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Ecological effects of roads in the Bow River Valley, Alberta
By Anthony Clevenger

> *"What is huge, conspicuous, and avoided by ecologists? The road network etching the land appears to be the only spatial element that essentially all landscapes have in common." (Forman 1998)*

Roads are noisy, dirty and scary. The last place one would want to carry out ecological studies. But here in the pollutant-ridden corridor with semi's buzzing by at 110km/hr lies the foundation of a field ripe to develop – road ecology…the science and application frontier of the next decade.

In September 1996, research was initiated to assess the ecological effects of roads in Banff and the surrounding national parks. This study focuses primarily on the Trans-Canada highway (TCh), its permeability for wildlife and effects in terms of wildlife mortality, movements, and habitat connectivity in the Bow River Valley (see *BNP Research Updates,* (1998) vol. 1, issue 1).

Banff has invested in highway mitigation measures such as fencing and wildlife crossing structures as a means of reducing road-related wildlife mortality and increasing habitat connectivity along the Trans-Canada corridor. Surprisingly, few studies anywhere have evaluated whether crossing structures work or whether they are successful in meeting their objectives. Furthermore, the few evaluations that have been carried out were limited to single species, primarily ungulates. No study that we are aware of has ever looked at the effectiveness of these mitigation measures in a multi-species or community level context.

Underpasses were first built in Banff between 1986-88. Ten structures were placed at roughly 2-km intervals from the east gate to Sunshine interchange. Park wardens monitored how well ungulates used them for two years after their completion. Although carnivores used the underpasses, documenting their passage was not a priority since the Park was mainly concerned with how ungulates responded to the structures.

There was a long dry spell between the late 1980's and the mid-1990's. Independent wildlife researchers and occasional park volunteers would check the underpasses during this period. However, because the information was not collected in a systematic manner it was of limited use for evaluating how well the Banff underpasses were working. In 1995, wardens began routinely monitoring the ten structures once again, together with a new metal culvert at Castle junction. The eleven underpasses were checked on average every 5-6 days, less often during summer and not at all in August, for 15 months.

When our research began in fall of 1996, coinciding with the release of the Banff-Bow Valley report, the underpasses were criticized in the report for their overall ineffectiveness, primarily because they were rarely used by large carnivores. For example, carnivores were reported to have never used the Morrison Coulee culvert. We soon began monitoring and since November 1996 we have checked the crossing structures for wildlife use every 2-3 days year-round, which has amounted to more than 7,000 crossing structure visits.

In order to evaluate how successful or effective an underpass (or overpass) may be, it's essential to define the expectations or develop criteria for evaluating them. No one has ever done that before in Banff, nor anywhere else in the world for that matter. Parks Canada's mandate underscores the importance of ecosystem structure and function, and preserving biological diversity, therefore in developing sound criteria for judging crossing structures animal communities and their processes must be contemplated and not only a few select species.

How to define success or effectiveness?

The answer is about as elusive as defining "ecological integrity" or "normal ecological conditions" for Banff's Bow Valley; nonetheless, we should strive to be as accurate and rigorous as possible. Elsewhere crossing structures have been considered effective "if the target species use them at least occasionally and are used by a large part of the local fauna". However crossing structures cannot be evaluated based on total counts of passages by species but rather in the context of species distributions and abundances. For instance, 200 elk crossings at one underpass is not necessarily more important than 2 grizzly bear crossings. In addition to allowing for natural movements to meet biological needs (food, cover, mates), functional crossing structures must facilitate dispersal and recolonization of new areas. How many passes per year are needed to be "successful"? There is no magic number. If tracks showed a target species used a crossing structure, then a biologist for a state or provincial transportation agency would consider it a success. A conservation geneticist would say one adult male grizzly crossing per grizzly bear generation (every 13 years) would be sufficient to stave off isolation effects and imperiling genetic diversity. A wildlife ecologist would hope for a bit more cross-highway movement. The more information available on species distribution, abundance, and ecological needs in the area, the easier it will be to accurately measure crossing structure effectiveness.

What factors influence the effectiveness of underpasses in Banff National Park?

