HIGHWAY RESEARCH, MONITORING, AND ADAPTIVE MITIGATION STUDY – BANFF, YOHO AND KOOTENAY NATIONAL PARKS

Contract No. – 5P424-022206/001/CAL

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Final report

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CONTENTS

In this final report we summarize the work we have carried out and the data collected since the contract start date 6 June 2002. Herein we describe the methods used to collect the field data and summarize the results during the 12-month period. To conclude, we discuss management recommendations for ongoing highway research, monitoring and analysis in the mountain park region.

1 Wildlife crossing structure monitoring

Contract monitoring period

There have been a total of 3738 through-passes by wildlife at the 10 phase 1 & 2 underpasses since the beginning of the contract on 6 June 2002 (Table 1A). Deer were the most frequently detected species at the crossing structures, followed by elk, wolves, sheep and coyotes. Among large carnivores, wolves used the structures 355 times, black bears 50 times, cougars 34 times, and grizzly bears 7 times. Compared to the wildlife passage frequencies, human passage was high; ranking third overall with 934 passes recorded.

There have been 2254 passages by wildlife at the 13 phase 3A crossing structures since 6 June 2002 (Table 1B). Among large carnivores, wolves used the structures 74 times, grizzly bears 22 times, cougars 22 times and black bears 12 times.

In the five months of monitoring, 5992 individual wildlife passes have been detected at the 23 crossing structures. Deer were detected using the structures most (3043 times), followed by elk (1536), coyotes (575), wolves (356), cougars (56), black bears (62) and grizzly bears (29).

Total monitoring period, 1996-2003

There have been a total of 37,507 through-passes by wildlife at the 10, phase 1 & 2 underpasses since November 1996 (Table 2A). Elk were the most frequently detected species at the crossing structures, followed by deer, wolves, sheep and coyotes. Among large carnivores, wolves used the structures 2986 times, cougars 587 times, black bears 526 times, and grizzly bears 36 times.

There have been 11,175 passages by wildlife at the 13 phase 3A crossing structures since November 1997 (Table 2B). Among large carnivores, wolves used the structures 254 times, cougars 197 times, black bears 166 times and grizzly bears 50 times.

In the 71 months of monitoring 48,682 individual wildlife passes have been detected at the 23 crossing structures. Among ungulates, elk were detected using the structures most (23,673 times), followed by deer (14,630), sheep (2315) and moose (18). Of the carnivores, coyotes used the structures most often (3244 times) followed by wolves (3240), cougars (784), black bears (692) and grizzly bears (86).

2 Mortality monitoring (Wildlife road-kills)

Since June 2002, a total of 125 animals were reportedly killed from collisions with vehicles on highways in Banff, Yoho and Kootenay national parks and Kananskis Country, Alberta. Of these, 99 (79%) were ungulates and 26 (21%) were carnivores (Table 3). Carnivore mortalities consisted of coyotes (n = 19), black bears (n = 4), wolves (n = 2) and lynx (n = 1). We list the mortalities by species and highway in Table 3.

On the national park section of the Trans-Canada Highway (Banff and Yoho) there were 30 road-kills consisting of 21 (70%) ungulates [13 deer, 6 elk, 2 moose] and 9 (30%) carnivores [7 coyotes, 2 wolf].

On Highway 93 North (Banff National Park) there were 8 road-kills consisting of 6 (76%) ungulates [4 deer, 1 elk, 1 mountain goat] and 2 (24%) carnivores [2 black bears].

On Highway 93 South (Banff and Kootenay National Parks) there were 21 road-kills consisting of 16 (79%) ungulates [11 deer, 4 moose, 3 elk, 1 sheep] and 5 (21%) carnivores [1 black bear, 1 lynx, 3 coyotes].

On the Trans-Canada Highway in Alberta province there were 52 road-kills consisting of 43 (83%) ungulates [26 deer, 15 elk, 2 moose] and 9 (17%) carnivores [8 coyotes, 1 black bear].

3 Snowtrack road transects

In the 2002-2003 winter season, snow conditions allowed for the phase 3B snow tracking survey to be completed seven times. A total of six different species (cougar or lynx, wolf, coyote, deer, elk, and moose) were identified and their behaviour and activity around the road was noted, i.e. approach the highway, cross the highway or traverse parallel to the highway. Table 4 summarises the date, locations (UTMs), direction, activity, and numbers of detections for each species.

Carnivores
Coyotes were detected along the highway 35 times but only crossed on 13 of these occasions. Cougar or lynx approached and crossed the highway two times. Wolves crossed the highway eight times.

Ungulates
Deer were detected 57 times and crossed the highway 38 times. Elk were detected 32 times and crossed 24 times. Moose approached and crossed the highway twice. Unidentified ungulates were detected six times and crossed the highway twice.

4 Documents prepared on CD

(*Sent by posted mail*)

Tables: 1, 2, 3 and 4 from Final Report
Database: Wildlife crossing structure monitoring
Database: Wildlife road-kills

Table 1. Summary of wildlife crossing structure use in Banff National Park, Alberta, June – November 2002.

