "floating" in time; tree-rings can only be dated relative to each other (Fritts 1976; Baillie 1982).

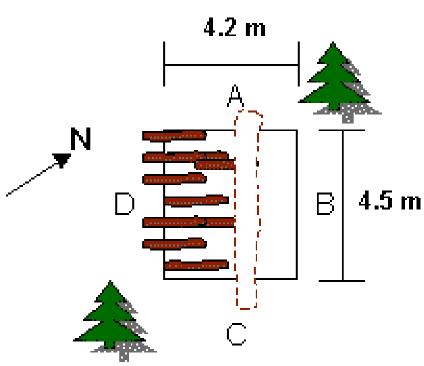

Figure 4. Mistaya River Cabin dimensions and orientation.

Absolute dating of human-built structures occurs when a construction timber and a living tree-ring chronology from the same site are crossdated (Fritts 1976). This procedure enables the determination of the construction timbers minimum year of death, the minimum year it was cut down for construction (Heikkenen and Edwards 1983; Nielsen *et al.* 1995; Pearson 1997). If the entire ring sequence is present (earlywood and latewood tissue), it is assumed that the tree was cut down sometime between the end of one year's growth period and the beginning of another. If only earlywood is present, it can be concluded that the tree was felled during that year's growth period (Baillie 1982; Nielsen *et al.* 1995; Baxter 1997). Precise dating is possible when a sample has bark, as this infers that the last year of growth is present (Baillie 1982; Nielsen *et al.* 1995). The felling date, however, is not necessarily the construction date (Fairchild-Parks and Harlan 1992; Nielsen *et al.* 1995), as the timbers may have been stored for a number of years or reused from older buildings (Nielsen *et al.* 1995). Nevertheless, previous studies have associated felling and construction dates by assuming that structures were built "green" (green wood is more easily worked and will shape differently than seasoned wood) (Heikkenen and Edwards 1983; Nielsen *et al.* 1995).

In the summers of 2001 and 2002, structure samples were taken in two forms: tree discs (360° circumference samples) with the use of a saw, and tree-core samples with the use of a two-thread 5 mm increment borer. Samples were taken predominantly on unfinished logs where surface bark was still present. Approximately 12 samples (6 logs sampled twice) were extracted from each structure (Heikkenen and Edwards 1983). If a living chronology was needed, twenty living trees within the immediate vicinity of the structure were sampled with the use of an increment borer (Fritts 1976; Nielsen *et al.* 1995).

Tree-ring samples were labeled with site and species information, and transported to the UVTRL for analysis. Samples were sanded with progressively finer sandpaper grades (80, 120, 240, 400 grit) to distinguish tree-rings for analysis (Nielsen et al. 1995). Tree-ring widths were measured to the nearest 0.01 mm with the use of the WinDENDRO digital image processing and measuring system (Guay *et al.* 1992). Samples were crossdated with the use of narrow marker years and quality checked using the International Tree-Ring Data Bank (ITRDB) software program COFECHA (statistically correlates tree-ring measurements and aids in the identification of measurement errors) (Holmes 1994).

RESULTS

For the Glacier Lake Cabin, 7 of 9 samples showed a minimum date of 1924 (Table 1). All of these samples had latewood and 5 had attached bark. Therefore we can conclude that timbers were felled for construction after the growth season of 1924, likely in the fall of 1924 or even the spring of 1925. However some of the samples displayed incomplete latewood, and were therefore cut towards the end of the 1924 growth season (late summer).

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Table 1. Age and felling dates of logs used in construction of Glacier Lake Cabin.

Sample Number	UVTRL Number	Crossdated Interval*	Age
1	01GLC01A	1878 - **1924**	47
2	01GLC01B	1784 - **1924**	141
3	01GLC01C	1791 - **1924**	134
4	01GLC02A	1783 - **1924**	142
5	01GLC02B	1784 - **1924**	141
6	01GLC03A	1766 - 1921	156
7	01GLC03B	1769 - 1923	155
8	01GLC04A	1783 - **1924**	142
9	01GLC04B	1771 - **1924**	154

*Crossdated interval = the temporal range of tree-rings (pith ring to bark ring) for each crossdated sample.

Table 2. Age and felling dates of logs used in construction of Mistaya River Cabin.

Sample Number	UVTRL Number	Crossdated Interval*	Age
1	01MRC01A	1634 - **1904**	271
2	01MRC01B	1633 - 1898	266
3	01MRC02A	1648 - **1904**	257
4	01MRC02B	1648 - **1904**	257
5	01MRC03A	1744 - **1904**	161
6	01MRC03B	1744 - **1904**	161
7	01MRC04A	1676 - **1904**	229
8	01MRC04B	1697 - **1904**	208
9	01MRC05A	1598 - **1904**	307
10	01MRC05B	1620 - **1904**	285
11	01MRC06A	1672 - **1904**	233
12	01MRC06B	1639 - **1904**	266

*Crossdated interval = the temporal range of tree-rings (pith ring to bark ring) for each crossdated sample.

For the Mistaya River Cabin, 11 of 12 samples produced a date of 1904 (Table 2). Two of the samples (1 with bark) displayed earlywood, while 9 of the samples displayed latewood (1 with bark). Therefore timbers were cut during the summer and fall of 1904, and possibly into the spring of 1905.

DISCUSSION

Glacier Lake Cabin

Construction timbers for the Glacier Lake Cabin were felled between the fall of 1924 and spring of 1925. The Parks Canada reports presented two plausible assessments; one report attributed the structure to Simpson, while another stated Simpson Jr. rejected the assumption on the basis that his father's cabin at Glacier Lake originally had a flat roof (Mellen and Lee 1983; Francis 1996). However, in considering the construction dates determined through tree-ring dating and additional historical research, including investigating biographical texts, Simpson is likely the original builder.

According to E.J. Hart, the director of the Whyte Museum in Banff and author of Jimmy Simpson: Legend of the Rockies, Simpson was beginning to secure his outfitting Lodge at Bow Lake during the 1920s. He was also actively taking visitors on guided trips in areas around Howse Pass, Mt. Forbes, and the North Fork of the Saskatchewan River, all of which are within 10 -15 km of the Glacier Lake Cabin. Hart even mentions Simpson guiding in the area of Glacier Lake (Hart 1991). In an interview with Bill Smyth, a resident of Banff, Smyth suggested the structure was likely one of Simpson's trapping cabins and it may have been used to store supplies for outfitting trips (Brelsford 2002). While this information does not place Simpson at the specific site, it does place him in the area during the construction time period.

Mistaya River Cabin

The Mistaya River Cabin timbers were felled for construction between the fall of 1904 and the spring of 1905. The Parks Canada reports presented two plausible builders, either Arturo Letourneau in the 1940s or Jimmy Simpson between 1903 and 1914 (Mellen et al. 1983; Mickle and Wallace 1996; Langemann and Perry 2001). It now seems evident that Simpson is more likely the original builder and that Letourneau reused the structure at a later date. Not only does the structure have the secretive appearance of a Simpson cabin, it was also constructed when Simpson was occupying the area between 1903 and 1914 (Mellen *et al.* 1983). Simpson was actively trapping in the area of the Mistaya River with his partner Fred Ballard until 1903 when Simpson took on the trapline alone (Hart 1991).

A similar structure to the Mistaya River Cabin is mentioned in a 1902 description of a trapline cabin documented by early 20th century mountaineers J. Norman Collie and Hugh E. M. Stutfield. Collie and Stutfield came down the mouth of the Mistaya River and discovered a cabin belonging to "two young trappers from Banff, Ballard and Simpson" (Hart 1991; Collie and Stutfield 1902). If Simpson is attributed to a 1902 cabin at the mouth of the Mistaya River, it is likely that he is also the builder of a 1904 cabin as he did continue trapping in the area after his separation with Ballard (Hart 1991).

CONCLUSION

It is plausible that Jimmy Simpson is the original builder of the Glacier Lake Cabin constructed between the fall of 1924 and spring of 1925 and the Mistaya River Cabin constructed between the fall of 1904 and the spring of 1905. However, while it is possible to place Simpson within the regions of each structure during their construction periods, it is clear that additional historical research would help clarify the building contexts. Future research could include interviewing Simpson's relatives, and accessing additional archival resources such as journals, outfitting records, and photographs. Nevertheless, this research promotes a better understanding of settlement history and assists Parks Canada in their attempt to interpret the heritage resources of the National Parks of the Canadian Rockies.

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ACKNOWLEDGEMENTS

This research could not have been completed without the assistance of Park Wardens Don Mickle and Rod Wallace and UVTRL alumni Colin Laroque. Research funding was provided by the Natural Sciences and Engineering Research Council of Canada, the Friends of Banff, the Royal Canadian Geographical Society and the University of Victoria Tree-Ring Laboratory.

