THE UNIVERSITY OF ALBERTA

Managing the Avalanche Hazard Faced by Backcountry Skiers

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

Department of Geography

EDMONTON, ALBERTA

Spring 1986

ISBN 0-315-30234-8

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR Lyle Arthur Sutherland

TITLE OF THESIS Managing the Avalanche Hazard Faced by Backcountry Skiers

DEGREE FOR WHICH THESIS WAS PRESENTED Master of Science

YEAR THIS DEGREE GRANTED Spring 1986

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Managing the Avalanche Hazard Faced by Backcountry Skiers submitted by Lyle Arthur Sutherland in partial fulfilment of the requirements for the degree of Master of Science.

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Date...January 24, 1986.........

Abstract

Three major objectives were addressed in this study of backcountry skiers in Banff National Park. The first objective was to determine backcountry skiers' perceptions of avalanche hazard, while the second was to determine the levels of avalanche knowledge possessed by the skiers and identify characteristics of the skiers related to avalanche knowledge. The last objective was to evaluate the effectiveness of present Parks Canada programs treating avalanche hazard and provide suggestions to improve the programs. While addressing these 3 objectives, it became evident that avalanches differ from other natural hazards in some important ways.

With respect to the first objective, several major conclusions may be made. First, avalanches are a salient major concern among skiers in the study area. Second, skiers tend to overrate the frequency of avalanches relative to expert opinion. Finally, several aspects of skiers' perceptions of avalanches were discussed Skiers tend to perceive that avalanches are a large phenomenon that only rarely pose a threat. The skiers in the study area seem to be aware that avalanches can pose a recognizable risk, but they believe that avalanches are unlikely to pose a problem to themselves personally.

To fulfil the second objective, several different indicators of avalanche knowledge were identified. These dealt with assessing the avalanche hazard, the decision to cancel or modify a trip and route selection. On an overall basis, the avalanche knowledge level of the respondents was poor, but it did improve as avalanche risk in the areas generally used increased. However, five characteristics of the skiers were identified which were strongly related to the indicators of avalanche knowledge. These were:

- reading of material dealing with avalanches
- previous avalanche involvement
- taking of avalanche safety courses
- being well equipped
- obtaining avalanche information.

Those with the higher ratings in these characteristics would generally have the best avalanche knowledge. Education, ~~in terms of reading~~ avalanche material and taking avalanche courses, appears to be the most important predictor of avalanche knowledge.

Relative to the third objective, it was found that skiers generally have a favorable opinion of the Parks Canada programs, but people often were not familiar with specific programs and often did not make use of services and information which they knew were available. Most improvements suggested by skiers dealt with improving access to more detailed information. The primary solutions suggested in this study were development of a ski information centre and installation of trailhead signs.

Finally, it has been shown that there are some important differences between avalanches and other natural hazards. For natural hazards in general, most people are ignorant of the character and extent of the hazard(s) for the area in which they reside and work on a permanent basis, while many think that the responsibility for hazard mitigation lies with the various levels of government, not the individual. In contrast, exposure to avalanches is on a temporary, recreational basis. It has been shown here that people tend to choose the level of avalanche risk to which they expose themselves in direct relation to their avalanche knowledge. Generally as avalanche risk faced increases, skiers make a greater effort to learn more about protecting themselves. People are self-motivated; since this is a voluntary, recreational activity from which they gain much pleasure. Management programs such as a ski information centre and trailhead signs are likely to attract their attention and voluntary participation.

Acknowledgements

I would like to thank a number of people who provided assistance during the course of this study.

First, I gratefully acknowledge the support provided by my supervisor, Dr. Harry McPherson. He provided guidance throughout the project and was always available when I needed to consult with him. The prompt return and constructive criticism of several drafts of the thesis were greatly appreciated. Also, I would like to thank my committee members, Dr. Denis Johnson and Dr. Jim Butler for reviewing the thesis.

I was fortunate to obtain assistance from several of my friends in areas where my skills are lacking. My skiing partner, Al Winter, spent many hours designing and testing the electronic equipment used to count the skiers along the trails. Rob Story and Joy Haxton lent their artistic skills, aiding in the development of the figures used in this thesis. Sharon Fowler typed portions of the thesis when time became a pressing factor.

Parks Canada personnel, notably Clair Israelson, Gord Irwin and Emile Yurasek, provided support which was greatly appreciated. Their aid was a major benefit to this study.

Finally, I must thank my wife, Anna, for her patience and moral support, even when it seemed that the thesis would never be completed.

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1. Introduction

1.1 Background and Objectives

Winter backcountry recreation has become increasingly popular in the last decade, particularly in mountainous areas (Valla 1980; Ward 1980; Spear 1981; Parks Canada 1984). With this larger number of people in areas subject to avalanches, there has been an increasing number of avalanche accidents (Williams 1978a; Armstrong 1981; Daffern 1983). Many of these accidents occured during periods when professional forecasters were aware of the high avalanche hazard (Gallagher 1967; Williams 1975; Stethem and Schaerer 1979, 1980), but the backcountry travellers, at least those involved in accidents, either were unaware of the risk or ignored the known risk for some reason.