A. Phase 1 & 2 Wildlife Crossings from 6 June 2002 to 31 March 2003

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
East	Open span	0	0	12	1	23	0	108	545	0	689	1
Carrot	Creek bridge	0	2	12	2	12	0	12	70	0	110	8
MCoulee	Culvert-lg	0	7	38	1	11	0	33	149	0	39	1
Duthil	Open span	0	11	176	3	20	0	88	157	0	455	5
Powerhouse	Open span	0	7	10	2	12	0	66	122	6	225	149
Buffalo	Open span	0	0	14	7	19	0	271	125	0	436	372
Vermilion	Open span	0	2	8	8	22	0	156	55	46	297	75
Edith	Open span	3	2	29	5	25	2	72	190	14	342	190
Healy	Open span	4	18	46	5	70	0	152	212	14	521	0
5-mi	Open-span bridge	0	1	10	0	8	0	164	67	174	424	133
Total		**7**	**50**	**355**	**34**	**222**	**2**	**1122**	**1692**	**254**	**3738**	**934**

B. Phase 3A Wildlife Crossings from June 06, 2002 to 31 March 2003 (Castle monitored since November 01, 1996)

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
WOP	Overpass	15	1	10	2	20	0	35	301	0	384	4
WUP	Culvert-lg	0	0	3	2	15	0	18	27	0	65	1
Bourgeau	Culvert-medium	0	1	0	0	22	0	2	1	0	26	0
WCR	Creek bridge	0	1	7	4	37	0	25	20	0	94	7
Massive	Culvert-lg	0	1	4	3	50	0	30	25	0	113	6
Sawback	Box	0	0	0	0	17	0	18	1	0	36	0
Pilot	Box	1	6	5	2	23	0	22	24	0	83	0
REUP	Box	0	2	0	2	42	0	32	15	0	93	0
REOP	Overpass	6	0	10	1	16	2	92	508	0	635	2
RECR	Creek bridge	0	0	2	3	23	0	22	100	0	150	40
Copper	Culvert-lg	0	0	5	0	42	0	18	235	0	300	8
John	Box	0	0	9	2	29	0	1	6	0	47	0
Castle	Culvert-lg	0	0	23	1	17	0	99	88	0	228	8
Total		**22**	**12**	**74**	**22**	**353**	**2**	**414**	**1351**	**0**	**2254**	**76**
Grand Total		**29**	**62**	**356**	**56**	**575**	**4**	**1536**	**3043**	**254**	**5992**	**1010**

Table 2. Summary of wildlife crossing structure use in Banff National Park, Alberta, November 1996 – March 2003.

A. Phase 1 & 2 Wildlife Crossings from 1 November 1996 to 31 March 2003

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
East	**Open span**	0	31	171	71	193	0	1553	2604	1	4624	20
Carrot	**Creek bridge**	2	39	148	52	88	0	443	234	0	1006	96
MCoulee	**Culvert-lg**	0	107	217	62	80	0	526	1109	1	2102	43
Duthil	**Open span**	5	101	1085	85	194	0	2292	747	0	4509	59
Powerhouse	**Open span**	2	40	273	43	103	0	1822	697	8	2988	1097
Buffalo	**Open span**	0	1	251	20	223	0	4340	340	0	5175	1926
Vermilion	**Open span**	2	8	202	74	248	0	3429	508	797	5268	639
Edith	**Open span**	5	19	162	86	158	0	1605	1470	189	3694	2558
Healy	**Open span**	18	167	336	65	380	0	1988	1176	23	4153	28
5-mi	**Open-span bridge**	2	13	141	29	139	0	1827	541	1296	3988	848
Total		**36**	**526**	**2986**	**587**	**1806**	**0**	**19825**	**9426**	**2315**	**37507**	**7314**

B. Phase 3A Wildlife Crossings, November 1997 to March 2003 (Castle monitored since 1 November 1996)

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
WOP	**Overpass**	32	19	41	21	81	6	237	1383	0	1820	27
WUP	**Culvert-lg**	0	6	10	24	53	0	153	148	0	394	14
Bourgeau	**Culvert-medium**	0	15	0	18	96	0	10	4	0	143	5
WCR	**Creek bridge**	1	5	14	33	151	0	248	61	0	513	25
Massive	**Culvert-lg**	1	9	6	11	157	0	264	226	0	674	15
Sawback	**Box**	0	3	3	2	65	0	103	28	0	204	26
Pilot	**Box**	2	28	8	12	85	0	129	65	0	329	19
REUP	**Box**	1	20	14	16	134	0	174	51	0	410	29
REOP	**Overpass**	8	9	36	2	91	11	891	2039	0	3087	20
RECR	**Creek bridge**	2	4	16	20	76	0	161	301	0	580	200
Copper	**Culvert-lg**	0	5	17	17	157	1	254	486	0	937	13
John	**Box**	0	17	19	20	211	0	28	24	0	319	7
Castle	**Culvert-lg**	3	26	70	1	81	0	1196	388	0	1765	142
Total		**50**	**166**	**254**	**197**	**1438**	**18**	**3848**	**5204**	**0**	**11175**	**542**
Grand Total		**86**	**692**	**3240**	**784**	**3244**	**18**	**23673**	**14630**	**2315**	**48682**	**7856**

Table 3. Summary of large mammal mortality, coyote size and larger, on the mountain park highways and provincial highways from 6 June 2002 to 31 March 2003.

