THE EFFECTS OF REDUCED SPEED ZONES ON REDUCING BIGHORN SHEEP AND ELK COLLISIONS WITH VEHICLES ON THE YELLOWHEAD HIGHWAY IN JASPER NATIONAL PARK

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Introduction

Jasper National Park (10,878-sq. km.) is located in the Rocky Mountains in the west-central part of the province of Alberta. The Yellowhead Highway stretches east to west across the width of Jasper National Park for 77km through the Athabasca and Miette river valleys. The Yellowhead Corridor is a main transportation corridor through the Rockies second only to the Trans-Canada highway.

The Jasper National Park portion of the Yellowhead Highway is a 2-lane paved highway with a maximum speed limit of 90km/hr. Traffic volumes fluctuate seasonally, maximum volumes occur from May to September. Traffic volumes from 1983-1998 increased 50% from 800,000 to 1.2 million vehicles per year. The Canadian National Railway (CNR) follows the same route. CNR traffic is consistent throughout the year; daily averages are 35 trains/day or 12,775 trains/yr. The number of trains has decreased marginally over the study period because of longer loads (CNR Jasper dispatch, 1998).

The Yellowhead Corridor is below 1350 meters in elevation, the majority of the corridor traverses the montane ecological zone. This zone is the smallest life zone in Jasper National Park at 7% but is the most biologically productive containing the greatest biodiversity of species and communities in Jasper National Park. A variety of wildlife from grizzly bears (Ursus arctos) to white-tailed deer (Odocoileus virginianus) are present adjacent to both transportation corridors.

Wildlife vehicle collisions have increased dramatically on both the Yellowhead and the CNR. During 1998 there were 113 recorded collisions on the highway and 60 on the CNR. The majority of animals involved in collisions are ungulates

In 1991 3 Slow Down for Wildlife Zones were installed on the Yellowhead highway reducing the maximum speed from 90km/hr. to 70km/hr. in these zones. This report assesses the effectiveness of lower highway speed zones on reducing elk (Cervus elaphus) and bighorn sheep (Ovis canadensis) collisions with vehicles. The results of this report are based 16 years of data from 1983-1990 (pre-installation, 8 years) and 1991-1998 (post-installation 8 years).

Background

Wildlife population and collision trends

Information on wildlife population trends adjacent to the Yellowhead corridor is limited for all species with the exception of elk. Elk population trends have been determined by both aerial and road side census. The elk population adjacent to the Yellowhead Highway and the CNR increased 132% from 400 B 928 elk, during the study period. The greatest increase (178%) occurred adjacent to 1 70km/hr. zone, (location 3). This zone is located between the town of Jasper and a large resort complex. Elk are attracted to each of these areas because of foraging opportunities. Bighorn sheep populations are believed to be stable or increasing slightly, (Wes Bradford Pers comm.).

Park wardens began collecting information on wildlife vehicle collisions in 1951. From 1951 to 1998, 3249 collisions with wildlife have been recorded on both the highway (2,414) and CNR (835). Elk (1065) are the most frequent species involved in collisions followed by bighorn sheep (590), mule deer (Odocoileus hemionus) (562), white-tailed deer (315) and moose (Alces alces) (257). Traffic volumes on the highway fluctuate seasonally, maximum volumes occur from May to September. During this period wildlife vehicle collisions on the highway show a corresponding increase.

A literature review of wildlife vehicle collisions in National Parks carried out by Damas and Smith in 1982 concluded that the problem of wildlife vehicle collisions was concentrated on the major corridors of higher speed traffic. The actual role that speed plays was not addressed in this study. Assumptions have been made in a number of experimental mitigation studies that lower speeds mean fewer collisions, (Pojar et al,1971). Damas and Smith suggested reduced speed zones in high collision locations as a mitigation measure to reduce wildlife vehicle collisions. In Jasper National Park the majority of collisions occur on the Yellowhead Highway and CNR where large wildlife populations exist adjacent to high volume traffic corridors.

In 1991 3 reduced speed zones (70km/hr.) where installed on the Yellowhead Highway. The criteria for selecting reduced speed zone areas were;

Location 1. Disaster Point, length 4km.
- bighorn sheep collisions
- traffic congestion

Location 2. 12-mile, length 2.5km
- bighorn sheep collisions
- traffic congestion

Location 3. Townsite Bypass, length 9km
- elk, bighorn sheep and mule deer collisions
- traffic congestion
- Pedestrian congestion.

Bighorn sheep occupy restricted habitat adjacent to the highway. The main habitat feature is rock outcrops adjacent to the highway. This allows easy access to escape terrain for bighorn sheep. There are 5 locations where these habitat features exist adjacent to the highway and these are the only highway locations where bighorn sheep collisions occur on the highway. Three of these locations are within 70km/hr. zones. Within these locations bighorn sheep are randomly distributed both spatially and temporally.

