THE UNIVERSITY OF CALGARY

UNGULATE MONITORING ALONG THE TRANS-CANADA HIGHWAY

BANFF NATIONAL PARK

by

Jonathan Miles Scott-Brown

A Master's Degree Project

submitted to the Faculty of Environmental Design

in partial fulfillment of the requirements for the degree of

Master of Environmental Design

(Environmental Science)

University of Calgary

Calgary, Alberta

March, 1984

THE UNIVERSITY OF CALGARY

FACULTY OF ENVIRONMENTAL DESIGN

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submitted by Miles Scott-Brown in partial fulfillment of the requirements for the degree of Master of Environmental Design

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ABSTRACT

UNGULATE MONITORING ALONG THE TRANS-CANADA HIGHWAY BANFF NATIONAL PARK

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Completed in partial fulfillment of the requirements of the degree of Master of Environmental Design

Supervisor: Dr. S. Herrero

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A plan is presented for monitoring the use of wildlife underpasses, fencing, texas gates and one way gates constructed in Phase I (km 0-13) of the Trans-Canada Highway Twinning Project in Banff National Park. The overall purpose of monitoring is to determine the success of wildlife mitigation measures and to apply these results to related highway projects elsewhere in Canada. A two phase approach incorporating short and long term objectives is presented. Criteria developed to assess the suitability of eight monitoring techniques include the need for knowledge of individual animal use and behavioural responses to wildlife defence structures. A 12V video surveillance system is selected as the technique most suitable for evaluating the success of wildlife underpasses. Track counts are the best means of measuring the success of wildlife fencing, texas gates and one-way gate structures. Together these techniques adequately assess the success of mitigation and satisfy the short term objectives of the wildlife monitoring program. Similar measures are proposed for monitoring in Phase II (km 13-27). Long term wildlife research requirements along the Trans-Canada Highway are presented. These include the need for better ungulate population data, the development of species management plans, studies on predator-prey interactions and the identification of key wildlife habitats and associated development conflicts in the Bow River Valley.

Key words:

Ungulates, monitoring, mitigation, Trans-Canada Highway, Banff, underpasses fencing, one-way gates, texas gates, video-surveillance system

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Many other individuals contributed towards the final preparation of the document. Marilyn Yeo of Parks Canada provided me with background material for drafting of maps. Special thanks go to Andra McLaughlin for her help in preparing the figures in the text.

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EXECUTIVE SUMMARY

In the past 25 years, animal mortality on highways in Banff National Park has become a serious problem. This concern was highlighted during a recent review of a project to twin the Trans-Canada Highway from the East Gate to the Banff Traffic Circle (Phase I) and later to the Sunshine Turnoff (Phase II). As a result, the installation of wildlife defence measures along the twinned highway including the use of fencing, underpasses and one-way gates was a condition of project approval.

This Master's Degree Project (MDP) presents a plan for monitoring wildlife use of these structures in Phase I (km 0 - km 13) of the Trans-Canada Highway Twinning Project. Long term research needs pertaining to future highway development in the Bow Valley are also presented.

Four species of ungulates, the elk, moose, mule deer and white-tailed deer, are found in the Phase I highway corridor. Although the presence of these animals has been reported since the time of the first explorers in the 1800's, a clear understanding of population dynamics and distribution of ungulates in the Bow Valley is presently lacking. Similar statements can also be made with regard to carnivore and fur-bearer populations in the highway corridor. While aerial surveys have been conducted to gain an understanding of ungulates numbers in the Bow Valley, these have failed to employ the use of standardized techniques and statistical analyses of the survey data. Without a statistical base in which to compare survey results, an accurate representation of population trends is not possible. This is particularly important in assessing the long term effects of highway development in the Bow Val-

ley.

Monitoring of animal defence structures is discussed in a general context of the overall aims of the environmental monitoring process. Environmental monitoring began as a means of evaluating the effects of pollution in the 1960's. With the development of environmental regulatory processes it also became a mechanism for measuring the effectiveness of mitigative measures.

For the purpose of this document, monitoring is defined as a long term programme of data collection focussing on predetermined environmental, social and economic indicators from project conception through to project abandonment. A case is made for considering environmental monitoring in an experimental context where data collected after initiation of project development can be compared to data collected beforehand in the baseline phase. This allows for a validation of impact predictions and an assessment of the effectiveness of mitigation measures. A feedback mechanism is proposed in which the results of environmental monitoring can indicate the success of mitigation and allow for changes in project design where deemed necessary. Monitoring can also indicate unexpected project impacts and allow for the additional imposition of mitigative measures. An important aspect of environmental monitoring is the applicability of the results to other similar but geographically distant projects. Monitoring can lead to an improved accuracy in impact prediction and a streamlining of the environmental impact assessment process.

Monitoring of underpasses, fencing, one-way gates and texas gates is considered in a regulatory context in which the purpose of monitoring is to indicate the effectiveness of wildlife mitigation measures. Based on this approach, a series of short term and long term objectives are generated. Short term objectives focus at the individual level and are aimed at determining the responses of animals to fencing, one-way gates and underpasses. Long term objectives focus at the population level and are directed at determining significant lasting effects of highway construction in the Bow Valley. A number of criteria are established to determine the relative merits of eight techniques to monitor the use of wildlife defence structures. The most important of these is the need to understand the use and behavioural responses of a number of wildlife species to underpasses, fencing, one-way gates and texas gates.

A number of direct and indirect methods are discussed as a means of evaluating the success of wildlife mitigation on the Trans-Canada Highway. The choice of a video-surveillance system is recommended as it is the only satisfactory method of determining the effectiveness of underpass structures. The other techniques are considered to be inadequate in determining the success of mitigative measures.

A 12 volt DC video-surveillance system is suggested as the best means of determining species use and behavioural responses to wildlife underpasses in Phase I of the TCH twinning project. The system features a portable design which will allow for monitoring at several locations. Track counts are recommended to measure animal responses to fencing along the highway right-of-way. A combination of track counts and the use of mechanical counters is suggested as a means of determining animal use of one-way gate structures. Track counts and a study of ungulate responses to texas gates are recommended to assess the effectiveness of these structures.

A similar monitoring programme is recommended for Phase II from the Banff Traffic Circle to the Sunshine Turnoff. Special attention should be directed towards determining the use of underpasses by bighorn sheep in this section.

Baseline studies are being initiated from the Sunshine Turnoff to Castle Junction and these will be used to justify the extent and necessity of wildlife defence structures in Phase III.

A programme of research outside of the immediate highway corridor is recommended to satisfy the long term objectives of the wildlife monitoring programme. Studies should be initiated on the use of underpasses by carnivores and the potential for predator prey interactions at underpasses. Video-surveillance may provide useful information on the potential for occurrence of this problem. The need for development of large mammal species management plans and a better understanding of the population dynamics of large mammal species in the Bow Valley is stressed. Important wildlife habitats should be identified and examined in light of proposed development conflicts. Consideration should also be extended to habitat manipulation measures should studies show the need for range enhancement of ungulate species in the Bow Valley.

Monitoring of wildlife defence measures along the Trans-Canada Highway in Banff National Park should provide useful information on the extent and severity of both short and long term impacts of highway construction in the Bow Valley. A concerted effort should be directed towards ensuring this goal as this project represents a unique situation both in a national parks and Canadian context.

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CHAPTER 1: INTRODUCTION

1.1 Statement of the Problem

Banff National Park currently covers a 6358 km2 area in southwestern Alberta and is located 112 km west of the city of Calgary (Figure 1.1). The Park contains 376 km of roads, 82 km of which constitute the Trans-Canada Highway (TCH) or Highway 1. The TCH accommodates 50-55% of all park automobile traffic in the summer months and 75% of the total park vehicular traffic throughout the year (Damas and Smith 1983).

In recent years, highway mortality of wildlife in Banff Park has become a significant problem. During the period from 1964 to 1978, 970 known animal vehicle accidents occurred on the Trans-Canada highway between the East Gate and the Yoho boundary (Flygare 1978). Nearly half (44.8%) of these recorded accidents occurred in the first 13 km from the East Gate to the Banff Traffic Circle. In total, 74.8% of all wildlife accidents on the TCH occurred between the East Gate and the Sunshine turnoff (km 27).

A variety of wildlife species are killed on the highway including elk, mule deer, white-tailed deer, moose, bighorn sheep, black bear, grizzly bear, coyote, mink and red fox. In 1978, elk and mule deer accounted for 74% of all wildlife fatalities occurring on the Trans-Canada Highway (Flygare 1979). From 1978 to 1981, a total of 384 ungulates were killed between the East Gate and Castle Junction (Flygare 1979, Harrison et al. 1982).

Not only is this mortality significant in terms of animal deaths but it is also costly in human economic terms. In 1980, vehicle repair costs resulting from wildlife collisions in Banff National Park averaged

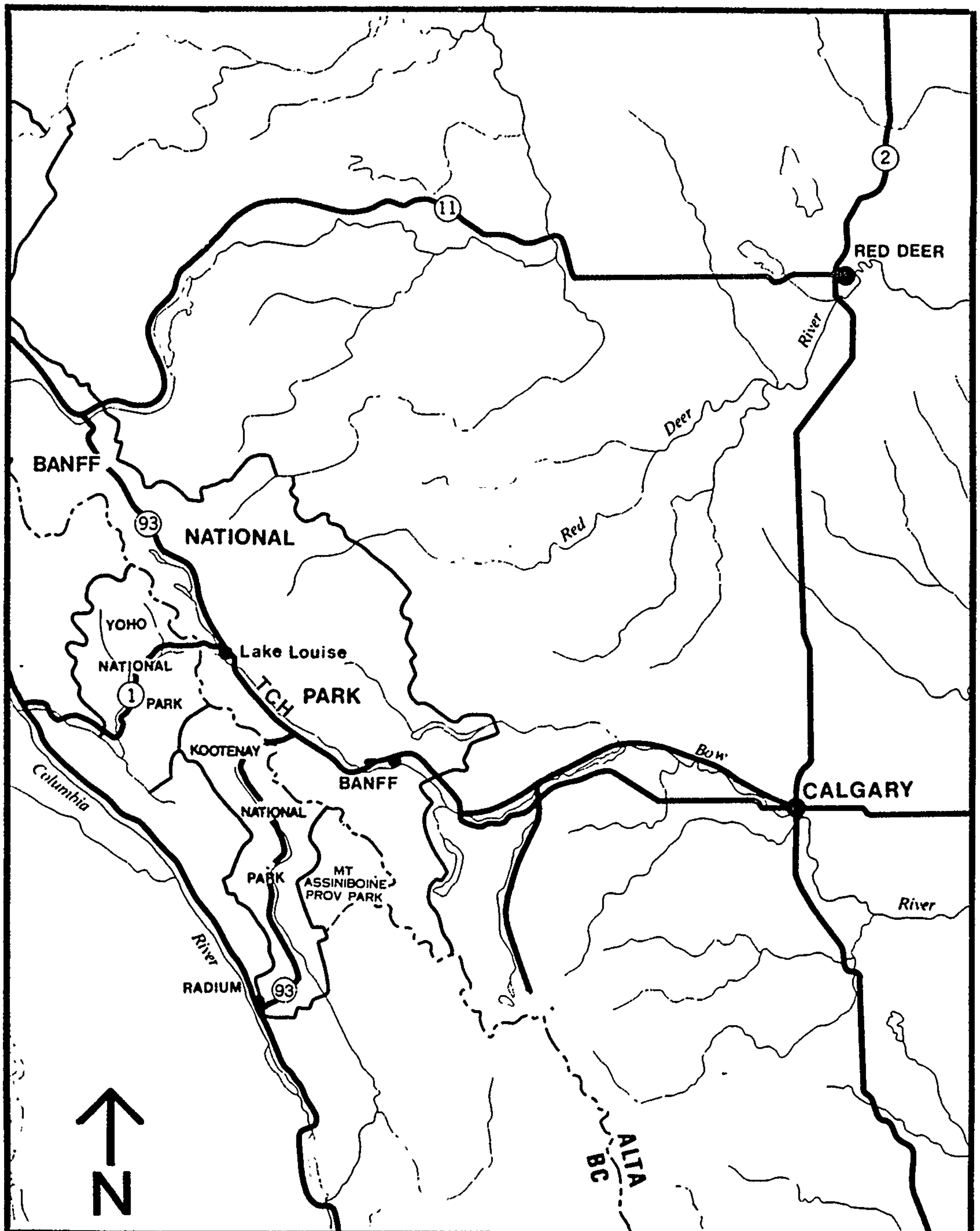


FIGURE 1.1 KEY MAP

Miles
10 0 10 20 30 40 50
10 0 10 20 30 40 50 60 70
Kilometres

$824 per vehicle (Harrison et al. 1980). During the same year, vehicle animal collisions in Alberta caused three million dollars of property damage or an average of $1000 per vehicle. Damage exceeded this amount in 30% of all cases (Sanderson 1983).

Public Works Canada (PWC) is in the process of constructing a four lane divided highway from km 0 to km 13 in Banff National Park (Phase I). Further extension of the highway to the Sunshine turnoff (km 27) is planned for Phase II by 1987. Concerns were raised during the Environmental Assessment Panel hearings over the current and potential future mortality of wildlife on the Trans-Canada Highway. As a result, the Environmental Assessment Panel recommended that Public Works Canada install mitigative measures including the use of fencing, one-way gates and underpasses to reduce and/or eliminate wildlife mortality on the Trans-Canada highway (FEARO 1979). The Panel also recommended that Parks Canada undertake a monitoring programme to evaluate the success of mitigation measures employed in Phase I.

The purpose of this Master's Degree Project (MDP) is to assess a variety of techniques available to determine the effectiveness of wildlife defence measures in Phase I of the TCH twinning project. Based on this review, recommendations on a monitoring and research programme will be presented for consideration by the Trans-Canada Highway Project Environmental Subcommittee.

Active on-site testing of monitoring techniques and equipment was not included as part of the Terms of Reference of the project. It is hoped that further testing and refinement of techniques presented in this document will be undertaken in 1984.

1.2 Terms of Reference

The project was carried out under contract to Parks Canada and overseen by representatives of the Natural History Research Division, Western Region in Calgary. The terms of reference were developed through consultation with officials from Parks Canada, Public Works Canada, the Canadian Wildlife Service and the Banff Park Warden Service.

Specific objectives of the study were to:

1. review information on the construction and effectiveness of animal defence systems in use along highways in the United States and Europe;
2. establish methods for evaluating the response of animals to underpasses, one-way gates and fencing;
3. develop recommendations on future wildlife research priorities associated with twinning of the TCH;
4. develop recommendations for Parks Canada's and the Environmental Sub-committee's consideration regarding possible modifications or additions to the ongoing monitoring programme being conducted by the Banff Warden Service;
5. review the security strategies of ungulates in relation to the landscape design of underpass structures.

In addition, the project also serves to fulfill the requirements of a Master of Environmental Design degree in the Faculty of Environmental Design at the University of Calgary.

1.3 Study Methods

The study began with a review of background information collected by the Natural History Division of Parks Canada, Western Region and the Banff Park Warden Service. Documents prepared by Public Works Canada in support of the Banff Highway Twinning Project were also consulted.

The assessment of available monitoring techniques and development of an appropriate monitoring plan was derived from a review of published and unpublished information produced by transportation and wildlife agencies throughout North America and Europe. Informal interviews of local personnel familiar with proposed equipment and techniques were undertaken to determine their suitability in measuring the relative effectiveness of mitigative measures proposed for Phase I.

Several field trips to Banff National Park were undertaken between August and October 1983 for the purpose of site analysis and investigations of the status of wildlife defence structures.

1.4 Approach

The purpose of this document is to provide recommendations on a monitoring plan to assess the effectiveness of mitigative measures on the Trans-Canada Highway. Because of the large scope contained within the Terms of Reference, certain topic areas are addressed in the Appendices rather than in the main body of the text. These include sections on the effectiveness of wildlife mitigation systems in other countries and a review of ungulate security strategies. The text will focus on developing a framework in which to consider the suitability of various techniques for assessing the success of underpasses, fencing and one-way gates on the TCH. Recommendations will be developed on the technique most suitable to meet this goal.

Since most of the information pertaining to the highway twinning project is current and not available in published form, much reliance has been made on the use of personal communications. Contacts with these individuals and their positions are listed in the Literature Cited section.

1.5 Organization of the Document

The MDP consists of seven chapters including the introduction, summary and recommendations.

Chapter 2 reviews the background of the Banff Highway Project and describes the mitigative measures to protect wildlife along the highway corridor.

Chapter 3 provides a historical perspective of ungulate species in the park and describes their current status and distribution along the first 13 km of the highway. The status of other wildlife species which may be affected by highway development is reviewed. Existing park policies pertaining to the protection and management of wildlife species in Banff National Park are discussed in light of the proposed wildlife monitoring plan.

Chapter 4 discusses the evolution of environmental monitoring efforts in Canada and its role in the environmental impact assessment process. Approaches to environmental monitoring are reviewed. The last section of the chapter discusses an approach to wildlife monitoring along the TCH and establishes objectives of the wildlife monitoring programme.

Chapter 5 contains the bulk of the document and consists of various techniques available to monitor wildlife use of animal underpasses, fencing, texas gates and one-way gates. in order to establish the effectiveness of mitigative measures. The advantages and disadvantages of each method are compared and preferred means of monitoring the mitigative structures are suggested.

Chapter 6 takes the results of the preceding chapter and discusses them on a site specific basis for Phase I of the twinning project. Recommendations on procedures and methods for evaluating the success of mitigative measures are provided. Detailed recommendations on monitoring procedures for determining wildlife use of underpasses are presented. Wildlife research needs for future proposed phases of TCH twinning in the Bow Valley are discussed.

Chapter 7 provides a summary of findings in the previous chapters and presents overall recommendations for establishing a monitoring plan to assess the effectiveness of mitigative measures in Phase I.

Appendix 1 reviews the success of wildlife defence measures along highways in the United States and Europe.

Appendix 2 discusses a behavioural approach towards monitoring the effectiveness of highway mitigative measures along the TCH. The security strategies of the major ungulate species found in Phase I of the TCH are reviewed. Suggestions are made as to the terrain requirements in the immediate vicinity of underpass locations.

Appendices 3 and 4 provide details on operational aspects of the proposed video-surveillance system.

Appendix 5 presents a summary of the available techniques to monitor wildlife along the Trans-Canada Highway. This section is ordered so that the reader can have easy access to comparative advantages and disadvantages of each techniques and their potential uses for the monitoring of wildlife in Banff National Park.

CHAPTER 2: THE TRANS-CANADA HIGHWAY TWINNING PROJECT

2.1 Project Background

Banff National Park had its beginnings in 1885 when the Federal government established a 1600 hectare reserve around several hot springs near the present day town of Banff for the purposes of establishing a health resort. The C.P.R. line was constructed through the Park between 1882 and 1885 and access to the newly established townsite of Banff was later provided by 1886. Prior to 1910, the use of motor vehicles was forbidden within the park and visitor use during this period was mainly restricted to those travelling there by train.

It was the establishment of a highway connection to the East that opened up Banff National Park to the general public. In 1907, the Alberta Government began construction of the Calgary to Banff highway and by 1911 the road was completed to Banff townsite. By 1912, the automobile was rapidly becoming the preferred means of local transportation within the park and the pioneering instincts of these early motorists had a tremendous influence on the later expansion of the Canadian parks system (Lothian 1976). A connection to Lake Louise was opened in 1920 and by 1927 it was possible to travel by road through the Kicking Horse Pass to Golden. The Banff-Windermere highway was completed in 1923 and in 1932, construction of the Jasper-Banff portion was initiated and later completed in 1940. Construction of a road network through the mountain parks provided the visitor with a variety of scenic views unparalleled by any other highway system in Canada.

By 1956, the road from Banff to Golden was upgraded to standards laid out by the Trans-Canada Highway Agreement of 1954 (PWC 1979). Construction was later initiated on a four lane divided highway from Calgary to the East Gate of Banff National Park by Alberta Transportation in 1966. Work on the highway was accelerated in 1967 and the road was eventually opened in its entirety by 1971.

Initial studies on twinning the Trans-Canada Highway through Banff and Yoho National Parks began in 1963 and environmental studies were later completed between 1971 and 1975. Public opposition to the twinning proposal and concern over world wide energy shortages led to a postponement of the project in 1974 (FEARO 1979).

Increased traffic volumes on the Trans-Canada Highway prompted Public Works Canada (PWC) to revive the twinning project and an Initial Environmental Evaluation of the first 13 km section was later completed in 1978 (Lombard North Group 1978). In May 1978, the proposal was referred by Public Works Canada to the Federal Environmental Assessment Review Office for initiation of a formal review under the Environmental Assessment Review Process (FEARO 1979).

In February 1979, an Environmental Impact Statement (EIS) was received by the Environmental Assessment Review Panel and public review of the document and the project was provided during a series of public hearings held in June of that year. On October 29 1979, ministerial approval was granted to proceed with twinning of Phase I subject to conditions laid out by the Environmental Assessment Panel (FEARO 1979).

An EIS for Phase II of the project covering the area from the Banff Traffic Circle to the Sunshine Turnoff was received in August 1981. Public information sessions followed in September 1981 and hearings later convened in January 1982. Ministerial approval to proceed with Phase II was later obtained on May 7, 1982.

At the present time, construction of Phase I is proceeding ahead of schedule and completion of the first 13 km to the Banff Traffic Circle is planned for early 1984 (B. Leeson pers. comm. 1983).

2.2 Project Description

The existing road right-of-way (ROW) through Banff National Park is a rural two lane paved and undivided highway with a pavement width of 13.4 m and a ROW width of 61 m (PWC 1979). The proposed new road will consist of an additional two lanes of traffic and will not require significant upgrading of the existing highway. The alignment of the twinned portion of the TCH from the East Gate to the Banff Traffic Circle (Phase I) is depicted in Figure 2.1.

The project incorporates three typical cross-sections which differ in median type and width (Figure 2.2). The Type "A" cross section consists of two additional lanes of traffic with a wide treed median between the opposing lanes. Type "B" consists of two additional lanes separated by a minimum depressed grassed median. Type "C" consists of an additional two lanes separated by a raised concrete barrier.