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Black Bear Relatedness in a Fragmented Landscape

Colin Kristian Reynolds

Fragmentation of habitat into smaller more isolated segments may cause deleterious effects on wildlife populations, including loss of genetic variability, increased intra- and inter-specific competition, and reduced population viability (Saunders *et al.* 1991, Gerlach & Musolf 2000). Habitat fragmentation may eventually result in reduced biodiversity through local extinctions (Wilcox & Murphy 1985).

The causes of habitat fragmentation can be natural (e.g., fire, flood) or anthropogenic (e.g., agriculture, roads). For National Parks in western Canada highways are potentially major obstacles to animal movement (Clevenger *et al.* 2002). In addition to limiting animal movements directly, highways can decrease long-term survival of wildlife populations (Page *et al*. 1996). In some instances, highway deaths can exceed mortality in hunted populations (Gibeau & Heuer 1996).

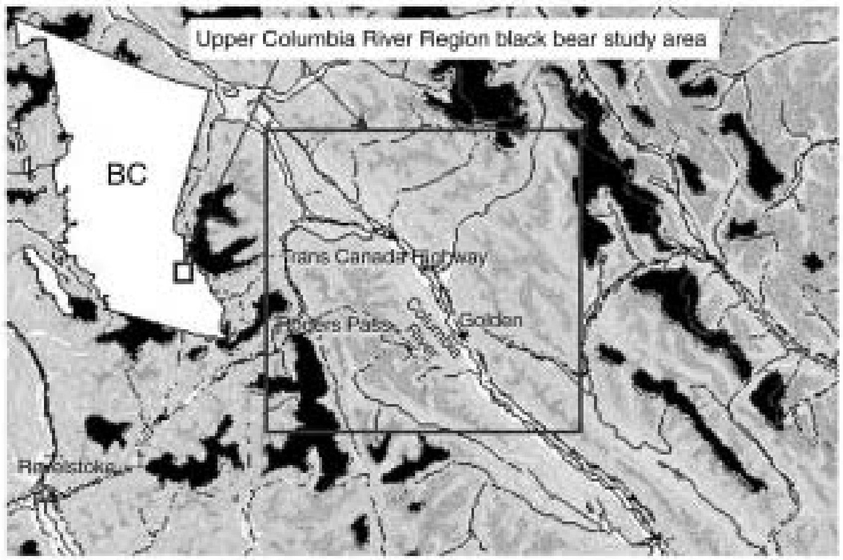

Figure 1.The Upper Columbia River region black bear study area, indicated on both the main map and inset map (British Columbia).

Black bears (*Ursus americanus*) are opportunistic omnivores that can exploit different habitat types. Serrouya (1999) showed that black bear movements are restricted in Banff National Park as a result of the Trans Canada highway (TCH). However, it remains unclear whether the exchange of genetic material is inhibited by decreased black bear movement. I assessed the genetic relatedness among black bears in an area bisected by both a highway and a river and to determine whether movements occurred across the highway and river Reynolds (2002). The effect of the TCH and Columbia River as barriers to black bear movement will be discussed.

Table 1. Program CAPTURE estimates of black bear numbers and density (/100 km^2) in the study area based on the M_t model.

	Estimate	Lower CI	Upper CI
Number			
All black bears	342	290	421
Males	151	122	200
Females	168	134	230
Density (/100km^2)			
All black bears	8.3	7.1	10.3
Males	3.7	3.0	4.9
Females	4.1	3.3	5.6

STUDY AREA

The multi-agency West Slopes Bear Research Project (WSBRP) was established to provide information for the management and conservation of black bears and brown bears (*Ursus arctos horribilis*). The WSBRP study area is within the Upper Columbia River region, centred on the town of Golden, BC., and includes the eastern portion of Glacier National Park and the western portion of Yoho National Park (Figure 1). The 4096km^2 study area was bounded to the east and west by the Rockies and Selkirk mountains, respectively.

METHODS

To assess black bear population size a closed mark-recapture model and CAPTURE software was used (Otis *el al.* 1978, White *el al.* 1982). A grid of the study area was established and consisted of 64, 8x8 km cells. One barbed-wire trap was placed in each cell for each trapping session resulting in a trap density of one trap per 64 km^2 (Figure 2). Four trapping sessions were conducted. They began on June 09, 1996 and ended on July 15, 1996 and were governed by the end of hunting season for the former and the arrival of berry season and end of easy shedding of hair for the latter.

Genetic tags generated from hair roots were used to assess black bear population size, population structure, and to infer if population fragmentation had occurred. This non-invasive approach was used because of its demonstrated success and relative low risk and cost

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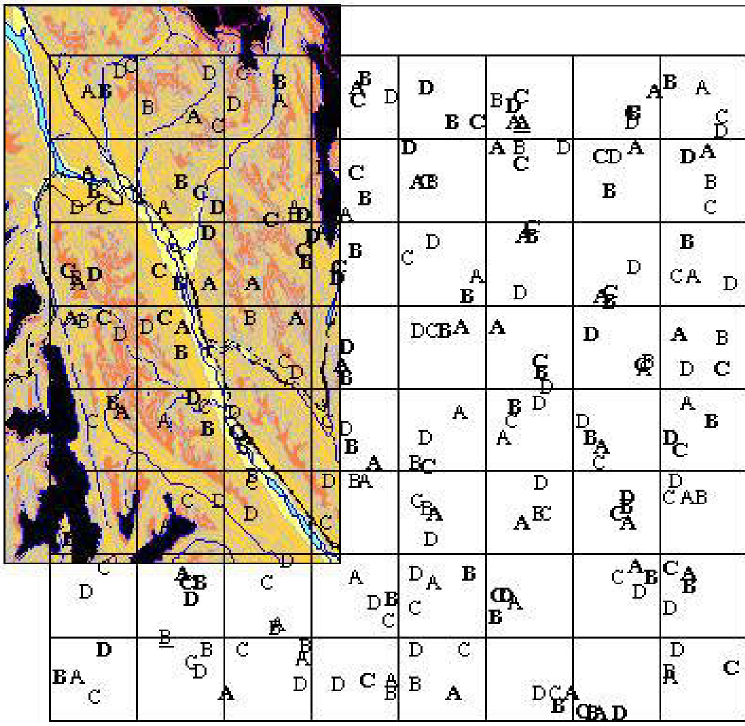

Figure 2. The trapping grid and barbed wire trap locations for the study. The bold letters A-D are the locations for barbed wire traps from trapping occasions A, B, C, and D, which had black bear hair root samples that produced microsatelite genotypes. Barbed wire traps that did not have samples are shown in normal font. Underlined trap locations were outside the intended trapping cell.

(Woods et al. 1999, Paetkau & Strobeck 1994). The genetic tags were generated using PCR and microsatellite technologies for the WSBRP because this combination allowed the use of hair roots collected in a field setting. Hair often yields a lower quality and quantity of DNA than could be utilized using other molecular methods to identify individuals. Species identification was done by PCR amplification of a segment of the mitochondrial control region. As a size difference exists in this region between brown and black bears, species discrimination is possible. Sex discrimination was achieved by amplifying a section of the Amelogenin gene; a deletion on the Y chromosome is diagnostic (Ennis & Gallagher 1994).

To verify whether the Upper Columbia River region black bears form a continuous population, the individual genotypes were used to generate allele frequencies for the study area quadrants and either side of both the TCH and Columbia River. Individuals were then assigned to the quadrant or side (depending on test), which had the allele frequencies in which their observed alleles were more likely to occur (Paetkau & Strobeck 1995). The genotypes of individuals captured in more than one quadrant or side were used in the generation of allele frequencies for all areas in which they were sampled.

(For details of the methodology for this study, see Reynolds 2002).

RESULTS

From the four trapping sessions in 1996, 1082 samples were identified as black bears. Of the 1039 successfully amplified samples, 120 mixed samples were removed from the analysis. The remaining 919 samples provided 185 different black bear genotypes. Sufficient DNA remained to sex-type 178 black bears into 90 females and 88 males. As a quality check of the results and methodology the individuals were compared to a previous study in the same area (Paetkau *et al.* 1988) using both the full individual genotypes and partial genotypes. Full genotype as well as sex matches were found for 16 individuals.

The Mt estimator from the CAPTURE program (heterogeneity given time variation) predicts 342 black bears (290-421 [95% Confidence Interval (CI)]) and a density estimate of 8.3 black bears/100 km^2(7.1-10.3[95% CI]) for the Upper Columbia River region (Table 1).

Three black bears were sampled on both sides of the TCH and two on both sides of the Columbia River. The likelihood of a black bear genotype belonging to the other side of a barrier (TCH or Columbia River) was higher 36% of the time (Figures 3 and 4). When the study was split into four equal quadrants 62% of the black bears had genotypes with a higher likelihood of occurring in a different quadrant than from the one in which they were sampled, indicating extensive mixing.