It's important to know what it is about a crossing structure that makes it attractive to wildlife or facilitate passage. There are a number of features associated with a crossing structure that can influence whether a species will use it: dimensions, noise, it's proximity to cover, towns, topography, amount of human activity, etc. By saying an underpass is important because it's where most individuals of a species crosses, means nothing unless it is qualified by information on what the "expected" crossing rates were (based on abundance in the area) and what crossing structure features were responsible for this success. The latter is crucial if better, more effective structures are to be built in the future.

In a recent paper we determined which of 14 crossing structure features (variables) large mammals responded to most. Using 35 months of data at the 11 underpasses built prior to 1991, we analyzed the data at three levels of resolution: individual species, species groups, and large mammal community. We didn't include the new crossing structures due to the short time they had been monitored. This variable scale approach was used because it met the dual needs of Banff's ecosystem-based management and individuals interested in single-species mitigation. We developed species "performance ratios" for four large carnivore (black bear, grizzly bear, cougar, wolf) and three ungulate species (elk, deer, moose). Unlike total counts, performance ratios take into account species abundance and distribution at each underpass and are calculated as the observed crossing frequency divided by the expected crossing frequency. Ratios were designed so that the higher the ratio, the more effective was the underpass in facilitating species crossings.

Our results showed that each species responded to the underpass features differently. Underpass length was most important for elk, whereas the proximity of an underpass to Banff Town affected grizzly bear crossings most. We identified two species groups, large predators/omnivores and ungulates. The influence of humans (whether it be the distance to town or amount of human passage at an underpass) consistently ranked high as a significant factor affecting crossings for individual species, species groups, and the entire large mammal community. At the species level, six of the seven species ranked at least one of the human activity variables as the most or second most important attribute influencing passage. At the group level, carnivores avoided underpasses close to town or with high levels of human activity. Carnivores also had a tendency to use underpasses close to major drainages. For ungulates the structural attributes were more important than human ones. Our results suggest that future underpasses designed around topography, habitat quality and location will be minimally successful if human activity is not managed.

The above paper has been accepted for publication in the journal *Conservation Biology* and will appear in February 2000, volume 14.

Are the crossing structures being used and how frequently?

Monitoring began in November 1996 and will continue the duration of the project. Wildlife use of the crossing structure is summarized in Table 1. Phase 1&2 consists of crossing structures built between 1986-88, Castle junction underpass was built in 1991, and phase 3A crossing structures were completed in December 1997. In the 35 months of monitoring, there have been 15 grizzly bear passes, nine passes from three known radiomarked adult males and six from unknown grizzlies. During the same period black bears have used the crossing structures for cross-highway travel 355 times, cougars 351 times, wolves 256 times, and coyotes over 3,000 times. Elk have accounted for more than 12,000 passes, deer more than 4,000, and sheep 603 passes.

The same species using the underpasses have been detected using the overpasses, although in different numbers. Sheep are the only species not using them so far. On the overpasses we have documented one grizzly bear pass, six black bear passes, two wolf passes, four cougar passes, 170 coyote passes, 385 elk passes, and 579 deer passes.

We haven't been able to consistently record crossing structure use by smaller fauna because our tracking medium does not consist of fine enough soil, nevertheless we commonly find hare, marten, weasel, squirrel, and mice prints in the structures. Human passage at the crossing structures has been surprisingly high, more than coyotes and nearly that of deer.

During the nearly three years of monitoring, the Bow Valley wolf pack consistently used underpasses, particularly Healy and Edith. Groups of up to four wolves have been recorded. When the pack was larger (8-9 wolves) we never observed more than 4-5 wolves using an underpass. Whether all members of the pack used the underpasses at one time or another, we do not know, but we suspect that occurred. The

Cascade pack, numbering between 14-17 wolves, has used the underpasses east of Banff but only in groups of 2-3 wolves. The Cascade pack spends anywhere from 3 weeks to 3 months in the Bow Valley in winter. The reluctance of the entire pack to use CS east of Banff until now has resulted in complaints that all Banff crossing structures are essentially ineffective, including the wildlife overpasses. It's extremely early to be judging how well the overpasses work (not yet 2 years old with vegetative cover still maturing) and it will certainly require more time to make a proper evaluation. The resident Bow Valley wolves have not used the overpasses and it's unlikely that they ever will since they traditionally cross the TCh at the Healy underpass less than two kilometres away. Evidence supporting this is that the first and only wolf to use an overpass was not a resident but was one of three transient wolves exploring the Bow Valley from the west.