The majority of elk collisions on the highway occur in a 30-km section, blocks 60-120). During the study period 315 elk collisions occurred in this section and 81 occurred outside this section. This section contains 1- 9km 70km/hr. zone, (location3). Elk are seasonally concentrated within the 30-km. highway section with the exception of a large herd that occupies yearly range adjacent to location 3.

Yellowhead Highway Design and Traffic Profile

Highway Design

The Yellowhead is a two-lane highway with a width design and posted speed of 90km/hr. Traffic lane widths are 3.7 meters. The shoulders are paved and 3 meters in width. Good visibility exists along most of the highway with horizontal curvature described as excellent and a high percentage of the highway has passing sight distance available, (Damas and Smith 1982). In 1992 in location 1 and 2 the centre line was changed from a passing lane to a no passing lane.

Seventy kilometre zones are marked on each side of the highway by 1.92m.x3.67m wildlife warning signs. Other locations on the highway are also posted with wildlife warning signs in the form of large white elk silhouettes. The local police detachment and the warden service issue a yearly average of 5,200 and 275 speeding violations respectively. Traffic volumes are similar in each of the 70km/hr. zones.

Traffic Profile

Traffic volumes have increased from 800,000vehicles per year in 1983 to 1.2 million in 1997. This is based partly on traffic counters and manual gate recording (which does not record traffic after 2400hrs).The majority of vehicles travelling on the Yellowhead highway are passenger vehicles. During 1995 at one centrally located traffic counter there were 749,691 passenger vehicles (81%) 110,275 transport trucks (12%) and 63,038 other vehicles 7% (buses and motor homes) recorded travelling greater than 90km/hr.

When the type of vehicle involved in a collision is known passenger vehicles and transport trucks are the most frequent vehicles involved in wildlife collisions. Buses and motor homes do not make up a significant component of known vehicle types. Thirty nine percent of vehicles involved in a collisions with wildlife are an unknown vehicle type, 33% are passenger vehicles and 28% are transport trucks. Transport trucks account for 12% of the traffic volume and 28% of wildlife collisions. Unknown vehicle types are recorded when an animal is found and the collision has not been reported to the warden service or the local police detachment. It is possible that a majority of unknown vehicle types are transport trucks because the collision damage to the truck may not be significant enough to report as an accident for insurance purposes. If this is the case the percentage of transport trucks involved in a wildlife collisions is greater than 28%.

The average speed of vehicles involved in wildlife collisions is not known. Figure 1 shows the average speed of passenger vehicles and transport trucks travelling greater than 70 km/hr in two slow down for wildlife zones and one 90km/hr. zone. The majority of vehicles reduce their speed from 90km/hr or greater when entering a 70km/hr. zone.

Table 1. Shows the number of vehicles in each speed category for two slow down for wildlife zones. During 1995 the majority of vehicles were travelling within 0-20km/hr. of the 70km/hr. posted speed limit. However, higher speed classes contain a significant number of vehicles relative to the number of animals killed on the highway.

Table 1. Number of vehicles in each speed class in two 70km/hr. zones, 1995.

	Mile 12 70km/hr.		Townsite 70km/hr.	
	Passenger	Transport	Passenger	Transport
70km/hr.	125,920	10,438	63,064	9,203
80km/hr.	270,582	40,837	193,143	63,258
90km/hr.	226,101	46,669	140,753	33,314
105km/hr.	68,119	12,648	29,286	4,029
130km/hr.	11,828	1,094	3,832	163
160km/hr.	1,139	31	415	12

Traffic volumes peak during the May-September period and there is a corresponding increase in bighorn sheep and elk collisions during this period. Monthly elk collision trends and traffic volume trends, Figure 2, show a stronger relationship than bighorn sheep collision trends and traffic volume trends, Figure 3 .

Method

When a collision is reported or found by the warden service the animal is removed and the information recorded. Most animals are located within 12-24 hours from the time the collision occurred.

A map of the Yellowhead Highway was segmented into 153 - 500-meter blocks and plotted using GIS. Collision locations are plotted based on field recording on U.T.M. 1-50,000 maps. U.T.M. 1:50,000 maps are accurate to within 100 meters. Information from each block is stored digitally and contains information ranging from the species to the type of vehicle involved in the collision. A 16-year study period was chosen because both periods 1 and 2 contain an equal number of years (8). Comparisons have been made using pre and post data collected from all locations on the Yellowhead and the CNR railroad line.

The analysis of data is limited to elk and bighorn sheep and does not consider the increase in traffic volumes. Other species are not represented in sufficient numbers to allow analysis. Location 1 and 2 contain insufficient samples with the exception of bighorn sheep. The analysis of elk is limited to location 3 because of insufficient sample sizes in location 1 and 2. The number of collision events is used for this analysis versus the number of animals killed; occasionally more than one animal is struck per collision.