DISCUSSION

Population estimates were generated for black bears in the Upper Columbia River region using a DNA mark-recapture protocol. However, the use of mark-recapture protocols to generate population estimates of wide-ranging animals can result in the violation of mark-recapture sampling assumptions (e.g., closed system, equal probability of capture). The study area was large in comparison to the average black bear home range, which reduces the total proportion of animals that move in or out of the study area. While having a large study area will reduce the total proportion of individuals that violate the assumption of closure it does not remove the possibility that some closure violation occurred. The large study area and financial concerns resulted in a lower than recommended trap density. The low trap density could have resulted in only a few individuals being captured multiples times and/or some individuals with no probability of capture. There were 44 individuals captured multiple times while 141 black bears were captured only once. Both closure violation and low trap density could contribute to an over estimate of population size. However, any over estimate of the population by this study appears to be minimal because the total number of black bears captured in this

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Black Bear Relatedness in a Fragmented Landscape

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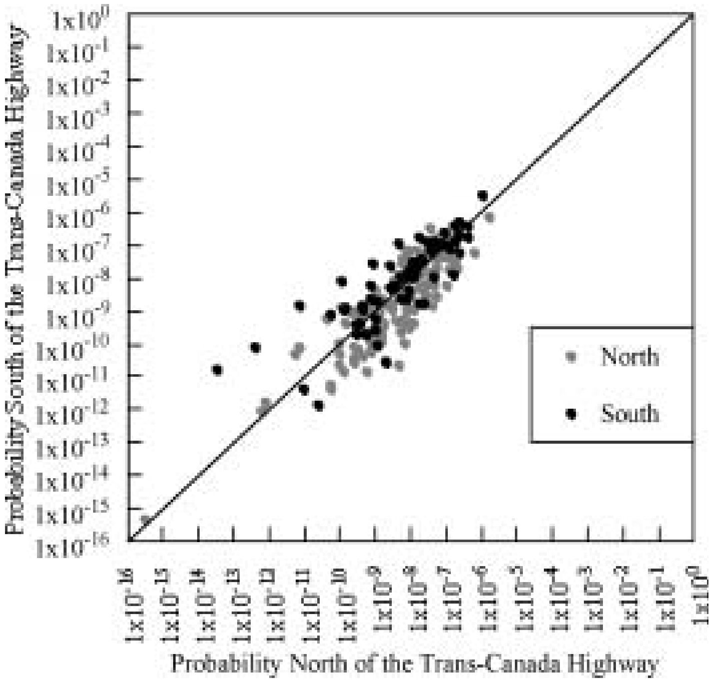

Figure 3 Upper Columbia River region black bears sampled North (black) of the Trans Canada highway and South (gray) of the Trans Canada highway. Black bears with genotypes which are more likely to be found in the group sampled North of the Trans Canada highway, based on the allele frequencies observed in both groups, are below the diagonal while those black bears more likely to be sampled South of the Trans Canada highway are above the diagonal.

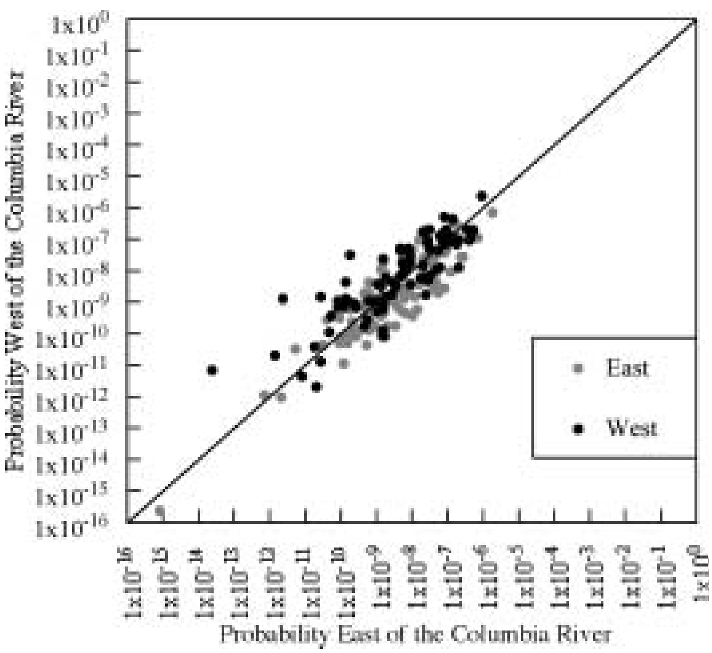

Figure 4 Upper Columbia River region black bears sampled East (gray) and West (black) of the Columbia River. Black bears with genotypes which are more likely to be found in the group sampled East of the Columbia River, based on allele frequencies in both groups, are below the diagonal while those black bears more likely to be sampled West of the Columbia River are above the diagonal.

and previous studies is 286, only 4 bears lower then the lower bound of the 95% CI of the population estimate.

Individuals were captured in traps on both sides of the TCH and Columbia River providing real time evidence of black bear movement across both, potentially fragmenting, landscape features. My results suggest that the TCH or Columbia River do not limit the movement of black bears in the Upper Columbia region. I was unable to find functional habitat fragmentation, unlike some other studies, for black bear for two reasons. First, black bears are found to be more tolerant of human transportation corridors in the Upper Columbia River region and extensively use timbered areas and right-of-ways located in valley bottoms to move through the area (Munro 2000). These movement corridors may be adequate enough to ameliorate fragmentation effects. Second, although black bears have been killed on this section of the TCH (Clevenger *et al.* 2002), mortality limiting genetic flow may not be large enough to be detected at the genetic level.

However, based on the body of available evidence, resource managers should remain cognizant of the effects of landscape fragmentation. Highway mortality, especially of black bears continues to be a problem. Continued monitoring of the black bear population (e.g., at five or ten year intervals), using similar methodology will ensure that mortality does not limit existing genetic transfer and diversity. If genetic isolation is detected, then clearly mitigation measures (such as underpasses), will need to be put in place to mitigate habitat fragmentation effects.

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- References concluded on page 7 -

THE COUGAR STREET MIDDEN
The role of archaeology in contaminated site clean-up

Gwyn Langemann and Rena Varsakis

Every town has a nuisance grounds. Informal at first, they grow of their own accord, and as the town grows they are formalized and relocated farther from the residences. Sometimes they are covered and forgotten, and the town continues to build over top of the old dumps. When eventually rediscovered, there can be consequences that were not a concern in the days before environmental assessments.

In 1999, two small houses on Cougar Street in Banff townsite were torn down to make way for a condominium complex. During the excavation, a compact one metre-thick lens of garbage was found under a metre of fill in the back yard. This contained bottles, china, tin cans, briquettes, and coal, all suggesting a date from the turn of the last century. Knowing the interest that archaeologists have in old bottles and china, the Banff National Park environmental assessment staff collected some of the best examples and brought them to our attention.

Now, a good garbage dump is the stuff of both ancient and modern archaeology. Our interest here is in establishing a reference collection of artefacts in good condition from a known context.If we have bottles and china from a known provenience and date, we can use this to help identify and date other bits that we find in less well understood archaeological situations. So in the case of the Cougar Street it was not the midden itself that was of archaeological interest, but the chance to get a sealed sample of artefacts from a tight time frame, associated with a particular culture, that had not been picked over by bottle collectors. The midden is not a site that we want to protect. We catalogued some of the best bottles and china, and thought no more of it.

But the Cougar Street midden did not rest quietly. Workers proceeding with the water and sewer line replacements under Cougar Street in 2001 continued to find the occasional artefact. Work on Marten street, behind the original find, discovered another concentrated part of the midden. Soil testing showed that the area was a contaminated site, where lead and other heavy metals had leached into the soil, either from the containers themselves or their one-time contents. Banff National Park now faces a contaminated site clean up.

Figure 1. Torpedo bottle, often used to hold mineral water.

How can archaeological analysis help in such a situation? In this case, the history of the midden is not clear. Warden Dave Hunter has found references in the Banff *Crag and Canyon* to an old nuisance grounds near Whiskey Creek, in the rear of the old NWMP barracks, which might match this location. These references suggest this dump was in use by 1901, and formally closed in 1907 when Superintendent Douglas set apart a new dump below the race track. The *Crag and Canyon* approved of this, noting that the growth of the town had brought the old dumping ground too near the residences.

An observation by the *Crag and Canyon* of May 24, 1913, has an uncanny ring of the present. "To the old timer it seems incredible that residences of a class not dreamed of in the days of Banff's somnolence should be in the course of erection or completely finished in such locations as the old nuisance grounds… or that homes costing $3,000 are located a stone's throw off the meandering course of Whiskey Creek."

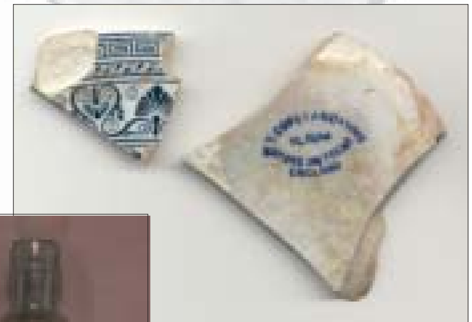

Figure 2. Transfer-printed tableware sherds of the Ilium pattern.