Highway	Region	Grbear	Blbear	Cougar	Lynx	Wolf	Coyote	Elk	Deer	Moose	Sheep	Mt. Goat	Total
TCH	Province	0	1	0	0	0	8	15	26	2	0	0	52
TCH	BNP	0	0	0	0	0	4	3	6	0	0	0	13
TCH	YNP	0	0	0	0	2	3	3	7	2	0	0	17
1A	Province	0	0	0	0	0	1	0	1	0	1	0	3
40	Kananaskis	0	0	0	0	0	0	1	7	0	0	0	8
93S	BNP	0	0	0	0	0	0	2	1	0	0	0	3
93S	KNP	0	1	0	1	0	3	1	10	4	1	0	21
93N	BNP	0	2	0	0	0	0	1	4	0	0	1	8
TOTAL		0	4	0	1	2	19	26	62	8	2	1	125

Table 4. Wildlife activity along Phase IIIB of the TCH during road surveys, winter 2002-2003.

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
COUGAR/ LYNX								
	26-Feb-03	1	562227	5691334	yes	north	2km east of Lake Louise	both sides of highway
	26-Feb-03	1	560395	5693582	yes	south	1.4 km east of Lake Louise	
Total	**Cross-Yes**	**2**						Probably one individual
	Cross-No	**0**						
COYOTE								
	06-Jan-03	1	557239	5698287	yes	south		crossed median
	28-Jan-03	1	550017	5700604	yes	south		good tracks, crossed directly
	05-Feb-03	1	557752	5696261	unk	north		tracks come up to hwy on N side, no tracks on south
	05-Feb-03	1	558145	569622	yes	north		
	05-Feb-03	1	557864	5695986	unk	south		tracks come up to hwy on N side, no tracks on S
	05-Feb-03	1	557611	5696878	yes	north		
	19-Feb-03	1	556932	5698031	yes	south		
	26-Feb-03	1	560148	5693890	no	south		
	26-Feb-03	1	565364	5687719	no	south		
	26-Feb-03	1	565391	5687691	no	south		
	26-Feb-03	1	565796	5687241	n	south		
	26-Feb-03	1	564561	5688586	yes	north		

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
COYOTE								
	26-Feb-03	1	566407	5685648	yes	south		
	26-Feb-03	1	562085	5691505	yes	south		
	26-Feb-03	1	560884	5692985	no	south		
	26-Feb-03	1	560745	5093153	yes	north		
	26-Feb-03	1	560529	5093421	no	unk		
	26-Feb-03	1	560426	5693546	no	north		
	26-Feb-03	1	559793	5694228	no	south		
	26-Feb-03	1	559741	5694253	yes	south		
	26-Feb-03	1	564930	5688192	yes	south		
	26-Feb-03	1	568215	5684377	no	south		meandered along highway
	26-Feb-03	1	568792	5683729	no	north		meanered along hwy
	26-Feb-03	1	568833	5683671	no	south		
	26-Feb-03	1	569053	5683431	no	south		
	26-Feb-03	1	567284	5685542	yes	north		
	26-Feb-03	1	569090	5683358	no	north		Probably same coyote?
	26-Feb-03	2	559543	5694335	no	North and south		meandered along highway, never crossing, within 10m
	26-Feb-03	1	569181	5683266	no	west		Same coyote? Just walked west along hwy
	26-Feb-03	1	569208	5683219	no	west		Same coyote? Just walked west along hwy

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
	26-Feb-03	1	565077	5688033	no	north		
	26-Feb-03	1	557655	5696679	no	west		within 10m, doesn't cross
	26-Feb-03	1	558306	5695406	no	south		approached road
	26-Feb-03	1	558735	5694745	yes	north		
Total	**Cross-Yes**	**13**						Probably 6 different individuals
	Cross-No	**22**						