Bighorn sheep

Bighorn sheep collisions occur on short (2-3 km) sections of the highway. The majority of collisions occur within 70km/hr. zones in locations 1 and 2. Collision comparisons between periods 1 and 2 are made and are expressed as a percentage increase or decrease. Collision trend data from the highway and CNR is also plotted and evaluated. Because bighorn sheep populations have remained relatively stable. And because the majority of collisions occur within 70km/hr zones, 167 versus 50 outside these zones, an ANOVA is used to determine significance. Collision data recorded in 70km/hr. zones from both periods is used in this analysis.

Elk

Elk collision data taken from a 30 kilometre section (blocks 60-120) of the highway is used in the analysis because this area contains a 70km/hr. zone and is most representative of this zone. Also, the majority of elk collisions occur in this section, 315 versus 398 in total. Collision comparisons between periods 1 and 2 are made and are expressed as a percentage increase or decrease. Collision trend data from the highway and

CNR is also plotted and evaluated. A chi-squared test is used to determine significance because elk are not randomly distributed over time. Collisions per kilometre are used to account for spatial differences within and between 70km/hr. and 90km/hr. areas.

Determining an expected value.

Data from blocks 60 -120 is used to determine an expected valve because these blocks are more representative of the blocks (91-108) within the 70km/hr. zone or location 3. The length of the area outside the 70km/hr. zone is 21 kilometres (42- 500 meter blocks) and the length of the area within the 70km/hr. zone is 9 kilometres (18-500 meter blocks). Collisions per kilometre are used in the analysis because of the difference in size between the two areas. Collisions increased from period 1 to period 2 outside the 70km/hr. zone from 2.94 collisions/km to 5.42 collisions/km or 84%. Collisions increased from period 1 to period 2 inside the 70km/hr zone from 6.88 collisions/km to 8.55 collisions/km or 24%. The increase in elk collisions per kilometre outside 70km/hr. zones was 60 % greater than the increase in elk collisions within the 70km/hr. zone. Expected values were determined by multiplying the observed valve by .60. Observed values less than 4 were grouped.

Results

Collision information for the 3- 70km/hr. zones and blocks 60-120 excluding location 3 (70km/hr.zone blocks 91-108) is listed in Table 3. Collision data for other species is in Appendix 1.

Table 3. Number of collisions for pre and post installation periods.

Species	Period 1	Period 2
	Location 1	
Bighorn Sheep	19	21
	Location 2.	
Bighorn Sheep	48	51
	Location 3.	
Elk	62	77
Bighorn Sheep	15	11
Elk 90km/hr.area	blocks 60-120 excluding 91-108	
	62	114

Bighorn sheep

During periods 1 and 2 , 165 collisions with bighorn sheep occurred in 70km/hr. zones and 50 occurred in 90km/hr. zones. In 90km/hr. zones bighorn sheep collisions decreased by 33% from 30-20 collisions. Inside 70km/hr. zones bighorn sheep collisions increased by .01 % from 82 B83 collisions. Bighorn sheep collisions increased by 36% on the CNR from 72-98 collisions. Collision trends on the CNR and within 70km/hr. zones show an upward trend from 1983- 1990 and a decreasing trend from 1990-1998. Collision trends in 90km/hr. zones are stable with the exception of 1988, Figure 4.

Bighorn sheep collisions increased in 2 of 3- 70km/hr. zones between periods 1 and 2. An analysis of variance (ANOVA) showed an association between bighorn sheep collisions and 70km/hr. zones, (Table 4). The association shows an increasing collision rate in 2 of 3 70km/hr. zones.

Table 4. ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.166667	1	0.166667	0.00044	0.98427	7.70865
Within Groups	1515.333	4	378.8333			
Total	1515.5	5				

Elk

Elk collisions increased by 84% in 90km/hr. zones (21kilometer section) from 62 to114 collisions between periods 1 and 2. Inside 70km/hr. zones elk collisions increased by 24% from 62 to 77 collisions. On the CNR elk collisions increased by 190% from 65 to 189 between periods 1 and 2. From 1983-1990 all collision trends show an upward trend.. This trend continues on the CNR and in 90km/hr zones. With the exception of 1991 elk collision trends from 1992-1998 show a decreasing trend in the 70km/hr. zone. figure 5.
Significance was determined by applying a chi-squared test to elk collisions in location 3 (blocks 91-108), described in section 3. The results of the chi-squared test showed an association between 70km/hr. zones and declining elk vehicle collisions (? ? =1, d.f.=11, P=<0.035).