Now there are issues of liability for the cost of contaminated site clean up, and the park wishes to establish the age of the deposits in the dump. This is difficult without any formal, archival evidence of the origin of the midden. The leases in this area appear to have been let in 1912, so the question that the park asked the archaeologists was whether or not the dump material predated 1912. That is, was the midden deposited by the leaseholders, or by more general use from the town as a whole beforehand?

To answer this question, we researched the manufacturing history of the 214 artefacts, primarily bottles and china, originally recovered from the Cougar street midden. The ceramics are primarily tableware, dominated by pieces with the early version of the Canadian Pacific Railway logo, but there are also other transfer prints and hand-painted decorations that have not so far been traced. The bottles were identified as liquor, medicine, perfume, soft drink, and preserving jars. Where the pieces had maker's

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THE CANADIAN INTERMOUNTAIN JOINT VENTURE:

Working together to maintain, enhance, restore and manage habitat for the benefit of wildlife and people in the Canadian Intermountain

The Canadian Intermountain region is located in the south and central interior of British Columbia and the Rocky Mountains of Alberta, encompassing several of Canada's National Parks (Figure 1). It is a landscape of widely varying elevation and climatic conditions resulting in a broad range of habitat types, including the grassland and shrub-steppe ecosystem of the Great Basin and northern Rocky Mountains, Caribou grasslands, Chilcotin Plateau and sub-boreal forests. These highly diverse ecosystems provide very important habitat for breeding, migrating and wintering waterfowl. With 373 bird species recorded thus far, this region contains one of the most diverse breeding bird faunas of any Canadian region. However, the Canadian Intermountain also supports a growing human population and extensive resource-based industries, including ranching, forestry, energy, mining and agriculture. While these activities sustain the Canadian Intermountain economies, they also pose a threat to waterfowl habitats and can have a profound influence on bird populations.

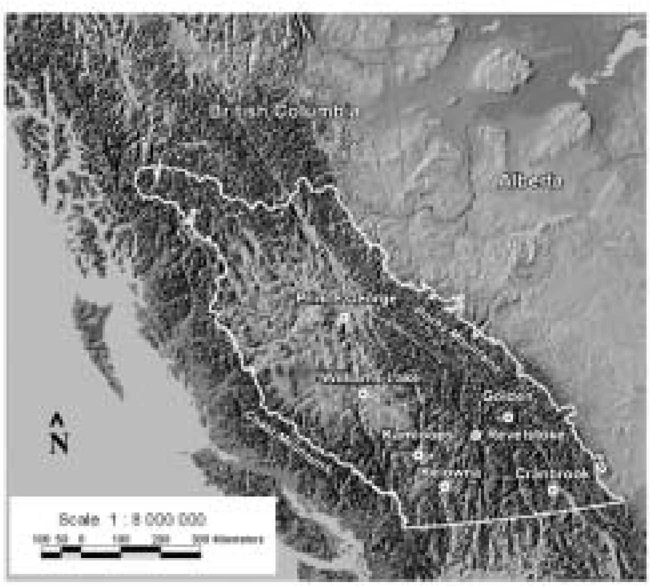

Figure 1. CIJV boundary, indicated by white line.

To minimize the impact of resource-based industries the Canadian Intermountain Joint Venture (CIJV) was formed. It is a partnership between the resource sectors, government agencies, First Nations, non-governmental conservation organizations, universities and individuals, that aims to address the needs of waterfowl and other birds in the Canadian Intermountain region. Using a habitat-based approach, the CIJV will define the critical structure and attributes of various types of important habitat and where sufficient data exists, determine quantitative habitat and population objectives.

Not only will Parks Canada's involvement in this joint venture help to guide and assist the Mountain Parks' avian research, but it will help to enhance greater park ecosystem partnerships while working towards Ecological Integrity.

For more information please contact:

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BIGHORN IN OUR BACKYARD (BIOB)

PROJECT UPDATE

Every fall the Radium-Stoddart Rocky Mountain Bighorn Sheep (*Ovis canadensis*) return to forage and mate in their critical winter habitat, which is centred on the village of Radium Hot Springs, B.C.. Historically, this region was characterized by fire-maintained grassland and open forest ecosystems, and supported up to 300 bighorn sheep. However, decades of fire suppression resulting in the encroachment and ingrowth of dense coniferous forests, as well as increasing human alteration of the landscape have created smaller and less suitable winter habitat for the sheep. As a result, the population of Radium-Stoddart Rocky Mountain bighorn sheep has dropped to as few as 140 individuals.

The Bighorn In Our Backyard Project (BIOB)[1] was initiated in 1997 by Osprey Communications and Parks Canada in order to highlight the needs of the wild bighorn and their associated ecosystem in the Radium area. It is an ecosystem-based education and research project involving a broad range of partners, including

[1] *Halverson, L.& B. Swan. 1997.* Bighorn In Our Backyard: Communities Working for Wildlife. Research Links 6[1]: 3,7.

community residents, ranchers, government and non-government agencies, and various interest groups. Several projects have been initiated to restore the fire-maintained grassland and open forest ecosystem in hopes of increasing the size and quality of the population's critical winter range. To date, restoration projects have been conducted on two provincial parcels of land (totalling approximately 140 hectares) on the Radium-Stoddart historic winter range. The areas were logged, thinned and the slash piles burned, thereby creating an ideal environment for the growth of grasses and decreasing the risk of catastrophic wildfire.

Photo: Larry Halverson

Parks Canada recently initiated the Redstreak Restoration Project in the south end of Kootenay National Park, in and around the Redstreak Campground. During January and February 2003, trees were cut and removed from three areas (totalling around 150 hectares), to restore the open forest ecosystem, reduce the dangerous fuel load and create a fire guard for Redstreak Campground. Given the right conditions, low intensity prescribed burns in these areas will begin early in spring 2003 to thin out the Douglas fir forests, to facilitate nutrient recycling and restore the open forest ecosystem.

Local landowners will soon be encouraged to support restoration efforts through a new BIOB initiative, the Private Land Stewards Program. BIOB hopes to assist landowners with the cost and planning of restoration, encouraging a stewardship ethic. Other ongoing BIOB Project initiatives include the Bighorn Community Monitoring Program and remote satellite monitoring of ten radio-collared bighorn sheep. With the continuing success of this collaboration these projects will help to identify bighorn sheep critical habitat and migration corridors, and thus refine ecosystem restoration efforts.

For more information or to request copies of the BIOB newsletter: the BIOB Beat, please contact:

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For more information on the Redstreak Restoration Project please contact:

Rob Walker, Fire and Vegetation Specialist, Radium Hot Springs. Tel: (250) 347-6155; rob.walker@pc.gc.ca

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The Cougar Street Midden

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marks on the bottom, or distinctive manufacturing techniques, a date for the original manufacture of the piece could be obtained. All of the datable pieces range from the 1890s to 1920.

Six soft drink or mineral water bottles were recovered; these are aqua coloured torpedo bottles, with distinctive round bases (Figure 1). The bottle was made in a two-piece mould, with an applied finish (the term for the top of the neck and lip). Torpedo bottles were made and used through the 19th century, and first patented in 1809 by William Hamilton of Dublin.

Two blue transfer-printed tableware sherds (Figure 2) are the *Ilium* pattern, shown in the 1882 W. T. Copeland and Sons catalogue. According to the Spode Museum in England, this variation of the *Ilium* pattern dates to c. 1894.

The CPR china was manufactured by A. T. Wiley & Co. in Montreal and France, beginning in 1902. Ironstone fragments manufactured by Alfred Meakin, Staffordshire, were manufactured between 1897 and 1900. Opaque white glass McLaren's cheese jars were manufactured between 1891 and 1902. An aqua glass liquor bottle was from a Lancashire company, made between 1899 and 1913. Altogether, the assemblage resembles those we have recovered from other early sites in Banff, such as the Banff Sanitarium Hotel, and the Hydropathic Hot Springs Hotel. Banff townsite was born with the advent of the railway, which also allowed businesses and residences to import a wide range of products from eastern Canada, England and France. The historic artefacts bear witness to this international commerce.

The manufacturing dates suggest that the bulk of the midden certainly dates from before 1912. However, when analyzing historic artefacts, one consideration is the lag time between the manufacture date, and the use and discard date. Items such as liquor bottles and food containers have a small lag time; ceramics, on the other hand, often have a much longer lag time. And there are some items from the midden that are clearly of much more recent manufacture, suggesting that people have not always been conscientious in disposing their garbage.

Archaeological analysis of the artefacts from the midden has also shown them to be primarily domestic, rather than industrial, and this may help to determine the possible sources of heavy metal contaminants. The lead may have leached from the solder in the tin cans themselves, or from such contents as paint.

The Cougar Creek midden site will be cleaned up, because it is a contaminated site, but the exact process and timing is not yet set. Geophysical testing has been done, and some of the contaminated soil removed, but there are still portions left to remove. However, the questions of liability for the cleanup are still under consideration, and archival and land titles research continues. Archaeological analysis has been able to contribute to the discussion by establishing an approximate age for the dump (1890s through 1920), and a source (domestic garbage rather than industrial).