DEER								
	18-Nov-02	1	556131	5698383	no	north		appoched hwy from S RofW and turned back
	18-Nov-02	1	555795	5699034	unk	south		meandered E-W on N RofW, appr hwy no track S side
	18-Nov-02	1	555367	5699308	yes	north	Just E of 93N OP	
	18-Nov-02	1	555955	5698763	yes	north		crossed 4 lanes with median
	18-Nov-02	1	562954	5690015	yes	north		
	18-Nov-02	2	571421	5681732	no	north		appoched hwy from S RofW and turned back
	18-Nov-02	2	571098	5681913	no	south	4.1km West of Castle OP	approched hwy from N RofW and turned back
	18-Nov-02	2	565802	5687326	yes	unk	12.1km West of Castle OP	
	18-Nov-02	1	569999	5682467	yes	north	5.6km West of Castle OP	approched and crossed hwy from N right of way
	18-Nov-02	1	555682	5699123	unk	south		100M west of previous deer same behv (same deer??)
	18-Nov-02	2	570954	5681953	yes	south	4.3km West of Castle OP	approched and crossed hwy from N right of way
	18-Nov-02	2	571188	5681886	no	south	4km West of Castle OP	approched hwy from N RofW and turned back
	06-Jan-03	1	557737	5696312	yes	south		crossed into forest
	06-Jan-03	2	556329	5698287	yes	south	just west of LL	2 lane highway
	06-Jan-03	1	557331	5697801	yes	north		crossed median
	06-Jan-03	1	557471	569579	yes	south		crossed median
	06-Jan-03	1	557737	5696312	no	east		turned around on S side of highway

	06-Jan-03	1	562923	5690026	yes	south		crossed into forest
	06-Jan-03	1	564873	5688246	yes	south		crossed into forest
	06-Jan-03	1	565149	5687946	no	west		turned around 10 m from the road
	06-Jan-03	1	565218	5687855	yes	south		crossed into forest
	06-Jan-03	1	565520	5687563	yes	north		crossed into forest
	06-Jan-03	2	572270	5681086	yes	north	start of Mannix pit	
	06-Jan-03	1	556229	5698305	yes	north	just west of LL	2 lane highway
	06-Jan-03	1	557502	5697165	yes	south		crossed centre median
	06-Jan-03	1	557471	569579	yes	south		crossed median
	15-Jan-03	2	562114	5691437	yes	south		meandered along s ditch then crossed
	15-Jan-03	1	567141	5685721	yes	south		same deer crossed hwy
	15-Jan-03	1	567597	5685223	yes	unk		poor tracks, slightly snow covered
	15-Jan-03	1	567555	5685277	no			meandered along N ditch
	15-Jan-03	1	567500	5685331	no			same deer approached hwy but no tracks on other side
	15-Jan-03	1	567394	568447	no			same deer walked along road then back towards tree
	15-Jan-03	1	567053	5685817	yes	unk		crossed at some point and meandered along WB ditch
	15-Jan-03	2	566926	5685956	yes	unk		crossed
	15-Jan-03	1	566857	5686030	no			
	15-Jan-03	1	555904	5698864	no			meandered along N ditch

	15-Jan-03	2	559961	5694082	yes	south		approached road and crossed
	15-Jan-03	1	571765	5691858	no			approached hwy
	15-Jan-03	1	563931	5689090	no			approached road and turned around in S ditch
	15-Jan-03	2	572264	5681093	yes	unk		tracks are slightly snow covered
	15-Jan-03	1	560037	5694002	yes	south		approached road and crossed
	28-Jan-03	1	567284	5685549	yes	unk		snow covered
	28-Jan-03	3	567514	5685311	yes	unk		poor tracks
	28-Jan-03	1	571202	5681878	no			N side deer approach hwy
Total	**Cross-Yes**	**38**						Probably 33 different individuals
	Cross-No	**19**						
ELK								
	18-Nov-02	1	571850	5681404	yes	north	3.1km West of Castle OP	walked across hwy
	06-Jan-03	2	571421	5681748	no	west		elk walking parallel to highway on N side
	06-Jan-03	2	571809	5681445	yes	south		meandered across highway to other side of road
	06-Jan-03	1	570820	5681996	yes	south		crossed highway and river
	06-Jan-03	2	571809	5681445	no	west		walking parallel to highway on N side
	15-Jan-03	3	553921	5699299	no			meandered along N ditch
	15-Jan-03	3	556111	5698466	yes	north		crossed
	15-Jan-03	1	568357	5684218	yes	north		poor tracks, slightly snow covered
	15-Jan-03	2	556384	5698250	yes	south		approached road and crossed

	28-Jan-03	1	558379	5695290	no			n side turned around, guardrail on s side, steep
	28-Jan-03	1	557354	5697760	yes	unk		gait 5' apart
	28-Jan-03	2	554831	5699316	yes	unk		snow covered tracks, melting snow
	05-Feb-03	2	564691	5688444	yes	north		approach road several times, meandered before cross
	05-Feb-03	2	557796	5696110	yes	unk		
	05-Feb-03	1	558929	5694571	yes	north		
	05-Feb-03	1	559027	5694516	yes	south		
	05-Feb-03	1	559985	5694072	yes	south		crossed road on angle
	26-Feb-03	2	569304	5683013	yes	north		walked directly across hwy, may have been moose
Total	**Cross-Yes**	**24**						Probably 23 different individuals
	Cross-No	**8**						