At the East Gate the west bound lanes use the existing right-of-way until km 3.0 when they are diverted to a new ROW on the North side of the existing highway. The new section continues to km 10.1 where the

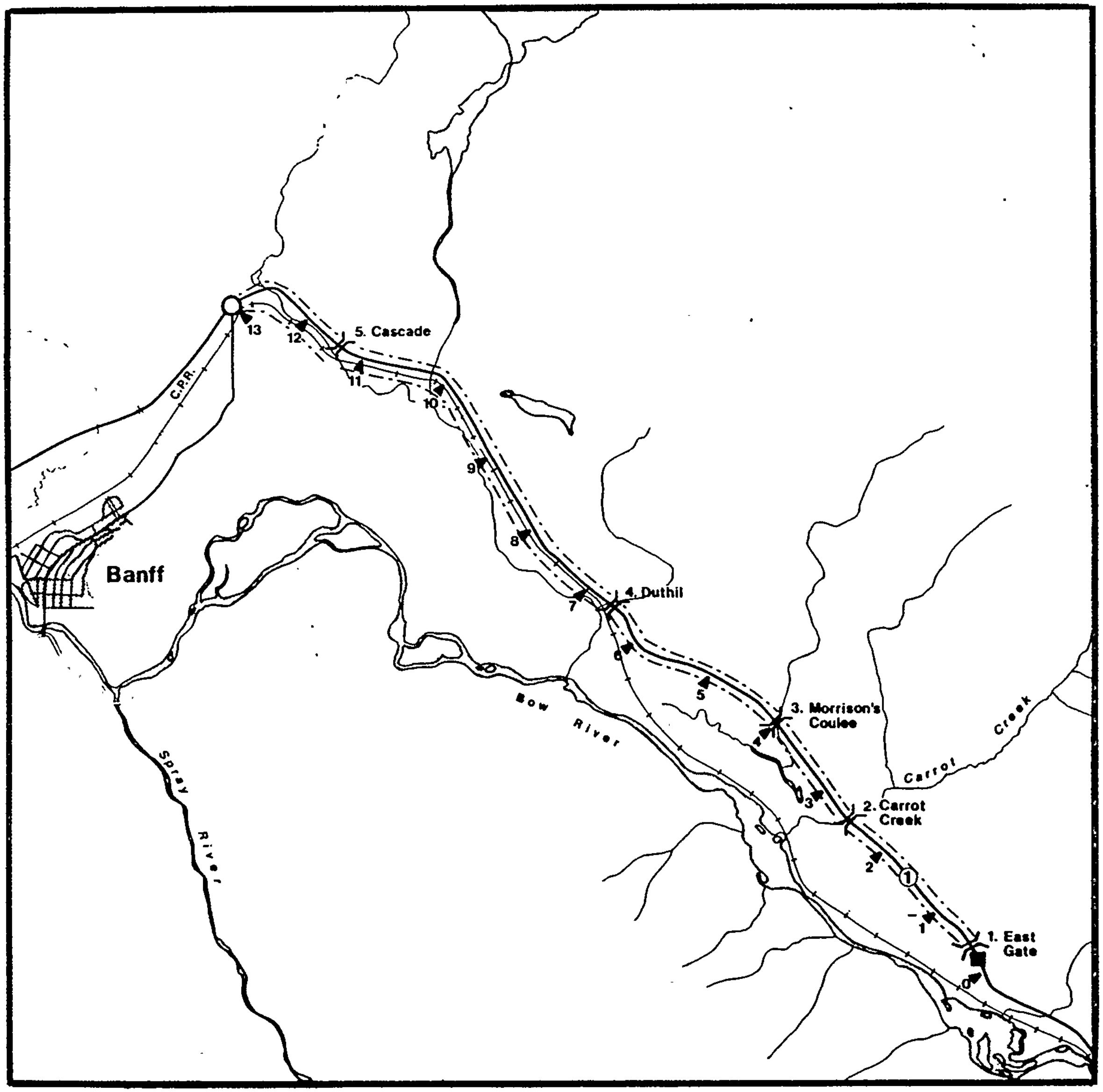


FIGURE 2.1

UNDERPASS AND FENCE LOCATIONS km 0-13

LEGEND

UNDERPASS LOCATION

FENCING

TRANS-CANADA HIGHWAY

PARK GATE

5 DISTANCE IN km

0 1 2
km

N

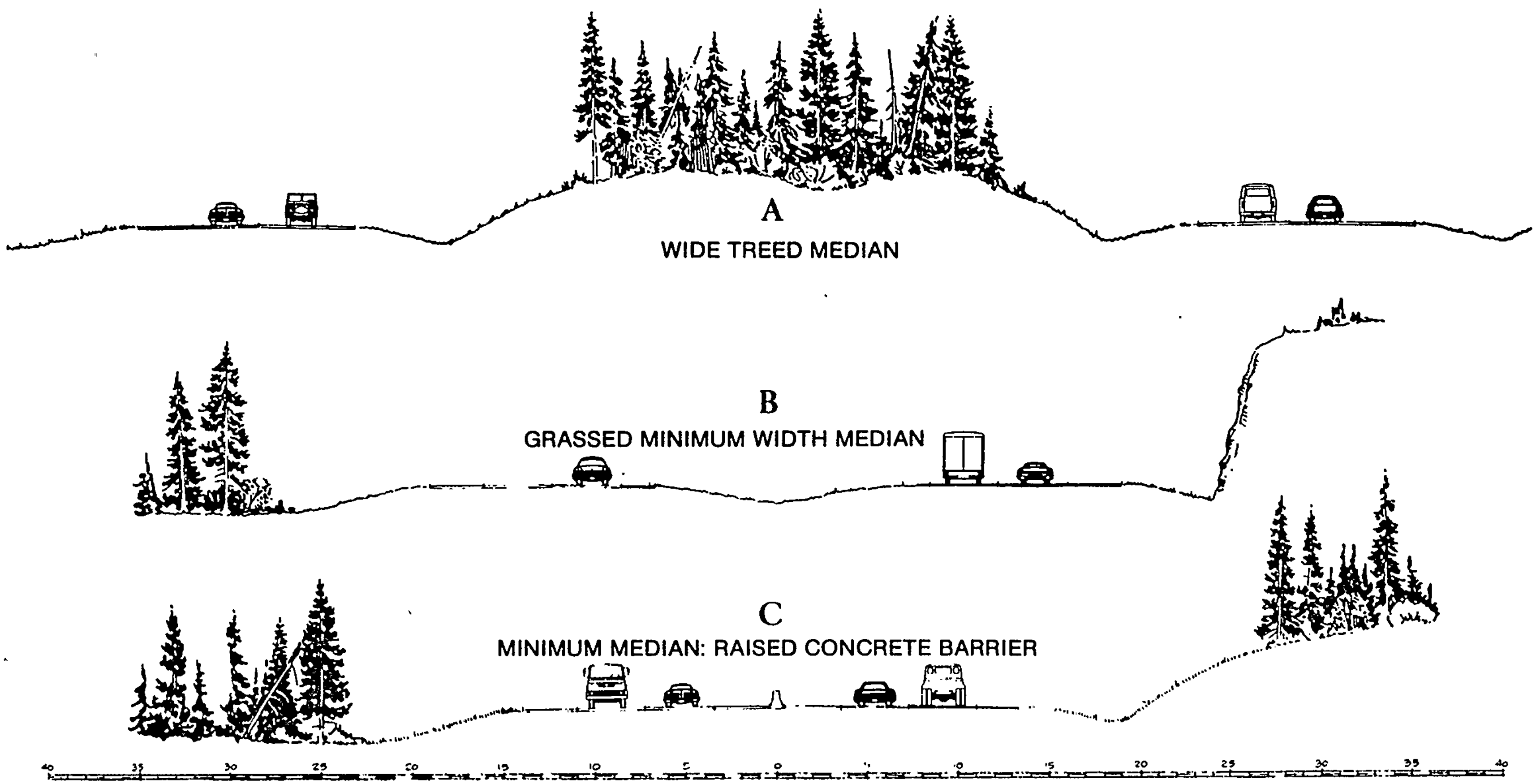


FIGURE 2.2 TRANS-CANADA HIGHWAY MEDIAN TYPES

Source: FEARO 1979

west bound lane is diverted back to the existing right-of-way. The west bound lanes follow the existing right-of-way to km 11.1 where they are diverted back to the new ROW on the north side of the highway. At km 11.9 the west bound lanes divert back to the existing right-of-way and follow this through to the traffic circle at km 13. An "A" cross section will be used to km 5.4 and a "B" cross section will be developed from there to km 11.4. A "C" type cross section will be used from km 11.4 for the remaining length of the highway to the Minnewanka Interchange at km 13. For a more detailed description of the road alignment the reader is referred to the Environmental Impact Statement prepared by Public Works Canada (1979).

2.3 Project Management

Overall responsibility for twinning of the Trans-Canada Highway through Banff National Park is being assumed by Public Works Canada. Environmental concerns are being addressed by the Environmental Subcommittee, one of six committees designated to manage various aspects of the highway project. An Environmental Coordinator has been appointed by Public Works Canada (PWC) to monitor and report on construction practices along the highway to both Public Works Canada and the TCH Environmental Subcommittee. Parks Canada is responsible for evaluating the effectiveness of mitigative measures employed in Phase I.

2.4 Highway Mitigative Measures

1. Fencing

The entire 13 km length of Phase I will be fenced on both sides with a 2.5 m high Page Wire Fence. Fence mesh size measures 15 x 15 cm and attempts will be made to minimize gaps at the bottom of the fence to 15 cm (PWC 1981a). Actual costs (1983$) of erecting a Page Wire Fence to km 6.4 are $247 000 or $19 300/km. The termination of fencing at the East Gate will utilize a New Jersey Type traffic barrier to prevent animal movements onto the east bound lanes (G. Allan pers. comm. 1984).

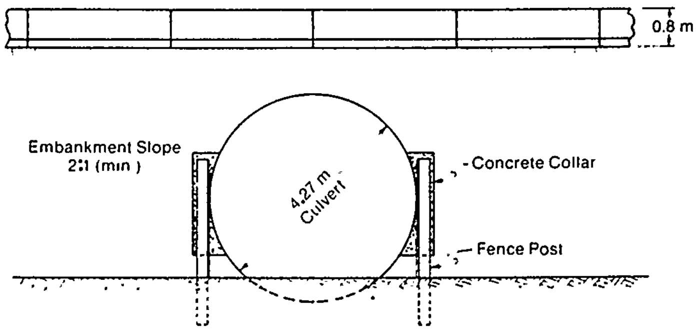
2. One-way gates

One way gates will be placed at irregular intervals on either side of the twinned highway to allow passage of animals trapped within the highway ROW. These structures are based on a funneling principle which allow easy passage from one side while preventing access from the other (Reed et al. 1974a). The one-way gates are similar to prototype designs tested at Elk Island National Park which have successfully allowed the passage of both male and female elk (PWC 1981b).

3. Underpasses

Five underpass structures are constructed in Phase I and these consist of two types (Table 2.1). Each underpass spans two lanes of traffic and the median is fenced to direct animal movements into the adjacent underpass under the remaining two lanes of traffic. The dimensions and configuration of each underpass type are depicted in Figure 2.3.

CULVERT



OPEN SPAN BRIDGE

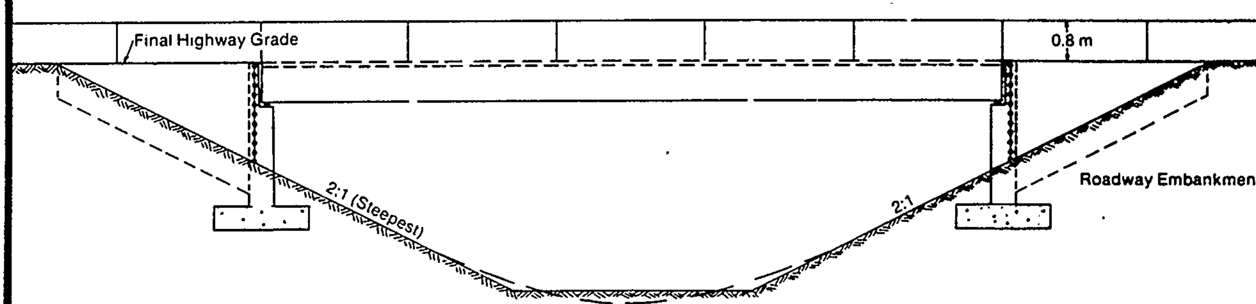


FIGURE 2.3 TRANS-CANADA HIGHWAY ANIMAL UNDERPASS DESIGNS

Source: FEARO 1982

Table 2.1. A comparison of underpass structures in Phase I of the TCH

Name	Location (km)	Structure Type	Cost (Actual$)
East Gate	0.6-1.0	Open span bridges	440 000 (1982$)
Carrot Creek	2.9	Open span bridge	350 000 (1982$)
Morrison's Coulee	4.0	Culverts	152 000 (1982$)
Duthil Flats	6.4	Open span bridges	242 000 (1983$)
Cascade	11.4	Open span bridges	245 000 (1983$)
		TOTAL	$1 429 000

Note: Carrot Creek underpass costs based on construction of one bridge only

Source: G. Allan Public Works Canada

A 4.27 m diameter culvert is in place at Morrison's Coulee (km 4.0) as an experimental trial to determine its suitability for deployment in Phase II. The cost of the culvert structure is substantially less than the open span bridge at $152 000 for both crossings (two culverts). Problems were encountered with drainage in the spring of 1983 and further modification of the surrounding terrain may be required (B. Leeson pers. comm. 1983).

Conventional open span bridge structures are constructed at the East Gate (km 0.6), Carrot Creek (km 2.9), Duthil Flats (km 6.4) and Cascade (km 11.4) crossings. The conventional bridge type is the more expensive of the two underpass types (see Table 2.1).

Reinforced earth structures consisting of a 10 m wide, 4 m high wide concrete "box" were initially considered for the East Gate and Duthil Flats underpasses. Since construction costs of an open span bridge were similar to those of a reinforced earth structure, the choice of the former was preferred as they were believed to be more effective as underpasses (B. Leeson pers. comm. 1983).

At the Duthil underpass (km 6.4), fencing will cross to the south side of the C.P.R. line and will continue through to the Banff Avenue intersection with the Minnewanka Interchange at km 13. Fencing will be extended from the Cascade underpass to the existing C.P.R. bridge to the south to prevent animals from exiting onto the tracks at that location.

4. Texas Gates

A prototype texas gate structure is currently being tested at the Valleyview Picnic Area (km 5.0). This structure consists of an experimental grating rather than the familiar bar type arrangement of a conventional cattleguard.

At the time of writing, construction of structures at all five underpass locations (East Gate, eastbound Carrot Creek Morrison's Coulee, Duthil Flats and Cascade) is complete. Construction of the westbound Carrot Creek underpass will be completed by the summer of 1984. Fencing is in place on both sides of the highway to the Duthil

Flats underpass (km 6.4). Erection of the remaining fenceline to km 13 and construction of the interchanges at the Banff Traffic Circle and Norquay turnoff will continue through the winter of 1983-1984 and be completed by the fall of 1984.

CHAPTER 3: WILDLIFE RESOURCES AND THE TRANS-CANADA HIGHWAY

The wildlife of Banff National Park is diverse in its extent and distribution and reflects the variety of habitats characteristic of a mountain environment. Four species of amphibians, one species of reptile, 281 species of birds and 58 species of mammals have been identified (Banfield 1958; Bow Valley Naturalists 1978; Van Tighem and Holroyd 1982; Holroyd and Van Tighem 1983).

3.1 Ungulate Distribution, km 0-13

With the possible exception of the grizzly and black bears, ungulates are the wildlife group of most interest to park visitors. Within the Phase I and II highway corridors four ungulate species have been identified; the elk, mule deer, white-tailed deer and moose. Bighorn sheep are found west of the Banff Traffic Circle and are not known to frequent Phase I.

The following section presents a historical overview and description of the present day status and distribution of each ungulate species within Banff National Park. The extent and magnitude of highway mortality in Phase I of the TCH is discussed.

3.1.1 Elk

Elk were noted in the Rocky Mountains by early European explorers in the 1800's, but sometime after 1850 the species became locally extirpated. The exact cause of its demise is unknown but may be due to a number of factors including weather, disease, habitat destruction and excessive hunting (Banfield 1958). Fifty seven elk were shipped to Banff National Park from Yellowstone in 1917 and this reintroduction was followed by another 206 Yellowstone elk between 1919 and 1920. By the early 1940's, reports from Jasper, Banff and Kootenay indicated that severe range deterioration was occurring and an elk reduction programme was subsequently initiated in 1941. The programme was discontinued in 1969 and by that time a minimum of 3923 elk had been destroyed (Holroyd and Van Tighem 1983). The elk population in Banff National Park was estimated at 1000 animals between 1975 and 1977 (Jacobson 1977).

Elk range throughout the Bow Valley from the East Gate to Lake Louise, but are more abundant at lower elevations. Significant numbers have been speculated to leave the Park from the East Gate to winter in the Canmore Corridor (PWC 1981b). Snow cover appears to be the major factor limiting the extent of elk distribution in the Bow Valley.

Studies in 1977 indicated that an estimated 150 elk were present between the East Gate and km 13 of the TCH (Lombard North Group 1978). Jacobson (1977) reported 171 elk between the East Gate and the Sunshine Turnoff from November through December 1976. Harrison et al. (1982) estimated between 262 and 376 elk were present from the East Gate to the Sunshine turnoff, but their estimates may be inflated over the norm due to the low snowfall and warm temperatures present in the Bow Valley that year. Bull:Cow ratios of 36:100 gained through aerial surveys in the winter of 1980-1981 compared favourably with a ratio of 39:100 for the Bow Valley (Holroyd 1979) and 37:100 for Banff Park as a whole (Flook 1970).

A minimum of sixty-six elk were killed on highways in the Bow Valley during 1978 (Damas and Smith 1983). A minimum of eighty elk or 20 per cent of the estimated population from the East Gate to Castle Junction were killed between October 1 1980 and April 30, 1981 (Jacobson 1981). Substantially more cows were killed than bulls, but this appears reflective of the sex ratio. Adult animals are killed more often (57 per cent) compared to young of the year (25 per cent) and yearlings (18 per cent).

During the period from 1964 to 1977, a minimum of 105 elk were reported killed on the TCH between the East Gate and the Banff Traffic Circle (Flygare 1978). A reported 33 elk were killed in 1978, 54 in 1979 and 37 in 1980 (Harrison et al. 1982). Holroyd (1979) estimated that the 372 elk present in the Bow Valley in 1976 could sustain an annual unnatural mortality between 33 and 77 animals and that road mortality may be exceeding the maximum predicted surplus of the population.

3.1.1.1 Evaluation of information

Historical records of animal distribution and abundance are both difficult to interpret and assess. Most observations of the early explorers were likely made on an opportunistic basis and the spectacle of large numbers of animals in a relatively pristine environment may have led to exaggerated reports of their abundance. The accuracy of this information is suspect and cannot be compared to the results of a statistically based survey of the present day.

The various elk studies which have been conducted in the Bow Valley suffer from a lack of comparable survey methods, poor statistical treatment of the data and differences in the size of the study area. None of the surveys conducted to date report proper confidence intervals on the data or discuss any means of statistical treatment. Without the use of confidence intervals, it is difficult to compare survey results between years in order to determine whether significant changes in population numbers are occurring. The importance of correction factors and means of overcoming visibility biases in aerial surveys is discussed later in this document in Chapter 5.

It is difficult to assess the significance of highway mortality on elk populations without a clear understanding of population dynamics. The problem is further compounded by the fact that crippling losses are not clearly documented. The impact of road related mortality on the Trans-Canada Highway may be greater than what has been reported by Holroyd (1979).

The extent of elk movements from the eastern boundary of Banff National Park into the Canmore Corridor is not completely understood. The Banff Park Warden Service is presently conducting an elk telemetry study to provide information on the extent of elk movements in the Bow Valley within Banff National Park.

3.1.2 Mule deer

Mule deer were consistently reported in Banff Park throughout the last century, but excessive hunting may have contributed to a rapid decline in the population by 1900 (Holroyd and Van Tighem 1983). Mule deer increased after the turn of the century, but numbers started to decline again in 1935 possibly due to increased competition for winter range with elk (Banfield 1958). Numbers increased again after 1940, possibly as a result of the elk slaughter programme, but highway mortality and severe winters in the 1950's and 1960's have reduced the population since that time (Holroyd and Van Tighem 1983). At present, good population data on the numbers of mule deer in the Bow Valley are lacking. Harrison et al. (1982) estimated 67-80 mule deer were present between the East Gate and Sunshine Turnoff in 1980-1981.

In relation to their known abundance, mule deer currently suffer significant mortality on the Trans-Canada highway. From 1964 to 1977, a minimum of 148 mule deer were killed between the East Gate and Sunshine Turnoff, 75 of which died on the highway between the East Gate and the Traffic Circle (PWC 1979). Holroyd and Van Tighem (1983) report that a minimum of 185 mule deer were killed on all Banff highways between 1945 and 1980. In 1979, 25 mule deer were killed between the East Gate and the Sunshine Turnoff and the kill declined to 19 and 15 animals respectively in 1980 and 1981 (Harrison et al. 1982).

Deer mortality along the highway appears to be correlated with heavy use of roadside habitats throughout the year and exhibits three peak periods (PWC 1979). The first occurs in May when animals are attracted to early green-up of highway edges. Female mortality is highest in June and may result from a need for nutritional forage along highway verges for the purposes of lactation. Mortality is also high in the summer months, largely as a result of heavy traffic volumes. The third peak occurs in the fall and may be a combination of increased movements associated with the rut and decreased forage availability under forest cover (Allen and McCullough 1976; Carbaugh et al. 1975).

The male:female ratio of road mortality is 73:100 and adults are killed more frequently (67 per cent) than are young of the year (18 per cent) and yearlings (15 per cent) (Damas and Smith 1983).

3.1.2.1 Evaluation of information

Mule deer are more difficult to census from the air than are the larger ungulates such as moose and elk. Gilbert and Grieb (1970) found aerial surveys only account for 30 to 50 per cent of the actual numbers of deer present.

Present population estimates place the number of mule deer in the Bow Valley between 60 and 80 animals (Harrison et al. 1982). This figure likely does not represent the actual number of mule deer present. Holroyd and Van Tighem (1983) state that further study of mule deer in Banff and Jasper is needed to adequately assess population size, determine population dynamics, delineate seasonal ranges and understand the extent of movements in and out of the Park boundaries. In short, the status of the mule deer in the Bow Valley is not clearly understood.

Similar statements can be made with regard to the extent of mule deer mortality on the Trans-Canada Highway. It has not been clearly established whether highway mortality is limiting mule deer populations in the Bow Valley. More detailed and rigorous censuses are required to adequately address this problem.

3.1.3 White-tailed deer

During the 1800's, white-tailed deer were found in fair numbers in the Alberta foothills and in the Cypress Hills area (Webb 1959). Numbers dwindled at the turn of the century but increased soon afterwards as agriculture, forest clearing and fire control led to an expansion of aspen-parkland habitat (Holroyd and Van Tighem 1983). Depletion of the more easily hunted mule deer may have also facilitated the spread of the white-tailed deer in Alberta. White-tailed deer have been called "the deer of the future" in the Province (Webb 1959).

The history of white-tailed deer in Banff National Park is uncertain and numbers appear to be low at the present time (Banfield 1958; PWC 1979). Harrison et al.(1982) estimated fewer than 20 white-tailed deer were present between the East Gate and the Sunshine Turnoff, but concluded that numbers observed during aerial surveys were insufficient to adequately determine population size and composition.

From 1964 to 1977, a minimum of 13 road-killed white-tailed deer were reported killed between the East Gate and the Sunshine Turnoff. Nine were killed in the first 13 km to the Banff Traffic Circle (Flygare 1978). In 1979, three white-tailed deer were killed between the East Gate and Sunshine and six road-killed animals were reported in each of 1980 and 1981.

White-tailed deer mortality differs from that of other ungulate species in that significantly more bucks are killed than does (81 per cent:19 per cent) (Flygare 1979). This could be related to a higher mobility of bucks associated with rutting activities (PWC 1979). Further population studies are necessary before any definitive causes can be ascribed to these differences in mortality.

3.1.3.1 Evaluation of information

Population estimates of the white-tailed deer in the Bow Valley are inadequate to assess the impact of road related mortality on the Trans-Canada Highway. It is not known whether the larger number of bucks killed on the highway is a result of low samples sizes, is reflective of unequal sex ratios or indicates a greater susceptibility of males to road mortality. Further study is required to determine the size and composition of white-tailed deer populations in the Bow Valley.