Gwyn Langemann and Rena Varsakis, Cultural Resource Services, Western Canada Service Centre, Calgary.
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Assorted items from the Parks Canada Archaeology Material Culture Reference Collection (see p. 15). Photos: Jack Porter,

The Parks Canada Archaeology Material Culture Reference Collection

Cultural Resource Services keep a large number of artefacts in each Parks Canada Service Centre, as a reference collection that is accessible to any researcher. These are all linked as part of the larger national reference collection. The bulk of the artefacts recovered from each archaeological excavation go into storage, but the most unusual, the most typical, the ones with the best ties to the unique nature of each precontact archaeological site or each National Historic Site, are kept handy as a reference.

Archaeology seeks to understand how people lived in the past; how they interacted with their physical environment, and with the other people in their houses and communities. Much of this we learn by studying the artefacts that people leave behind.

When archaeologists excavate a site, whether historic or precontact, they systematically peel a site down through the layers of time. In the process, artefacts are recovered. That is why excavation is done so carefully: so that the individual artefacts can be firmly linked to particular time periods or features within the site; so that we know which ones are older and which younger, and which ones are associated with particular activity areas. Artefacts that are looted from a site, or recovered from a disturbed site, are of less value than artefacts found in their original context. This is because they are not tied to a particular time period or feature, and are simply floating in unknown space and time. But even these "floaters" can be of use if they can be matched up with some other artefact that does come from a known context.

Reference books can be consulted in order to describe an artefact, but it is also important to compare them to known artefacts, from known places and times. This is where the reference collection comes in. Sometimes only a small part of an object is found, but it can be identified if compared to a whole object. For example, very few of us anymore can identify parts of a horse and wagon harness, or small parts of horse-drawn farm machinery, yet these are commonly found on historic sites.

WHAT DO WE KEEP IN THE REFERENCE COLLECTION?

For precontact sites, we keep examples of all the variety of lithic materials found, so that researchers can use the same terms to describe stone tool materials (obsidian, Banff chert, Swan River chert, Bowman chert, Gog formation quartz crystal). The geological sources of some lithic materials can be identified, so that we know where people were travelling to get the stone in the first place. We also keep examples of the diagnostic artefacts, the ones that change over time and so are useful to date an occupation in a site. The style of projectile points changes in a well established series from the early postglacial large unnotched spear points, through smaller notched atlatl points, to very small arrow points, to historic metal trade points. For Banff National Park we have prepared a separate reference tray of projectile points from components that also have radiocarbon dates, and so are very securely dated.

For historic sites, we keep examples of distinctive china patterns and bottle types, because these are particularly useful for dating a time period. Fashions change, manufacturing techniques change, advancing technology makes certain artefact types obsolete. The maker's marks left on the underside of china pieces, and embossed in bottles can often be used to determine a time range. Anyone who has tried to replace a piece in their set of good china, only to be told that the pattern has been discontinued, can appreciate the usefulness of known patterns for providing a date.

The use of a reference collection allows an accurate and consistent description of the artefacts, and therefore allows a comparative analysis of two different sites. Do these two prehistoric campsites have the same type of lithics for their tools, or were the people getting their stone from different quarries? Do these historic sites have the same types of ceramic and glassware, or is one getting luxury imported ware while the other is using cheaper local ware? Material culture analysis allows us to answer many questions of technological and social history.

WHAT ARE THE MAIN USES OF THE COLLECTION?

- To identify unfamiliar or broken artefacts
- To date pieces, through comparison with similar artefacts from known contexts
- To facilitate comparisons between sites
- To allow accurate and consistent descriptions of artefacts
- To provide artefacts for interpretive displays at the parks and sites

WHO USES THE COLLECTION?

- Archaeologists from the Service Centre
- Other Parks Canada archaeologists
- University students
- Professional archaeologists from universities, provincial heritage offices, and consulting companies
- Park interpretive staff

Movements, Mortality and Mitigation:
An Overview of the Final Report on Roads and Wildlife in the Canadian Rocky Mountain Parks

In *Research Links* 7[1], Spring 1997, we featured an article on A.P. Clevenger's preliminary study of highway effects on wildlife in Banff National Park (Clevenger 1997). Since then, Clevenger and his research associates have continued to examine questions related to the Trans-Canada highway's role in wildlife mortality, and contributed other articles to *Research Links* dealing with specific studies on cougars (*Puma concolor;* see Gloyne and Clevenger 1999) and tiger salamanders (*Abystoma tigrinum*, see Clevenger *et al.* 2000). After more than 5 years of research, they produced a final report on studying the impacts of roads on wildlife in the Canadian Rocky Mountain Parks and assessing performance of highway mitigation measures (Clevenger *et al.* 2002). What follows is a summary of their findings, conclusions and recommendations, based on the final report.

A.P. Clevenger

Between November 1996 and March 2002, I led a team of researchers who studied various aspects of highway-influenced wildlife mortality and the effectiveness of Parks Canada's mitigation efforts (fencing, underpasses, overpasses) along a busy stretch of the Trans-Canada Highway (TCH) in and near Banff National Park (BNP), AB. The research focused primarily on the highway's permeability to wildlife in terms of its effects on wildlife mortality, wildlife movements, and habitat connectivity in the Bow River Valley. We investigated five main research areas to evaluate means of mitigating road effects on wildlife and make recommendations for future transportation planning schemes in the mountain parks: 1) Wildlife crossing structure monitoring, 2) habitat linkages and patterns of wildlife movement across roads, 3) patterns of wildlife mortality on roads, 4) mitigation effectiveness in reducing wildlife mortality on roads, and 5) GIS-based modeling approaches to identify mitigation placement and wildlife movement across roads.

STUDY AREA

The primary study area is in the Bow River Valley along the TCH corridor in BNP, approximately 100 km west of Calgary. The first 45 km of the TCH from the eastern park boundary (phase 1, 2, and 3A, see Figure 1) is four lanes and bordered on both sides by a 2.4 m high wildlife-exclusion fence. The remaining 30 km to the western park boundary (phase 3B) is two lanes and unfenced. Parks Canada plans to upgrade phase 3B to four lanes with mitigation within the next 5 to 10 years. Twenty-two wildlife underpasses and two wildlife overpasses were constructed between 1980 and 1998 to permit wildlife movement across the four-lane section of TCH. The secondary study area extends along the TCH from the Kananaskis River (Highway 40) west of Calgary, to the western boundary of Yoho National Park. Other highways in this study include Highway 40 in Kananaskis Country, and Highway 93 in Banff and Kootenay National Parks.

METHODS AND RESULTS

1. Wildlife Crossing Structure Monitoring

Our wildlife crossing structure monitoring began in November 1996. During a 64-month period we consistently checked crossing structures (Figures 2 and 3) for wildlife use by identifying tracks at 2m wide, raked track-sections. In addition, at the two wildlife overpasses (Figure 3), infra-red-operated TrailMaster 35mm camera systems were used to photo-document wildlife passage. Wildlife is defined herein as wolves, coyotes, cougars, lynx, black bears, grizzly bears, mule and white-tailed deer, elk, Rocky Mountain bighorn sheep and moose. (Tracks of unidentified canids, and small and medium-sized mammals were noted, but a detailed study of these species is not part of this summary.) Human use (foot, bike, ski, horse) at the crossing structures was also quantified.

During the 64 months of monitoring, more than 37,379 individual wildlife passes were detected at the 22 crossing structures. General trends for the four top species using the structures in Phases 1 and 2 are, most common to least common: wolves, cougars, black bears and grizzlies. The trend for phase 3A was slightly different, with fewer wolves than black bears (i.e., in descending order: cougars, black bears, wolves and grizzly). Unlike

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the crossing structures in phase 1 and 2 that have been in place for nearly two decades, construction of phase 3A crossing structures was completed approximately four and a half years ago. Therefore annual trends reflect both the effectiveness of the structures in facilitating animal passage across the TCH, and adaptation of resident wildlife to new structures. Human passage at some of the crossing structures has been surprisingly high, more than coyotes and nearly that of deer.

In BNP, an underpass is located within 200 m of each overpass. After 4.5 years, some species-specific patterns emerged: grizzly bears, wolves and all ungulates tend to prefer overpasses, cougars prefer underpasses, and black bears do not appear to have a preference.

We expected that if the crossing structures provided a safe habitat for traversing the TCH we would see this reflected in the temporal patterns of wildlife overpass use by different species. Yet, we also expected the frequency of crossings to be generally higher at night, when traffic volumes are low and highway noise is minimized. The temporal patterns we observed appear to be synchronous with the species' known activity patterns. However, the temporal pattern of grizzly bear crossings matched the temporal pattern of road crossings on low as well as high volume roads in our study area. We observed some interesting dynamics in predator and prey populations (more cougars in the area, a new pack of wolves established east of Banff townsite, and a general decline in the elk population near Banff townsite) that we expected would influence crossing structure use by both predators and prey. We found that predator use of underpasses increased substantially and that elk underpass use increased slightly over the course of the study.