MOOSE								
	26-Feb-03	1	569090	5683358	yes	north		Very large tracks
	26-Feb-03	1	568084	5684541	yes	south		
Total	**Cross-Yes**	**2**						Probably 1 individual
	Cross-No	**0**						
UNGULATE								
	15-Jan-03	1	570802	5682010	no			approached road
	15-Jan-03	2	571957	5681332	no			walking parallel to road
	15-Jan-03	2	571810	5681448	yes	south		same ungulates meandered across road
	28-Jan-03	1	571202	5681878	no			unk gait, 5' btw, snow covered
Total	**Cross-Yes**	**2**						Probably 2 different individuals
	Cross-No	**4**						
UNKNOWN SPECIES								
	18-Nov-02	1	564133	5688987	yes	unk	14.6km West of Castle Jct	
	05-Feb-03	1	572459	5688144	no	south		poor tracks, animal approach road turn back
	05-Feb-03	2	559615	5694297	yes	unk		older looking tracks
	05-Feb-03	1	559985	5694072	no	north		approach but no cross
Total		**3**						Probably 3 different individuals
		2						

WOLF								
	28-Jan-03	2	572594	5680836	yes	north		crossed hwy from N side, chasing deer
	28-Jan-03	2	572594	5680836	yes	south		crossed highway back to north side, chasing deer
	12-Feb-03	2	558664	5694805	yes	south	East side of the twin bridges	M Percy reported
	12-Feb-03	2	558913	5694543	yes	north	East side of the twin bridges	M Percy reported
Total	**Cross-Yes**	**8**						Probably 2 or 4 different individuals
	Cross-No	**0**						

APPENDIX

Recommendations for ongoing research, monitoring and analysis in the mountain parks

Content

Purpose for continuing research

Problem

Major highways are superimposed on much of the North American landscape. Compared to other agents of fragmentation roads are less conspicuous, but cause changes to habitat that are more extreme and permanent. Many roads are barriers or filters to horizontal natural processes such as animal movement[1,2]. Road systems also alter the spatial patterns of wildlife and the general function of ecosystems within landscapes. In the Mountain Parks region, roads represent a serious obstacle to maintaining ecological connectivity by impeding movement of wildlife and representing a significant source of wildlife mortality.

The Trans-Canada Highway (TCH) is a potential barrier for wildlife movement in the Mountain Parks and the significantly larger Central Rocky Mountain ecosystem. Given the national importance of the cross-country transportation corridor and popular attraction of Banff National Park, traffic volumes have increased 40% within the last 10 years[3]. Scheduled TCH improvements in the Kicking Horse Canyon will increase traffic densities and effectively place greater stress on a mountain region highly-impacted by transportation and human development. Reduced landscape connectivity and impeded movements due to roads may result in higher mortality, lower reproduction and ultimately smaller populations and lower population viability. These deleterious effects have underscored the need to maintain and restore essential movements of wildlife across the TCH and other roads in the Rocky Mountains[4,5].

Remedial action

To mitigate the effects of roads, passage structures for wildlife are now being designed and incorporated into some road construction projects[6,7]. Wildlife passages are in essence site-specific movement corridors strategically placed over a deadly matrix habitat of pavement and high-speed vehicles. Yet the impact of transportation systems on wildlife ecology and remedial actions to counter these effects is an emerging science. Currently there is limited knowledge of effective and affordable passage designs for most wildlife species[8].

State of knowledge

We know that highway passages are used by wildlife[7,9,10], yet level of use varies between species, higher taxa, locations and landscapes, and the reasons why are unclear[8]. Recommended minimum dimensions have been suggested for some ungulate species[7,10,11], but the needs of wide-ranging species are vague[1]. Human activity can significantly influence passage use[12]. Others have inferred that the location of a crossing structure, particularly in relation to habitat quality, might be the most important feature[7,13]. In spite of these valuable kernels of information, gaping holes in our knowledge of functional wildlife passage systems remain.

Practically all of the research findings have been based on single-species analyses and limited attention has been paid to multiple species and community-level relationships[1,14,15]. A key variable in mitigation planning is cost. Passages are expensive measures, but a large research void exists in determining cost-effective designs[14]. Human activity is one of several confounding variables in passage performance analysis. Yet the masking effect of confounding

variables has not been considered in study designs so far. Doing so would help produce more rigorous results and tease out meaningful ecological relations[16].

Value of long-term study

Passages are static structures imbedded in dynamic landscapes. How well passages ultimately perform will depend on how well they accommodate changes in species distributions, abundance and behavioural profiles. Studies have generally failed to address the need for wildlife habituation to such large-scale landscape change[17]. Long-term monitoring of wildlife populations in relation to landscape change, in concordance with passage structure studies, will provide reliable information on species relationships, natural processes, and in this unique case, the functionality of passages for wildlife in facilitating normal life history patterns[18].

What have we learned?
What were the management research questions addressed to date?