The reasons why the backcountry travellers were unaware of the risk or chose to ignore it have not been previously studied in detail. Avalanche research, to date, has been directed toward the assessment of snow stability, avalanche triggers, protection of structures, avalanche control by explosives and other means, land use planning, techniques for search and rescue of victims and other similar topics (Schaerer 1962; Fraser 1978; Ives and Krebs 1978; McClung 1978; Norem 1978; Perla 1978a; Perla and Martinelli 1978). This study was focused on the human aspects of avalanche research, specifically the backcountry skiers' awareness, perception and knowledge on which to base decisions with respect to avalanches. Only backcountry skiers were considered, since they constitute the largest group of winter backcountry users in mountainous areas and they are readily identifiable.

Studies that have been published on backcountry skiers have been only case histories or summaries of past accidents (Williams 1975; Stethem and Schaerer 1980; Armstrong 1981; Williams and Armstrong 1984), with only a few exceptions such as Daffern (1983), who was one of the first to recognize the importance of providing information to the recreational audience, with his guide to avalanche safety for skiers and climbers. In the more general field of natural hazards research, there have been numerous studies concerning environmental risk.

Many studies have discussed user attitudes and perceptions of hazards other than avalanches (e.g. Saarinen 1966, 1982a; Jackson and Mukerjee 1974; Jackson 1981).

However, avalanche risk differs from other hazard risks in some important ways. The major difference between avalanches and other hazards is that the skiers move through the zone of risk and can control the level of risk in a relatively short time frame (much like a driver on a busy highway) as opposed to the more or less permanent assumption of risk associated with fixed residence in an area subject to commonly studied hazards such as floods, drought, windstorms and earthquakes (White 1974a; Burton *et al.* 1978; Kates 1978). Also, exposure to avalanches in the backcountry is generally on a voluntary, recreational basis.

Smutek (1981) argues that most recreational backcountry skiers are not aware of the danger and do not freely and knowingly accept the risk of avalanches. They perceive the hazard level to themselves as being quite low. This perception is similar to that recorded in other hazard studies. Jackson and Mukerjee (1974) concluded from their study in San Francisco that people have a tendency to dismiss the earthquake hazard as not troublesome, and consciously minimize the expected damage that may occur to their properties. This could be explained by the fact that people assume accidents will only happen to others (Burton *et al.* 1978; p. 106).

This research project will be directed toward understanding the backcountry skiers' awareness and perception of avalanche hazard, as well as the knowledge levels of the skiers with respect to avalanche hazard, and the related management implications. There are three major objectives incorporated in this study, which are:

- determine the skiers' perception of the avalanche hazard
- determine levels of avalanche knowledge and identify factors which are related to avalanche knowledge or ability to make avalanche risk assessments
- assess the effectiveness of a set of existing information programs treating avalanche hazard and provide suggestions for improvement.

These objectives are closely interrelated. For example, the first 2 objectives must be achieved before meaningful suggestions can be made to improve the management programs.

The first objective is related to effective management of avalanche hazard. To develop effective programs, one must determine whether backcountry skiers have an accurate perception of the avalanche hazard, and whether they are concerned about the hazard. Salience, awareness and perception influence decisions which could affect the safety of the skiing party. Preparations made by the users to reduce hazard levels may be affected by their risk perception. If it is found that people have inaccurate perceptions of the risk, it may indicate that modifications to present programs or development of additional programs directed toward public safety with respect to avalanches is required.

The second objective is to determine the avalanche knowledge levels of the backcountry skiers and identify characteristics of the skiers which are good predictors of their knowledge. Knowing which characteristics are most closely related to competence or ability to travel safely in avalanche prone terrain could be a key step toward modification of existing or development of new programs intended to improve the level of public safety. To develop effective programs, one must be aware of skier knowledge levels with respect to avalanche safety, typical experience levels of skiers (both in terms of number of years experience and number of encounters with actual or potential avalanche incidents or accidents), type of data collected by the skiers and method of data collection on which risk assessments are based and decision guidelines employed. Only when problem areas are identified can advances be made toward solving them.

Fulfilling the first 2 objectives will partially address the third objective of assessing the effectiveness of existing programs dealing with avalanche hazard and associated safety procedures, while providing some material on which to base suggestions for improvement. This third objective will be addressed more directly by determining user awareness of present programs, obtaining user evaluations of the major program presently in place and obtaining suggestions for future actions both for several specific programs which could potentially be instituted and in a more general context.

1.2 Study Area

Banff National Park was chosen as the study area, since it has a high level of backcountry use in areas potentially susceptible to avalanche. Also, Parks Canada has developed an active management program in an effort to reduce the number of avalanche accidents involving backcountry skiers. Four specific trails or areas used as sites for user interviews were selected in consultation with Parks Canada (C. Israelson, personal communication, 1983; J. Flaa, personal communication, 1984; G. Fortin, personal communication, 1984). The location of the 4 trails within Banff National Park is illustrated in Figure 1.1. These trails are accessible from the highway system in the park on a day use basis, although some people may use the trails to commence multiday trips. Trails or areas selected include Mosquito Creek, Redearth Creek, Bow Hut and the Pipestone trails. There is potential for avalanche accidents in the first 3 of these areas, although they vary somewhat in risk levels. There is no danger of avalanches along the Pipestone trails. The 4 trails were chosen to provide as broad a spectrum of terrain conditions and avalanche risk as possible.