2. Linkages and Patterns of Wildlife Movement Across Roads

In this group of research projects, we looked at some of the key factors influencing the decisions of animals to use the crossing structures, and where/when animals crossed a busy, unfenced, unmitigated section of highway. We investigated these issues using data from our year-round monitoring of BNP wildlife crossing structures.

In phases 1 and 2 (where adaptation effects should be low because the structures have been present for up to 12 years), we found that human use was a significant factor influencing species passage. In addition, we noted that

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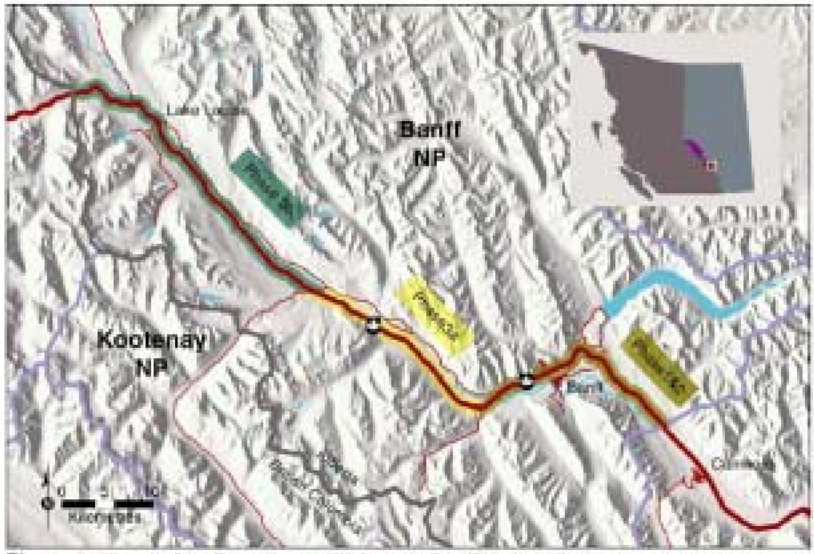

Figure 1. Phases of the TransCanada Highway in Banff National Park

Figure 2. Locations of wildlife crossing structures on phases 1 and 2 of the TransCanada Highway in BNP.

Figure 3. Locations of wildlife crossing structures on phase 3A of the TransCanada Highway in BNP.

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carnivores used structures close to drainages, whereas ungulates avoided them.

As a sequel to the phase 1 and 2 study, we examined a completely new set of crossing structures in phase 3A. Contrary to the phase 1 and 2 findings, our results indicated that structural attributes best correlated to passage for predator and prey species, whereas human-related factors were secondary. The patterns we observed conform to the evolved behaviours and life history traits of the different species. Some species preferred open passage structures areas (e.g. overpasses and open span underpasses; grizzlies, wolves, elk and deer), and others (black bears and cougars) preferred more constricted passages that provide cover. In a related study, cougars crossed most frequently when structures were located near high quality habitat, suggesting that, for this species, the structures effectively provided connectivity between habitat on both sides of the highway.

We examined the relationships between roads, grizzly bears and their habitat in a protected area with low road density, but dominated by a major transportation corridor and highway system. We looked at grizzly bear spatial response to roads, road-crossing behaviour, crossing location attributes and habitat, as well as temporal patterns of cross-road movements in relation to sex, season and traffic volume. In general, low volume roads were far more permeable to grizzly bears than the TCH, and males were generally found closer to roads than females. The probability of bear crossings also increased as vegetation density increased, and as distance to the nearest drainage decreased.

3. Patterns of Wildlife Mortality Across Roads

Wildlife-vehicle collisions have been a problem in the mountain national parks, and a cause for concern among park managers and transportation planners for years. Development of practical highway mitigation will rely on an understanding of patterns and processes that result from highway accidents, which involve elk and other wildlife. These research projects were conducted using new and existing data for wildlife-vehicle collisions. We used caution when analyzing data collected without a global positional system for reasons discussed in the Conclusions and Recommendations section.

Between 1981 and 2002, 46 large carnivores were killed on the TCH. Wolf mortalities (82%) were predominantly on unmitigated, unfenced sections. Black bear road kills were equally split between mitigated and unmitigated sections. Mortality was highest (63%) for all large carnivores on unmitigated sections of highway.

When analyzing elk highway mortality, we found the sex ratio of elk-vehicle collisions was significantly different from that found in the population, and highly skewed toward greater male mortality throughout the 15-year study (1985-2000). The age ratio of elk-vehicle collisions was highly skewed toward greater subadult mortality from 1986-1995. We also isolated the effects of traffic volume and elk abundance (which was particularly important) on elk-vehicle collision rates. Significant interactions indicated that road type influenced these effects. Greater elk abundance led to increased collisions.

Wildlife collisions most often involved commercial/large vehicles vs. passenger vehicles, and were inversely correlated with injury accidents and weather conditions. On the other hand, time of day (reduced visibility related to dusk/darkness) was a strong factor. The noise/disturbance from increased traffic volume appears to deter road crossings for elk, deer, birds, small mammals, and we noted lower mortality for these species in high-traffic areas.

4. Mitigation Effectiveness in Reducing Wildlife Mortality on Roads

We evaluated highway mitigation fencing as it affects wildlife-vehicle collisions along three 4-lane sections (phase 1, 2 and 3A) of the TCH. We collected data on wildlife-vehicle collisions and animal intrusions on the fenced right-of –way from 1981-1999, and found that after fencing was installed, collisions were clustered close to the fence ends. Proximity to major drainages also likely influenced the location of collisions. Post-fencing collisions with ungulates were reduced effectively (number of collisions decreased by 80%), but mitigation effectiveness was mixed for carnivores. Black bear, grizzly and cougar easily climbed over the mitigation fence, whereas coyotes accessed the right-of-way by going under the fence at numerous ground gaps.

Fencing is not buried in phases 1 and 2, but it is buried in phase 3A, and there were significantly fewer wildlife intrusions in phase 3A as a result. However, 55% of wildlife intrusions on phase 3A east of Castle Junction were elk occurring within 1 km of the junction.

Fencing repair and maintenance is extremely important in preventing wildlife intrusion, and we discovered that the many step-traverse and one-way gates on the TCH provided easy access for wildlife. We replaced many of these with single-swing gates where necessary, and removed/fenced over many gates. Since July

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2000, 146 incidents of fence damage/insufficiencies have been reported and repaired by our staff.

5. GIS-based Modeling Approaches to Identify Mitigation

In this section, we looked at questions regarding mitigation planning and methodologies, focusing primarily on the unmitigated phase 3B section of the TCH. We developed several GIS approaches to model animal movements across the TCH. One group of models consisted of three different but spatially explicit species-specific habitat models to identify linkage areas across the TCH. Another group consisted of models of regional movements to assess the congruence of existing wildlife structures and identify potential locations for future mitigation. Still other models dealt with local scale movement and road crossing/mortality. For each model, we used an empirical version as a yardstick to measure accuracy.

All models for animal movement and habitat showed a reasonably good fit with empirical data. In addition, the models identified areas along the fenced, mitigated section of the TCH that were important for wildlife movement. Using the results of local scale movement models, we analyzed the attributes of highway crossings with the average highway conditions. Although not always statistically significant, a clear pattern of association with lower noise levels, higher habitat quality and areas of relatively abundant open vegetation characterize areas of both successful and unsuccessful highway crossings.

The analysis of the spatial relationship between the mortality locations and highway crossing locations revealed a lack of association between them. Our conclusion was strengthened by the analysis of the spatially accurate road survey data obtained by snow tracking. This fact suggests that further research is needed to establish whether the locations of unsuccessful crossings are simply random, or whether there are certain landscape, habitat or highway-related attributes that explain wildlife-vehicle collisions. Our previous research suggests that the latter hypothesis is true.

OVERALL CONCLUSIONS AND RECOMMENDATIONS

Criteria for Mitigation Effectiveness

Identifying criteria for evaluating mitigation effectiveness is an extremely difficult task, as “effectiveness” varies across species, landscapes and even political boundaries. The details of this undertaking are too cumbersome to describe here (see Chapter 7 in Clevenger et al. 2002), but we have several pertinent comments and recommendations. No individual crossing structure design fits all. Further, the crossing structures will only be as effective as the land and resource management strategies around them. Mitigating highways for wildlife is a long-term process (many decades), and will affect individuals and populations. Thus, highway mitigation strategies need to be proactive at both scales to ensure that crossing structures remain functional over time amid dynamic ecological processes. This requires continuous long-term monitoring as exemplified in our study.