Mitigations evaluation research

1. *What are the wildlife crossing structure attributes that facilitate passage?* We know what are key factors influencing wildlife passage at the crossing structures and how to manage people and habitats so that wildlife use at the structures is optimized.
2. *What is the relative importance of large, open-span viaducts (eg, 5-Mile bridge) vs. smaller, bridge-span wildlife underpasses to large carnivore movement?* (i.e. will the existing underpass designs suffice or do carnivores need large extensions of raised highways?).
3. *Can drainage culverts serve as effective habitat linkages?*
4. *How effective is BNP mitigation at reducing road mortality?*
5. *What fence designs (buried, unburied) effectively impede wildlife intrusions onto the TCH?*

Mortality and crossing research

1. *What are the patterns of wildlife-vehicle collisions with respect to population parameters?*
2. *What are the patterns and factors influencing small vertebrate fauna road-kills?*
3. *What are the relationships between grizzly bears, highways and habitat in the Bow Valley?*
4. *What are some of the factors influencing successful and unsuccessful road-crossings by wildlife?*
5. *Are successful and unsuccessful road-crossing locations by wildlife the same?* (are they spatially correlated?).

We have recommended mitigation options to reduce mortality and barrier effects on the Trans-Canada Highway

We have recommended prioritization of Trans-Canada Highway mitigation projects and funds (including retrofitting)

We have developed appropriate measures of success for mitigation

What do we still need to learn?
Implications of research in the Mountain Parks

1 Factors contributing to wildlife-vehicle collisions - *coarse- and site-level analyses*
There is virtually nothing known concerning the factors explaining wildlife-vehicle collisions, anywhere in the world[18]. A handful of coarse-scale studies have been conducted using data with high spatial error (>500 m)[19,20,21]. Our research has accumulated more than 600 high-accuracy road-kill locations (<3 m) in the Mountain Parks since 1998. We will conduct analysis of factors (habitat, road, wildlife population) contributing to collisions with wildlife on Mountain Park highways. These road-kill location data will be used to conduct a fine scale, site-level analysis of factor contributing to wildlife-vehicle collisions. The same data will be used for a broader coarse-scale GIS analysis of how landscape factors influence wildlife-vehicle collisions. The work will add to existing management information needs for assessing highway impacts on wildlife including the TCH impacts on wildlife movements in the Kicking Horse Canyon, Yoho National Park. It will make a significant contribution to identifying and devising wildlife-vehicle mitigation.

2 Grizzly bear movement in relation to the TCH - *pre- and post-highway improvement*
Radiomonitoring of grizzly bear movements needs to continue in BNP, particularly in relation to major highways. In the last two years, two grizzly bears have been killed on the unfenced TCH. Other unfenced mountain highways have claimed the lives of grizzly bears in the past and presently account for the highest levels of road mortality[22]. These losses have a tremendous impact on maintaining an already precarious grizzly bear population in the Central Rockies ecosystem[23]. Continuing ongoing research collaboration and cost-sharing with the East Slope Grizzly Bear project (ESGBP) is a cost-effective means for Parks Canada to support multidisciplinary ecosystem level studies in the Mountain Parks.

3 Time series analysis of wildlife crossing structure function and efficacy
Long-term research and focused investigation of species ecological relationships has provided the basis of many principles of wildlife and conservation biology. Our mitigation research clearly indicates that short-term sampling can provide spurious results and does not adequately sample the range of variability in species and wildlife crossing structure use patterns in landscapes with complex wildlife-human land use interactions. During our 5-year study we witnessed highly fluctuating large predator and prey populations. Extensive prescribed burning planned in the lower Bow Valley will likely affect the distribution of wildlife and their habitat near highway mitigation passages, primarily grizzly bears. We will continue quantifying and assessing wildlife behaviour and level of use at the passages to collect novel and key information on the functionality of passages for wildlife in facilitating normal life history patterns. Last, monitoring is low-cost, yet the ecological benefits are many. These benefits have a direct positive impact on decision-making based on sound research.

4 Modeling of highway mortality vs. barrier effects on population persistence.
This is an important question in light of potential fencing on phase 3B and other highways in the Mountain Parks. We are collaborating with Drs Jochen Jaeger and Lenore Fahrig (Carleton University, Ottawa) who are conducting research to address this problem. They are refining and

validating models using empirical data from BNP, testing the effects of highways as barriers to animal movement (complete fencing/no mortality) compared to unfenced highways (increased mortality risk) on population persistence[24]. Models of this type generally focus on mice and amphibians; however, Banff is one of the few locations in the world with empirical data to model these effects for large mammals. Specifically, park management is interested in knowing, when and under what conditions is a fenced highway better than unfenced in terms of population persistence?

5 Development of cost-effective and innovative wildlife passage designs.
We will measure performance of different passage designs types based on their engineering cost and ecological benefits for representative and fragmentation-sensitive species. This analysis will be conducted using data quantifying wildlife use of varied passage designs in North America including Banff. This effort will be the first attempt to gather, review and synthesize as much information as possible on passage use by wildlife, actual construction costs and ecological performance. As a result, we will create an accessible database and serve as an information clearinghouse for reports documenting wildlife passage use, costs and performance evaluations.