1.3 Thesis Outline

Following this brief introductory chapter, the thesis is broken into several major parts. First, the literature review sets the stage for the study, discussing the work that has been done to date and the relationship of this work to the thesis. The difficulty of managing avalanche hazard in backcountry areas is clearly evident after reading this section. Next, the methodology for this study is presented. The study population is described, along with sample design, development of the questionnaire used to structure the interviews, field testing of the questionnaire and the electronic field equipment, data collection and the preparation of the data for analysis. Third, a more detailed description of the study area and the skiers who use it is provided. This outline of the management scenario is used to present a description of the climate and physiography of Banff National Park, the winter of 1984-85, types of skiing available in the area, the trails at which the interviews were undertaken, the number of people

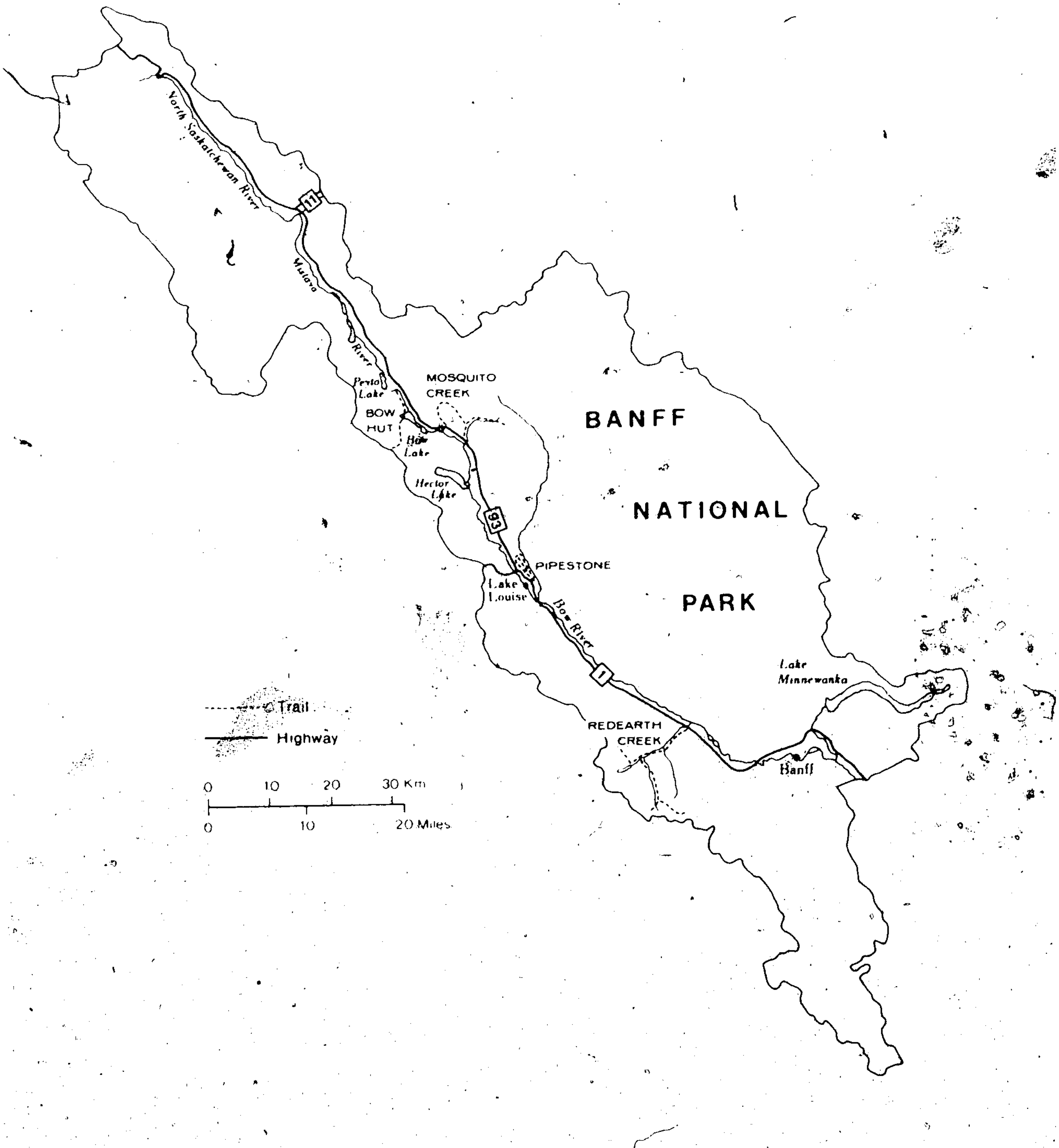

Figure 1.1 The Study Area

using the study trails, the type of people using the trails, several characteristics of the ski parties who use the trails and the types of skiing done on the trails.

The remaining chapters deal directly with the 3 main objectives of the thesis. First, the findings with respect to skier salience, awareness and perception of avalanche hazard are presented. The second objective is treated in 2 chapters, the first dealing with several indicators of avalanche knowledge or expertise (i.e. ability to make decisions that do not lead to accidents when travelling in avalanche prone terrain), and the second outlining some of the factors related to these knowledge indicators. The first of these chapters introduces the indicators of avalanche knowledge used in the study, which are ability to rate the avalanche hazard, history of cancelling or modifying a trip in the past because of avalanche hazard and route selection ability. Scores on these indicators are related to level of avalanche risk faced on the day of the interview to give an overall impression of the respondents' expertise levels. In the second of these chapters, the expertise indicators are compared to a number of skier characteristics to determine which ones best predict avalanche expertise. These factors include staying overnight in the backcountry, previous trail use, past avalanche involvement, experience, being the party leader, avalanche safety education, reading of avalanche material, carrying safety equipment and obtaining information with respect to the avalanche hazard.