Discussion

There are significant differences between bighorn sheep and elk collisions. The majority of bighorn sheep collisions occur during dawn to dusk versus elk collisions that occur during dusk to dawn periods. And elk are distributed over a larger area. Although bighorn sheep are considerably smaller than elk an assumption can be made that sheep are easier to see by drivers during daylight periods versus elk during low light periods. It can also be assumed that drivers are more likely to take action to avoid a collision with bighorn sheep when they are more visible.

The application of winter mix (sand mixed with salt) and foraging opportunities attracts bighorn sheep to the highway. Bighorn sheep are not disturbed by traffic volumes and become de-sensitized to traffic volumes. Bighorn sheep conjugate in small groups on and adjacent to the highway and remain in the traffic lanes despite traffic volumes. Traffic congestion usually occurs and vehicle speeds are reduced because of the traffic congestion. Traffic congestion is not as great in 90km/hr. zones where bighorn sheep are involved in collisions. Bighorn sheep collisions declined by 30% in 90km/hr zones and increased slightly in 70kmhr. zones. Traffic congestion may have a greater effect on bighorn sheep collisions than vehicle speed.

Comparisons between bighorn sheep highway collisions and CNR collisions are not as strong for bighorn sheep versus comparisons for elk. This is because bighorn sheep occupy restricted habitat on both corridors and the Athabasca River limits sheep movements in location 1 and 2. Comparisons between elk collisions on the highway and the CNR are more vigorous because the CNR is within 100-200 meters of the 30km area used in the analysis of elk data and there are no barriers to elk movements between the highway and CNR

Although large elk populations are present adjacent to the Yellowhead Highway elk do not exhibit similar behaviour patterns as bighorn sheep. Specifically the tendency to remain in the traffic lanes despite traffic volumes.

Elk populations have increased from 400-928 (132%) adjacent to this area during 1983-1998. The greatest increase in the elk population (178%) 99-276 occurred adjacent to location 3 (70km/hr.). Location 3 experienced a 25% increase in elk collisions versus an 84% increase in 90km/hr. zones. Despite the dramatic increase in the elk population adjacent to this 70km/hr. zone collisions with elk did not increase at the same rate as experienced in 90kn/hr. zones or on the CNR.

Conclusion

Although there is a relationship between traffic volume and wildlife collisions the relationship between traffic type, vehicle speed and collisions is not known.

Bighorn sheep collisions decreased 30% in 90km/hr. zones and increased slightly in 70km/hr. zones. Bighorn sheep collision trends in 70km/hr zones and on the CNR show a downward trend from 1991-1998. Bighorn sheep collision trends in 90km/hr. zones from 83-1998 remained stable with the exception of a peak in 1988. An ANOVA showed an association between 70km/hr. zones and an increase in bighorn sheep collisions in location 1 and 2. Bighorn sheep behaviour probably negated the effects of reduced speed zones on reducing bighorn sheep vehicle collisions. Elk collisions increased 84% in 90km/hr. zones and 24% in location 3, 70km/hr. zone. This smaller increase (24% versus 84%) occurred despite the dramatic increase in the elk population adjacent to location 3. Elk collisions on the CNR increased by 190% from 1983-1998. Elk collision trends during 1983-1990 on the highway and the CNR show an upward trend. After installation (1991-1998) of the 70 km/hr. zones this trend continues in 90km/hr. zones and on the CNR. The collision trend in location 3 (70km/hr. zone) shows a decreasing trend for the majority of the period. A chi-squared test showed an association between 70km/hr. zones and decreasing elk/vehicle collisions. Reduced speed zones had a significant effect on reducing the rate of elk vehicle collisions.