6 Assessment of methodologies for habitat linkage modeling across highways.
Using a regional-scale, GIS-based approach work needs to be undertaken to identify movements of wildlife across the TCH in Yoho National Park. The linkage modeling results will provide park managers with sound management information to begin discussions of TCH impacts on movements and potential mitigation locations and options. Model results will be tested using data collected from empirical road mortality and crossing data from winter road surveys.

When used in a GIS environment, regional or landscape level connectivity models of sufficient resolution can facilitate the identification and delineation of barriers and corridors for animal movement[1,25]. This provides for the development of a more integrated land use strategy by taking into account different land management practices and prioritization of habitat conservation concerns. Currently there is a need to identify critical habitat variables and existing protocols for modeling linkages based on best available data, including existing plans, aerial photography, and remotely sensed data. This work will build on research grounded in environmental science to identify and evaluate approaches for reducing habitat fragmentation and its effect on wildlife populations.

7 Effect of habitat fragmentation by highways on the genetic subdivision of fauna populations.
Natural barriers such as lakes, rivers and mountains can cause the genetic separation of subpopulations. Similarly, some landscapes have become fragmented by an increasing number of major highways. One of the objectives of the Banff NP Mgt Plan is to restore and maintain secure, essential movement corridors in the park, particularly in relation to the TCH. Studying the effects of habitat fragmentation on small- and medium-sized fauna is a key action proposed in the plan.

8 Population-level assessment of highway impacts and mitigation efficacy
Up until now, most highway research and assessments of mitigation effectiveness have been focused at the individual level. It will be critical to know how landscape fragmentation by roads and the conservation measures designed to reduce fragmentation affect the viability of

populations in the Canadian Rocky Mountain region. Future research needs to focus specifically on the conservation value of highway mitigation and how it influences population persistence. Novel model approaches have been developed to address this question by interfacing demographic parameters with habitat suitability maps imported from a GIS[26,27]. Population persistence scenarios can be created varying passage across the TCH with and without wildlife crossing structures, and varying the amount of passage with reference to actual or observed passage rates.

This is an excellent and timely management exercise for most management indicator species in BNP, but most importantly for grizzly bears given the high quality demographic information currently available from the ESGBP dataset.

What do we still need to learn?
Implications of research beyond the Mountain Parks

Relevance to applied conservation and improved environmental policy
The impact of roads on the environment is well-documented and gaining attention worldwide[2,28]. Significant advances in our understanding of these impacts have been made in the last decade[1], however the means to adequately mitigate these impacts are slower in coming. Scientific research in this area has been limited while an aggressive transportation program is being carried out across Canada and the United States. Provincial and state transportation agencies are building costly structures for wildlife connectivity, yet the long-term research to determine the most effective approaches has not taken place[14]. Most efforts to date have been short-term monitoring to see if target species are using the passages, but little consideration has been given to factors that would improve future efforts[14].

Today there are potentially a variety of wildlife passage systems that could be installed on highways. The problem lies in the type of systems that are most cost-effective and understanding what are effective design criteria for selected wildlife species[14]. We believe one of the most useful contributions of long-term Banff highway research will be to continue seeking facts and patterns, in careful observational and rigorous studies on animal movement patterns across passage structures in varied landscapes with complex wildlife-human land use interactions. Unfortunately, few wildlife passages are generally found on any given stretch of highway. Fewer have co-lateral wildlife research ongoing, and fewer still have systematic monitoring programs. We are confident the research we propose will continue to make significant advances in this new frontier of road ecology.

The only highway mitigation study area of its kind
The Trans-Canada Highway and its accompanying mitigation in Banff is an ideal study area and one-of-a-kind laboratory for research on highway effects and mitigation for wildlife. There is no other location in the world with as many and diverse types of wildlife crossing structures or accompanying data on wildlife distribution, movement and ecology. Besides having exceptionally diverse forms of wildlife passages (5 designs) set in the landscape at two distinct temporal periods (recent, old), the mitigation research can boast of having the world's longest, year-round monitoring program and largest dataset on passage use by wildlife. This alone has allowed our research to be on the leading edge of investigations regarding the effectiveness of highway mitigation passages in maintaining landscape connectivity. Further, these investigations could not have been possible without the numerous co-lateral wildlife studies investigating animal ecology and predator-prey interactions in the Banff-Bow Valley.

A solid foundation
The Bow Valley ecosystem, heavily modified and altered by human activity and development, is in a constant state of flux and change[4]. Monitoring species' populations in relation to these human-related elements, in concordance with wildlife passage studies, will provide greater information and novel research results regarding the influence of road systems on habitat fragmentation and effective road-crossing structures. The existing six years of Banff research forms a strong foundation for continued learning and evaluation of mitigation passage function.