This brings up some important questions. Firstly, were the overpasses situated in the most suitable place to be used by carnivores? This question is important, because without knowing its answer, we cannot appropriately evaluate how effective they are for carnivores or compare their effectiveness to different underpass types. Secondly, do these overpasses represent the most appropriate design or can we improve on it? Overpasses in Europe are essentially "green bridges", as they refer to them. They link habitats over roads without causing animals to change their normal path of travel. The arched design of the Banff overpasses obstructs cross-highway field of view for wildlife in addition to making them climb up into the "unknown" while crossing. Lastly, after our research is complete we might discover that the best way to spend mitigation dollars is not with a few overpasses, but rather on more, but less expensive underpass designs. We have assumed in Banff that overpasses provide greater permeability, however, this has yet to be proven anywhere.

What is the behaviour of animals towards the underpasses?

Little information exists on how animals respond to crossing structures in terms of behaviour and time required to adapt to new structures. Furthermore, previous studies have focused on only one or two crossing structures and all have taken a single-species approach. Previous work in Banff showed that some carnivores have difficulties negotiating roads by using crossing structures. During the last 3 winters we have collected data by snow-tracking animals approaching the crossing structures within a 100 m radius of their entrances. By comparing the number of animals that approach the crossing structures to the number that pass through it, we can gauge the efficacy of each structure. We've monitored multiple species responses to more than 20 different crossing structures of varying age and design along 45 km of TCh. We are interested in determining species-specific responses to crossing structures and whether their responses differed between new and old structures, and how much time might be required for animals to adapt to new crossing structures.

Of 549 transects surveyed, ungulates avoided entering the old crossing structures (pre-1991) 5% of the time and 15% on the new crossing structures. Wolves avoided all crossing structures on average 18% of the time (range, 17-21%; n = 35), whereas cougars refused to enter crossing structures 3% of the time (range, 0-8%). The above results are preliminary. We will collect data during the fourth and final season this winter before preparing a final analysis.

How do pine martens manage to get across the Trans-Canada corridor?

Drainage culverts are common features in road and rail corridors. Yet we know little about how culverts may increase road permeability and habitat connectivity for small critters. Last winter we monitored mammal use of TCh culverts in Banff. Like the underpass evaluation above, we looked at how species responded to many variables (structural, landscape, and road-related) and identified which were most important in explaining passage rates and culvert effectiveness. Species performance ratios (i.e., observed passage frequency / expected passage frequency) were evaluated for eight mammal species and 24 culverts. Sooted track-plates were placed in the culverts to collect data on animal use, while outside the culverts snowtransects provided us with data on expected occurrence. Carnivores (weasels, martens) used more culverts and used them more frequently than small mammals (hares, red squirrels, mice, shrews); however, small mammals were more abundant on the snowtransects.

Results suggested that as traffic volumes increase and road corridors widen, all mammals smaller than coyotes had a greater tendency to use culverts for cross-highway travel. These species generally avoid open areas and we expect the same response for road corridors. Thus, this increased reliance on culverts could be explained by the fact that animals are trying to avoid a heightened risk of predation as well as direct highway mortality. Small mammals and other prey species preferred small culverts as opposed to large ones for passage. This supports that they perceive predation risks to be greater in large culverts. Our findings suggest that for many small and medium-sized mammals, drainage culverts can mitigate the harmful effects of the TCh corridor. For forest-associated species, like those in our study, culverts can provide a safe means of crossing the TCh and a vital habitat linkage. To maximize road permeability for small fauna, we are recommending frequently spaced culverts (150-300 m) of varying sizes situated in close proximity to shrub or tree cover.