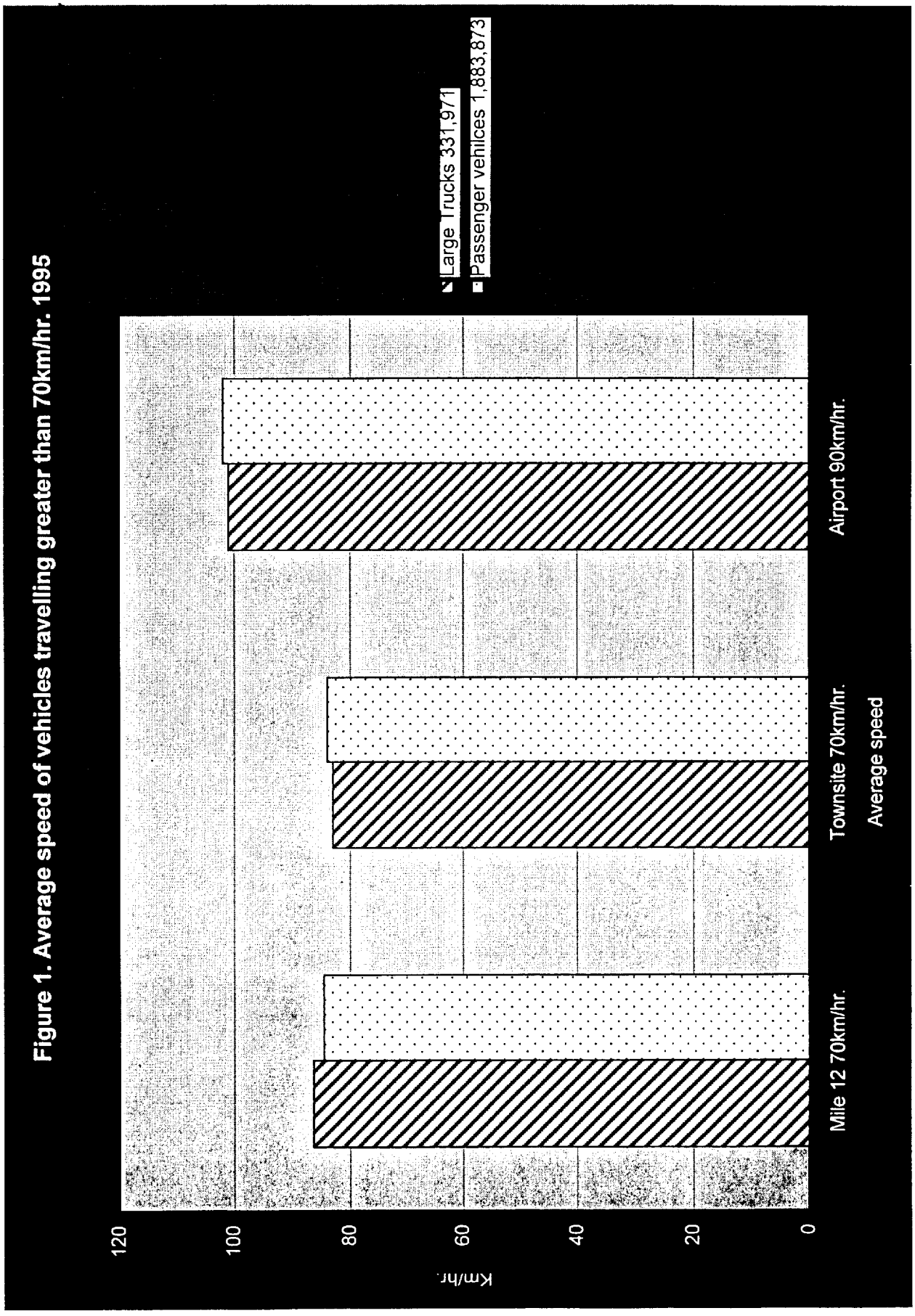
Figure 1. Average speed of vehicles travelling greater than 70km/hr. 1995
Large Trucks 331,971
Passenger vehicles 1,883,873
Km/hr.
120
100
80
60
40
20
0
Mile 12 70km/hr.
Townsite 70km/hr.
Airport 90km/hr.
Average speed