The variety of wildlife provides a unique opportunity to assess conservation value at multiple levels.

Challenges and opportunities

The anticipated growth in population and projected highway improvement plans in the Mountain Parks region, coupled with the resounding concern for maintaining large-scale, landscape connectivity has generated interest in mitigation passages as conservation tools. High quality targeted research precedes effective applications. We thoughtfully design our research at the landscape scale relevant to management indicator species and to real conservation decisions. This work will advance our understanding of the utility of cross-highway corridors in maintaining viable wildlife populations and effects of habitat fragmentation by roads. Furthermore, it will provide practitioners and managers with much-needed information and enable well-founded decision-making with regard to wildlife passage placement, design and functional criteria. Our results will provide a sound scientific basis for effective planning, policy and implementation in the Mountain Parks region and beyond. Perhaps more important, we believe it will inspire confidence in government agencies and society as a whole that transportation impacts on wildlife and biodiversity loss is worthy of substantial and continuing investment.

Fertile area of applied ecological research

Banff is an ideal study area for investigations of the ecological effects of roads, providing many research topics that attract graduate students and research scientists alike. Five MSc projects and four PhD projects have examined various effects of the Trans-Canada Highway on the ecology of single species, guilds of species and whole ecosystems. Past and ongoing independent research has extensively used the Mountain Park highway study area (see *Appendix 1*).

Why is there a need to continue?

1 Collaboration is critical for regional-scale interagency resource management

Collaboration with ongoing Parks Canada wildlife research

The TCH monitoring and research has played an important part in the execution of other park-supported wildlife studies. Highway passage monitoring has provided Parks with valuable year-round information regarding species recolonization of the Bow Valley (Fairholme wolf pack), seasonal and annual population trends of multiple species, and current information on wildlife movements needed for management actions (captures). Collection of road-kill data and database management has provided an important service to resource managers in the Mountain Parks and Alberta province, as well as serving as a clearinghouse of readily accessible road mortality information.

G8 Kananaskis Environmental Legacy project

Systematic year-round monitoring of road mortality and wildlife use of crossing structures will provide critical information for national park and provincial resource managers. This information will be essential for monitoring the success of the two, newly scheduled wildlife passages in the Bow Valley; one at the Rundle Canal above Canmore and one on the TCH at Deadman's Flats. Both are Kananaskis Environmental Legacy projects. Continued monitoring is a cost-effective means to prepare for future highway mitigation and land-use planning in the increasingly developed lower Bow Valley.

2 Species at risk

The highway research has implications on the conservation and management of grizzly bears and wolverine, both present in the study area and currently listed in the "*May be at Risk*" category of Alberta Wild Species. Moreover, two species in the "*Sensitive Species*" category (lynx, cougar) are present in the study area. Three of the four species have been documented using the Banff wildlife passages and as road-kills on the TCH in the Bow Valley.

3 High quality science for sound management decisions

With Parks Canada budgets being lean, cost-effective approaches are the norm when allocating science dollars. The TCH mitigation research has been a model of cost-efficient research and national park investment. Compare the TCH mitigation project's number of peer-reviewed publications per years of Parks-supported research, or per research dollar investment (*Appendix 2*). It is doubtful there is any other wildlife research project, past or present, that rivals the TCH research in terms of productivity and delivery of well-founded science for critical resource management decisions.

4 Small cost for a Parks Canada project that they should be showcasing

Montana State University's Western Transportation Institute (WTI) is supporting the principal investigator by providing partial salary support. Next year this may turn to full salary support. The project PI is applying for external research grants to continue the research project. If Parks Canada does not take the lead in this pioneering research, it needs to be at minimum a key player and should at least contribute to the basic monitoring operation costs. Last fiscal year, Parks Canada did not contribute any money for research, only basic monitoring funding from the

Highway Service Centre. At the time of writing, it appears that Parks Canada this new fiscal year 2003-04 is deliberating over whether to fund even the basic monitoring costs.

Banff and Mountain Parks can take the lead

Parks Canada in the Banff-Bow Valley possesses the only large-scale complex of highway mitigation of its kind in the world. This by default allows Banff to be in the forefront of highway mitigation research, if they seize upon the opportunity. The significance of the structures and research around them has resulted in Banff leading the world in mitigation performance research, design criteria, and connectivity studies for wide-ranging animals at landscape scale. The long-term research has proven to be of worldwide importance[1,18]. The quality of science and contribution it is has made to this critical and emerging field of applied ecology in a mere five years is undisputable. Transportation corridors present some of the most severe land-use conflicts the Mountain Park jurisdiction and in the entire Yellowstone to Yukon region. The problems they present will only become greater and more complex in the future, posing major new challenges for transportation and wildlife, but also offering important opportunities for advancement. Continued investments in transportation-related wildlife research will be needed if these opportunities are to be realized.

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Appendix 1

~ Graduate thesis research ~

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Appendix 2

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