The third objective is addressed in a chapter dealing with the role of Parks Canada in avalanche risk management. This chapter opens with a comparison of avalanches to other natural hazards, such as earthquakes and floods, and the management implications. The next major portion provides a history of Parks Canada's programs, followed by a discussion of the survey results with respect to the present programs. The three major areas covered by the survey of importance here are awareness of Parks Canada's programs, comments with respect to the backcountry avalanche hazard forecast and possible future accident likelihood reduction programs. The final portion of the chapter treats suggested methods to improve the Parks Canada programs and to reduce the future number of avalanche accidents. The major findings of the thesis are summarized in the concluding chapter.

2. Literature Review

As outlined in the introduction, there is only a small volume of literature that deals directly with the backcountry skier's perception of avalanche hazard or avalanche knowledge. Fortunately, one may use an oblique approach, and also consider related fields in the literature to supplement that treating backcountry users who subject themselves to the risk of avalanches. These related fields include the natural hazards literature, the risk literature and the wilderness recreation literature.

2.1 Avalanche Hazard Literature

The human aspects of avalanche hazard cannot be divorced from the physical aspects, because of the obvious influence of the latter on the former. A brief summary of the literature pertaining to the physical aspects of avalanches is discussed here to provide a better understanding of how they can affect people, followed by a review of the literature treating the human aspects. Before continuing, it is appropriate to define an avalanche as a mass of snow and any entrained material sliding or falling down a slope.

2.1.1 Physical Aspects of Avalanche Hazard

The majority of the literature which has been published dealing with avalanche hazard falls into this category. The literature treating the physical aspects of avalanche hazard may be subdivided into a number of groups, which include:

- weather and terrain
- snow behaviour
- protection against avalanches
- forecasting
- land use planning
- techniques for search and rescue.

2.1.1.1 Weather and Terrain

Avalanches cannot occur without appropriate weather and terrain conditions. Nine weather related parameters that are generally recognized to be important in avalanche formation include new snowfall depth, snowfall intensity, precipitation intensity, crystal type, new snow density, rate of settlement, air temperature and windspeed and direction (LaChapelle 1966, 1974). These factors, along with terrain, are among those reviewed by respondents in this study when they make their own hazard assessments.

New snowfall has been identified as the single most important cause of avalanches (Perla and Martinelli 1978; Price 1981; Roch 1981). The rate at which snow, and particularly precipitation (measured in water equivalent), accumulates affects the rate of stress application to the snowpack (Atwater 1966; Judson 1967; Perla 1970, 1977). Some snow crystal types in new snow are more likely to promote avalanches than other types (Atwater 1952; Judson 1967; LaChapelle 1969). Higher density new snow is more likely to cause avalanches because of rapid weight accumulation (LaChapelle 1969). Major avalanches can be triggered by rain (Schaerer 1962; Hutcheon and Lie 1978). Rate of settlement is associated with temperature and wind (Perla and Martinelli 1978; Daffern 1983). Low temperatures reduce the rate of settlement and prolong periods of snow instability, while wind tends to increase the rate of settlement. Air temperature is most important in spring, when above freezing temperatures can significantly weaken the snowpack (Zingg 1966; Schaerer 1967; Armstrong 1976). Loading of avalanche slopes by wind transported snow is one of the most significant causes of avalanches, particularly in continental climates such as in the Rocky Mountains of Canada (Judson 1964; LaChapelle 1966; Roch 1981).

For avalanches to occur, the terrain must be appropriate. Factors to consider include slope angle, aspect, roughness and vegetation (Martinelli 1974; Perla and Martinelli 1978; de Quervain 1979; Stethem and Perla 1980).

2.1.1.2 Snow Behaviour

The behaviour of snow and its physical and mechanical properties has received a great deal of practical and theoretical attention in the literature. The snowpack has complex physical properties, complicated by the fact that snow is a thermodynamically unstable substance, as a result of existing near its melting point (Perla and Martinelli 1978). This instability allows the snow pack to change noticeably in even short periods of time (e.g. Seligman 1936; LaChapelle 1970; Fraser 1978; McClung 1980; Adams and Brown 1982), either gaining or losing strength. The complex physical properties of snow, along with the potential for rapid strength change, make it difficult for the average backcountry skier to make accurate assessments of snow stability. The snow pack exists as a layered structure. Weak layers in this structure are particularly important with respect to avalanches (LaChapelle and Armstrong 1976; Perla and Martinelli 1978). Finally, a significant amount of effort has been directed toward understanding the triggering mechanisms of avalanches (Brown *et al.* 1972; Mellor 1973; Perla 1978a; McClung 1981).

2.1.1.3 Protection Against Avalanches

There are 2 common means of protection against avalanches — artificial triggering of avalanches and protective structures. The goal of artificially releasing avalanches with explosives is to frequently release small (at least in a relative sense) amounts of snow at a controlled time. In this way large, catastrophic avalanches which occur at unpredictable times are hoped to be prevented (e.g. Gardner and Judson 1970; Gubler 1977; Israelson 1978). Structures may be designed to divert avalanches from areas where they could cause damage or loss of life; to have sufficient strength to resist the force of the avalanche; or to hold the snow in place on the mountain (e.g. Schaerer 1962; Assessment of Research on Natural Hazards Staff 1975; Fraser 1978; Perla and Martinelli 1978; Mears 1979). Neither of these artificial means of protection are likely to be of widespread benefit to backcountry skiers here in Canada, because of the large areas involved, relatively light usage in any specific area and cost considerations.