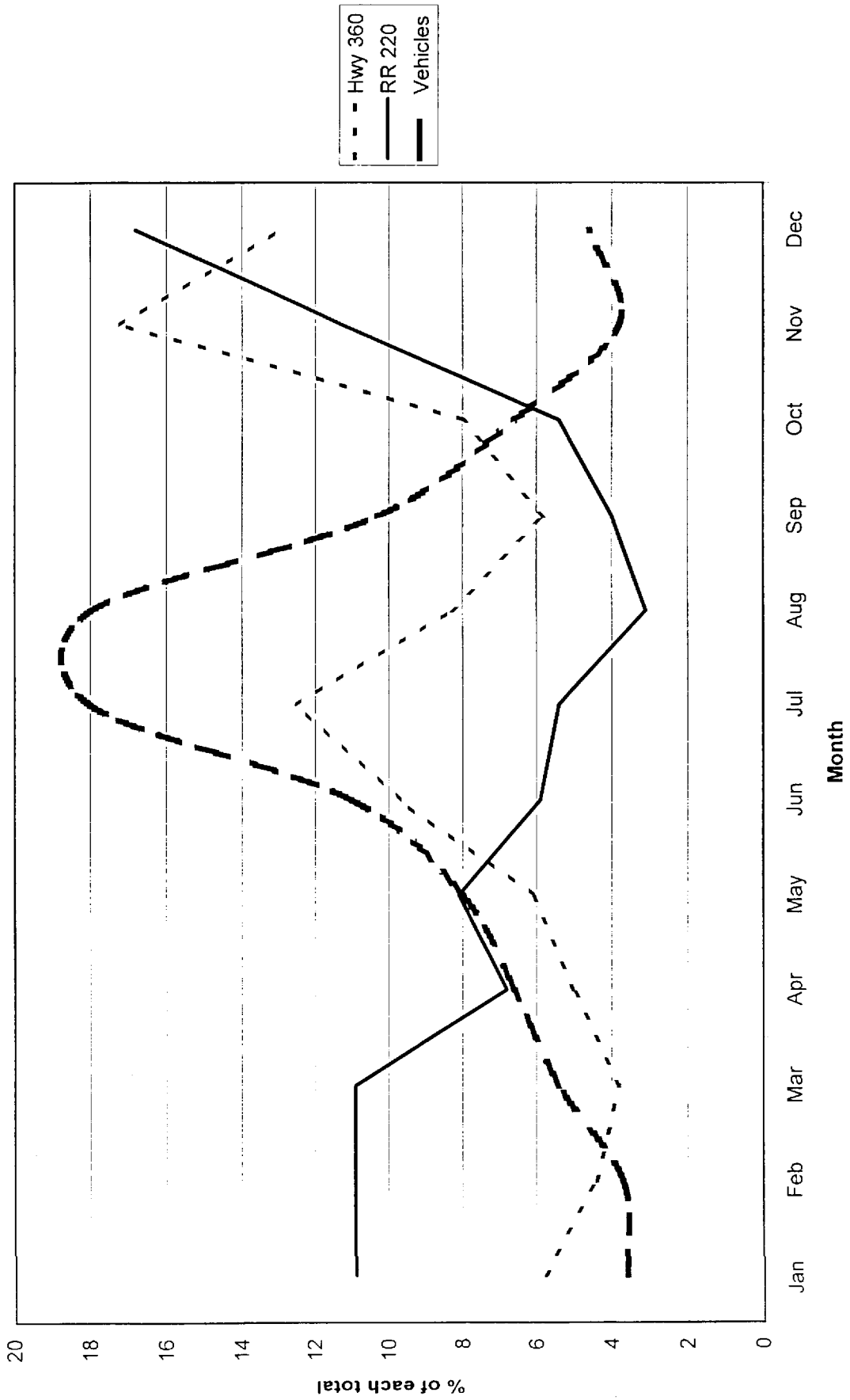

Figure 2. Monthly bighorn sheep collision trends 1951-1998 & average vehicle volumes