Mitigation Effectiveness Related to Crossing Structure Use and Wildlife Mortality

The degree to which crossing structures are used is related to a species’ ecological needs, which may vary widely between years. Sub-optimal habitat on one side of the road and good habitat on the other should result in fewer crossings. Given variability such as this, it is difficult to obtain convincing and scientifically credible evidence that highways are true barriers to animal movement. During our mortality studies, we found that interpretation of collision data was further complicated by large reporting error. The average reporting error on wildlife-vehicle collisions was almost twice as large in the national parks compared to provincial studies. To provide greater reporting accuracy and save time, we recommend the regular use of a GPS unit in the field. The spatial error of current data is sufficiently large that analyses may not be robust, nor provide useful information for mitigation planning.

Mitigation Recommendations

Barrier effects on mitigated sections of highway are concerns for predators and prey in BNP. (For some years, one seasonally-occurring wolf pack consistently avoided underpasses.) Adding one new crossing structure and improving the existing one may help to rectify such problems. To prevent barrier effects in phase 3B, highway mitigation planning will be different than previous mitigation projects because the upper Bow Valley is characterized by an assemblage of large mammal species with low population densities and higher sensitivity to human disturbance than the typical fauna of the middle and lower Bow Valley. We recommend a mitigation strategy that incorporates more high-quality wildlife crossing structures at more frequent intervals (roughly 1.5 km between structures) than in the past. There should also be greater sensitivity to ecological concerns in the highway mitigation design process.

We devised three categories of proposed wildlife crossing structures with the following design criteria:

- Primary or high quality or wildlife crossing structure: a 50-70 m wide overpass or extended bridge underpass of equal width as the

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overpass, and triple the height of the phase 1 and 2 open-span underpasses (≥7 m);

- Secondary wildlife crossing structure: an open-span bridge underpass at least double the width and height of the open-span underpasses in phase 1 and 2;
- Tertiary wildlife crossing structure: an open-span bridge underpass, or 4x7 m metal culvert with typical dimensions found for existing structures on phase 1, 2, and 3A
- We recommend there be a total of 17 crossing structures along phase 3B (a distance of approximately 34 km of TCH – from Castle Junction to the BC border): 6 primary structures, 4 secondary structures, and 7 tertiary structures
- At all wildlife underpasses, we recommend adding stump walls, or rows of dense shrub material, or down woody debris to one wall to provide greater connectivity between habitats and movement of more varied fauna.

For phase 3B, we have the advantage of pre-planning mitigation experiments. Building experiments into the structure design/construction would enable us to undertake side-by side comparison of underpass and overpass use by wildlife (as in Chapter 2, Clevenger *et al.* 2002), which would provide us with convincing results regarding crossing structure efficacy (because the results would contain few assumptions and are unambiguous). We believe the ecological benefits and future engineering cost-benefits from the single experiment on phase 3A are of great value for future mitigation guidelines and recommendations.

We recommend the implementation of human use management plans within the transportation corridor that address human activity at or near the crossing structures. Ideally, we need to minimize current levels of human use by localizing human impacts to one or two crossing structure, while devising alternative and viable means of safe highway crossing for recreational pursuits (e.g., pedestrian bridges).

Appropriate measures of success

Simply measuring road effects on wildlife populations is not an effective measure of mitigation success, as the effects of a road as a barrier to landscape connectivity can take several generations to be observed. Instead, we believe the most assured way to maintain viable populations is to have effective road-kill reducing measures in place. The more immediate effects of mortality appear to be greater threats to wildlife populations that a gradual decline in viability due to lack of connectivity.

Functional wildlife crossing structures will promote immigration and population viability. The latter requires a minimal amount of cross-highway passage to stave off isolation effects. We believe the amount of passage we have detected in the past 5 years is sufficient to meet those requirements. Long-term monitoring is essential for assessing how changes in wildlife population distribution, demographics and variability in species behavioural profiles, result in wildlife crossing structure permeability and perturbation to the park ecosystem.

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Copies of, “Movements, Mortality and Mitigation: Final Report on Roads and Wildlife in the Canadian Rocky Mountain Parks— November 1996-March 2002,” are available on CD (PDF format) from Tom Hurd (tom.hurd@pc.gc.ca) or Cathy Hourigan (cathy.hourigan@pc.gc.ca).

TOE OF THE ATHABASCA GLACIER SAFETY SIGNAGE PROJECT AND EVALUATION 2002

Trevor McFadyen

The Athabasca Glacier is North America's most accessible glacier, and a spectacular point of interest in Jasper National Park (JNP). The Athabasca is visited by over a million people annually who report it to be one of their most authentic and exciting national park experiences. Visitors to the Icefield Centre, the nearest service centre to the Athabasca Glacier, have the choice to experience the glacier via Snocoach, guided hike or by walking a short, steep trail to the toe. Exploring the toe of the glacier can be hazardous. The glacier ice is accessible from the trail, and people have traditionally walked on the toe regardless of safety messages that advise them against doing so. In the past decade, three visitors died falling into crevasses only metres from the edge of the glacier.

The Toe of the Glacier Trail is a visitor/ wilderness interface. The ice front distinctly demarcates the boundary between a safe visitor service area (the trail) and an unpredictable and dangerous wilderness area (the glacier surface). However the glacier intersects the end of the trail, and visitors are often tempted to explore its alluring surface of numerous ice formations like crevasses, moulins, erratics, ice caves and periglacial streams.

The Toe of the Glacier Safety Signage Project was initiated after a tragic accident on July 4th, 2001 claimed the life of a ten-year-old boy. The boy was exploring the toe of the glacier with his father when he fell through a snow bridge and into a crevasse. Wardens responded quickly and worked frantically to extract the boy, but the tight confines of the crevasse proved unmanageable and the boy perished of hypothermia before he could be extracted. Park management felt the need to re-examine how the public perceive and use the area.

THE PROJECT

New safety signage along the trail was needed to provide visitors with an understanding and appreciation of the hazards and dangers in the area. In the past, signs at the Toe of the Glacier were developed from the perception that most visitors assume the glacier is a safe extension of a hardened trail, rather than a wilderness interface. Previous signage relied on passive models of communication that attempted to inform visitors that the glacier was unsafe. "Passive models of communication assume that, if a message is transmitted, it is received, accepted and acted upon by the recreationalist" (McCool and Braithwaite 1992). However most passive models of communication do not effectively influence the behaviour of visitors.

The Icefield Centre comprises an extensive exhibit gallery, so we decided to concentrate on safety messaging while using an interpretive technique called personalization. Personalization helps people envision themselves in situations and is a powerful cognitive dissonance technique used by Health Canada on tobacco product warning labels.

To design signs for the Toe of the Glacier Trail, we considered different audiences and psychological profiles. Audiences range from young children to the elderly, so personalization was achieved by illustrating concerns specific to these demographics. For example, psychological profiles included the two Locus of Control personalities: internal and external. "Individuals with an internal locus of control believe they can influence their future through appropriate behaviour; people with an external locus of control disposition believe their future is predominately determined by forces beyond their control" (McCool and Braithwaite 1992). Messages encourage the internal LOC to control their behaviour while encouraging the external LOC individual to make adjustments to the hazards in the area. Most hazard and risk studies assume the external LOC individuals are less likely to adapt their behaviour to protect themselves in hazardous situations (e.g., living in a tornado-prone area) (McCool and Braithwaite 1992). However, we note

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Figures 1 and 2. New signs at the toe of the glacier include vivid graphics and caution visitors about glacier safety.

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that in some situations internal LOC individuals may actually be more apt to display risky behaviour, because they believe they control the degree of risk. These individuals are often catalysts that others to follow onto the glacier.

In developing the messages, we wanted to convey them frankly and directly. Subtextual messages and the message tone were considered in an attempt to reduce the degree of condescending language. We felt this approach was especially important as previous tests on national park communication products found that "simply *telling* people how to behave will not necessarily change their attitudes or behaviour" (Thomlinson and McVetty 1999). Visitors to Canada's national parks do not want a list of regulations in negative, guilt-laden language, but rather advice on how to have a safe and enjoyable holiday.

Test signs were developed for the 2002 operating season and subsequently a study involving pre-trip (along the trail), post-trip and visual observations was initiated to examine the effectiveness of that communication design and of the area changes overall. The signs were created with short text, and large illustrations (see Figures 1 and 2), to communicate messages to different audiences: e.g., "streakers" take only cursory glances while "studiers" read every word. Conveying the message quickly is important as visitors rarely stop to read signs along the trail because they are "in a hurry to get to the glacier[1]."

RESULTS

Surveys were conducted pre- and post-visit (213 and 318 respondents respectively), and 114 visitors were observed on the glacier to determine whether they crossed the barrier. Most of the respondents were from Canada and the United States and aged 26-35 years. The majority of respondents were visiting the Athabasca Glacier for the first time (77% of pre-visit 73% of post-visit respondents), and only 28-38% of visitors had previously visited the Icefield Centre. Of those, only 1% reported the Icefield Centre staff as a source of information while only 8% reported the Icefield Centre displays as a source of information. The greatest source of information about the Athabasca Glacier came from other

Figure 3. Pre-visit responses to key questions. Dark shading=disagree; light shading=agree.