2.1.1.4 Forecasting

Avalanche hazard forecasting is based on inputs from weather, terrain and snow behaviour. These inputs are discussed above. LaChapelle (1980) argues that forecasting of avalanche hazard is still a technical art rather than an exact science. Professional forecasters who evaluate the stability of the snow are utilized to safeguard ski areas, highways, mines and other installations. Artificial methods (generally some type of explosive) may be used to trigger avalanches when the forecasters feel that conditions are unsafe (Perla and Martinelli 1978; Williams and Armstrong 1984). Backcountry skiers, as will be discussed later, may formulate their own stability prediction and/or obtain professional forecasts.

2.1.1.5 Land Use Planning

Land use planning, with respect to avalanches, is a process where areas at risk are identified and mapped, and suitable legislation or guidelines for the use of these areas developed. This type of land use planning has received particular attention in Europe where there are high population densities in mountainous areas (e.g. Oppliger 1975; Frutiger 1977; Hestnes and Lied 1980). Here in North America, most land use planning is restricted to construction developments and highways (Ives and Krebs 1978; Freer and Schaerer 1980; Mears 1980), since our mountains are relatively undeveloped. There has been some effort with respect to regional mapping of hazard areas, with much of the emphasis on the hazard for backcountry users (e.g. Ives and Bovis 1978; Hackett and Santeford 1980; Ives and Plam 1980).

2.1.1.6 Techniques for Search and Rescue

When the preceeding adjustments to avalanche hazard fail, we are left with search and rescue — looking for and recovering live or dead bodies from the avalanche debris. There is a significant amount of literature on search and rescue procedures (e.g. Seligman 1936; MacInnes 1972; Fraser 1978; Perla and Martinelli 1978; LaChapelle 1979; Setnicka

1980; Daffern 1983), since action cannot be avoided after an accident, whereas it may be and often is (with particular reference to the backcountry skier) prior to an accident.

2.1.2 Human Aspects of Avalanche Hazard

The body of literature dealing with backcountry travellers who subject themselves to the risk of avalanches may be broken into several categories to facilitate discussion. First, there will be a brief discussion of the direction of avalanche hazard management research. Next, research findings of grouping backcountry skiers will be presented. This will be followed by an outline of the "typical" avalanche victim. The fourth aspect covered here will be a listing of some of the reasons why avalanche accidents occur. Subsequent discussion will consider decision making with respect to the risk of avalanches and some of the ways to reduce the number of future avalanche victims.

2.1.2.1 Direction of Avalanche Hazard and Management Research

McFarlane (1984) found that most avalanche management programs in Canada deal only with the physical aspects of the hazard, ignoring the human aspects. Only recently has there been a move toward supplying information to and educating area users (e.g. More *et al.* 1984; Valla 1984). This shift is appropriate given the increasing number of winter recreationists and increasing concern for avalanches. As an example pertinent to this study, Parks Canada (1984) reports a major increase in cross country skiing in the 4 contiguous mountain parks (Kootenay, Yoho, Jasper and Banff) between 1972 and 1976, and a subsequent increase at a slower rate. Public interest in avalanche hazard rose markedly in the 1960's and 1970's, taking a content analysis of the Banff newspaper as an indicator (Gardner 1982).

2.1.2.2 Grouping of Backcountry Skiers

To date, there is evidence that backcountry skiers may be divided into 3 groups (Daffern 1981; More *et al.* 1984; Williams and Armstrong 1984):

- those who travel on or near marked trails, are only vaguely aware of avalanche danger, and would prefer to stay in safe areas
- those who travel in avalanche areas as well as in safe areas; possessing a basic awareness of avalanche danger, but limited experience
- those with good avalanche knowledge and experience who concentrate their activities in avalanche areas.

From a limited survey, More *et al.* (1984) report that about 75 percent of the skiers are in the first group, 20 percent in the second and 5 percent in the third.

2.1.2.3 The "Typical" Avalanche Victim

It is instructive to consider what or whom constitutes the "typical" avalanche victim. Based on a study of avalanche statistics in the United States from 1950 to 1975, Williams (1978a: p.232) states that "the victim is male, 27 years old; has had several years of skiing or mountaineering experience, and didn't know an avalanche from a snowball". The meaning of this statement is clear. Most avalanche victims, while perhaps competent skiers, climbers or other type of winter sportsmen, had virtually no avalanche awareness training and therefore were unaware of the risks they were taking (Williams 1978a). Generally people are not killed on the large, obvious (even to the neophyte) avalanche slopes. Most killer avalanches are of small to medium size and are triggered by the victims themselves (Gallagher 1967; Williams 1975, 1978a; Stethem and Schaerer 1979, 1980; Williams and Armstrong 1984).

2.1.2.4 Reasons for Avalanche Accidents

A number of reasons for avalanche accidents become evident from a review of avalanche accident case histories (Gallagher 1967; Williams 1975; Stethem and Schaerer 1979, 1980; Fesler 1981; Williams and Armstrong 1984). These include:

- poor route selection
- inexperience in hazard recognition

- inexperience in hazard evaluation
- negative event feedback
- lure of steep slopes and deep powder.

These reasons, perhaps with the exception of the last one, could lead one to conclude that only inexperienced people are caught in avalanches. However, it is not uncommon for people who are considered to be experienced and cautious mountaineers to be caught in avalanches (Williams and Armstrong 1984). Some of the world's greatest mountaineers have been killed by avalanches (Lev 1978).