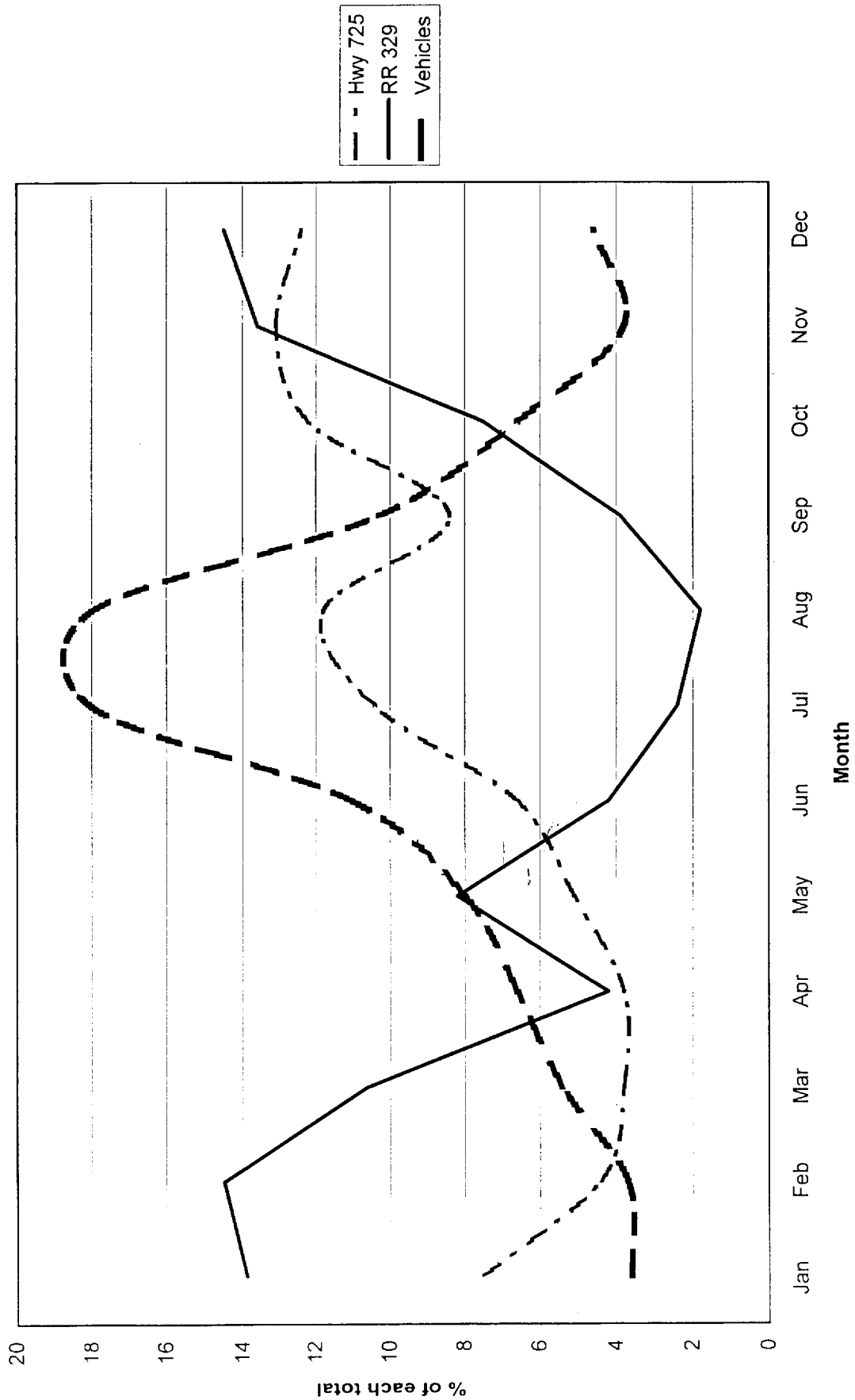

Figure 3. Monthly elk collision trends 1951-1998 & average monthly traffic volumes