3.1.4 Moose

Moose were commonly reported by early European explorers in the 19th century. However, outbreaks of unknown diseases in the late 1840's and again in 1900 decimated the park population (Banfield 1958; Soper 1970). Moose was a major meat source for early settlements in the foothills and overhunting may have also been a major factor in the decline of moose populations in the Rocky Mountains (Holroyd and Van Tighem 1983). It was not until 1925 that moose reappeared in the Bow Valley (Banfield 1958) and the population expanded after that date in response to increased habitat availability resulting from a series of forest fires at the the turn of the century (Parks Canada 1982). An explosion of beaver numbers during the 1940's and subsequent habitat deterioration may have led to a decline of moose numbers through to 1950 (Mair 1952). Competition between moose and beaver at this time may have resulted in a decreased availability of aspen and willow habitats leading to a food shortage.

Moose numbers in the Bow Valley are low at present and may reflect a decline in habitat quality as succession in the Bow Valley proceeds once again to climax. In addition, highway and railway mortality are also responsible for limiting moose numbers in the Bow Valley. Holroyd and Van Tighem (1983) report that 56 moose were killed on highways and 43 animals died on railways in Banff National Park between 1945 and 1980.

Holroyd (1979) reported 12 moose were present between the East Gate and Castle Junction in January 1978, while Harrison et al. (1982) tallied nine animals between the East Gate and Sunshine Turnoff in January 1981. These nine animals may have represented a seasonally high immigrant population and Harrison et al. (1982) conclude that only three to four moose are resident year round between the East Gate and Sunshine Turnoff. Most of these animals are restricted to areas west of the Banff Traffic Circle. The entire park population was estimated at 100-125 animals in 1976-1977 (Jacobson 1977).

From 1964 to 1977, eight moose were killed on the TCH between the East Gate and the Banff Traffic Circle (Flygare 1978). In 1979, one moose was killed between the East Gate and the Sunshine Turnoff while two kills were reported in 1980 and one in 1981 (Harrison et al. 1982). Most animals were killed near riparian habitats, with the majority of mortality occurring in the Duthil area (PWC 1979).

Holroyd (1979) estimated that moose in the Bow Valley could sustain an annual mortality of 1.5 - 3.75 animals. An average of three animals/year were killed between the East Gate and Lake Louise from 1976-1978. Based on these figures road related mortality is equal to or exceeding the predicted annual surplus of moose populations in the Bow Valley (Harrison et al. 1982).

3.1.4.1 Evaluation of information

The reports of disease outbreaks in the mid 1800's and at the turn of the century are at best conjecture and are not substantiated. By the 1920's, moose likely did respond to increased habitat availability but there is little documentation on their abundance at this time. Moose numbers have only been reported since the initiation of aerial surveys in the late 1970's. At the present time, insufficient data is available to make statements regarding the distribution, productivity and population dynamics of moose populations in the Bow Valley. Numbers of this species do appear to be low in comparison to elk and mule deer.

3.1.5 Bighorn sheep

Bighorn sheep numbers declined substantially in the Rocky Mountains between 1860 and 1915 possibly as a result of overgrazing, excessive hunting pressure, range competition with livestock and several bad winters (Stelfox 1978). With the protection afforded by the boundaries of Banff National Park, numbers tripled by 1936 when the population was estimated at 2000 animals (Parks Canada 1981b). Numbers continued to increase in the Park into the 1940's but declined soon afterwards possibly due to an outbreak of pneumonia-lungworm disease coupled with competition with elk for winter range and a series of severe winters (Banfield 1958; Stelfox 1978; Parks Canada 1981a). By 1950, sheep numbers in the park stood at 350 and by 1966 had increased to 1300 (Stelfox 1978).

Jacobson (1977) estimated that 750 to 800 sheep were present in the park between 1975 and 1977. Sheep numbers in Alberta were estimated between 7100 and 7900 animals in 1974 (Wishart 1978).

Bighorn sheep currently do not use any of the area between the East Gate and the Banff Traffic Circle and no road mortality has been reported there (PWC 1979). Mortality however is high on the Phase II section, particularly between the Norquay Interchange and Five Mile Overpass (km 23.5). Ninety percent of the 107 bighorn sheep killed on park highways between 1964 and 1977 were recorded in this section (PWC 1981b). This area may be acting as a "dispersal sink", attracting animals to replace those killed on the Trans-Canada highway (PWC 1981b).

3.2 Other Wildlife Species

Additional species recorded as road kills on the TCH include the grizzly and black bears, cougar, coyote, red fox, mink and badger. Holroyd and Van Tighem (1983) quote warden estimates that 55 to 80 grizzly bears and 120 black bears were present in Banff Park in 1980. From 1945 to 1978, a minimum of 43 black bears were reported as road kills in Banff National Park. Three grizzly bears were killed on the Trans-Canada Highway between 1964 and 1977 (Flygare 1978). Seven grizzlies were reported as road kills between 1975 and 1977 (PWC 1981a). The significance of highway mortality on bear populations in Banff Park is unknown as numbers in the Park are not clearly understood.

The following species accounts are drawn from Holroyd and Van Tighem (1983). The cougar is considered to be very rare in Banff National Park at present and populations are likely maintained by dispersal from areas outside of the park boundaries. Since 1945, seven cougars have been reported killed on highways within the Park. Coyotes are abundant in Banff National Park and from 1964 to 1976, 15 road killed coyotes were reported. The red fox is very rare in both Banff and Jasper and five animals have been reported killed on Banff highways since 1964. Mink are locally common in alluvial wetland habitats of the Park and since 1964, five fatalities have been reported. Badgers were once more common in the Bow Valley than they are today and since 1959, only one animal, a road kill in 1975, has been recorded.

While the absolute mortality figures for these species may not seem significant when compared to the number of ungulate kills, the proportion of the population killed relative to their overall abundance may be a concern. This problem is perhaps further compounded in that kills of smaller animals may not be as readily reported as those of the larger and more visible road killed ungulates. With the exception of perhaps the coyote, highway mortality may be a significant factor limiting populations of these other wildlife species in the Bow Valley. More research is needed to establish whether this is truly the case.

3.3 Ungulate populations, Park policy and the TCH

The purpose of this section has been to provide a historical perspective on the abundance and distribution of ungulates in Banff National Park and to consider the accuracy of this data and present day information. From the reports of early explorers, it appears that moose, bighorn sheep and mule deer were the most numerous of the ungulates in historical times. These three species differed in their forage preferences and competed little for low elevation grassland and parkland winter ranges (Cowan 1950). Elk were present in the Park in the early 1800's but by mid-century reports indicate that the species had all but disappeared from the Rocky Mountains. Woodland caribou, wood bison and white-tailed deer were present in Banff Park in very low numbers (Holroyd and Van Tighem 1983). The wood bison apparently became extirpated from the Park by the middle of the 19th century and today are found only in the Buffalo Paddock area near the Banff townsite.

The arrival of the first Europeans in the 19th century had a significant effect on ungulate populations in the Rocky Mountains. Excessive hunting pressure in addition to the natural mortality factors of disease and severe winters appear to be responsible for a major decline in moose, deer and sheep numbers by the turn of the present century. Elk, never common to Banff Park, were reintroduced from Yellowstone National Park in the 1920's.

With the protection afforded by Banff National Park, certain species, notably elk, underwent rapid increases in numbers. Grazing pressure increased and with the instigation of fire control measures range conditions in the Park began to show signs of severe over exploitation by the 1940's. This resulted in the initiation of an elk reduction programme which likely contributed to subsequent increases in mule deer and bighorn sheep populations. Predator control programmes in the 1940's and 1950's may also have been responsible for increases in ungulate numbers.

The upgrading of the highway in 1956 and increased vehicular traffic over the last 25 years has resulted in significant road mortality of the Park's ungulate populations. In effect, highway and railway mortality could be removing a significant portion of the predicted annual surplus of ungulate populations.

It becomes apparent from the foregoing discussion that present day knowledge of historical trends in ungulate populations is at best sketchy and based to a large degree on anecdotal information. Recent aerial surveys have attempted to provide some information on the current status and distribution of ungulates in the Bow Valley, but since this data only represents a few years effort it is inadequate to make any substantive statements about trends in numbers.

The implementation of wildlife highway mitigation measures will significantly reduce and may in the long run completely eliminate mortality on the Trans-Canada highway. Ungulate mortality however will continue along the C.P.R. line through the Park, and may limit the numbers of some species, particularly moose.

The long term implications of decreased wildlife mortality on the Trans-Canada Highway on ungulate numbers and range conditions in the Bow Valley are difficult to predict on the basis of existing information. Increases in ungulate numbers may lead to the re-establishment of predator populations in the Bow Valley. Wolves are presently found in the Front Ranges, particularly the Clearwater, Panther, Red Deer and middle Cascade River watersheds (Holroyd and Van Tighem 1983). These animals are expanding their range to include the Bow Valley in response to an expanding prey base. At best, this statement is conjecture but such a possibility could arise in future.

Plans for scheduled and carefully controlled burning in the Bow Valley as outlined by Lopoukhine and Whyte (1983) could lead to an expansion of ungulate habitat. Such a burning programme is dependent upon the clear establishment of a vegetation plan approved through the

Natural Resources Management Process (Lopoukhine and Whyte 1983).

Section 3.2.3 of the current Park policy for National Parks states that:

> "natural resources within National Parks will be protected and managed with minimal interference to natural processes to ensure the perpetuation of naturally evolving land and water environments and their associated species" (Parks Canada 1979).

However manipulation of naturally occurring processes may take place if the following occurs (Parks Canada 1979):

1. natural processes have been altered by man and manipulation is required to restore the natural balance;
2. a major natural control is absent from the Park (eg. predation);
3. the population can not be maintained by natural forces.

The long term effects of highway construction on ungulate populations in the Bow Valley are unknown. In order to assess the impacts of highway development and to determine the effectiveness of mitigation, a clear understanding of ungulate population dynamics is needed.

CHAPTER 4: ENVIRONMENTAL MONITORING, IMPACT ASSESSMENT AND THE TRANS-CANADA HIGHWAY

4.1 Introduction

The purpose of this chapter is to consider a framework around which a programme of wildlife monitoring along the Trans-Canada Highway can be developed. The chapter will begin with a review of the concept of environmental monitoring and then examine its role in the environmental impact assessment process. This approach will then be applied to the wildlife monitoring programme along the first 13 km of the Trans-Canada Highway. Objectives of the monitoring programme will be outlined and these will help focus the data requirements and techniques needed to assess the effectiveness of mitigative measures in place in Phase I. Criteria for evaluating the suitability of these techniques in adequately fulfilling the objectives of the wildlife monitoring programme will be developed.

4.2 Approaches to Environmental Monitoring

The development of environmental monitoring stemmed from a mounting concern over the global impact of man's activities in the environment during the 1960's. This concern arose from the perception of the possibility that certain life sustaining biosphere processes were being altered, as evidenced by carbon dioxide buildup and indications of ozone depletion in the upper atmosphere. In addition, there was growing evidence concerning the deleterious effects of industrial pollutants, such as mercury and DDT, on human health.

In 1972, at the request of the Preparatory Committee for the United Nations Conference on the Human Environment in Stockholm, the Scientific Committee on Problems in the Environment (SCOPE) of the International Council of Scientific Unions recommended the establishment of a Global Environmental Monitoring System (GEMS) (Martin and Sella 1977). The initial purpose of GEMS was to monitor global levels of pollutants but the programme later shifted its focus to include monitoring of the state of global natural resources. GEMS was conceived as a coordinated effort of member states of the United Nations and the United Nations Environmental Programme (UNEP) to gather data in order to make effective environmental management decisions on a global scale. In addition to this programme, smaller scale monitoring of ecosystems was launched as part of the Man and the Biosphere Programme (MAB) under the auspices of the United Nations Educational Scientific and Cultural Organization (UNESCO). A number of biosphere reserves were established under this programme to study ecological relationships in areas virtually unaffected by human activity and to use these sites as benchmarks to compare with other areas (Johnson and Bratton 1978).

The development of the National Environmental Policy Act (NEPA) in 1969 in the United States and the Federal Environment Assessment and Review Process in 1973 in Canada saw the beginnings of environmental assessment as a means of reducing the impacts of human activity. Similar developments have followed in at least 13 other developed countries including Australia, New Zealand, Sweden, Japan and several members of the European Economic Community (OECD 1979). The environmental assessment process required a system of impact prediction and impact monitoring in order to facilitate and justify both political and economic decisions regarding the outcome of proposed developments.

4.2.1 Definition of terms

Environmental monitoring had its beginnings as a descriptive activity aimed at ensuring integrity of ecosystem functions on a global and regional scale. With the development of environmental regulation and legislative authority in the United States, monitoring also became a means of enforcing regulatory standards and determining the success of mitigative efforts. However, the term monitoring is still used as a "catch-all" phrase and some further clarification of the various uses of the word is needed.

Two general types of monitoring activities have been described. Descriptive monitoring involves the collection of data on specific environmental parameters and how these may be affected by human activity. Descriptive monitoring is further subdivided into source monitoring, ambient monitoring and effects monitoring. Source monitoring describes the nature and quality of a pollutant prior to its distribution into the environment. Ambient monitoring refers to the nature and quality of a pollutant once it is dispersed into the environment. Effects monitoring describes the consequences of a pollutant's activity on humans, plants, animals and materials (National Academy of Sciences 1977; Lang and Armour 1980; Harvey 1981; Ausmus 1982).

Regulatory monitoring is used in connection with environmental regulation and has two functions. Firstly, it ensures that environmental standards are being met and secondly, it serves to investigate whether the aims of environmental policies are being achieved (Harvey

1982). Regulatory monitoring is either of a self-assessment nature, undertaken by the proponent, or of an enforcement nature, undertaken by government agencies. In this regulatory context, Bankes and Thompson (1982) define monitoring as the systematic collection of data comprising key indicators of the social, environmental and economic impacts of a project. The purpose of monitoring is twofold, ensuring effective environmental regulation and predicting the impacts of future related projects. Further discussion of environmental monitoring in this chapter will centre on monitoring as a regulatory activity in the environmental assessment process.

Before proceeding, it is necessary to distinguish between the terms environmental monitoring, environmental surveillance and environmental inspection, because these terms are often used interchangeably and can lead to confusion.

Monitoring is a quantitative, repetitive, long term, data oriented activity ideally beginning in the pre-construction phase and extending through to project abandonment (Aird 1982). In contrast, surveillance is a qualitative, visual, point in time assessment occurring in the construction phase aimed primarily at compliance to regulatory standards (Aird 1982). Environmental inspection is undertaken by the proponent of a development to ensure that the construction contractor is complying with the terms of the contract (Mitchell 1982). Using the definition of Harvey (1982), surveillance and environmental inspection are actually types of regulatory monitoring activities. They differ from monitoring in that they only occur at a particular point in time, in this case the construction phase.

4.2.2 Monitoring and the environmental impact assessment process

Since the introduction of the Federal Environmental Assessment and Review Process in 1973 and its subsequent amendment in 1977, environmental impact assessment (EIA) in Canada has undergone substantive change. Once initially considered as an administrative procedure for environmental protection, EIA grew into more of an environmental and socio-economic planning exercise with a narrow geographical focus centring around analysis of the proposed development. Recent impact assessments such as the Beaufort Sea Hydrocarbon Development Project have demonstrated an even broader scope and the ideal of EIA is now developing as a comprehensive regional planning exercise (Beanlands and Duinker, 1983).

As EIA has broadened in its scope, the focus of the process itself has moved through the following four phases (Thompson 1982):

1. baseline inventory
2. impact prediction
3. mitigation and management
4. monitoring and evaluation

Examination of early environmental impact assessments shows that the majority were large, multi-volumed documents with most effort directed towards determining baseline conditions in the environment (Syncrude Canada Limited 1978, Esso Resources Canada Limited 1978, Alsands Project Group 1978). Impact prediction was largely a subjective exercise involving a consideration of the effects of the proposed project on the ambient environment.

Over the last decade, ecological research has demonstrated that ecosystems are dynamic rather than static in their nature and these principles have been applied to environmental management by Holling (1978) in his book Adaptive Environmental Management and Assessment. This approach is based on the realization that everything cannot be measured at a single point in time and that these uncertainties in our understanding of the environment can only be resolved on an ongoing experimental basis.

In their recent report "An Ecological Framework for Impact Assessment in Canada", Beanlands and Duinker (1983) extend this idea to conclude that EIA should not be thought of as a step by step progression but rather as an interdependent process with the recognition of environmental monitoring as an integral component of the overall assessment process. Development projects should be considered in an experimental context in which operational phase monitoring should be conducted to test hypotheses generated in the baseline phase. Recent EIS (environmental impact statement) guidelines for the Beaufort Sea Hydrocarbon Development show a movement towards incorporating experimental monitoring early in the impact assessment process. These guidelines stipulate that the proponent develop a monitoring plan as part of the EIS, prior to project approval (Rigby 1982).

Figure 4.1 illustrates the trend towards the comprehensive inclusion of environmental monitoring into the environmental assessment process. Case 1 depicts the situation in which EIA proceeds in a step by step "ad hoc" fashion with environmental monitoring often tacked onto the end of the process as an afterthought. Monitoring is aimed more at

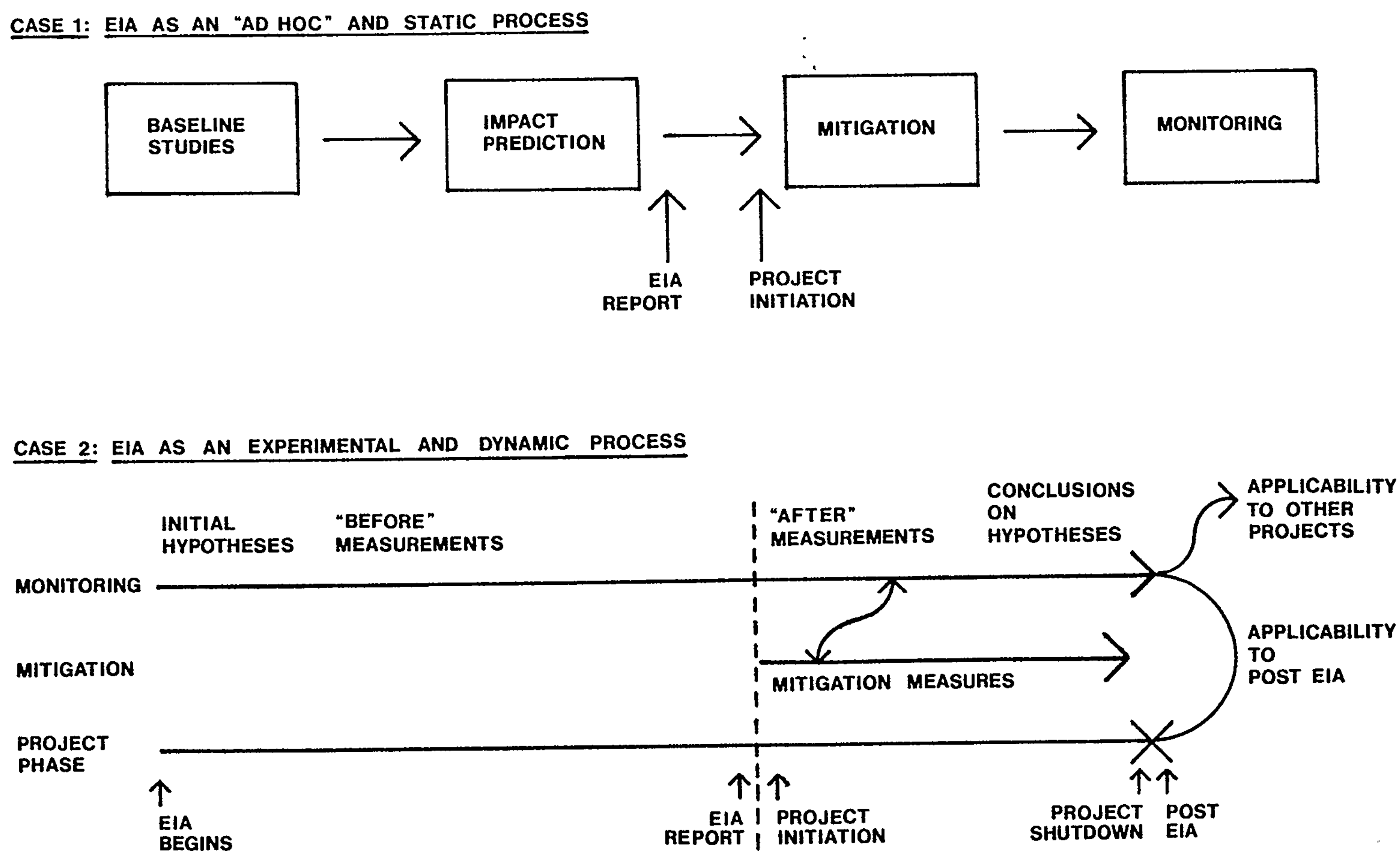


FIGURE 4.1 ENVIRONMENTAL MONITORING AND THE EIA PROCESS

Adapted from BEANLANDS and DUINKER, 1983 determining the short term success of mitigative actions rather than examining the long term impacts of project development.

Case 2 is an example of EIA as an ongoing experimental process with the purpose of environmental monitoring geared towards understanding the differences in established environmental parameters before and after development. The baseline inventory programme proceeds as part of the initial phase of the monitoring programme and gives an indication of "before" conditions prior to project commencement. The "after" measurements when compared to the "before" measurements can give an indication of the extent and magnitude of project impacts. The utility of an environmental monitoring programme depends to a large degree on the adequacy of baseline data against which changes in environmental parameters can be measured (Aird 1982).

A key component of the environmental monitoring programme then is the establishment of a statistically adequate description of baseline conditions against which substantive changes resulting from project development can be measured. Environmental monitoring constitutes a basic learning process where the project is effectively an experiment to measure resultant changes in the environment through time.

Monitoring provides a means of validating predictions of short and long term environmental impacts. Hypotheses regarding possible project impacts can then be tested. Long term environmental monitoring may also provide data on higher order, secondary and tertiary impacts which may not be immediately obvious (Rosenberg et al. 1981). Monitoring will also allow for the detection of unexpected and perhaps major impacts which were not predicted in the impact assessment phase.

In addition to testing hypotheses on project impacts, measurements of environmental conditions during project development and operational phases are essential to assess the effectiveness of mitigative measures. Continued monitoring of established environmental parameters throughout the various phases of the project to abandonment can indicate how successful mitigative efforts are in producing an acceptable level of impact. If monitoring indicates otherwise, then steps can be taken to correct the problem, thereby ensuring conformity to regulatory standards. This "feedback loop" between monitoring and mitigation is an important component of the environmental impact assessment process (Figure 4.1).

Another important aspect of environmental monitoring is the application of results and lessons learned from the experience towards impact prediction of similar projects in other areas. This will result in a greater ability to make more accurate impact predictions and implement more effective mitigation measures in future projects. In addition, the need for extensive baseline studies and production of voluminous environmental impact statements can be avoided.

While both of these cases in Figure 4.1 represent opposite ends of the spectrum of approaches towards environmental monitoring and although the latter idealized situation may never be realized, indications are that current thinking by government agencies and practising environmental professionals is moving in that direction. Murray (1982) reviewed a number of FEARO reports and concluded that there was an implicit acceptance of monitoring in the Federal Environmental Assessment and Review Process. The need for monitoring was endorsed by the Environmental

Assessment Panels for the Shakwak Highway in the Yukon, exploratory drilling in the Davis Strait, twinning of the Trans-Canada Highway in Banff National Park and for twinning of the CP railway line in Glacier National Park (FEARO 1978a, 1978b, 1979, 1982 and 1983).