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Mortality of wildlife on roads in the Banff-Bow Valley

By Kari Gunson

1. Small- and medium-sized vertebrates ~ Road corridors and networks are structural components of virtually all our natural landscapes. The ecological effects of these roads and vehicles range from habitat fragmentation to an increase in noise levels reducing biodiversity within the surrounding environment. A more direct impact of roads is the increasing number of roadkills linked to higher road densities and traffic volumes. Roughly half of the reported wildlife deaths in Banff can be attributed to highways

As part of our research, a survey was undertaken to collect information on small and medium sized vertebrate roadkills. Two routes are used for the survey. These include: 1) the Trans-Canada highway (TCh) from highway 40 to the BC/AB border at the Kicking Horse Pass and 2) highway 1A from 5-mile bridge to Lake Louise. Typically vertebrates coyote-sized and smaller are recorded as they aren't readily observed by park wardens, rangers and highway contractors responsible for collecting roadkills. Information on large mammal roadkills is being collected as another part of our research.

Tallied results from August to November 1997, April to November 1998, and April to September 1999, showed a total of 771 animals (60 identified species) have been collected from 768 different road sites. These included 254 mammals (25 species), 226 birds (31 species) and 149 amphibians (2 species). During the past three years we sampled a total of 43,092 km of roads - the equivalent of driving the TCh coast-to-coast six times! Of this distance, 9,213 km were surveyed on highway 1A and 33,879 km on the TCh. Taking into account the kilometres of road surveyed in the combined spring, summer, and autumn seasons, animal kills were the highest during the summer months, with mammals being 48% of the kills, amphibians 59%, and birds 48%.

Along the TCh birds were the most common roadkilled taxa accounting for 40% of all mortality, mammals were second accounting for 35%, and amphibians third with 25%. Amphibian kills were high in 1999 due to two periods of mass migrations by tiger salamanders across the TCh near Seebe in August. During their migrations the salamanders travelled 280 m in a northerly direction where 111 individuals were killed on the TCh. Only eight were collected as most were entirely destroyed on the road.

On highway 1A, mammals were most frequently killed at 54%, followed by birds at 25% and amphibians at 21%. Mammal kills were higher along highway 1A with 0.01 roadkills/km as opposed to 0.005 roadkills/km along the TCh. Bird and amphibian kills were relatively the same on both roads.

Further roadkill surveys and measurements at the roadkill sites will be carried out in autumn, and data analysed during the winter. Site measurements will characterize the local vegetation type, road features, and topography.

Our ongoing research will allow us to identify where particular species, taxa, and vertebrate communities within the Bow Valley might be susceptible to high mortality rates along roads. The means and capabilities of mitigating road effects on these "forgotten fauna" by wildlife crossing structures and drainage culverts are being investigated within our research project.

Large mammals ~ For the newsletter we have summarized large carnivore mortality on the TCh in BNP between 1981-1999. During the 18 years a total of 34 animals have been killed, 16 wolves, 15 black bears, 2 cougars and 1 wolverine (Table 2). Nearly half of the roadkilled animals were wolves. Eighty-one percent of the wolves were killed in unmitigated sections compared to 19% on mitigated. More than half of the black bears were killed on the unmitigated section (54%) vs. 46% on the mitigated. For all carnivores, 71% of the deaths occurred on unmitigated sections of TCh compared to 29% on mitigated. Last year our roadkill survey (above) recovered two separate roadkilled lynx (juvenile and adult female) on the unmitigated section of TCh east of BNP.

The high percentage of black bears killed on mitigated sections is a result of animals being able to climb the fence and access the right-of-way. We are recommending that modifications be made to the wildlife fence design that will prevent bears and cats from climbing over the fence.

Can we judge the success of the Banff crossing structures?

Nearly three of every four large carnivore mortalities on the TCh in Banff occurs on an unmitigated section of highway. It's no wonder, traffic levels on the TCh can be so high that 5 seconds don't pass without a car or truck whizzing by. Moreover, rarely is there an instant when a vehicle isn't visible to an animal at the road edge. The difficulties of animals successfully crossing a road like the TCh are quickly apparent. The crossing structure monitoring data indicate that they are being used quite readily, and obviously sparing animals that would otherwise end up dead on the side of the road.

Judging the success of the crossing structures is not a simple, routine procedure. We stress the importance of a multi-species approach to evaluating the effectiveness of Banff crossing structures. In the larger scheme of things (Y2Y) Banff is a keystone protected area, one where successful mitigation has be designed to preserve biological diversity and the integrity of the natural landscape processes.

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