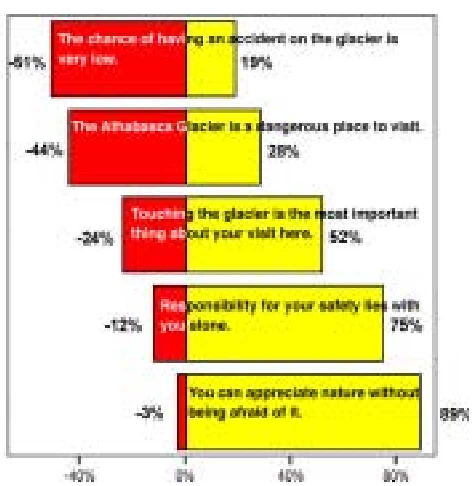

Figure 4. Post-visit responses to key questions. Dark shading=disagree; light shading=agree.

Parks Canada publications. This implies that the Icefield Centre is not dependable as a sole source of information about the hazards of the glacier and that safety messaging should come from multiple sources, especially publications (e.g. pamphlets and signboards).

Visitor attitudes were evaluated pre- and post-visit. Of pre-visit responses (Figure 3), 37% believed that the chances of having an accident were high, vs. 28% who believed the chances were low. Opinions were essentially split on whether the Athabasca Glacier was a dangerous place to visit (27% agreed, 28% disagreed), and on whether touching the glacier was the most important part of the visiting experience (39% agreed, 38% disagreed). Interestingly, most post-visit respondents (Figure 4) believed that the chances of having an accident are high (51%), however the number of visitors who felt the Athabasca Glacier was a dangerous place to visit decreased (44% disagreed). Touching the glacier was reportedly important to more visitors post-visit.

Visitor attitudes regarding responsibility for safety did not change from pre- to post-visit, with 74-75% of respondents reporting that they agreed or strongly agreed that the responsibility for their safety lies with them alone. Respondents also agreed overwhelmingly that they could appreciate nature without being afraid of it (90% pre visit and 89% post visit).

We randomly observed visitors stopping at the signs as they walked to and from the glacier. More than 50% of visitors walked by the signs without stopping on the way up, and more than 90% failed to stop on their way down. The visitors that did stop paused for less than 30 seconds. Signs near the trail head, at the top of a steep incline, and at the edge of the glacier received the most readership.

Visitors were better at identifying key messages post-visit, with one exception. The

[1] Unpublished evaluation, Toe of the Athabasca Glacier hazard perceptions, Warden Service, Parks Canada.

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number of visitors who incorrectly answered that altitude is not a concern actually increased post-visit. For all other messages, the respondents generally identified the correct message pre-visit, and the number of correct responses increased post-visit. Of note was an increase in the understanding that the fall is not the greatest danger in a crevasse accident (69% to 86%), and that accidents are as likely on the trail as on the glacier (44% to 62%).

Most pre-visit respondents reported that they intended to go on the glacier (78%), while 90% of post-visit respondents reported that they did so. Fourteen percent of post-visit respondents reported that they crossed the barriers. Our observers noted that 82% of visitors went on the glacier, and 10% crossed the barriers (not all of the observed visitors were necessarily respondents). Reasons for crossing the barrier included (in order): having experience with the conditions, wanting to get higher, the barrier was unclear or broken, to take photos, to get a better view, and because others were doing it. The reasons provided for not crossing the barriers included (in order) the signs and associated messages along the trail, it was too dangerous or unsafe, did not need to, and the barriers.

DISCUSSION

As expected, the report provided many examples of just how much of an enigma the area presents for park managers and challenges many commonly held beliefs about public safety attitudes in national parks. For instance, pre-visit respondents perceived moderately high hazard and risk, and had higher than anticipated ability to identify key messages. These results are the antithesis to our assumption that people visiting from largely urban centres bring a poor understanding of hazards/safe behaviour in wilderness areas. It may be that urban visitors are more uncertain about wilderness hazards, which motivates them to seek more information. Upon seeing the area, visitors' perception of risk decreased, perhaps because of the low slope of the glacier, the ease at which the glacier can be accessed, late-lying snow (that may have covered crevasses under snow bridges) and especially the other people engaging in apparently safe and enjoyable behaviour. Essentially the degree of hazard and risk perceived did not match the degree of hazard and risk anticipated, and this led to a shift in attitude and behaviour.

This attitudinal change in or re-evaluation of risk perception may be based on peripheral cues, ability or knowledge. For instance, avalanche safety instructors have reported that an increase in knowledge and awareness of avalanche hazard can give rise to reduced risk perception among backcountry skiers, which in turn results higher confidence in avalanche predicting abilities, and poor choices in avalanche terrain (Lisa Paulson, Parks Canada Park Warden, *pers comm.*). This concept alludes to a very complex relationship between hazard and risk perception that makes attitudinal and behavioural modification difficult and supports the idea that passive communication does little to achieve either.

It seems that at the Athabasca Glacier, peripheral cues and experience with glacier conditions reduced visitors' risk perception and tempted them to cross barriers. In reality, only trained mountaineers have the experience to cross the barriers safely. Even so, many Albertans visit the glacier several times over the course of their lives and pass the tradition of exploring the ice on to their children and grandchildren. Although the signs encourage visitors to consider their personal venerability in light of their actions, and attempt to keep risk perception high, barriers and signs will have to be maintained for a long time before this behaviour changes.

Most visitors believe they are solely responsible for their safety while in wilderness areas. This also debunks commonly held beliefs that public safety communication programs need to emphasize that Parks Canada shares responsibility. A large number of respondents believe that nature can be appreciated without being feared, which suggests that cognitive dissonance can be used in interpretive messaging without creating a "nature is bad" perception among target audiences.

Despite the low numbers of people who stopped to read them, signs were reportedly the major deterrent against crossing the barriers on the glacier or engaging in risky behaviour. More controlled testing may have strengthened the results, however, tests were not conducted without the signs, nor were tests conducted to rate the effectiveness of signs without the barriers, because of unacceptable risk to public safety.

To increase readership of safety signs, we recommend that large descriptive illustrations or photos should be used to catch the attention of "streakers," and suggest that signs be placed at natural stopping places (tops of hills, view points) where people are motivated to stop already. Of course, non-personal media is only a moderately effective channel of communicating risks and cannot be as dynamic or effective as personal communication. However, further research may improve our ability to entice visitors to stop and read interpretive safety signs.

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Evaluation Study by Eugene Thomlinson, Client Research Specialist, Western Canada Service Centre

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Meetings of Interest

September 6-10, 2003 The Wildlife Spciety Annual Conference. Burlington, Vermont.This confernce will feature workshops on open space design, monitoring with GPS, gap analysis, and a plenary session on the North Americal Model of wildlife conservation. For more details see: www.wildlife.org/conference/index.cfm

September 9-10 2003 The Canadian Council on Ecological Areas (CCEA).Yellowknife, NWT. The workshop will consist of invited papers and panel discussions by protected areas researchers in government, the private sector, non-governtmental organizations and universities. An objective of this conference is to assess the status of protected areas in northern regions and their adequacy for wildlife conservation. For details see: www.ccea.org/workshop.pdf

October 15-17, 2003 Remediation Technologies Symposium 2003. Banff, AB. This symposium is the premier remediation technology transfer event for environmental professionals, encompassing the latest innovations in soil and groundwater remediation. For information/registration contact: Sylvia Poldrugovac: Tel. (780) 429-6363; poldrugovac@esaa.org; http://remtech2003.com

October 16-19, 2003 The Canadian Society for Ecological Economics (CANSEE), 5th Biennial Conference. Jasper National Park, AB. Featuring keynote speakers Herman Daly and John Cobb.Jr., co-authors of “For the Common Good.” The theme of this conference is “ Sustainability: Are we making genuine progress? For conference information, contact: James Van Leeuwen, Conference Organizer: Tel. (403) 852-9670; cansee2003@cansee.org

November 19-22, 2003 Society for Ecological Restoration International’s “Assembling the Peices” Restoration, Design & Landscpe Ecology.” Austin, Texas. This conference will focus on design aspects of restoration, with the expectation of significant participation by landscape architechture, land planning, civil engineering and landscape ecology professionals. See the website: www.ser.org/meeting.php?pg=2003conference

May 2-6, 2004 Fourth World Fisheries Congress. Vancouver, BC. The congress theme, Reconciling Fisheries with Conservation: The Challenge of managing Aquatic Ecosystems, will be addressed by a world class list of speakers, session topics, posters, presentations, round table discussions etc. Contact Advance Group Conference Management Inc. Tel: (604) 688-9655; fish2004@advance-group.com; http://www.worldfisheries2004.org

June 6-10, 2004 North American Benthological Society 52nd Annual Meeting. University of British Columbia, Vancouver, BC. In addition to speakers and other presentations, there will be a variety of recreational, educational and research-related field trips during this conference. Contact John Richardson: jrichard@interchg.ubc.ca; http://faculty.forestry.ubc.ca/richardson/NABS2004.htm