In a recent symposium on environmental monitoring presented by the Alberta Society of Professional Biologists, McCart (1982) pointed out that at the present time EIA is a pseudo-science in which hypotheses on project impacts are generated but never actually tested. Detailed environmental monitoring programmes would be able to test these hypotheses and would greatly improve the accuracy of impact predictions of similar future projects. Through the monitoring of representative projects a body of knowledge could be established on the range of specific project impacts and mitigative options.

This section has discussed a number of functions that environmental monitoring serves in the impact assessment process. An environmental monitoring programme can be very cost effective as important elements of the environment can be priorized and the extent of changes over time resulting from project development can be assessed. To summarize, the benefits of monitoring are as follows:

1. it will provide an opportunity to assess the accuracy of initial impact prediction;
2. it will ensure compliance with regulatory standards;
3. it will measure the success of mitigative actions;
4. it will enable the detection of unexpected impacts;
5. it will allow for feedback and readjustment of project mitigation efforts;
6. it will provide an opportunity to predict the impact of similar future projects (Bankes and Thompson 1982).

4.2.3 Level of effort and understanding

The two questions that often arise at the initiation of an environmental monitoring programme are what should be monitored and how should monitoring be done? To begin, a monitoring programme should focus on key indicators that have either an environmental, social or economic importance (Bankes and Thompson 1980). While this may reduce the ability to measure the extent of change to the overall system, it does ensure that mitigation is directed towards the important parameters identified in the assessment phase.

The problem of how to monitor depends upon the level of information needed to assess the success of mitigation efforts and the amount of funds and manpower available. In a recent study of monitoring the impacts of surface mining in the western United States, three levels of monitoring effort were discussed (U.S. Fish and Wildlife Service 1977). A low level study addresses those parameters that relate only to the most significant environmental effects and is aimed at compliance to established environmental regulations. A medium level study is the best practical approach to monitoring within the constraints of time, cost and manpower. The difference between low and medium levels of effort relates to the level of parameters under study and the sampling intensity. A high level study represents the "best available" technology and produces a higher level of understanding through more intensive data collection. Factors against a high level study include complexity of equipment, equipment costs and skilled manpower requirements. However, a high level of analysis may allow for earlier detection of changes in study parameters and may delineate causal factors of project impacts not indicated by lower levels of analysis.

4.3 Environmental Monitoring and the Trans-Canada Highway

4.3.1 Rationale for monitoring

The report of the Environmental Assessment Review Panel for Phase I of the Banff Highway Project recommended that Parks Canada evaluate the effectiveness of measures to mitigate vehicle animal kills for possible use of similar techniques elsewhere in Canada (FEARO 1979). The Panel also recommended that a committee be established to ensure that highway design and construction practices meet the high environmental and aesthetic standards consistent with the demands of a National Park. Furthermore, the Panel recommended that PWC should provide an Environmental Coordinator to oversee construction practices and be responsible for submitting regular reports to PWC and the Environmental Subcommittee.

The report of the Phase II Environmental Assessment Panel endorsed the continuation of the highway committee and Environmental Coordinator throughout construction to km 23. Monitoring results from Phase I were to be incorporated into Phase II and a formal evaluation of the success of mitigation measures was to be conducted by Parks Canada and made available to the public. The Panel in the Phase II report stated that the overall responsibility for monitoring and evaluation rested with Parks Canada, but that Public Works Canada was responsible for the redesign and costs of any changes to mitigation measures as deemed necessary from the results of monitoring (FEARO 1982).

Construction of Phase II fencing and underpass structures is scheduled for initiation in late 1984 with an expected completion date by late 1986 (PWC 1981a). The results of the Phase I monitoring programme will be of little use however in planning the type of structures to be constructed. The Phase II Environmental Assessment Panel recognized that insufficient information would be available from monitoring results of the experimental culvert structure at Morrison's Coulee (km 4.0) for inclusion of such a structure in Phase II (FEARO 1982).

The level of monitoring to be undertaken by Parks Canada was not outlined in detail by the Environmental Assessment Panel. The objectives of the monitoring programme were not established nor were means suggested as to how the effectiveness of mitigative measures were to be determined. Future environmental assessments should specify the scope and extent of the environmental monitoring programme prior to project approval.

4.3.2 Objectives of the wildlife monitoring programme

The setting of clear objectives is important in order that environmental monitoring be perceived not as an end in itself but as an essential step in the environmental impact assessment process (Harvey 1981).

With regard to the Trans-Canada Highway, objectives of the wildlife monitoring programme can be broken down into short term and long term components. Short term objectives are aimed at determining the initial effectiveness of mitigation structures in allowing passage of animals. Long term objectives of monitoring are aimed at determining the lasting impacts of highway construction on ungulate populations and range conditions in the Bow River Valley.

4.3.2.1 Short term objectives

Short term objectives in this document were established on the basis of information needs necessary to judge the effectiveness of mitigative measures in Phase I and to make design modifications where deemed necessary. The results from Phase I monitoring are also applicable to the monitoring of and design modification to structures in Phase II. The short term objectives focus on an individual approach rather than at the population or species level.

It is felt that a limited number of animals will use the underpass structures initially and it may be more important to ascertain individual use by age and sex rather than a gross understanding of the degree of species use. Specific short term objectives of the monitoring programme should:

1. determine whether the wildlife defence measures are effective in reducing ungulate mortality on the Trans-Canada Highway;
2. determine the immediate use of underpass structures by ungulates in the Bow Valley;
3. determine the relative use of each type of underpass;
4. determine the response of individual animals to underpasses and fencing, one-way gates and texas gates.

4.3.2.2 Long term objectives

Long term objectives focus at the population level and are geared towards determining significant lasting effects of the imposition of mitigative measures on the TCH. Long term objectives of the monitoring programme should:

1. determine the responses of ungulate populations to decreased mortality resulting from highway mitigation measures;

2. examine possible changes in animal movement patterns between traditional ranges;

3. examine changes in habitat utilization and range condition resulting from changing animal use.

4. outline a programme of research for possible future twinning of the Trans-Canada Highway to the western Park boundary.

4.3.3 Level of analysis

The choice of the scope and extent of the wildlife monitoring programme ultimately depends on the type of results that are needed to determine the effectiveness of mitigative measures. The types of question asked, or the level of understanding, dictates the level of effort undertaken in the monitoring programme.

The differences between a high and low level of effort involved in the monitoring programme are shown in Table 4.1. A high level of effort involves a quantitative, intensive approach compared to a qualitative, low key approach of a low level of effort. In some situations, a low level monitoring can provide an indication of the effectiveness of mitigative measures. In other cases, a high level of analysis may be required to provide answers to a more complicated problem. The difference between the two approaches then are the types of questions that are asked and the level of detail required to provide adequate answers. A monitoring programme should be comprehensive in its nature, encompassing both high and low level monitoring efforts.

Table 4.1. A comparison between high and low level of effort in the wildlife monitoring programme on the TCH

Low Level	High Level
concentrates on population use	concentrates on the use by individual animals
qualitative approach	quantitative approach
limited manpower needs	manpower needs may be intensive
equipment minimal	equipment needs may be complex
limited comparative use for Phase II	results applicable to Phase II
frequency of monitoring periodic	frequency of monitoring continuous

4.3.4 Criteria for evaluation

Section 4.3.1. of this document outlined the rationale for monitoring of wildlife measures on the TCH as recommended by the Phase I Environmental Assessment Panel (FEARO 1979). Section 4.3.2 outlined the short term and long term objectives of the wildlife monitoring programme. This section builds on these recommendations and presents four criteria upon which a decision regarding the choice of monitoring techniques can be made.

4.3.4.1 Effectiveness

The Environmental Assessment Panel recommended that Parks Canada evaluate the effectiveness of wildlife mitigation measures so that these techniques can be applied to similar highway projects elsewhere in Canada. Effectiveness incorporates two aspects. Firstly, it refers to how successful the mitigative measures are in reducing the current level of ungulate mortality on the Trans-Canada Highway. This would include a consideration of whether highway mortality is increasing or decreasing as a result of highway development. Continued monitoring of animal mortality on the highway as presently undertaken by the Banff Park Warden Service is the best way of determining the success of mitigative measures in reducing ungulate mortality on the TCH. Effectiveness can be measured in these terms as the percent reduction in mortality over previous years as a result of the placement of fencing and underpasses along the highway.

More importantly perhaps, effectiveness refers to how useful the mitigative structures are in facilitating animal movement across the TCH. This particular definition of effectiveness is what the bulk of this document is concerned with. Monitoring should provide information on how these structures are being used by ungulates and whether certain design aspects need to be altered. Ungulate use should be considered both as how often animals cross through the underpass structures and as how animals respond behaviourally to the structure itself. Indications of avoidance behaviour may necessitate modification of the structure design or some aspect of the surrounding terrain.

4.3.4.2 Age and sex differences

With the exception of white-tailed deer, more ungulate females are killed on the Trans-Canada Highway than are males. Female mortality was 1.5 to two times as frequent in moose (61.8 per cent of total mortality) and mule deer (60.5 per cent of total mortality) and over three times as frequent for elk (75.3 per cent of total mortality) (Flygare 1979).

There are major differences too in the ages of ungulates killed on the TCH. Of the 67 road killed mule deer of known ages between 1964 and 1977, nearly half (47.8 per cent) were in the two to four year old class and 20.9 per cent were in the four to six year old class. Similarly, of the 78 elk of known ages killed on the TCH in the same period, 38.5 per cent were in the two to four year old class and 25.6 per cent were calves (Flygare 1979).

Whether these age and sex differences in road mortality are due to the larger number of females and certain age classes in the vicinity of the highway, a greater susceptibility of these groups to road mortality or a combination of both factors, is not clearly understood.

In monitoring wildlife use of underpass structures, it may be useful to determine the age class and sex of animals passing through the underpass structure. In addition to providing information on the age and sex of animals adjacent to the highway, it may provide data on whether specific sex and age classes are encountering difficulties in using the underpass structures.

4.3.4.3 Multi-species use

Twinning of the highway through Banff National Park differs from other similar projects in the United States in that a number of ungulate and other wildlife species are involved. Four species of ungulates occur in Phase I and five in Phase II compared to the one or two species (mule deer and elk) which were studied in the United States. In addition to the ungulates, carnivores such as the grizzly bear, black bear and cougar are also expected to make use of the underpasses and valuable information as to their numbers and behaviour could also be gained. Due to this unique situation, monitoring techniques should provide information on the level of use of mitigative structures by the variety of wildlife species present in the highway corridor.

Predator-prey interactions at underpass locations should be investigated as a possible deterrent towards ungulate use. In addition, interspecific interactions between ungulates and other wildlife species should be studied as they may have an effect on animal use of underpass structures.

4.3.4.4 Behaviour and design of mitigative structures

Highway development in Banff National Park is also unique in that the wildlife mitigative measures are specifically designed with consideration for ungulate security requirements. This differs from the situation described by Reed et al. (1975) in Colorado. Two types of underpass structures have been developed for the TCH Twinning Project. These include the open span bridge and 4.27 m culvert structures. As mentioned in Section 2.3, these two structures differ substantially in cost and although none of the experimental culvert structures are to be employed in Phase II of the project, they may be deployed in similar projects elsewhere in Canada. Monitoring techniques should therefore be able to determine differences in animal use between the two types of structures.

However, since the Morrison's Coulee experimental culvert is placed in an area of relatively low ungulate use prior to installation, simple comparisons of the frequency of use between the two underpass types would not be valid. A more useful comparison could be determined through behavioural observations of ungulates as they approach each underpass type. If it can be demonstrated that there are no apparent differences in behavioral responses of animals between the two underpass types, then widespread use of the more inexpensive culvert structure can be justified.

Twinning through Banff National Park is also unique as the Park's ungulate populations are for the most part unhunted and resident in the area year round. Studies in the United States involved hunted mule deer that migrated through the area only in the spring and fall months (Reed et al. 1975; Ward et al. 1980). Schultz and Bailey (1978) found that unhunted elk in Rocky Mountain National Park showed little reaction to normal human associated activity along roads. Animals in Banff National Park may show a much higher use of underpass structures than hunted ungulate populations which occur in other highway projects outside of a National Park context. Monitoring in Phase I should determine how quickly animals adapt to these structures and the changes in the reactions of ungulates over time. The response of animals to underpasses and fencing in Banff National Park may serve as a benchmark reference of the response of largely unhunted and undisturbed animals.

Animals in Banff Park will likely be making use of the underpass structures throughout the year compared to the twice yearly situation in Colorado and Wyoming. Monitoring techniques should also show whether there are any differences in the reaction of ungulates to underpasses on a seasonal basis.

In summary, it is important that monitoring techniques be available to provide data on the behavioural responses of animals to underpasses, fencing, one-way gates and texas gates. The use of behavioural observations such as avoidance reactions are one means of indicating the need for possible design modifications.

4.3.5 Chapter summary

This chapter began with a review of the current thinking with regard to environmental monitoring. Monitoring originated as an activity geared towards understanding and measuring the effects of man's activities in the environment and developed into a means of environmental regulation as the environmental impact assessment process matured.

A case was made for implementing environmental monitoring programmes on an experimental basis in order to test impact predictions based on the results of monitoring. The purpose of this activity is to gain a body of information on the array of possible impacts of representative projects and apply this data base to similar but undeveloped projects. This would greatly aid in streamlining the environmental assessment process and reduce the proliferation of redundant and voluminous environmental impact statements.

Another major function of environmental monitoring was as a regulatory activity aimed at determining the effectiveness of mitigative efforts. Monitoring will not only allow for compliance with established regulatory standards but will also serve to indicate the success of mitigation efforts.

Wildlife monitoring on the Trans-Canada Highway is primarily aimed at determining the effectiveness of mitigation measures rather than as an experimental study of the effects of highway development. Success is measured in terms of reducing the current level of ungulate mortality and allowing unimpaired movements of animals from one side of the highway to the other. This should include an understanding of the behavioural responses of a number of animal species to underpass crossing structures and how this changes over time.

CHAPTER 5: WILDLIFE MONITORING TECHNIQUES AND THEIR APPLICATION TO THE TRANS-CANADA HIGHWAY

This chapter will evaluate a number of wildlife monitoring techniques as a means of determining the effectiveness of wildlife mitigation measures on the Trans-Canada Highway. Based on a review of these techniques, suggestions will be put forward as to the design of monitoring procedures for underpasses, fences, texas gates and one-way gates. deployed in Phase I. Detailed recommendations pertaining to monitoring of wildlife underpasses are presented in Chapter 6.

The assessment of wildlife presence and use of a particular geographical area or habitat can employ either a direct or an indirect approach (Sanderson 1965). Direct measurements involve actual sightings of the animal under study and are often manpower intensive and costly. Indirect measurements rely on the assessment of animal sign or some measurement of their presence and do not require the active visual participation of the observer. Various indices have been developed to convert the frequency of animal sign into a measurement of relative animal densities.

The following sections will discuss a number of direct and indirect techniques available to monitor wildlife defence structures on the Trans-Canada Highway. A summary of the advantages, disadvantages and potential uses of each technique is also presented in Appendix 5.

5.1 Direct Surveillance Methods

5.1.1 Aerial survey techniques

The advent of aerial survey techniques has allowed wildlife biologists to census wildlife populations over large and previously inaccessible areas. Although subject to sources of error, aerial surveys are most accurate when large groups of animals are to be censused in relatively open terrain and the technique loses its usefulness when the densities of solitary animals in dense vegetation are to be determined.

Aerial surveys of ungulates can be employed to obtain a total count or invoke a variety of sampling procedures using transects or quadrats to gain an estimate of the total population. The size of the study area is the major factor limiting the choice of total counts as a census technique.

Although aerial surveys can provide an indication of animal numbers over large geographical areas, they are subject to a number of visibility related biases such as aircraft speed, altitude and transect width (Caughley 1974). Weather conditions, habitat type, terrain, time-of-day and observer skill can also affect the accuracy of counts (Le Resche and Rausch 1974). These factors must be taken into consideration so that replicate counts will provide an accurate indication of trends in animal numbers and distributional patterns. Correction factors have been developed to overcome some of these visibility biases. LeResche and Rausch (1974) reported that experienced observers only counted 68 per cent of the total moose present under ideal survey conditions in Alaska. Stelfox and McGillis (1977) state that only 25 to 50 per cent of deer and 50 to 75 per cent of elk are sighted in winter aerial surveys. Gilbert and Grieb (1957) concluded that aerial counts of mule deer ranged in accuracy from 34 to 49 per cent of the total known animals present. Multiplication factors can be applied to census results to gain a more accurate indication of the number of animals present in the surveyed area. Aerial photography is also useful to check the accuracy of counts when large groups of animals are involved (Norton-Griffiths 1974).

Because of the inaccuracies involved in aerial surveys, the importance of placing confidence intervals on the survey data can not be overemphasized. In addition, techniques should be refined so that the survey results have a precision within 20 per cent of the mean at the 95 per cent confidence interval (Stelfox and McGillis 1977). A description of suggested techniques to reduce bias in aerial surveys in order to improve accuracy of counts is presented in Appendix 6.

Quadrat sampling procedures have been used to survey moose in Alaska and were noted to be twice and four times as effective as total counts and strip transects respectively (Evans et al. 1966). Siniff and Skoog (1964) employed quadrat sampling to survey caribou in Alaska and found it particularly adaptable to mountainous terrain, where transect sampling might be difficult. A disadvantage of quadrat sampling involves the significant amount of transport time between quadrats, particularly if large sample areas are involved. Transect sampling is both more efficient and economical compared to quadrat sampling when counts are to be corrected for visibility bias or when density trends are required (Caughley 1977). Such would be the case in a monitoring programme where year to year trends are required to assess changes in animal population numbers. Observer and pilot fatigue are considerably less on straight line transects than the repeated circling and backtracking involved in quadrats (Stelfox and McGillis 1977).

Harrison et al. (1982) employed a strip transect approach using a Bell 206 helicopter to conduct aerial surveys of the Bow Valley during the winter of 1980-1981. Three observers were utilized, altitudes were maintained between 150 and 175 m AGL and all sightings were initially recorded onto 1:50 000 topographical maps. Where possible animals were identified to age and sex class. Further aerial surveys to monitor ungulate distribution in the Bow Valley should utilize a similar strip transect approach so that comparable data can be obtained.

5.1.1.1 Evaluation of aerial surveys

The advantages and disadvantages of aerial surveys as a monitoring technique on the TCH are shown in Table 5.1. Aerial surveys are time efficient and large geographical areas can be covered during the same day. The primary use of this technique should be for determining numbers and distribution of ungulates during the winter months in the Bow Valley. This technique would be very cost-effective to determine trends in use of winter range within the Park. Aerial surveys should be flown on predetermined flight paths using standardized census methods. The use of confidence intervals is important in order that the results of subsequent surveys are comparable. Aerial surveys are also subject to a large degree of visibility bias, particularly with regard to the census of mule deer compared to more highly visible species such as elk and moose. In addition, accurate determination of age and sex is difficult from the air. Another drawback of aerial surveys is their significant cost ($550/hr for helicopter and $200+/hr for fixed-wing aircraft).

Table 5.1. Advantages and disadvantages of aerial surveys

Advantages	Disadvantages
-quick and easy to perform	- costly (helicopter-$550/hr)
-gives information on overall distribution and position	- subject to observer visibility bias
-large areas can be covered within one day	- no indication on the frequency of animal crossings through underpasses
	- limited behavioural observations
	- limited age and sex determination

Aerial surveys could be useful in determining animal responses to fencing, but this would be dependent on suitable snow conditions and good visibility from the air in the the vicinity of the fence line. Although tracks could be mapped from the air, a more suitable application would be as an aid in focussing the extent of follow-up operations on the ground. As a technique for monitoring animal use of underpasses, aerial surveys are not recommended. Limited behavioural data on the responses of ungulates to underpass structures is possible with this technique. In addition, aerial surveys could not provide useful information on how often animals pass through underpass locations.

5.1.2 Roadside surveys

Roadside surveys were undertaken at weekly intervals in Banff National Park to census ungulate use in areas adjacent to the Trans-Canada Highway in January and February 1980 (Harrison et al. 1980). Information on animal activity was gathered by driving the roadside shoulder and recording the presence of animal sign (bedding sites, feeding craters and tracks). The program was discontinued after February 1980 due to poor snow conditions. In addition to these weekly counts, roadside censuses were taken at three week intervals before sunrise and after sunset to record ungulate activity and presence along the highway.

5.1.2.1 Evaluation of roadside surveys

The major advantage of roadside surveys is that they are inexpensive in comparison to other techniques such as aerial surveys. Some limited behavioural observations of animals would be possible and accurate age and sex ratios of observed animals at underpass locations could be obtained. Some observations on animal responses to fencing would also be possible with this technique.

The major disadvantage of roadside surveys is that the utility of the technique is limited to times of adequate snow cover. Roadside surveys do not provide a continual record of animal use and responses to fences, one-way gates and underpasses. Duplicate sightings of animals are also a potential problem. In addition, the presence of a slow moving vehicle along the edge of the highway may distract animals in the immediate vicinity of fences and underpasses thereby affecting behavioural observations.

5.2 Indirect Surveillance Methods

5.2.1 Track counts

Track counts are a useful and time-tested means of determining animal presence and gaining an indication of animal use. Most research on track counts has been conducted in the USSR, Scandinavia, Canada and the USA, countries in which snow conditions permit ready tracking. Biologists in the Soviet Union have developed formulae for converting the number of tracks counted into animal densities (Formosov 1932; in Rivard 1982). Western biologists have preferred to use the results of track counts as an index of relative abundance rather than an actual estimation of numbers (Overton 1971).

Table 5.2. Advantages and disadvantages of roadside surveys

Advantages	Disadvantages
-relatively inexpensive to perform	- presence of observer may bias observations
-some limited behavioural observations possible	- limited to periods of adequate snow cover
	- does not indicate frequency of animal use through underpass structures
-accurate age and sex ratio of observed animals is possible	- duplicate sightings a problem

In a well documented evaluation of track count techniques for monitoring wildlife populations in Canadian National Parks, Rivard (1982) states that track counts are influenced by observer and sampling bias as well as exogenous and endogenous influences on animal activity. He concludes that track counts provide more useful information on animal activity and distribution than they do estimates of relative or absolute abundance.

A number of researchers have employed track counts to gain an indication of animal distribution and behaviour in relation to roads. Ward et al. (1976) tallied the number of ungulate crossings along gravel forestry roads by counting tracks along the roadside edge. Michael (1976) conducted track counts on 1.6 km transects perpendicular to Appalachian Highway 48 in West Virginia.

In Banff National Park, Harrison et al. (1980) counted ungulate tracks on three transects parallel to Phase I of the TCH. Track counts were conducted on strip transects and the data was standardized to the number of tracks per km-day from the following formula:

$$\text{Number of tracks/(km-day)} = \frac{\text{number of tracks}}{\text{length of transect} \times \text{days since last snowfall}}$$

Counts were discontinued after February due to poor snow conditions in the Bow Valley (Harrison et al. 1982).

It should be noted that the foregoing discussion has focussed on the use of track counts as a technique to arrive at an index of animal use within a particular habitat type (tracks/km-day). Track counts can also be used to determine the number of animal approaches and crossings at an underpass location. This data provides an index of animal use (tracks/day) at a particular underpass site. At the present time (January 1984), the Banff Park Warden Service is counting tracks in sand traps placed at the entrances of underpasses at the East Gate and Morrison's Coulee. Mule deer, black bear and coyote tracks have been noted at the East Gate and elk use has been recorded at Morrison's Coulee (P. Jacobson pers. comm. 1983).