Route selection is the most important skill of one travelling in avalanche prone terrain (Daffern 1983). There are numerous documented cases of poor route selection leading to accidents (e.g. Stethem and Schaerer 1979, 1980; Williams and Armstrong 1984). Daffern (1981) makes an apt point when he states that people are generally reluctant to retreat -- they will only retreat if they are sure that is dangerous, not if they are unsure that it is safe. Choosing a safe route is closely related to hazard recognition and evaluation.

The majority of backcountry skiers utilizing avalanche terrain seem to lack the ability to recognize the hazard. Williams and Armstrong (1984) cite examples where accidents occurred even after visible and audible warning signs should have made the risk obvious. From the results of a study of winter backcountry users near Mount Hood, Oregon, Couche (1977) concluded that, regardless of training and experience, very few people knew how to recognize avalanche terrain hazards. Similarly, a limited survey of ski tourers in Kananaskis Provincial Park, Alberta, indicated that 75 to 85 percent of the individuals had little to no avalanche awareness and yet were skiing in avalanche terrain (More *et al.* 1984).

Programs intended to increase avalanche awareness and knowledge have at least at times been ineffective. Studies such as Fesler (1981), Gallagher (1981), Smutek (1981) and More *et al.* (1984) indicate a lack of use of avalanche warnings by backcountry skiers. McFarlane (1984) holds that it is not always because the victims do not know any better that they become involved in avalanches. Often it is because they do not understand the warnings. Certainly there are documented cases of avalanche accidents occurring after people have been specifically warned not to use an area by knowledgeable authorities (Williams and Armstrong 1984). One of the reasons for this ignorance may be inexperience in hazard evaluation or a clear decision to disregard the expert evaluation and make a decision more in accord with their own assessments (as will be documented in the natural hazards literature review).

Hazard evaluation is decision making under conditions of risk. A more general discussion of this topic is presented later in the literature review, but there are specific aspects of this problem presented in the avalanche literature.

Smutek (1981) argues that since the sequence of recognition, evaluation and qualified acceptance appears to be absent in the vast majority of avalanche accidents reported, most avalanche accidents are not a freely and knowledgeable accepted risk. It appears, from studies of accident case histories (e.g. Stethem and Schaerer 1979; 1980), that avalanche victims rarely base their decisions upon all of the information available to them and actually seem to be unaware of what data to look for and how to assess it. For the most part, alternative solutions remain unexplored and trip objectives are rarely identified in terms of safety and risk considerations (Fesler 1981).

There are several reasons why decisions made with respect to avalanche risk can be faulty. Decision making involves hard work, stress and doubt, while physical strain is imposed by often severe weather and terrain (Perla and Martinelli 1978; Fesler 1981). People have a tendency to simplify decisions, in an attempt to reduce the amount of work, stress and doubt, particularly since this is "only" a recreational activity. Decisions are often made quickly, because of time and environmental constraints (e.g. severe weather). It is not surprising then that people tend to make important and potentially life threatening decisions in a way that one would condemn while sipping tea in front of the fireplace. Avalanche victims may make decisions based upon factors that they perceive to be important at the moment (e.g. I have to back at work on Monday morning). What must be remembered is what is important to them may not be important to 'Mother Nature' (Fesler 1981). Also, there is the group factor; no one member of the group likes to admit concern and turn around prematurely (Perla and Martinelli 1978). As a final point, there is a tendency toward overcaution as one learns about avalanche hazard, but this is later, at least temporarily, replaced by overconfidence (Daffern 1983).

Negative event feedback is another reason for faulty decisions (Smutek 1981; Williams and Armstrong 1984). If a person skiis a slope that is quite steep, and it does not avalanche while he skiis it, he may consider similar slopes encountered in the future to be safe. There may be a number of such occurrences, confirming the wisdom of his decisions, until one day a similar slope may avalanche. This is an example of where increased experience may not lead to increased safety if factors other than slope angle are not taken into consideration.

Enthusiasm may be detrimental to decision making. Deep powder and steep slopes are powerful lures that have clouded skier's judgements since the sport began (Perla and Martinelli 1978; Stethem and Schaerer 1979; Williams and Armstrong 1984). Programs intended to reduce the risk of avalanche hazard to backcountry travellers must pay close attention to these reasons for accidents.

2.1.2.5 Risk Taking With Respect to Avalanches

To determine acceptable risk, recreationists must evaluate the risk in proportion to the benefits; the greater the benefits, the greater the acceptable risk (Williams and Armstrong 1984). For example, a group of tired, cold ski tourers may have to decide near the end of the day if the benefits of a shortcut through avalanche prone terrain (which would get them to shelter and warmth an hour faster than the longer, safer route) are worth the risk. The ability to determine the acceptability of the risk (to weigh the risk against the benefits) requires training and experience. Every individual uses his value system, training and experience to evaluate risk. In fact, some people view risk as essential to the enjoyment of the sport (Ward 1980; Williams and Armstrong 1984).

2.1.2.6 Methods of Reducing Avalanche Losses

The general approach advocated by most writers to reducing avalanche losses (to backcountry travellers) is public education (e.g. Seligman 1936; Assessment of Research on Natural Hazards Staff 1975; Perla and Martinelli 1978; LaChapelle 1979; Valla 1980, 1984; Ward 1980; Daffern 1981, 1983; Fesler 1981; Gallagher 1981; Spear 1981; More *et al.* 1984). Initiatives such as avalanche seminars can curb the future number of avalanche accidents by helping backcountry travellers make their own judgements in an informal way (Ward 1980). Only by understanding the physical processes which take place can one know what data is relevant to decision making and only by understanding the technology available to obtain the data (e.g. hasty snow pits or shovel shear tests) can one retrieve the information (Fesler 1981). Education is required to optimize decisions.