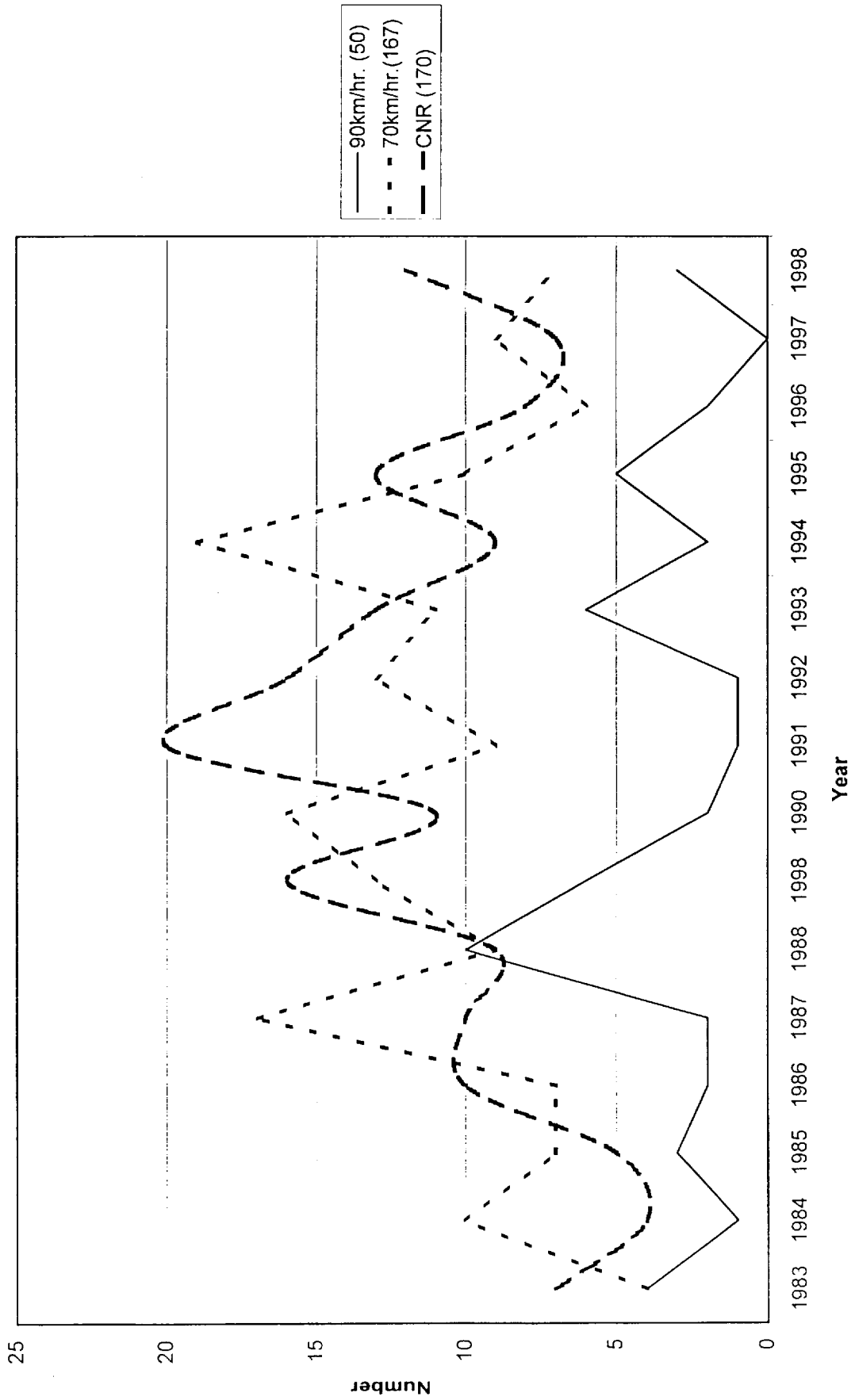

Figure 4. Bighorn sheep collision trends 1983-1998

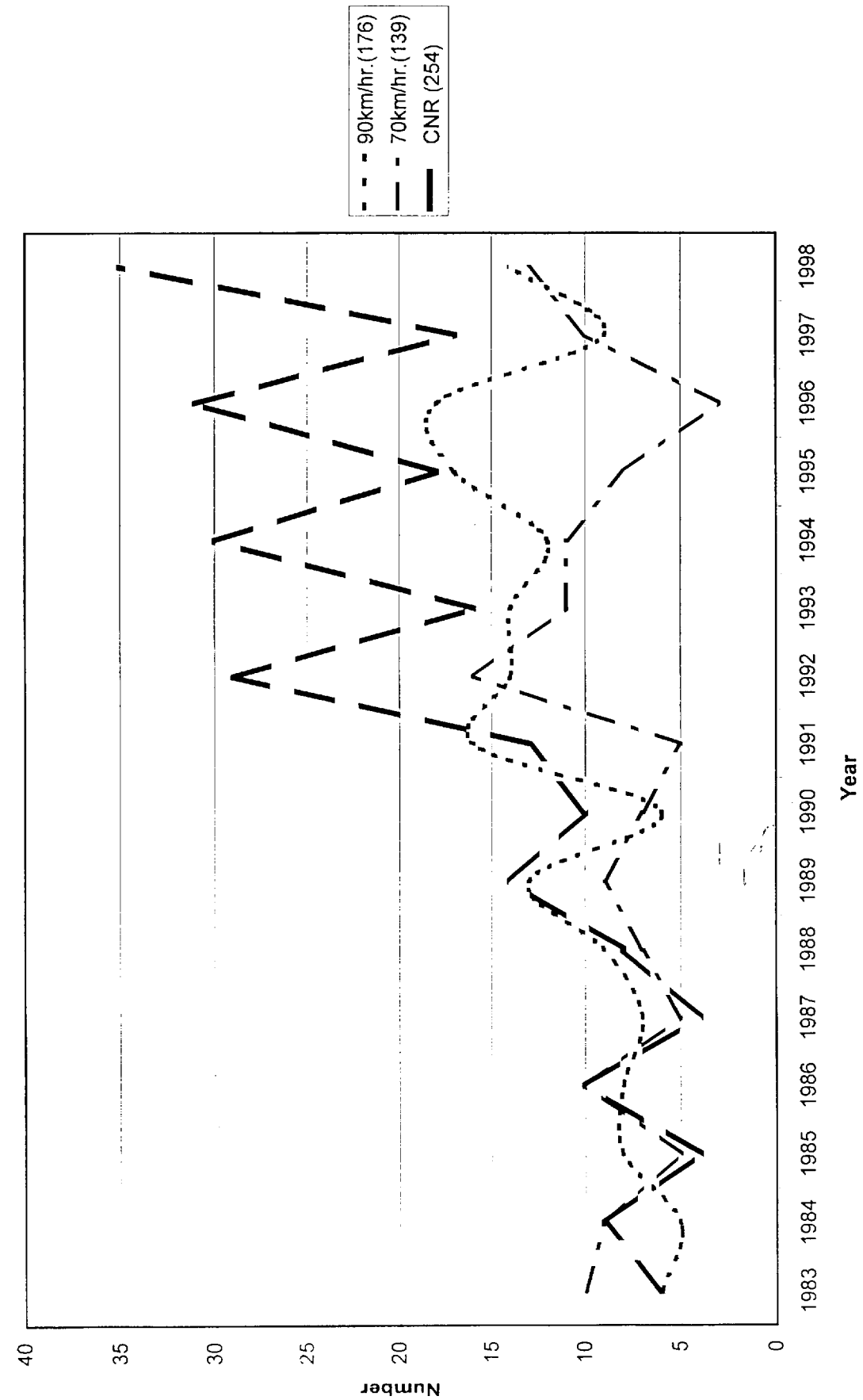

Figure 5. Elk collision trends 1983-1998