5.2.1.1 Evaluation of track counts

The advantages and disadvantages of track counts as a monitoring tool for underpasses in Phase I are shown in Table 5.3. Track counts are inexpensive both in terms of manpower and equipment costs. If carefully conducted, this technique could provide useful information on animal use and responses to fencing, one-way gates, texas gates and underpasses along the Trans-Canada Highway. Track beds could be established at the entrances and exits of underpasses and one-way gates. The number of tracks present could be counted over a specific time period (three to four days) to determine relative animal use. Some behavioural information could also be gained from examination of track counts. Tracks could be followed back from the underpass structure to see if animals approached the structure directly or exhibited some type of avoidance behaviour. The number of direct approaches could be com-

Table 5.3. Advantages and disadvantages of track count techniques

Advantages	Disadvantages
-technique is simple to perform	- requires suitable tracking medium (snow or sand)
-equipment and costs minimal in comparison to other techniques	- large sample sizes required to generate adequate confidence intervals may be restricted by budget and manpower constraints
-little disturbance to wildlife or their habitat	- cannot recognize individuals
-good estimation of animal use over time	- difficulties under conditions of heavy animal use
-could get some indication of approach and avoidance behaviour	- gives index figure, not density estimate
	- cannot determine age and sex

pared to the number of approaches involving avoidance. Track beds would require raking every three to four days and snow counts could replace sand counts in the winter. Track counts could also be used to gain an indication of animal responses to fencing. The number of approaches to a particular stretch of fence and the reactions of animals as they encounter the fenceline could be documented.

The major disadvantage of track counts is that they provide an index of use and not an actual indication of animal abundance. In most cases, examination of track counts would not indicate the actual number of animals encountering fencing and underpasses. This is considered a major drawback when compared to other techniques such as photocell counters and photography which provide numerical data on animal use. Track counts would not be a useful technique for determining the behavioural responses of individual animals to underpasses. One of the major disadvantages of track counts is that individual animals cannot be recognized, some species cannot be distinguished (eg. mule and white-tailed deer) and the age and sex of animals using the underpass structure cannot be determined. The technique is most useful under conditions of light animal use and problems could be encountered if large numbers of animals pass through the structures. This could make it difficult to accurately determine the number of animals using the underpass or one-way gate structure.

Track count transects could be established back from an underpass location (eg. one km) in order to determine patterns of animal use in relation to the location of underpass structures. Many of the disadvantages of track counts at underpasses discussed previously also apply to track count transects. Another major limitation of winter track transects is the requirement for suitable snow conditions. The ideal time for track counts is about three to four days after a fresh snowfall. Problems have been encountered with poor snow conditions forcing cancellation of previous winter track count surveys in the Bow Valley (Harrison et al. 1982).

5.2.2 Pellet counts

Pellet counts have been employed by wildlife researchers to gain an understanding of the degree of ungulate use in a particular habitat or location. They are relatively simple to perform, are inexpensive in terms of equipment costs and provide a relatively good indication of animal use, provided they are undertaken early enough in the season. Neff (1968) presents a good review of the pellet group technique in determining trends in big game use.

Pellet counts involve a determination of the density of ungulate faecal pellet groups per unit area. This figure is then divided by a daily defecation rate to give an estimate of days-use/area for a particular habitat type. Pellet group densities are usually calculated for a number of differing habitat types in order to determine habitat preferences.

Pellet counts can be carried out either on a series of parallel linear transects or circular plots. Neff (1968) stated that transect counts are favoured over plot counts in that they are more time efficient and accurate.

Pellet counts can only be used to gain an indication of trends in ungulate use and do not provide an estimate of absolute numbers or densities. The accuracy of censusing ungulate populations by means of pellet counts assumes knowledge of the following (Sen 1982):

1. daily defecation rate
2. length of deposition period
3 use of efficient sampling methods

Neff (1968) reviews the defecation rates of a number of ungulate species including elk, moose and mule deer. A mean rate of 13 to 14 groups/day was described as a realistic figure of pellet group deposition. Franzmann et al. (1976) determined a mean daily defecation rate of 17.6/groups day in Alaska. Defecation rates vary with forage quality, range condition and percentage of fawns in the herd, as fawns are known to have a considerably higher defecation rate than adult animals.

The deposition period is the period of elapsed time since the last pellet count. As they are counted, pellet groups are either completely cleared from the plot or marked with paint. Clearing is more time consuming, but avoids the possibility of duplication on successive counts.

Neff (1968) also states that the greatest problem affecting the accuracy of pellet counts arises from observer bias. Observer bias arises from missed pellet groups due to fatigue, plot size and shape, density of obscuring vegetation, percentage of snow cover and difficulties in observer interpretation at plot boundaries. Care must be taken to standardize counting procedures and to adhere strictly to these standards, particularly when large numbers of observers are involved.

5.2.2.1 Evaluation of pellet counts

As a monitoring technique on the TCH, the advantages and disadvantages of pellet counts are shown in Table 5.4. The major advantage of pellet counts is that they are simple to conduct, are easily repeated and require a minimal outlay of equipment. However, problems may be involved in sampling procedures. Because of possible variation in the pattern of pellet deposition, large sample sizes may be required in order to generate adequate confidence intervals. Preliminary trial runs are suggested in order to obtain the number of sample plots required for minimal statistical analysis. Careful application of this technique however can generate preferences for particular habitat types and can determine long term trends in animal abundance and distribution.

The major application of pellet counts has been to determine the relative use of a particular habitat type by ungulates in the winter months. Holroyd and Van Tighem (1983) used pellet counts to assess the importance to ungulates of various ecosites in Banff National Park. As a technique for assessing the effectiveness of underpass structures along the TCH, pellet counts are limited in their application. The major disadvantage is that pellet group densities are an index of animal use and are not reflective of actual numbers. Age and sex differences in ungulate use of underpasses cannot be ascertained from pellet counts. In addition, species differences, such as between the mule deer and white-tailed deer, cannot be determined. Pellet counts are restricted to ungulate species and do not provide any information on use by other groups such as carnivores. No information on how animals respond or make use of the underpass structure is possible with this technique.

Table 5.4. Advantages and disadvantages of pellet counts

Advantages	Disadvantages
-simple to perform	- are an index of use not estimation of abundance
-easily repeated	- some species identification difficult
-limited equipment needs	- does not provide indication of rate of passage through underpass
-preferences for a habitat can be determined	- age and sex differences in animal use cannot be established
	- technique may require large sample sizes to generate adequate confidence intervals

5.2.3. Telemetry

Slater (1965) defines telemetry as the instrumental technique for gaining and transmitting information from a living organism and its environment to a remote observer. Telemetry techniques are used by zoologists for three general purposes (Lehner 1979):

1. locating an animal, plotting its movements and determining home range size and habitat use (radio-tracking);
2. locating an animal for the purposes of direct visual observation for behavioural analysis;
3. recording physiological data such as heart rate, metabolic rates and body temperatures (biotelemetry).

The techniques of radiotracking and biotelemetry and their application to monitoring of wildlife defence structures on the TCH are discussed in the following sections.

5.2.3.1 Radio-tracking techniques

The radio-tracking of large mammals uses a narrow band FM transmitter usually fitted to a neck collar. A directional antenna and receiver system is used to detect radio signals emitted by the transmitter. Through the use of triangulation the observer can determine the location of the radio-collared animal allowing him the opportunity for further visual observations.

Radiotracking can give an indication of animal movements, dispersal patterns, habitat preferences and size of home range. It is extremely useful for monitoring the movements of secretive carnivores such as foxes, wolves, mountain lions and grizzly bears (Storm 1965; Koelenosky and Johnston 1967; Seidensticker et al. 1973; Hamer and Herrero 1983). A general criticism to date is that most radiotracking studies have consisted largely of investigations on the activities and movement patterns of a number of wildlife species with no explicit hypothesis testing (Lance and Watson 1980). The technique should be used as a research tool to extend the ability of an observer to interact with his study animal rather than as an end in itself.

Radiotracking systems can be automated to record the presence of an animal without the need for an observer. An event recorder was used to automatically record the presence of radio-collared ducks at nest sites (Gilmer et al. 1971). The system was designed to operate on DC power which provided up to 72 hours recording on two 6 V batteries. The system operated through a temperature range from -2C to +31C. Daily checks were necessary to check the recorder and readjust the event recorder. A similar system could be adapted to record the presence of radio-collared ungulates at underpasses on the Trans-Canada highway.

The major disadvantage of radiotracking techniques is that it is manpower intensive and requires significant equipment costs. Transmitters and collars cost between $300 and $400 while the receiver scanner system is priced around $2500 (R. Russell pers comm. 1983). Only small numbers of animals can be followed at one time and this can lead to problems with low sample sizes. In addition, the effects of an FM transmitter and collar on animal movements are unknown but are probably insignificant.

5.2.3.2 Biotelemetry

Recent studies by MacArthur et al. (1982) and Stemp (1983) used an instrumented system to record heart rates of free-ranging bighorn sheep in relation to various levels of human harassment. The system consisted of subdermal electrodes coupled to an external FM transmitter and harness assembly. An FM receiver and dual track tape recorder was used to record EKG output and verbal descriptions of behaviour. Implantation of the electrodes took less than twenty minutes and the external harness appeared to pose no physical handicap to the animal. Transmitter battery life was estimated close to 2 months with an effective range in the field of at least one km (Johnston et al. 1980). While the mean duration of heart rate response did not differ significantly from the mean duration of overt behavioural responses, MacArthur et al. (1982) concluded that heart rate telemetry did provide a more quantitative assessment of responses to disturbance than did visual observations of behaviour.

Heart rate telemetry should not be initially considered as a monitoring technique for determining animal responses to underpasses, fencing and one-way gates. It could be tried at a later date if it can be shown by other means that use of these structures is limited. Heart rate telemetry could be used to quantitatively measure whether animals show adverse physiological reactions to wildlife defence structures. Research could also be undertaken in researching the initial heart rate responses of ungulates to underpass structures and how individuals adapt to the presence of the structure over time. Heart rate responses of animals to differing types of crossing structures (open span bridge, culvert and overpass) could also be investigated.

5.2.3.3 Evaluation of telemetry

Radiotelemetry as a method for monitoring the success of underpass structures has several advantages and disadvantages (Table 5.5). Radiotracking could be used to provide information on the movements of a number of radiocollared animals in relation to wildlife defence structures. Accurate time and place locations are possible from the air, from a vehicle or on foot. This allows the observer to determine movement patterns and calculate the size of an animal's home range. Radiolocations of animals could provide the observer with an opportunity for visual observations of animal reactions to fencing, one-way gates and underpasses.

Radiotelemetry is a time consuming, manpower intensive exercise particularly in mountainous terrain where accurate radio locations of animals are difficult. Only small numbers of animals can be followed at one time. This technique would not determine the overall use or rate of passage of animals through the various underpass structures.

5.2.4 Photoelectric cells

Photoelectric cells employ either a microwave, infrared or visible light beam which when broken by an animal records its presence. These devices are commonly used by Parks Canada to record hiker use of trails within the National Parks (G. Harrison pers. comm. 1983).

Ward et al. (1980) used a microwave transmitter receiver system to set off deer warning signs along a highway in Wyoming. The system required two 100AH batteries to operate through a temperature range from -30C to +60C. The batteries operated the transmitter for approximately 30 days and the receiver for 30 days. Harlow (1979) used an automatic

Table 5.5. Advantages and disadvantages of telemetry

Advantages	Disadvantages
-individual animals can be distinguished	- only small numbers of animals can be followed
-accurate time and place locations are possible	- tracking is time consuming and manpower intensive
-movements could be plotted to determine distribution in relation to underpass structures	- no information is gained on the rate of passage through structures
-behavioural and physiological data could be collected	- behavioural data only possible if the animal and observer are at the underpass at the same time
-system could be automated to record the presence of collared animals	

photocell device (PE cell) to record the entry and exits of badgers from their den areas in winter. The system featured two photoelectric relay units coupled to an event recorder which was adaptable to a 12 V DC power supply. The circuitry of each photoelectric receiver was modified through the addition of a capacitor to determine direction of animal movement. An observer was required to mark the event recorder once a day to establish a time reference.

Harder (1971) developed a photoelectric cell system to record nocturnal activities of mule deer in a Colorado orchard. Photo-electric cells were set at 0.8 m above ground to avoid triggering by small mammals. Red filters were placed on the cells to minimize the visual disturbance to deer. The output from the photoelectric cells was recorded on a moving, time calibrated event recorder. The system operated on AC power and the event recorder required changing of the roll chart every 6-7 days.

A photocell system could be constructed to record the passage of animals through underpasses on the TCH. An array of two photocells could be placed at each of the entrance and exit of an underpass to record number of animals passages and directionality of movement. Each photocell should be set high enough off the ground (eg. 0.5 m) so as to preclude their triggering by small mammals.

Infrared solar powered photocells are currently in operation to monitor ungulate movements under a 13 km long coal conveyor belt at the Obed Mountain Coal Project near Hinton, Alberta. Ten photocell systems have been placed at identified crossing sites to record ungulate passage under the conveyor belt. The need to collect behavioural information was not considered important and photocells were favoured over a video-surveillance system as a cost-effective alternative. The capital costs of each photocell were \$600 to \$700 each for a total cost of \$7000 - \$8000 (T. Adamson pers. comm. 1984).

5.2.4.1 Evaluation of photocells

The advantages and disadvantages of photoelectric cells are discussed in Table 5.6. Photoelectric cells are virtually maintenance free and could run on a 12 V power supply for several months. Photoelectric cells can provide information on the rate of passage of animals through underpass structures but it is not possible to distinguish individual animals or determine species use. No behavioural data can be collected with this technique. A major limitation of photocells is that the transmitter and receiver system is only operative over a distance of about 25 m (C. Price pers. comm 1984). Photocells would be useful for measuring animal passage at spot locations such as underpasses, one-way gates or texas gate structures. These devices would not be useful as a means of measuring animal responses to fencing.

A more appropriate use of photoelectric cells perhaps is in combination with a photographic recording system. Cameras could be placed to record the presence of animals at the entrance of the structure and photocells could be used as a mechanism to trigger the camera.

An alternative to the use of photocells is to employ an ultrasonic detector which can indicate the presence of an object up to 10 m away. The advantage of an ultrasonic detector is that only a single unit is required compared to the transmitting and receiving units of a photocell system. Costs of the ultrasonic detector are similar to a photocell system and cost about \$100 per unit.

Table 5.6. Advantages and disadvantages of photoelectric cells

Advantages	Disadvantages
-provides a record of animal passage in a specified period	- no indication of species, sex and age class
-system is easy to operate and can be left for up to a week before recharging of batteries is needed	- no information can be collected on behavioural responses
-much more quantitative than pellet or track counts	- observer required to mark daily time reference and periodically change charts in the event recorder Digital counter could be used in place of an event recorder
-minimal manpower needs	- could not be used to assess animal responses to fencing

5.2.5 Photographic surveillance

Photography is a useful means of recording the behavioural activities of animals and with the use of an automatic triggering device, the presence of an observer-operator is not required. Film also provides a lasting record of animal activity which can be replayed and analyzed at a later date.

Still photography, motion picture photography and video-tape recordings have been made of animal responses to underpasses and highways in the United States. Diem et al. (1973) used a 35 mm remote time lapse system to record deer and antelope responses to highways in Wyoming. The system was coupled with a timer which shut the camera off at night. The 35 mm camera system employed a fixed f-stop which limited the quality of photographs, however much advancement has been made with variable aperture lenses since that time.

Diem et al. (1973) also tested an 8 mm remote time lapse system which was inoperative at night. The camera operated successfully at -30 degrees Celsius and the 6 volt battery powered the system up to a period of 15 weeks. Ward et al. (1980) employed a 8 mm system to record deer utilization of underpasses in Wyoming, but modified the system so it could be used at night. The system used a microwave detector, a camera run-selector with run times from 1 to 256 seconds, two 12 volt batteries and a photo-switch and lamps which became operative in the dark. The batteries and film, had to be changed every 7 days and capital costs (1980 US$) of each system averaged $1200. Diem et al. (1973) stated that 35 mm systems were 4-5 times as expensive as Super 8 mm systems, while film costs were 7-9 times as expensive.

Reed et al. (1973) used a continuous video time-lapse system to view the entrances and exits of underpasses on Interstate 70 in west central Colorado. The system was activated in the evening and ran continuously for approximately 12 hours. The operator viewed the film the following day using 24 hour time-lapse speed for detailed observation of behavioural responses. Both artificial lighting and an infrared filter system were tested to determine whether artificial illumination prevented deer use of underpasses. The data indicated that use of the underpasses and overt behavioural responses were not affected by artificial lighting. The use of the military pink infrared filter provided comparable imagery to an artificially lit situation.

5.2.5.1 Evaluation of photography

The advantages and disadvantages of photographic techniques over other research methods is shown in Table 5.7. The primary suggested use of photography is for recording the behavioural responses and use of underpass structures by wildlife. The major advantage of this technique is that a visual identification of the animal using the underpass is possible. If a microwave or photocell triggering device is used, then the number of passages in a specified time period can be determined. Not only can the species and sex be identified but the animal can also be placed into a particular age class to indicate whether there are age-specific differences in animal use. Overt behavioural responses of animals entering the underpass structure could also be recorded. Reed et al. (1975) identified the following three behavioural responses of mule deer to underpasses:

1. "look-up" response- investigative behaviour at the structure entrance;

2. "tail-up" response- tail held level in alarm posture;

3. "muzzle to ground" response- olfactory examination of the ground, possibly for metatarsal scent.

Behavioural responses could be analyzed at the underpasses to determine whether the animal is alert or relaxed upon entry to the structure.

The major disadvantage of photographic techniques are the costs. An 8 mm movie system similar to that used by Ward et al. (1980) costs from $1500 to $2000 while video costs are substantially higher, as much as five to six times the cost of 8 mm systems (P. Morris pers. comm. 1983). However once installed, the camera system would require little in associated manpower needs resulting in lower operating costs in comparison to other manpower intensive techniques such as pellet and track counts.

Another factor against the use of movie cameras or video systems is the potential for theft or vandalism. Means could be employed to reduce the possibility of theft, but could add substantially to the cost of the system. Photography would only be useful at localized points such as underpasses, one-way gates and texas gates and would have limited applications towards assessing the responses of animals to fencing.

Table 5.7. Advantages and disadvantages of photography

Advantages	Disadvantages
-equipment could be leased	- cost of equipment high
-low manpower requirements to operate	- requires intensive analysis of film or videotape
-provides visual identification of animals using underpasses	- could be prone to theft or vandalism
-can analyze behavioural responses	- could be problems with power and cold temperatures
-provides record of animal passage	- film costs are high, especially video and 35 mm
-individual animals could be identified	- could require daily checks
	- restricted to localized points and would not be useful for measuring responses to fencing

5.2.5.2 Choice of photographic techniques

Three types of photographic techniques have been discussed. These include a 35 mm single lens reflex system, an 8 mm or 16 mm movie camera system and a video camera recorder system. Early applications of photography to the study of animal behaviour used either a 35 mm still camera or 8 mm movie camera as these represented the state of the art in technology at the time (Gysel and Davis 1956; Abbot and Coombs 1964; Dodge and Snyder 1970; Patton et al. 1972 and Temple 1972). However, advances in the availability of video technology in recent years have now made it accessible to the wildlife researcher.

A comparison of the three systems is presented in Table 5.8. Although higher in cost than the other two systems, the video recorder camera system for monitoring the use of wildlife underpasses is preferred for the following reasons.

1. Data Analysis

The major advantage of video systems is that videotape is much easier to process and analyze than are 8 mm and 35 mm camera systems. Both 35 mm and 8 mm film require developing either as prints, slides or rolls of film. Videotape can be directly replayed onto a monitor after recording while both 8 mm and 35 mm film requires either a projector or single frame analyzer. Videotape can also be slowed down and photographs can be directly taken off the monitor. Videotape therefore is a much better record of animal activity and is easier to handle than is 35 mm or 8 mm film.

Table 5.8. A comparison of photographic techniques for wildlife monitoring on the TCH

	Technique		
	35 mm SLR	8 mm movie camera	Video camera-recorder
Data Analysis	Requires developing Prints produced	Requires developing Playback on projector or frame by frame	No developing Playback on VCR
Data Collection	Motor drive required Triggered by photo cell system	Continuous, triggered by photocell system	Continuous triggered by photocell system
Night Use	External lighting required	External lighting required	External lighting required or use of a low light level camera
Power Needs	Nicad battery	12 volt DC	12 volt DC or 120 volt AC
Cost	$2000 +	$1500 +	$ 7500 +

Note: Costs of 8 mm and 35 mm systems are for camera purchase only. External lighting sources are required which will significantly elevate price.

2. Night Use

Both the 8 mm and 35 mm system would require an external light source in order to provide useful imagery at night. A low light level video camera would require only an infrared light source (such as a 12 volt automobile tail light bulb). Although not demonstrated to be a problem in Colorado, the use external lighting may be a distracting influence to animals using underpasses in Banff National Park. The most significant limitation of external lighting is the requirement for frequent battery changes if AC power was not available. The need for more frequent battery changes and maintenance of the external lighting system for the 8 mm system may result in higher operating costs than a low light level video surveillance system.

3. Power Requirements

A 35 mm camera system requires a nickel-cadmium rechargeable battery to power the camera and motor drive and a 12 V DC or 120 V AC power supply for external lighting. An 8 mm movie camera would run off a 12 V DC battery and external lighting would also require 12 V DC or 120 V AC power supply. Photovoltaic cells could be adapted to recharge the 12 V automotive battery supply while in use or a standard AC battery charger could also serve the same function.

4. Cost

Capital costs of the video system are about five to six times the cost of 8 mm and three to four times the cost of a 35 mm system (P. Morris pers. comm. 1983). The lower operating costs for maintenance of the video system (ie. less frequent maintenance and battery changes) favor this alternative in the long term over the 8 mm and 35 mm systems. The costs of 8 mm and 35 mm systems presented in Table 5.8 will be elevated, due to necessity of using an external lighting system.

5. Evaluation of photographic techniques

The choice of which photographic technique is most suitable for monitoring of wildlife underpasses is a trade-off between cost and convenience. Capital costs of a video system are considerably greater than a 8 mm system however the requirement of external lighting in order for the 8 mm system to function effectively at night might offset the difference. The low light level video camera system is far superior under poor lighting conditions when most animal use could be expected. The greatest advantage of the video system is its convenience, which will ultimately result in lower operating costs over the expected lifetime of the equipment. The videotape can be viewed immediately compared to a time delay required for the developing of 8 mm film. Video images can be slowed down and stopped allowing for photography off the monitor screen. Videotape is a far easier system to analyze than would be 8 mm film. Given these advantages a video system is preferred over the other alternatives of 35 mm and 8 mm.

5.3 Evaluation of monitoring techniques

This chapter has reviewed a number of wildlife inventory and assessment techniques as to their usefulness in assessing wildlife use of underpasses, fencing, one-way gates and texas gates along the TCH. While they differ in their scope and degree of manpower and equipment requirements, these techniques represent a scale of increasing effort and complexity.

A set of four criteria for evaluating the techniques for monitoring of animal underpasses and fencing was presented earlier in the document in Section 4.3.3. These criteria have been applied to the eight techniques described in this chapter and this evaluation is presented in Table 5.9. The primary emphasis on data requirements was the need to understand how often animals make use of underpass structures (effectiveness), to measure the behavioural responses of animals to those structures and to identify individuals as to species, age and sex.