Education, in combination with appropriate equipment can save lives. Stethem and Schaerer (1979, 1980) cite instances of preparation such as transceivers, shovels and the knowledge required to use them saving lives in cases of avalanche burial. The backcountry skier must depend on the preparedness of his own party; help is too far away.

Avalanche hazard warning systems can be useful means of communicating the hazard to the public (Judson 1975; Perla and Martinelli 1978; Williams 1978b; Daffern 1983), though these systems are insufficient in themselves. Education on the use of these systems is required (McFarlane 1984; More *et al.* 1984).

Signs placed at trailheads or along trails can be useful to alert people to the potential for avalanche danger. Great care must be taken to ensure that the signs accurately reflect the changing conditions throughout the winter. Warnings of high instability in periods when the snow is stable can lead people to ignore these signs (Williams and Armstrong 1984).

Complete closure of trails or areas has been used in some instances, but the technique has not proven to be entirely successful, particularly with closures over extended time periods. Numerous examples exist of people being killed in areas that were closed to the public (e.g. Gallagher 1967; Williams 1975; Stethem and Schaerer 1979, 1980; Williams and Armstrong 1984).

To conclude this section on a positive note, there is some initial evidence that public information programs have had some success. In the United States, the number of people killed in avalanches from 1971 to 1979 remained relatively stable, while the number of people involved in winter recreation, particularly cross country skiing, increased heavily (Armstrong 1981; Gallagher 1981). Valla (1984) has identified a similar tentative conclusion in France. In Canada, there was a definite increase in avalanche accidents in the early 1970's, likely coincident with increased use. See Figure 2.1 for more information on this trend. However the number of fatalities seemed to stabilize in the late 1970's and early 1980's, while use continued to increase. More research is required to provide further evidence for this trend and to determine what level of knowledge the backcountry travellers have and how they receive their knowledge (Gallagher 1981).

2.2 Natural Hazards Literature

Since there have been few research projects devoted to the study of backcountry skiers who subject themselves to the risk of avalanches, one must look elsewhere in the literature. Avalanches may be included within the more general realm of natural hazards. Over the past 20 years, and to a lesser extent earlier, a significant amount of work has been done in the natural hazards field. A short example which relates factors important to avalanche risk assessments for a backcountry skier is presented to identify the aspects of the natural hazard literature of relevance to this study. Following this, the relevant aspects of the natural hazards literature will be discussed.