Of all the techniques presented in this chapter, photographic surveillance meets all the criteria described in Chapter 4. The use of a video camera recorder system is recommended over 8 mm and 35 mm camera systems. Although video surveillance is the most costly of all the techniques presented, this expense can be justified by the superior level of information that this technique produces.

The use of track counts is recommended for monitoring of the use of one-way gates and fencing. Track count data in the vicinity of underpasses could be compared to the results of photographic surveillance. A detailed monitoring plan describing the use of these techniques follows in chapter 6.

Table 5.9. Evaluation of wildlife monitoring techniques for the TCH project

TECHNIQUE	CRITERIA			
	Effectiveness	Age and sex Use	Multi-species Use	Behaviour and Design
Aerial Survey	N	Y	N	P
Roadside Survey	N	Y	N	P
Track Counts	Y	N	P	P
Pellet Counts	N	N	P	N
Telemetry	Y	Y	N	Y
Photoelectric Cells	Y	N	N	N
Photography	Y	Y	Y	Y

Y - meets criteria established in Chapter 4
N - does not meet criteria established in Chapter 4
P - partially meets criteria established in Chapter 4

CHAPTER 6: A WILDLIFE MONITORING PROGRAMME FOR THE TRANS-CANADA HIGHWAY

6.1 Introduction

Chapter 4 presented a review of the current practice of environmental monitoring in Canada and established a number of objectives for monitoring of wildlife defences on the Trans-Canada Highway. Chapter 5 evaluated a number of methods available to monitor wildlife use of fences, underpasses and one-way gates along the Trans-Canada Highway. This chapter will build on this discussion and present a monitoring programme that should be considered for implementation by Parks Canada in Phase I of the TCH twinning project.

The approach followed in this chapter will be of a "cookbook" nature providing a number of specific recommendations on the scope and requirements of the wildlife monitoring programme on the Trans-Canada Highway. The majority of the chapter will centre on recommendations for monitoring of wildlife defence measures undertaken in Phase I of the highway project. Means of monitoring wildlife use of underpasses, fences and one-way gates will be documented. Research needs for specialized structures such as texas gates will be discussed. Manpower requirements, time frames and estimated budget costs will be featured as part of this discussion.

The remainder of the chapter will discuss monitoring needs for Phase II of the TCH (km 13-27), Phase III to Castle Junction and further wildlife research requirements in the Bow Valley away from the Trans-Canada Highway corridor. Results from the Phase I monitoring plan should help to further define the shape of future research along the Trans-Canada Highway.

6.1.1 Approach

The variety of techniques presented in Chapter 5 represent a number of solutions to the problem of measuring the effectiveness of wildlife defence structures on the Trans-Canada Highway. These techniques address the short term objectives that were discussed in Section 4.3.3.1 of Chapter 4.

To review, the arguments for understanding species use and use by specific age classes and sex were stated in Chapter 4.

1. Little is known regarding the population dynamics and herd composition of ungulates in the Bow Valley;
2. The diversity of wildlife species in the highway corridor expected to make use of the underpasses is unique;
3. The behavioural responses of animals to the two types of underpasses should be understood in order to justify use of the more inexpensive culvert structure.

Based on the criteria outlined in Section 4.3.5 of that chapter only the video-surveillance system can provide information on all of the following:

1. effectiveness - how often animals make use of wildlife defence structures
2. multi-species use - how different species react to and make use of underpasses
3. use by sex and age class - how differences in sex and age may affect species use of underpass structures
4. behaviour and design - how animals react to wildlife defence structures and how this response changes over time

While it may appear at first that the choice of a video-surveillance system is a "high tech" and costly solution to the problem, nonetheless it is the only means available to adequately address these criteria and meet the objectives of the wildlife monitoring programme outlined in Chapter 4. None of the other methods presented in Chapter 5 completely satisfy all of these criteria. Without an understanding of the above, monitoring efforts will be inadequate in terms of assessing the success of wildlife mitigation efforts on the TCH. Since Phase I of the Trans-Canada Highway Project represents a test-case situation in regard to the extent of wildlife mitigation measures, monitoring and follow-up studies will also set a precedent for additional highway twinning in Banff National Park and in other major highway projects in Canada. The applicability of the results of the monitoring programme to other highway projects is important enough in itself to justify the level of effort advocated in this document.

The sections that follow set out the means of achieving both the short and long term objectives of the wildlife monitoring programme outlined in Chapter 4. The first section, Section 6.2, addresses the short term objectives of monitoring in Phase I. Section 6.3 discusses future wildlife research in the Bow Valley and addresses the long term objectives of wildlife monitoring along the Trans-Canada Highway in Banff National Park.

6.2 Monitoring Plan for Phase I

6.2.1 Underpasses

6.2.1.1 Overview

Based on discussions with the Alberta Government Telephones (AGT) Special Products Division in Calgary and Edmonton, two types of video surveillance systems were developed for monitoring wildlife use of underpasses on the Trans-Canada Highway. Both a 12 V DC and 120 V AC system were considered. The availability of power along the Trans-Canada may restrict the choice of a video surveillance system as at the present time AC power is not available (B. Leeson pers. comm. 1983).

The comparative costs of the two video surveillance systems are presented in Table 6.1. The 12 V system is roughly two times the capital cost of the 120 V AC system, but would provide more efficient service, would require less maintenance and would result in lower operating costs than the 120 V system.

While perhaps more costly, the 12 V DC system is judged to be superior to the 120 V AC system because of its ease of operation. The 12 V DC system features a low light level SIT (silicon intensifier target) camera which does not require an external light system in order to be effective at night. A 12 V automobile tail light bulb would provide enough IR radiation to produce good quality imagery at night and would not result in extensive battery drain (R. Hobbs pers. comm. 1983). A 12 V battery could power the entire system for three to four days at which time a freshly charged battery could be exchanged. The expended battery could be recharged on an AC battery charger and be available for re-use at a later date.

There are several alternatives to the use of batteries as a power source. The first is to use a photovoltaic panel to provide a continuous charge to the 12 V battery supply. Calculations of the current needed to power the video system are presented in Appendix 3. The approximate cost of a photovoltaic panel that will operate on every day of the year is about $4000 (C. Price pers. comm. 1984).

Another more costly but reliable power source is to employ a thermoelectric generator (TEG). Global Thermoelectric Power Systems Ltd. in Bassano have developed thermoelectric generators as a remote power

Table 6.1. Comparative costs of a 12 V DC and 120 V AC video surveillance system

1. 12 V DC system	$
Camera RCA TC1034	9043.00
Heat lamp	64.00
Custom cabinet	320.00
VCR JVC HR2650	1920.00
Video timer	900.00
Video monitor	275.00
Photocell trans./receiver	100.00
Photoelectric control	300.00
4 12 V automotive batteries	250.00
Utility trailer	300.00
TOTAL	13 472.00

2. 120 V AC System	$
Camera RCA TC1005	2696.00
Custom cabinet	320.00
VCR JVC HR7100U	1024.00
Video timer	900.00
Video monitor	275.00
Heater	80.00
Photocell trans./rec.	100.00
Photoelectric control	300.00
Honda generator EM600	600.00
Lamp illuminator	1174.00
Utility trailer	300.00
TOTAL	7769.00

Source: Al Riise, AGT Special Products Division, Calgary source for telecommunication and navigational equipment and to provide cathodic protection in pipelines. Thermoelectric generators work on a thermocouple principle where current is generated upon differential heating of two dissimilar metals in an array of thermocouples or a thermopile. TEG's are designed to operate on propane, butane and natural gas. They are extremely reliable, require little or no maintenance and are silent in their operation. Another advantage of the system is that waste heat generated in the thermopile can be recycled for heating purposes. The major disadvantage of TEG's is their size and cost. The TEG and shelter are not readily portable and a video system powered by this means would have to be established at one location. Costs of a TEG system are approximately $6000 for the shelter and about $5200 for the generator (Global Thermoelectric Power Systems 1984).

The 120 V AC system would require a portable generator where power was not available. An additional fuel tank would be necessary in order for the generator to run for a two to three day period. Small generators are available on the market which are relatively quiet (Honda EM 600 - 68 db @ 5 m), but the reliability of prolonged motor operation over extended periods is questionable.

In addition, the 120 V camera is not as sensitive as the 12 V camera and would require an external lighting source to generate suitable imagery at night. The disturbance of noise from a continually running generator and disturbance of an external light source at night must be considered as a possible negative influence on animal use of underpasses. Based on the problems in using a 120 V system, the choice of a 12 V DC system is preferred.

Further information on purchase options of video equipment can be obtained from representatives of the AGT Special Products Division in Edmonton.

6.2.1.2 System design and equipment needs

Five wildlife underpasses will be constructed by the winter of 1983 - 1984. These include four open-span bridges (East Gate, Carrot Creek, Duthil and Cascade) and one experimental culvert structure (Morrison's Coulee). Since each of these five locations differ in terms of present animal use and the type of structure present, monitoring of all five sites should initially be considered.

The video surveillance system is designed to be portable so that it can be moved between the underpass locations. Access to underpasses would be provided either through existing swing gates or one-way gate structures. The construction of additional swing gates at some underpasses may be necessary where access is not currently available.

The required components of the system are featured in Table 6.1. A video camera, lens, portable VCR and monitor would be cased in a protective housing and placed on a small utility trailer which would also house the 12 V battery supply. The housing would be locked and the trailer could be chained to a tree to prevent theft. The trailer would be set back from the underpass entrance at a distance of 15 - 20 m in order to provide a 30 degree viewing angle (Reed et al. 1973). A photocell array would be placed at the entrance of the underpass and would trigger the camera when an animal passed through the beam (Figure 6.1).

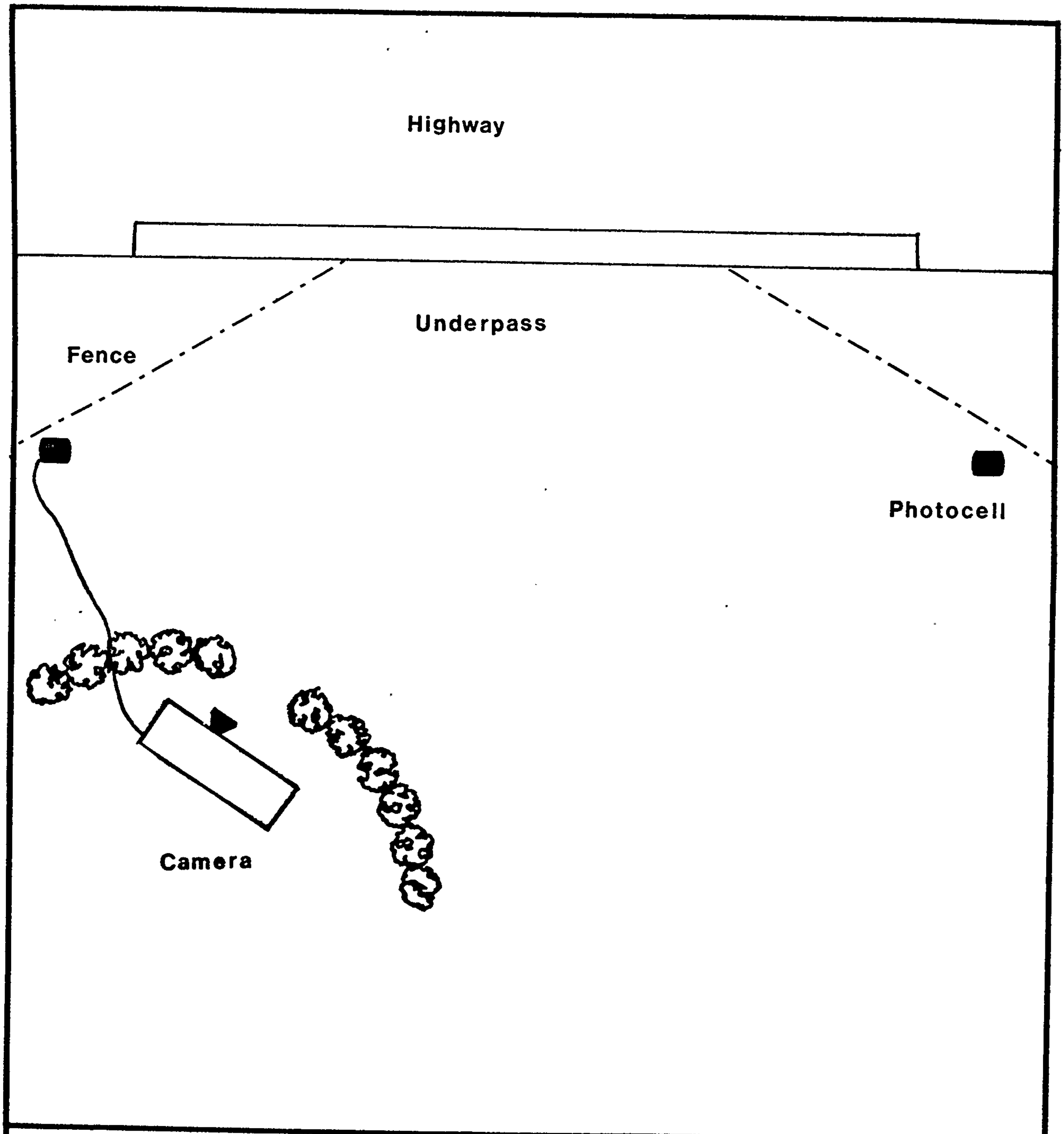


FIGURE 6.1 PLAN VIEW OF VIDEO CAMERA ARRANGEMENT

A timer could be placed on the video-camera to allow it to run for variable time periods. An interval of 60 seconds would likely be sufficient in order to determine species, age and sex in addition to collecting some behavioural observations. A video timer would place the time of the passage directly onto the videotape thereby producing a time and date record of animal passage. A small 12 V bulb also placed on a timer would provide enough light to operate the camera during darkness.

Photocell arrays would also be placed at the entrances of the remaining underpasses not subject to video-surveillance and connected to a digital counter. The number of passages recorded by this method could later be compared to the results gained from video surveillance. The photocell array could be set up to record the direction of animal movement through the underpasses.

6.2.1.3 Manpower and maintenance requirements

Until the initial results of the video-surveillance monitoring programme have been analyzed, it is difficult to predict how often the videotape would require changing. Since the camera would only operate when an animal crosses through the photocell beam, the number of passages of animals through the structure will determine how often the videotape would need replacing. Given the low use of the underpasses at present, a conservative estimate of five passages per hour as a maximum number is suggested. If the camera would be set to run for 60 seconds once triggered, then the total time per hour that the camera would be in operation is at most five minutes. Based on this calculation of five minutes of play for every actual hour of real time, an 8 hour video tape could last up to four days. The accuracy of this estimate can be checked once preliminary videotape data has been analyzed (Appendix 4).

The 12 V battery supply would need to be exchanged at this time, while the digital counters at the remaining underpasses should be checked and reset at every 24 - 48 hour intervals. The addition of a photovoltaic cell could extend the period in between battery changes.

6.2.1.4 Data analysis

An example of a proposed data form for determining animal use is presented in Table 6.2.

The major focus of analysis is to catalogue the passage of animals through the underpass structure and determine behavioural response to the structure. The type of activity through the underpass has been adapted from Reed et al. (1975) and consists of the following:

Approach - animal enters camera field of view and turns around
Entrance - animal noted to disappear from view
Exit - animal appears in camera field of view either having come from the other direction or turned around in the underpass structure

Net passage is calculated by subtracting the number of exits from the number of entrances and can either be positive or negative thereby indicating the prominent direction of movement.

In addition, some attempt should be made to measure the behavioural responses of animals to underpass structures. Hicks and Elder (1979) developed a five point code system to classify the presence of humans in the Sierra Nevada Mountains of California. A modified system is suggested for use at animal underpasses on the TCH.

0 Unconcerned - animal moves through underpass easily with no indication of disturbance

1	Concerned	- animal slowly moves towards underpass, shows investigative behaviour
2	Moderately concerned	- animal trots towards underpass, exhibits avoidance and reapproaches structure
3	Highly concerned	- animal is agitated, shows avoidance behaviour and does not reapproach structure

This classification system is preliminary and could require modification upon initial analysis of animal responses to underpass structures.

Table 6.2. Sample Video analysis data form

Date: ______________

Observer: ______________

Underpass Location: ______________

REF. NO.	TIME	SPECIES	SEX	AGE CLASS	ACTIVITY			RESPONSE
					Ap	En	Ex	

Species:

bs - bighorn sheep
el - elk
wt - white-tailed deer
md - mule deer
mo - moose
ot - other

Sex:

m - male
f - female

Age Class:

YOY - Young of the year
YRL - Yearling
YAD - Young adult
ADU - Adult

Activity:

Ap - approach
En - entrance
Ex - exit

Response:

0 - unconcerned
1 - concerned
2 - moderately concerned
3 - highly concerned

6.2.1.5 Time frame and costs

1. Time frame

The Environment Assessment Panel report for Phase II of the Banff Highway Project states that Public Works Canada agreed to be responsible for monitoring of fences and underpasses during the first year with Parks Canada assuming responsibility after that time (FEARO 1982). Long term monitoring is therefore the responsibility of Parks Canada. However, funds for the programme are to be included as part of the overall construction costs of Phase I and Phase II.

Based on estimates obtained from Public Works Canada, costs ($1983) of the wildlife defence measures are as follows:

Fencing	$19 300/km @ 26 km	=	$ 501 800
Underpasses	9 total	=	$1 429 000
	TOTAL		$1 930 800

Note: Fencing costs (1983$) to km 6.4 are extended over 26 km.

Actual costs from km 6.4 to km 13 may be greater

Underpass costs based on nine underpass structures

2. Costs

Costs of a monitoring programme (operating and capital) expressed as a percentage of the total cost of wildlife mitigation are as follows:

Monitoring Programme Costs	Percentage of Total Wildlife Mitigation Cost
$ 10 000	0.5%
$ 25 000	1.3%
$ 50 000	2.5%
$100 000	5.2%

There are no established precedents as to what percentage of the total mitigation cost should be spent on monitoring. It should be noted that if a culvert underpass is found to be suitable just once in a later project, then a $100 000 monitoring cost will be more than recovered.

Initial purchase of a video surveillance system is proposed and a trial operational period of 6 months is recommended. The video system could be rotated between underpass sites on a 10 - 14 day basis, until a decision is made whether to purchase further equipment. Based on preliminary estimates the total capital cost of a single video system is approximately $13 000.

Operating costs of the video-surveillance system will likely equal or exceed the unit capital costs of video equipment. Based on an analysis of five minutes per hour or two hour of operation per camera per day, the use of three to four camera systems and associated maintenance tasks would require the services of one person year per year of monitoring. Based on a salary of $20 000 per year and overhead costs of approximately $10 000 per year, the operating costs of video-monitoring would total $90 000 over a three year period.

6.2.2 Fencing

Monitoring of wildlife fencing should be for maintenance purposes and to determine the responses of animals to the fence structure.

Maintenance along the fence should involve a minimal amount of effort. Weekly inspections could be made to repair any holes or replace fallen fence sections. Snow drifting should be monitored in the winter months as to ensure that the fence remains a barrier to ungulates.

Analysis of animal responses to fencing can be best carried out by means of track counts. Although limited to periods when snow conditions permit ready tracking, this technique would provide useful information on ungulate encounters with fencing. This technique would not however provide information on age and sex differences in reaction of animals to fencing. An example of a data sheet for wildlife responses to fencing is shown in Table 6.3.

The focus of monitoring is directed towards examining animal approach and avoidance behaviour in relation to fencing. The fence line could be walked in either direction from an underpass location and the instances of animal encounters with fencing recorded as indicated on the data sheet. This activity could be conducted at weekly intervals when snow conditions permit tracking throughout the winter. The approach would provide information on the following:

1. how an animal approaches a fence;
2. the reaction of animals at the fence line;

Table 6.3. Sample data sheet for analysis of ungulate response to fencing

Date: ____________ Location: ____________
Observer: ____________ Transect: ____________
Time: ____________ Weather: ____________

Snow Depth: ____________

TRACK RESPONSE

Type of track: Deer ________ Elk ________
Moose ________ Other ________

Distance from underpass: ____________
Response to fence:

Moved right ________
Moved left ________
Backtracked ________

Distance travelled along fence line: ____________ (m)
Direction travelled:

Moved to underpass ________
Moved away from underpass ________
Moved away from fence ________

3. whether fencing is successful in directing animals towards the underpass;

4. changes in the response of animals to fencing over time.

6.2.3 One-way gates

One-way gates are to be established at irregular intervals along the fence line to allow animals trapped inside the fence a means of returning to safety.

Monitoring of one-way gate structures should provide an indication of the frequency of use by animals and how successfully these structures are navigated. The number of times animals cross through one-way gate structures could be determined by means of a mechanical counter. The counter could be reset every 2-3 days and the number of passages in that time period could be calculated. Measuring ungulate use of one-way gates by this method would be complicated by the chance of humans using the gate to access areas on the other side of the fence. Since stopping on the highway will not be encouraged, it is likely that human use of these structures will be minimal.

In addition, track beds could be established on either side of one-way gates in the vicinity of underpasses. The sand track beds would require raking every 3-4 days in order to obliterate the recorded tracks. During the winter months, snow track counts could be conducted in place of the sand track bed counts. Counts on either side of the one-way gate structure could be compared to the mechanical counter to see whether the structures were successful in permitting animal passage in the intended direction and preventing ungulate access to the highway right-of-way.

Swing gates should also be placed at strategic locations to allow passage of large numbers of animals which have become trapped inside the median and may not use the one-way gate structures as an escape. These gates could be opened and animals herded through to safety on the other side of the fence. This would occur only under extreme situations such as when posing a serious hazard to automobile traffic.

6.2.4 Texas gate structures

The purpose of texas gates is to prevent animals from entering the TCH right-of-way from access roadways. The passage of automobiles across texas gates renders ineffective techniques such as video surveillance and photocell counters as these devices would be triggered by both animals and vehicles.

Reed et al. (1974b) used a combination of track counts and observations of released deer to determine their response to modified texas gate structures in Colorado. Track counts were undertaken in the field while observations of released animals were restricted to controlled conditions. In addition to track counts at the approaches to texas gates, the rails of these structures were examined for the presence of hoof scuff marks and hair.

Monitoring of texas gate structures on the Trans-Canada Highway could involve two similar activities. Firstly, snow track counts could be undertaken in the winter months on both sides of the texas gate to determine whether animals were able to cross the structure. Sand track beds could be placed on either side of the texas gate in order to record deer use in other seasons, but due to the expected volume of automobile traffic this practice is not recommended. An alternative would be to test a texas gate in an area not open to automobile traffic. The limitations of track counts have been discussed elsewhere in Chapter 5 of this document.

Another consideration of a more research oriented activity would be to release captured elk and deer at experimental texas gates in order to observe their behavioural responses. Deer and elk could be obtained by means of a winter trapping programme. The number of instances animals crossed these structures could be recorded and occurrences of approach and avoidance behaviour could be documented. This research should be conducted in an area away from the Trans-Canada Highway to avoid possible automobile collisions.

6.2.5 Monitoring of wildlife mortality on the TCH

Records should continue on the occurrences of wildlife deaths on the Trans-Canada Highway. The number of wildlife vehicle accidents after the imposition of mitigation measures could be compared to the pre-construction mortality data to develop an idea of the effectiveness of wildlife defence structures in reducing vehicle accidents. This figure can be measured in terms of a per cent reduction in wildlife mortality along the Trans-Canada Highway. As discussed in Chapter 4, this is one means of demonstrating the effectiveness of wildlife mitigation measures on the Trans-Canada Highway.

6.2.6 Achievement of short term objectives

Short term objectives focus at the individual level in order to ascertain how animals respond to fencing, one-way gates and underpasses. The mechanisms proposed in this section meet all of these objectives.

1. Continued monitoring of road kills along the TCH will indicate if wildlife mortality is increasing or decreasing as a result of highway twinning (Objective 1);

2. The video-surveillance system will provide information on the behavioural responses and use of underpasses by wildlife species on the TCH (Objectives 2 and 4).

3. Video-monitoring of the culvert and open span bridge structures will show the relative use of both structure types and may justify use of the more inexpensive culvert (Objective 3).

4. Track counts can be used to determine the response of animals to fencing, one-way gates and texas gates (Objective 4).

Results of the Phase I monitoring programme will be useful in defining the extent of monitoring activities in Phase II. Monitoring of the wildlife defence structures as proposed in this section will assess the effectiveness of mitigation. If the results of monitoring indicate that mitigation is ineffective, then steps can be taken to redesign the wildlife defence structures.

6.3 Future Wildlife Research in the Bow Valley

The purpose of this section is to provide a number of recommendations pertaining to the direction of future wildlife research in relation to highway development in the Bow Valley. This includes research for Phase II of the highway twinning project (km 13-27), future proposed twinning to Castle Junction and beyond and areas away from the highway corridor which may suffer indirect impacts of highway construction. These recommendations will address the long term objectives outlined in Chapter 4.

6.3.1 Phase II

Five underpasses, one overpass and an additional over/underpass were originally planned for Phase II of the Banff Highway Project (FEARO 1982). Three formal open span underpasses will now be constructed in Phase II (km 15, km 18 and km 22) and an additional concrete box structure may be used on occasion by wildlife. The overpass structure planned at the Bighorn Sheep Exhibit has been replaced in favour of an underpass at km 18.9. The possibility of allowing animal movements across the Norquay overpass is currently under consideration but at this time the issue has not been resolved (B. Leeson pers. comm. 1984).

The underpasses will be designed to allow safe passage of bighorn sheep across the Trans-Canada Highway, a situation not encountered in Phase I. While deer and elk have successfully crossed through underpasses in the United States (Reed et al. 1980, Ward et al. 1980), Banff National Park represents the first instance where underpasses will be specifically constructed for bighorn sheep.

Construction of Phase II began in 1983 and a paved surface will be completed by 1986 (G. Allan pers. comm. 1984). Little information will be available from the monitoring of Phase I mitigative structures to be of use in over/underpass design in Phase II, but the suitability of a video-surveillance system would have been assessed at that time.

Recommendations for monitoring in Phase II of the project are as follows.

1. Incorporate a similar video-surveillance programme as in Phase I

A video-surveillance system should be considered for placement at the entrances of representative underpasses in Phase II. Digital counters could be placed at the underpasses not subject to video-surveillance as they were in Phase I.

2. Monitor the behavioural responses of bighorn sheep

Since very little is known regarding the behavioural responses of bighorn sheep to highway overpasses and underpasses special consideration should be given towards a study of the subject. Video-monitoring of underpass locations in Phase II could provide good data on this subject. If it becomes apparent that sheep are not using these structures, then consideration of further research using heart rate telemetry may be warranted. Several studies have been conducted on the heart rate responses of bighorn sheep to human disturbance (MacArthur et al. 1980, Stemp 1983 and Chabot pers. comm. 1984) and a similar study may be warranted to determine the heart rate responses of bighorn sheep to highway underpasses.

6.3.2 Research for Phase III

At the present time, terms of reference are being drawn up for initial ungulate investigations from the Sunshine Turnoff to Castle Junction (B. Beswick, pers. comm. 1983). These studies will be similar in scope to those conducted in Phase I by Harrison et al. (1980, 1982).

The overall number of ungulate mortalities in this section is much lower than that recorded in Phase I and Phase II. However, more moose are killed in this stretch than there are in the first 27 km (Harrison et al. 1982). Studies to determine ungulate crossing sites may indicate if moose are more commonly found along the highway edges in the stretch from the Sunshine Turnoff to Castle Junction.

The need for and extent of wildlife defence measures in this section will be determined once the results of these studies have been analyzed.

6.3.3 Research outside of the Bow Valley

The long term objectives of the wildlife monitoring programme are identified in Section 4.3.2.2 of Chapter 4 and concern the significant lasting impacts of highway construction in the Bow Valley. If successful, the imposition of mitigative measures along the TCH will lead to decreased wildlife mortality in the highway corridor. However, the effect of this decreased mortality, particularly among the ungulates, is unknown as the status of many wildlife species in the Bow Valley is not clearly understood at the present time. In order to gain an understanding of the long term effects of highway twinning, a number of recommendations are presented in this section that address the long term objectives of the wildlife monitoring programme outlined in Chapter 4.

1. Development of large mammal species management plans

The Report of the Environmental Assessment Panel for both Phase I and Phase II recommended that Parks Canada develop and implement an overall management plan for large mammals in Banff National Park (FEARO 1979; 1982). This plan should be developed to take into account the incremental effects of highway twinning on animal movements and habitat, and of past and future projects which have affected or may affect the species concerned (FEARO 1982).

Management plans are needed to manage effectively the wildlife species present in Banff National Park in light of impending demands upon their habitat. The British Columbia Fish and Wildlife Service has recently established a number of species management plans for both game and non-game species (British Columbia Fish and Wildlife Branch 1980, 1981). Similar plans could conceivably be developed for major wildlife species of Banff National Park. The management plans should be developed in the following manner:

1. set goals of management;
2. identify objectives to meet the goals;
3. establish policies to fulfill the objectives;
4. implement programmes consistent with policy;
5. monitor implementation and adjust programmes where appropriate.

In order to set objectives of each species management plan, a clear understanding of species population trends is necessary. Such an understanding is not available at the present time.

2. Initiate a programme to understand population dynamics of major large mammal species in the Bow Valley

In order to set management objectives, numbers of the species to be managed and population trends should be clearly understood. A programme of standardized aerial surveys should be undertaken to census ungulates in the Bow Valley. A procedures manual should be developed so that replicate surveys can be flown with a minimum of observer bias. This manual would lay out the methods to be followed to ensure that survey results are comparable and that statistical analyses of the data can be performed (Appendix 6).

The elk telemetry study, presently underway by the Banff Park Warden Service may provide valuable information on the extent of elk movements in and out of the East Park boundary. Similar studies could be considered for mule and white-tailed deer, although with the latter low sample sizes could be limiting. An understanding of animal movements in and out of the Park could indicate whether any changes resulting from highway construction are occurring (Objective 2, Section 4.3.2.2).

3. Potential for predator-prey interactions

The restriction of animal crossings to certain points along the Trans-Canada Highway could present an opportunity for predators at underpass locations. This situation if it occurs could form a significant deterrent towards ungulate use of these structures. Studies should be launched to investigate the potential for predator-prey interactions at the entrances and exits of underpasses.

Video-surveillance structures proposed for Phase I and II could indicate the presence of carnivores at underpasses and provide useful information on their behaviour.

4. Identify important wildlife habitats and establish areas of conflict with proposed developments in the Bow Valley

Holland and Coen (1983) have recently classified Banff and Jasper National Parks under the Ecological Land Classification System. Important wildlife habitats were identified as part of this document (Holroyd and Van Tighem 1983). Parks Canada and the Canadian Wildlife Service also carry out a range monitoring programme through examination of a number of grazing plots throughout the Bow Valley.

In addition to twinning of the Trans-Canada Highway, it is important to gain an understanding of the effects of other developments that may further reduce the availability of habitat to some wildlife species in the Bow Valley. In particular, the expansion of the Banff townsite and Olympic preparations in the Canmore Corridor could seriously affect habitat for some species, particularly elk and moose. The impact of Olympic development for the 1988 Winter Games and expansion of recreational opportunities in the Canmore Corridor could lead to decreased habitat availability and possible harassment of ungulates. In contrast, possible changes in hunting regulations such as curtailing the bow hunting season may benefit ungulate populations. The long term impacts of recreational development in the Canmore Corridor should be considered. Movements of ungulates into and out of the East Park boundary are not understood and a census programme to provide information on this subject could be used to predict impacts of development in the Canmore Corridor on Park ungulate populations.

5. Monitoring of railway kills on the CPR line

Railway mortality of wildlife is an equally serious problem as is mortality on the Trans-Canada Highway. Attempts should be made to monitor mortality on the railway and compare its magnitude to the TCH. Although railway mortality data is more difficult to collect, it is important to gain a clear understanding of its severity on wildlife populations, particularly when a concerted effort is being made to reduce wildlife mortality on the TCH.

6. Monitoring of range plots in the Bow Valley

Six browse plots and ten grass/sedge plots have been established on either side of the TCH from the East Gate to the Sunshine Turnoff (G. Harrison, pers. comm. 1984). Their purpose is to gain information on ungulate browse and range utilization in the Bow Valley. These browse and grazing plots are not production plots and cannot give an estimate of animal use or range carrying capacity. However, if monitoring along the TCH shows that underpass crossing areas are not being used by ungulates, then examination of these plots could show if extensive overbrowsing or overgrazing is occurring as a result of restricted movements. More detailed browse and grazing studies would have to be conducted in order to determine whether an observed increase in browsing or grazing pressure was detrimental to range condition.

7. Development of a habitat manipulation strategy

If it can be demonstrated that ungulate numbers are increasing in the Bow Valley as a result of decreased mortality on the Trans-Canada Highway and there is encroachment on some habitat types by both natural and anthropogenic processes, then it may be necessary to initiate a programme of habitat manipulation. Wisely (1982) evaluated a number of habitat manipulation techniques as to their applications in Kananaskis Country. Consideration could be given towards habitat enhancement for certain wildlife species, notably the ungulates, in the Bow Valley. Any attempts of habitat manipulation should be developed within the overall context of species management plans.

6.3.4 Achievement of long term objectives

Long term objectives are aimed at the population level in order to determine significant lasting effects of highway construction on wildlife populations in the Bow Valley. As indicated in Section 3.1, monitoring efforts should concentrate on the ungulates as this group suffers the highest highway mortality and are of the greatest interest to park visitors. The programmes outlined in Section 6.3.3 attempt to meet these objectives.

1. A programme of repeated aerial surveys should establish the response of ungulate populations to decreased mortality resulting from the construction of wildlife defence structures on the TCH. Aerial surveys could provide an indication of animal densities, trends in distribution and an estimate of productivity (Objective 1).

2. The results of the elk telemetry study if continued over a long period could provide useful information on the extent of elk movements in the Bow Valley. In conjunction with the aforementioned programme of aerial surveys, information could be gained on animal movements patterns in the Bow Valley

(Objective 2).

3. Monitoring of grazing and browse plots could provide a rough estimation of range condition in relation to potential increases in ungulate numbers arising from decreased highway mortality (Objective 3). More detailed browse and grazing studies will be required to gain information on range carrying capacity and to determine levels of animal use.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The focus of this document has been to develop recommendations on a system for monitoring of underpasses, fencing and one-way gates in Phase I of the Trans-Canada Highway Twinning Project. Recommendations are also made for monitoring of wildlife defence structures in Phase II and on research associated with further highway development in the Bow Valley.

Criteria were developed to address the short term and long term objectives of the wildlife monitoring programme. The criteria included the need for information on the following:

1. how often animals use underpasses, one-way gates and texas gates;
2. species use of underpasses, fencing, one-way gates and texas gates;
3. age and sex of animals using underpasses;
4. behavioural responses of animals to underpasses, fencing, one-way gates and texas gates.

The effectiveness of wildlife defence systems is measured in how successfully the structures are used by animals and secondly how successful they are in reducing wildlife mortality on the highway. Only the photographic surveillance system provided a visual identification of animals at underpasses and a measure of behavioural responses as they approach and enter these structures. No other technique discussed in Chapter 5 provides as detailed a level of analysis. A video system was preferred over the alternatives of 8 mm and 35 mm systems. Suggested conclusions with regard to aspects of monitoring of underpasses, fencing, one-way gates and texas gates are presented in the following sections.

7.1.1 Underpasses

Two types of video-surveillance systems were discussed in this document. A 12V video-surveillance system is recommended over a 120V system. The reasons for this decision are that a 12V system would not require an extensive light system to be effective at night and it would avoid problems associated with the noise and operation of a portable generator.

Photocells could be employed to trigger the video camera when an animal enters the camera's field of view. Once triggered, a timer would run the camera for a period of 60 seconds. A small 12V lamp would also be set to a timer to enable operation of the camera at night. The time of animal entry into an underpass location would be recorded directly onto videotape by means of a video timer.

Options for power of the video system include the use of rechargeable 12V batteries or deployment of a photovoltaic panel.

The video system would be mounted on a portable trailer allowing it to be moved to several locations. The potential for theft could be reduced by chaining the entire system to a nearby tree or fence post.

A system of two photocells could be used to measure the use of underpasses not subject to video-surveillance. This system would however be less effective as it would not provide information on species use or behavioural response.

Purchase costs of a single video-surveillance system are approximately $13 000. Operating costs would require one-man year at a cost of $20 000 and overhead costs of about $10 000 per year of monitoring.

7.1.2 Fencing and one-way gates

The best means of measuring the responses of animals to fencing is through the use of track counts. The focus of this evaluation will be to determine the approach and avoidance behaviours of animals to wildlife fencing.

Because of expected low use, mechanical counters could be employed to measure the passage of animals through one-way gate structures. Sand beds could be set on either side of the one-way gates as a check against mechanical counters.

7.1.3 Texas gates

Monitoring of texas gates is a problem because of automobile passage through these structures and the use of techniques such as video-surveillance or photocell counters is not recommended. Instead, a programme of track counts in the winter months and the possibility of using sand beds in other seasons is suggested. While this technique will not provide information on numbers, sex and ages of animals crossing these structures, it could indicate whether they were effective in deterring animal use.

A research programme could be established to study the behavioural responses of released deer and elk to texas gate structures. Such a study should be conducted away from the Trans-Canada Highway to avoid possible collisions with automobile traffic.

7.1.4 Future Research in the Bow Valley

The restriction of animal movements to underpass crossing points and the potential reduction of animal mortality on the Trans-Canada Highway may have significant long term effects on ungulate populations and range conditions in the Bow Valley. In order to address this question, several areas of long term research needs have been outlined.

Records of wildlife mortality on the TCH should be continued. Comparison of these results with past data will indicate the success of fencing and underpasses in reducing the number of animal kills on the highway. More information on large mammal population dynamics and distribution is necessary before any long term changes resulting from highway construction can be ascribed. Large mammal species management plans are needed that focus on specific management objectives. Habitat conflicts with proposed developments should be outlined and placed into the context of an overall habitat management plan for the Bow Valley.

Several other areas of research are suggested. The potential for predator-prey interactions could be studied by means of the video-surveillance system. The reactions of bighorn sheep to highway underpasses in Phase II also warrants investigation and heart rate telemetry studies may be useful in conjunction with video-surveillance at these locations.

In conclusion, the construction of wildlife defence structures along the Trans-Canada Highway in Banff National Park represents the first major effort of alleviating the problem of wildlife mortality on a major highway system in Canada. Given the precedent established as to the importance of mitigative measures in this project, monitoring efforts should also reflect a similar level of commitment towards assessing the effectiveness of mitigation. A two phase approach incorporating short term and long term objectives allows for the determination of both the initial and the potential lasting effects of highway construction on wildlife populations in the Bow Valley. The video-surveillance system presented in this document is the best means of determining the responses of animals to underpass structures. Track counts and the use of mechanical counters can provide an adequate assessment of the response of animals to fencing, one-way gates and texas gates. An experimental study of the responses of released animals to texas gates could provide additional information on the effectiveness of these structures. Together these techniques satisfy the short term objectives of the wildlife monitoring programme. The long term objectives can be addressed through a number of recommendations which include the need for better population data, the need for species management plans, specialized research on predator-prey interactions and responses of bighorn sheep and a habitat management plan identifying range conditions and areas of development conflict in the Bow Valley.

If a concerted effort is directed towards the monitoring of wildlife defence structures on the TCH, then the ongoing effectiveness of mitigative measures can be assessed. This will ensure that construction and operation of the Trans-Canada Highway Twinning Project can be compatible in the long run with the existence of wildlife populations in the Bow Valley.

7.2 Recommendations

1. The implementation of wildlife mitigation measures in Banff National Park is unique and efforts should be directed towards the establishment of a monitoring programme that will adequately measure the effectiveness of mitigation.

2. Monitoring of wildlife defence structures should be a quantitative and easily replicated exercise. Results from the monitoring programme should be made public. Lessons learned from this project should be applied to similar projects elsewhere in Canada.

3. Monitoring should identify species use and behavioural responses of animals to underpasses, fencing, one-way gates and texas gates.

4. The choice of a video-surveillance system is the only technique of those assessed that will adequately determine the effectiveness of wildlife underpasses.

5. A 12 volt video-surveillance system is recommended over a 120 volt system to monitor wildlife use of underpasses on the TCH. Capital costs of equipment are approximately $13 000 per system. Operating costs are estimated at $30 000 per year.

6. Fencing, one-way gates and texas gates should be monitored by means of track counts. Mechanical counters could also be placed in one-way gates as a check against track counts.

7. An experimental study should be established to research the responses of released animals to texas gate structures.

8. Recording of wildlife kills on the TCH should continue. Comparison of this data to wildlife mortality figures prior to highway twinning will indicate the effectiveness of mitigative measures in reducing highway mortality.

9. Monitoring of mitigative measures in Phase II should ascertain their use by bighorn sheep. Video-surveillance of underpasses structures in Phase II could be continued from Phase I.

10. Baseline studies in Phase III from the Sunshine Turnoff should determine the need for and extent of wildlife defence measures in this section.

11. Management plans should be developed for large mammal species in the Bow Valley. These should specify management objectives for each species and identify programmes to meet these objectives.

12. The population dynamics and distribution of large mammals, particularly the ungulates, in the Bow Valley are not clearly understood. Programmes should be undertaken to increase the knowledge of large mammal distribution and population dynamics in order to ascertain the long term effects of highway construction in the Bow Valley.

13. Aerial surveys in the Park should follow standardized procedures. Survey results should be subject to statistical analysis in order to compare the results of replicate surveys.

14. The potential for predator-prey interactions at underpasses could be studied by means of video-surveillance. Valuable information could also be gained on carnivore distribution and behaviour.

15. A habitat management plan should be developed. Critical wildlife habitats should be outlined and areas of development conflicts should be identified. Monitoring of browse and grazing plots along the TCH should be continued.

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APPENDIX 1

Wildlife Defence Systems in Other Countries

Wildlife mortality is a recognized problem on highways in countries throughout the world. With the exception of the United States, Canada and Sweden, very little is being done to alleviate the situation.

Dagg (1977) states that wildlife automobile accidents are just as prevalent in Europe as North America with over 23 000 reported accidents occurring every year. This compares to a figure of 45 000 to 90 000 wild animals killed annually on roads in Canada (Damas and Smith 1983). In Germany, annual road losses of 800 fallow deer, 60 000 roe deer, 1000 wild boar and 120 000 hare were reported, while in Denmark vertebrate losses on roads increased from 7.5 million to 10.5 million between 1957 and 1965. Bannikov (in Dagg 1977) reported that 26 per cent of all moose in the Moscow region were killed on highways or railways while in Sweden hundreds of reindeer are lost every year to road and railway accidents (Klein 1973). Flygare (1979) reported that in 1977, 6400 ungulate mortalities occurred on Swedish highways with 50 per cent of all accidents involving moose. The average cost to motorists of ungulate highway accidents in Sweden was $1460 (1977 Canadian$).

In Australia, Coulson (1981) reported that the majority of road accidents in Victoria involving kangaroos go unreported and that the impact of automobile accidents on macropod populations was unknown. Macropod and feral pig losses are also high in the state of Queensland but the situation is regarded more as a nuisance rather than as a problem.

In the United States, most concern is expressed over deer losses on Interstate highways, particularly in the states of Pennsylvania, Wisconsin, Colorado, Michigan, Wyoming, Utah and California. An average of 22 000 white-tailed deer were killed annually on highways from 1967 to 1971 in Pennsylvania (Puglisi et al 1974). On Interstate 80 in Wyoming, 571 mule deer were reported killed on a 88 km stretch of highway between 1967 and 1975 (Goodwin and Ward 1976) and between 1970 and 1978, a total of 1005 deer, 160 pronghorn antelope and 19 elk were reported killed (Ward et al 1980). While this discussion is by no means exhaustive, it does give an indication of the extent of mortality occurring on U.S highways. This is largely reflective of the greater abundances of larger mammals, particularly the ungulates, in North America.

1. Effectiveness of Mitigative Measures

Harrison et al (1980) provides a good review of potential mitigative measures for alleviating wildlife mortality on highways. For a description of these techniques the reader is referred to that document. The following discussion will centre on a review of the effectiveness of these measures undertaken primarily in Colorado and Wyoming in the United States.

1. Underpasses

Results of underpass testing to permit ungulates access across major highways has been reported by Reed et al (1975), Reed (1980), Reed (1981), and Ward et al (1981).

A concrete box underpass (3.05m high x 3.05m wide x 30.5m long), located near Vail Colorado, has been monitored over a ten year period from 1970 to 1979 (Reed 1981). In addition, eleven other underpass structures were periodically monitored from 1968 to 1979. Track counts and photocell counters were used at the Vail underpass from 1970 to 1972 and a video time lapse system was installed between 1972 and 1973. Visual observations were made for 0500 to 0700 hours during the spring-summer migration period at the Vail underpass from 1974 to 1979. Track counts were undertaken periodically throughout the year at the other underpass locations and at weekly intervals during deer migration periods. The Vail underpass has been successful in permitting 61 per cent of the local deer population across the highway (Reed 1975). Behavioural responses of deer to the Vail underpass have not changed substantially in the ten years of spring-summer use. About 75 per cent of the deer exiting the underpass were reluctant, wary or frightened. Reed (1981) attributed the small size of the underpass as the reason deer were reluctant to make use of the structure during the migration period.

Regular daily morning inspections were made of underpasses along Interstate 70 in Wyoming (Ward et al 1980). Track beds were established at the entrances of three bridge type underpasses and one concrete box type underpass and track counts were made daily. Difficulties were encountered with heavy deer use, drifting snow and poor weather conditions. An automatic day night super 8 mm movie camera was installed at two underpasses from April through June 1979. An average of 1604 passes were made through three bridge type underpasses and four concrete box underpasses in the fall and winter periods of 1977 to 1978 and 1978 to 1979. Similarly, an average of 884 passes were made in the spring of 1978 and 1979. Use of the bridge type overpass versus the concrete box type was 63 per cent:37 per cent in the fall and winter of those two seasons and 93 per cent:7 per cent during the spring months (Ward et al 1980).

2. Fencing and One-way Gates

Fences greater than 2.5 m in height have been demonstrated to be effective in reducing wildlife access to highway corridors (Harrison et al 1980). Using a minimum benefit cost ratio of 1.36:1, Reed et al (1982) stated that 5, 10 and 15 dead deer/km of highway/year were the minimum number of animal deaths necessary to justify 2.4 m fencing on one side of the highway, on both sides and on both sides with an underpass respectively. Costs included both the costs of vehicle repair and the economic value of deer.

Six 2.4 m high fences were evaluated along I-70 in Colorado as to their effectiveness in reducing animal mortality (Reed 1980). Deer in the vicinity of fences were marked with numbered neck bands or automatic tagging devices (Siglin 1966). Radio-collars were also placed on doe mule deer and their movements were followed in relation to the fence line. No statements were made regarding the relative success of these techniques in assessing the effectiveness of fencing. A cumulative average reduction of 78.5 per cent (range 67.8 per cent-86.5 per cent) in deer mortality was recorded in fenced locations.

Ward et al (1980) monitored deer movement in relation to a 12.6 km stretch of fence along I-80 in Wyoming. Twenty deer were marked with collars or ear tags and 41 animals were fitted with radio-collars. The authors concluded that the results of the tagging programme were quite inefficient compared to the results of radiotelemetry.

The use of eight one-way gates installed in fencing along I-70 near Vail, Colorado was recorded by Reed et al (1974a). Track beds were established at the entrance and exit of each one way gate and checked against a mechanical gate counter. A total of 558 passages were recorded between 1970 and 1972 of which 96 per cent were in the one way direction for which the gate was intended.

One-way gates were also installed along the experimental 12.6 km fence of I-80 in Wyoming but no results of their use by deer was reported (Ward et al 1980).

3. Deer Guards

Reed et al (1974b) report on the effectiveness of cattleguard structures to prevent the movement of deer and elk across access roads leading off a major highway. The deer guards consisted of flat steel rails arranged perpendicular to traffic flow and were of three lengths (3.7m, 5.5m, and 7.3m). The authors conclude that 89 per cent of all animals tested either walked, trotted or bounded across the structures. The length of the cattleguard did not appear to be significant and deer did not show any attempts to jump across the structure. Deer were observed using their dew claws to successfully cross such structures and may do so in other cattleguards where flat steel rails are employed.

Harrison et al (1980) state that conventional texas gates are not effective in preventing movements of ungulates across roadways. However, a modified texas gate structure has worked successfully over a number of years in Elk Island National Park. This structure, which used 7.6 cm diameter steel pipes rather than flat steel rails, was five to six metres in length and had a 3 m pit dug beneath it. The pit served as a deterrent towards attempted crossings as it created an uncertainty in footing for the animal. In addition, the longitudinal support beams were placed in such a fashion that the animals could not walk on them (Harrison et al 1980).

While a similar type of structure may be successful in containing deer movements across access roads on the TCH, the safety aspects of permitting passage of all types of vehicles must be considered. Gates could be placed at the sides of deer guards to allow passage by visitors on foot.

APPENDIX 2

Ungulate behaviour and the design of underpass structures

Recent developments in the study of animal behaviour have begun to incorporate a holistic or systems approach towards understanding why animals act in the way they do. This approach has taken its cue from many scientific disciplines ranging from molecular biology and physiology to ethology and human sociology resulting in the creation of a new discipline which Wilson (1975) termed sociobiology. Sociobiology attempts to explain the actions of individuals and the resultant social behaviour of groups in terms of enhancing the reproductive fitness of the individual, or the ability of the organism to express its genes in subsequent generations. In order to maximize fitness, the actions of individual animals are organized into adaptive strategies which incorporate a variety of behavioural responses and body features thereby enabling the individual to adjust best to its immediate surroundings (Geist 1982). These adaptive strategies couple the innate results of genetic and social inheritance with the individuals learned responses as dictated by the demands of the ambient environment. The concept of species adaptive behavioural strategies is a new one in ethology and one that is just beginning to be both understood and applied by wildlife managers.

This statement is particularly true with regard to the design of wildlife underpass structures across major highway routes. Early designs of wildlife underpasses near Vail, Colorado did not incorporate principles of animal behaviour such as anti-predator and security strategies and limited use by mule deer over a ten year period demonstrate their ineffectiveness (Reed et al. 1975). About 75 per cent of deer leaving the underpass structure showed signs of uneasiness and this

(Schultz and Bailey 1978).

Flight distance is defined by Altmann (1958) as the distance to which a person can approach an animal without causing it to flee. Schultz and Bailey (1978) found that flight distances for elk were greater for an approaching person than an approaching vehicle in Rocky Mountain National park. Altmann (1958) found that flight distances varied in relation to differences in seasonal behaviour, nutrition and habitat as well as differences in learned behaviour by the individual or group. The acceptance of human activity by elk and their responses to underpass structures may vary both by sex and by season. Thus the security requirements or differing flight distances will reflect the seasonal differences in timing between the sexes.

Elk are a very gregarious species but they exhibit great variability in socialization between the seasons, sexes and populations (Peek 1982). Elk characteristically segregate their habitat utilization by sex, coming together as a group during the short period of the rut in the fall. During the winter months, females group together in open grasslands as an anti-predator strategy (Geist 1982).

Males segregate from cows, forming groups after the rut which dissolve once antler drop occurs. Bulls then become solitary animals, compromising security in favour of forage quality (Geist 1982). Bulls firstly must not compete with females and secondly must maximize antler growth so as to become a competitive force during the rut.

During the winter months, snow depth is the major factor limiting the distribution and movement of both sexes. Snow depths of over 71 cm are critical to elk and depths over 76 cm severely curtail movement and impose heavy energetic demands (Skovlin 1982).

response has not changed significantly between 1970 and 1979 (Reed 1981). Geist (1979) in his submission to the Environmental Assessment Panel reviewing Phase I of the TCH, stressed that underpass design should reflect species security strategies in order that they be successful in facilitating animal passage.

Designs of underpass structures constructed in Phase I of the TCH do incorporate principles of animal behaviour as evidenced by the large culvert structure at Morrison's Coulee (4.27 m diameter). However, in order that these structures be successfully used by ungulates and other wildlife species, the surrounding landscape should also incorporate features of the animals security strategies. This section will briefly review the security strategies of major ungulate species present in Phase I - the elk, mule and white-tailed deer and moose. Recommendations will also be made on landscape design that takes into consideration the adaptive strategies of these four species. This approach will not present an in-depth review of the ecology of each species, but will rather concentrate on aspects of animal behaviour applicable to the design of underpass structures and the surrounding landscape.

1. Elk

Elk are an ecotone species adapted to an existence in both forest and open plain habitats (Geist 1982). In response to the complexity afforded by this environment, the species adapts readily to new situations and learns quickly as evidenced by its acceptance of human activities in National Parks. Furthermore, this ability of elk to tolerate and adapt their behaviour to the presence of humans seems to be a characteristic more so of unhunted rather than hunted populations

During the birth season, female elk remove themselves from the group and seek out isolated, but secure places to calf. Female elk and their calves again form groups in open areas about three to four weeks after parturition, again as an anti-predator strategy rather than a foraging preference. Bulls avoid females so as not to directly compete with those of close genetic stock and seek solitary lifestyles in habitats that offer better quality forage.

Elk are commonly seen along the grassy edges of the Trans-Canada Highway. Given their tolerance of humans when not hunted and their capacity for learning new situations, elk should adapt quickly to underpasses and fencing.

2. Mule and White-tailed deer

Mule and white-tailed deer differ greatly in their anti-predator strategies and this is reflected in their differing tolerances of human activity. Although much is known about the biology of these species, their security strategies are not well understood.

Mule deer are neither a highly gregarious nor a strictly solitary species (Mackie et al. 1982). It is suspected that the social organization of mule deer consists of female clans related by maternal descent. Bucks disperse as individuals or gather in groups of unrelated animals (Geist 1981). Bucks generally roam further and have larger home ranges than females (C. Yarmoloy pers. comm.).

Mule deer attempt to detect danger from long distances through their excellent vision, hearing and use of wide open habitats. They avoid predators through a complex pattern of evasive movement termed "stotting" which allows rapid vertical ascents of steep slopes (Geist 1981). This requires precise timing and a calm disposition in the face of danger.

Mule deer adapt very well to the presence of human beings when unhunted as in the Rocky Mountain National Parks. These animals are commonly seen in Waterton townsite where they calmly walk along town streets and bed out on the green lawns of residential homes (Geist 1980). It is this adaptable trait of the mule deer that will likely enable them to make better use of the underpasses along the Trans-Canada Highway than the more wary and cautious white-tail.

In contrast to the mule deer, white-tailed deer are shy, secretive and generally elusive (Hesselton and Hesselton 1982). They are much more excitable and rely on speed and quickness to outrun a predator rather than the uncertainty in movement and direction exhibited by mule deer. White-tails have a well developed system of trails, allowing for a quick and unimpeded escape. Normally they conceal themselves in the day and venture into open fields under cover of night. They will form large secure groups if forced to winter out in the prairie (Geist 1981). The lower threshold of excitement in white-tailed deer makes them less tolerant of human activity than the calm disposition of the mule deer. Because of this reason, they may not adapt as readily to underpass structures on the Trans-Canada. This statement cannot be substantiated until monitoring results are available from Phase I.

3. Moose

Although much is known about the ecology of the moose, little work has been attempted on determining the importance of anti-predator strategies to the species. Moose are a pioneering species, frequenting successional habitats such as burns, logged-over areas and avalanche slopes. They are essentially solitary in their habits and generally exhibit movements between several seasonally distinct home ranges (Franzmann 1978). Moose do not seem to be territorial and their home range rarely exceeds 5-10 sq. km . (Le Resche 1974). However, they do appear to maintain an individual distance into which they are reluctant to accept visitors (Geist 1963).

Compared to the elk, moose show little tendency to aggregate in large groups or exhibit a rigid social organization. The basic social unit is the cow-calf association which is maintained throughout the year until prior to the next birth season when the mother becomes aggressive and chases off her calf. After parturition, the mother and newly born calf remain together and moose do not form post-calving aggregations as do elk. Traditional movement patterns may persist over several generations and are likely passed onto the calves as they accompany their mothers.

Unlike male elk, bull moose do not assemble large harems but form rutting groups ranging in size from two to thirty animals (Geist 1963; Coady 1982). After breeding, males band together in loose groups with individuals leaving and returning to the groups throughout the day. In summer, bulls become single and search out areas of high quality forage where they can maximize their growth in preparation for the rut.

Moose will bear either a single calf or twins, depending on the abundance of forage. Moose adapt by maximizing reproduction and favouring dispersal of juveniles which chance upon newly created seral stands of plant succession (Geist 1978). Conversely, in stable habitats such as the Bow Valley, where carrying capacity for moose is currently decreasing, selection will favour long lived cows that bear a single large young (Geist 1974).

Because of their large size, generally solitary nature and tendency to frequent ecological "hotspots", or areas of high productivity, the anti-predator strategies of moose may assume a secondary role behind their foraging strategies. However as they feed, moose are experts in using terrain such as burn areas, willow thickets and waterbodies to hinder predators (Geist pers. comm. 1981).

At the present time, moose are not common in the Bow Valley with most animals being found west of the Banff traffic circle in the Vermilion Lakes area. Little use of fencing and underpasses is expected by moose in Phase I of the TCH Twinning Project.

Landscape Design Recommendations

Based on the adaptive strategies of these four species, generalized statements can be made with regard to the design of the landscape immediately surrounding the underpass structures. Since these strategies differ significantly among these species, compromises will be necessary, but perhaps can be accommodated without significantly reducing overall use.

1. Cover to Open Space Ratios

Thomas et al. (1979) have developed a number of practical recommendations to make forestry operations compatible with the preservation and enhancement of wildlife habitat in the Blue Mountains of Washington and Oregon. Special consideration was given to the habitat requirements of deer and elk which are applicable to the TCH situation.

Moose, elk and deer are edge adapted species which benefit from the creation of forest openings that lead to an increase in habitat diversity (Sopuck et al. 1979). The major factor limiting ungulate use of an open area appears to be the requirement of security and this differs significantly from species to species.

Numerous studies have been conducted on the responses of ungulates to forest clearings resulting from forestry operations, and these show that most ungulates prefer moderately sized openings up to 50 to 70 ha in size (Sopuck et al. 1979). Thomas et al. (1980) have tried to relate ungulate security to the distance from cover by defining sight distance which is the distance at which 90 per cent of a deer or elk is hidden from an observer. Hiding cover is defined as the vegetative cover capable of obscuring a standing adult deer or elk from human view at a distance equal to or less than 61 m, or one sight distance. Hiding cover for moose was not described by Thomas et al. (1980) but due to their larger size, a longer distance than 61 m will be required to hide a moose from human view.

Deer appear to be less flexible than moose and elk in terms of their cover requirements and are more restricted to forest edges (Sopuck et al. 1979). Thomas et al. (1980) state that most use by elk and deer occurs within 183 m from the edge between forage and cover areas. In aerial surveys of a 31 km^2 aspen cutover area in northern Saskatchewan, MacLennan (1975) found that deer, elk and moose ranged an average of 49 m, 80 m and 177 m respectively. Deer were significantly closer to cover than expected, whereas elk were considerably further away. The large size of the cutover area may have limited the distance at which ungulates chose to venture from cover. In an analysis of deer and elk clear cuts in Montana, Lyon and Jensen (1980) found that elk had much higher security requirements than did deer. Elk preferred smaller clear cut openings that deer, but were more tolerant of larger openings.

Thomas et al. (1979) state that a ratio of 40 per cent of the land in cover to 60 per cent in forage represented optimum habitat for deer and elk in the Blue Mountains of Washington and Oregon. Of the 40 per cent cover for elk, 20 per cent was in hiding cover, 10 per cent in thermal cover and the remaining 10 per cent either in hiding or thermal cover with the onus on thermal cover in the winter months. Deer cover requirements are somewhat different as they require 20 per cent in hiding cover, 10 per cent in thermal cover, 5 per cent in fawning cover and 5 per cent in either hiding, thermal or fawning cover.

Parker and Morton (1974) found that the optimal size of a clearing for moose was between 40 and 50 ha in Newfoundland. Telfer (1974) suggested that moose could tolerate clearings up to 140 ha, but that the larger areas would not be utilized until after 15 or more years after logging when regrowth of the understory would provide sufficient cover.

Stemp (1983) monitored the heart rates of five bighorn sheep at Ram Mountain, Alberta. Escape terrain was noted to be the most consistent security feature. Only 16.6 per cent of all sheep were seen more than 250 m from cliffs and this was seen as perhaps limiting the ability of bighorn sheep to utilize forage resources.

These studies show that considerable variation in the preferred distance from cover differs within each species due to differences in habitat characteristics, animal densities, hunting pressure and degree of disturbance. Nevertheless, attempts by Thomas et al. (1979) to make some practical recommendations regarding the ratio of open spaces to cover does involve some compromise. For optimal use of underpasses along the Trans-Canada Highway it may be useful to adopt some of the recommendations of Thomas et al. (1979) with regard to cover requirements.

1. No portion of the underpass should be more than three sight distances or 183 m from cover.

2. Areas of cover in the vicinity of underpasses should have a diameter of 183 m providing an interior zone of 0.3 ha which would obscure the animal from all directions.

3. The tree planting scheme should not impede an animals ability to see a route through the underpass to the other side of the structure.

2. Footing

Geist (1979) stressed that careful attention should be paid to footing across the underpass structure so that it is compatible to the surrounding landscape. Bridge surfaces are covered with soil in Norway to enable reindeer to cross over streams where controlled water levels have made fording impossible (Klein 1971). Reindeer would not cross over a wooden surface since the sound of their hooves presents a situation analogous to an uncertain crossing over ice covered ground.

Evidence of frequent ungulate crossings of the Trans-Canada Highway in Phase I demonstrates that the contrast between the hard asphalt surface of the highway and the softer ground of surrounding terrain can be tolerated. However, it is likely that the animal is wary upon crossing such a different type of surface. The minimizing of contrast in footing at underpasses will likely reduce the wariness of ungulates encountering these structures and may aid in facilitating passage.

Once completed, the floor of the Carrot Creek underpasses may require some type of modification. Ward et al. (1980) found that elk preferred to cross perpendicular to streams rather than parallel to them as the noise of the running water hinders their hearing. The construction of a small berm parallel to the creek to act as a noise dampener and the use of a small backhoe such as a "bobcat" to excavate a small trail would greatly enhance animal use of this structure.

3. Tree planting

Selective tree planting will aid to shield animals from the visual disturbance of oncoming traffic and will provide cover in open areas Such cover may also be beneficial to carnivores in ambushing their prey.

Where the headlights of approaching vehicles may be distracting to ungulates in the fenced median area, small enclaves of conifers should be considered. Tree planting would also aid in lessening traffic noise that may be distracting to ungulates.

Tree planting should be considered in the median between opposing traffic lanes at the Carrot Creek, Morrison's Coulee and Duthil Flats underpasses. This will greatly reduce the linear perception of wide open spaces on either side as an animal exits from an underpass structure onto the median. A mix of both coniferous and deciduous trees could be used to accomplish this purpose.

4. Trails

Trails could be constructed or upgraded at the entrances and exits of underpasses as a means of improving animal passage. Ward et al. (1980) found that elk preferred slopes of less than 20 degrees perpendicular to roads whereas mule deer showed no preferences towards slopes.

Trails should not exceed 20 degrees in order to receive optimal use by elk. Again, the use of a "bobcat" or hand construction techniques would be preferred to minimize the surface disturbance to the surrounding area.

APPENDIX 3

Estimated photovoltaic requirements for a 12V video system

1. Total load (camera + VCR) = 53 watts

2. Load estimate (5 min/hr x 24 hrs.) = 2 hours

3. Total load = 53 watts = 4.42 Amps @ 12 V

4. Use = 4.42 Amps x 2 hours = 8.84 Amp-hrs./day

5. Photovoltaic Panel yields 9.2 Amp-hrs. each day (average annual value) for a cost of $4000

APPENDIX 4: Videotape requirements of the video-surveillance system

1. Assume timer runs camera at one minute intervals an average of five times per hour = 5 minutes playing time/hr

2. In a 24 hour period = 120 minutes or two hours playing time per day

3. An average tape consists of 8 hours of playing time and would last for four days before replacement is needed

APPENDIX 5: SUMMARY OF WILDLIFE MONITORING TECHNIQUES

The purpose of this section is to provide the reader with a concise summary of all the wildlife monitoring techniques discussed in Chapter 5 of this document. It is organized to allow an easy comparison of the relative merits and drawbacks of each technique. Potential uses of each technique are suggested for the monitoring of wildlife responses to animal defence structures on the Trans-Canada Highway.

1. Aerial Surveys

Advantages

- useful for covering large geographical areas
- replicate surveys can provide an indication of ungulate population trends in the Bow Valley
- time efficient if funds are available to cover aircraft rental
- habitat preferences of animals can be determined
- can determine animal densities in a given survey area

Disadvantages

- not suitable for determining wildlife use of underpasses
- costly ($550+/hr for helicopter, $200+/hr for fixed wing)
- subject to visibility and observer biases
- restricted primarily to ungulates, some ungulate species are more visible than others
- limited to winter months
- limited behavioural observations are possible from the air

Potential Uses

- census programmes to determine population trends Such a programme should employ a statistical base
- could be used to indicate the presence of animals in relation to fencing and underpasses on a regional basis This would determine whether animals were avoiding underpasses and fencing or were not present in the vicinity

2. Roadside Surveys

Advantages

- relatively inexpensive to perform in comparison with other techniques
- allows for limited behavioural observations if animals are present
- relatively easy to obtain accurate age and sex ratios of observed animals compared to techniques such as aerial surveys
- could obtain visual observations of animal responses to fencing and underpasses

Disadvantages

- presence of observer may bias observations
- does not provide a continual record of animal use
- if tracks and sign are to be examined the utility of this technique is limited to periods of adequate snow cover
- safety aspects of driving highway shoulder should be considered

Potential Uses

- baseline studies to determine animal crossing areas eg. Phase III
- could be established as part of a track counting programme to measure animal responses to fencing

3. Pellet Counts

Advantages

- easy to perform
- inexpensive in terms of equipment needs
- can provide trends in seasonal habitat use
- if permanent transects are employed, year to year comparisons are valid

Disadvantages

- restricted to ungulates
- manpower intensive
- subject to observer and visibility biases
- an index of use not an estimate of numbers
- does not provide information on wildlife use of and responses to fencing and underpasses

Potential Uses

- long term use of habitat types in the Bow Valley
- could be useful technique if funds are limited but manpower is readily available

4. Track counts

Advantages

- easy to perform
- low equipment costs
- could provide useful information on animal responses to fencing
- can provide indication of approach-avoidance behaviour to underpasses and fencing

Disadvantages

- index of use not an estimate of numbers
- subject to suitable snow conditions in winter, sand traps could be used in summer months and at localized points such as underpass entrances and exits
- cannot determine age and sex of animal
- some species identification is difficult

Potential Uses

- to determine animal responses to fencing
- to determine indication of use of one-way gates

5. Radiotracking

Advantages

- accurate locations of study animals possible
- useful for studies of secretive and wide ranging animals
- determination of home range size and movement patterns possible
- system could be automated to record presence of animal at a particular location

Disadvantages

- manpower intensive
- equipment costs high
- limited to small sample sizes
- not useful for determining use of underpasses by wildlife
- battery life on collars is restricted

Potential Uses

- study of animal movements in and out of park boundaries
- study of wide ranging species such as grizzly bear and cougar
- locations can be pinpointed to allow visual observations

6. Heart Rate Telemetry

Advantages

- heart rate is a good correlation of stress
- provides quantitative comparison to overt behavioural observations
- may indicate stress conditions exist when overt responses do not

Disadvantages

- costly
- requires specialized equipment and expertise
- only small numbers of animals can be followed
- time intensive both to collect and analyze data

Potential Uses

- could be considered if shown that animals are not using structures
- research on the physiological responses of animals to underpass structure types
- research on the responses of bighorn sheep to overpasses in Phase II

7. Photocells

Advantages

- inexpensive to deploy
- has been used previously by Parks Canada to record hiker use of trails
- provides quantitative assessment of number of animals passing through a particular location
- low maintenance

Disadvantages

- does not indicate species, age and sex
- no information on behaviour possible
- not useful for assessing responses to fencing

Potential Uses

- could be used to record animal passage through underpasses, overpasses or texas gates when information on species, age and sex is not required
- could be used at underpass locations not subject to video surveillance

8. Photography

Advantages

- can identify animals by species, sex and age
- allows for analysis of overt behavioural responses
- provides lasting record on film or videotape
- relatively easy to operate and maintain

Disadvantages

- equipment and film costs high
- requires analysis of film or videotape
- could be manpower intensive
- power a problem if AC system used
- film needs changing every five to seven days

Potential Uses

- behavioural responses to underpass and overpass structures
- identification of animals by species, age and sex
- determining differences in use of structure types (eg. culvert vs. open span bridge)

APPENDIX 6: IMPROVING THE ACCURACY OF AERIAL SURVEYS

The following recommendations are provided to minimize observer bias in order to strive for a precision within 20 per cent of the mean at the 95 per cent CI. For further aspects on the use of aerial surveys refer to Stelfox and McGillis (1977).

1. Fly preestablished transects marked on 1:50 000 topographic maps.

2. Employ the use of standardized transect widths or quadrats. (eg. 200m either side of the aircraft)

3. Fly at an established altitude (eg. 150 m AGL). Mark aircraft struts with tape so that the transect width is demarcated at flight altitude (see Stelfox and McGillis 1977).

4. Maintain a standard speed (eg. 160 km/hr).

5. Standardize the use of survey aircraft. Helicopters are preferred to fixed-wing aircraft in mountainous terrain.

6. Maintain the use of the same pilot where possible to minimize navigation error.

7. Employ the use of two observers and a navigator. The navigator should record all observations onto topographic maps. The use of a mylar overlay may be useful to reduce costs.

8. Ensure that repeated surveys in successive years are undertaken at the same time of year.