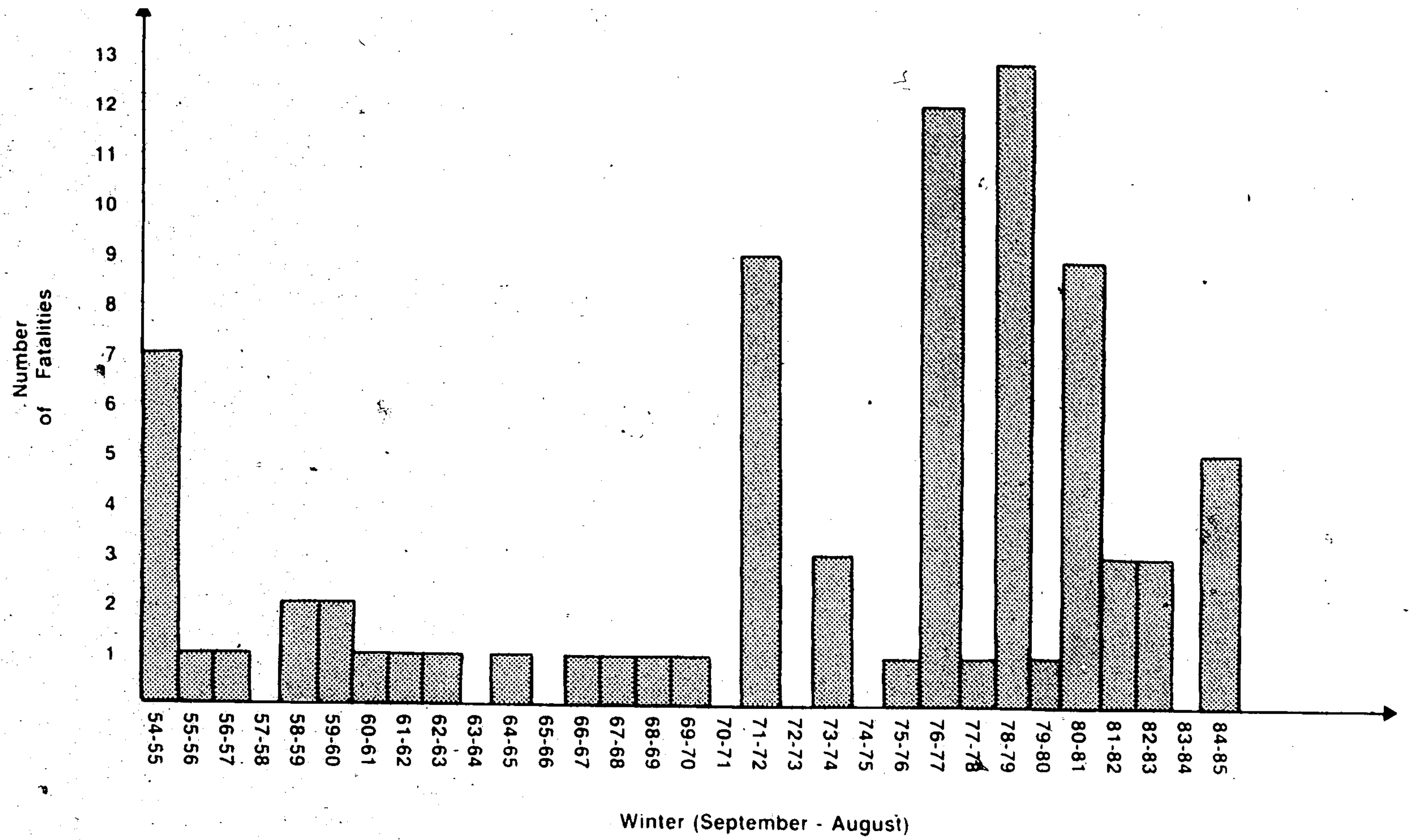

Figure 2.1 Recreational Avalanche Fatalities in British Columbia and Alberta (Excluding Snowmobiling)

Sources: Stethem & Schaerer 1979; Stethem & Schaerer 1980; Schaerer, pers. comm., 1984; Avalanche News 1980-85

2.2.1 Factors Important in Avalanche Risk Assessments

A short example outlining the factors related to a backcountry skier's assessment of avalanche risk is presented here to serve as a guide to the natural hazards literature, to identify the relevant portions of this broad literature. The example taken is that of a backcountry skier preparing to ski down a steep gully. Let us assume that avalanches may occur in this gully. The skier could make an assessment (either conciously or subconciously) of the likelihood of an avalanche, before committing himself to the gully. This decision would be based on one or more of the factors discussed below.

First of all, experience with the geophysical event (e.g. avalanches) must be considered. Geophysical events or evidence of geophysical events (e.g. an avalanche track through a treed area) form the basis of a person's experience with respect to natural hazards. Events need not be of a scale to cause a hazard before they become a portion of one's experience. In the case of the hypothetical backcountry skier, his experience with avalanches may consist of one harmless event, such as sighting snow sliding down a mountain while driving from Jasper to Banff. Without this direct or some other indirect experience, the skier has no information on which to base a decision and, at any rate, would be unaware of the risk.

One must be consciously aware of an event before it becomes significant and affects decisions to be made. As an example, while moving into the flat area above the steep slope, the skier may hear the "whoomp" of a large area of snow settling. He may or may not consider this to be a significant event. To the trained observer, this is an indicator of snow instability, but the skier may consider it only to be a natural sound, perhaps caused by the wind.

Assuming the person is aware of avalanches in general, he will have some perception of such an event. For example, the skier could perceive that avalanches are unlikely to occur and if they do occur, their magnitude would not be large enough to affect him. This could ultimately influence the decision.

The skier's personality may also be related to risk assessments. For example, the action taken by the skier would depend upon whether he considered avalanches to be an act of God, whether he felt that he had some control over the degree of risk to which he exposes himself, whether he was a risk taker, whether he just felt lucky on that day or whether he was by nature timid or aggressive. Because of the difficulty of measuring or assessing personality traits and their impact on risk assessments, this factor is ignored in the remainder of the thesis.

What one knows about avalanches is also likely to affect their behaviour. The skier may know that snow will slide only on steep slopes and evaluate the angle of the gully as not very steep. Knowledge may have been acquired through accumulated experience, avalanche safety courses, reading material dealing with avalanche safety and public information programs, to provide a list of the most common sources. This bit of knowledge and the related evaluation may lead a skier to believe a particular slope is safe, so that he will ski down it.

Also, the skier's emotions may influence his behaviour, as mentioned in the review of the human aspects of the avalanche literature. The skier may be enjoying a beautiful day and be eagerly awaiting the descent through the untracked powder. With these thoughts predominant in his mind, any consideration of avalanche risk is unlikely. Given the above factors, the attitude of the skier may be to ignore avalanches, and the final decision or ultimate behaviour could be to ski down the gully, disregarding the risk of avalanche, unless some institutional action, such as an area closure enforced by legislation, discouraged him.

If researchers or management agencies expect to have some effect on the number of avalanche accidents, they must take into account factors such as those outlined for the skier above. The factors which were not addressed in the review of the avalanche literature above will be examined in the natural hazards literature. Although the factors will be treated from a general natural hazards viewpoint, the material it is certainly applicable to avalanche hazard specifically, as well.

2.2.2 Specific Factors in the Natural Hazards Literature

The preceeding example outlined a number of factors related to avalanche risk assessments made by backcountry skiers to be reviewed in the natural hazards literature. These factors are experience, awareness, perception, knowledge, evaluation, attitudes, behaviour and institutional actions.

2.2.2.1 Experience

Saarinen (1982b) states there is little doubt that prior natural hazards or disaster experience is related in some manner to preparedness level or behaviour. However, there are some intervening factors. First of all, extreme events are rare. People have little experience with them and their memories of such events dim rapidly over time. Second, events within one's experience may be less destructive than future ones. Third, a topic which will be discussed in more detail later, natural hazards may be of a low priority. As a final intervening factor, Kiecolt and Nigg (1982) have found that frequent experience can breed contempt of the hazard. For example, past experience with hurricanes could lead to nonevacuation during future hurricanes.

2.2.2.2 Awareness

As mentioned in the skier example above, the level of the experience must surpass some salience threshold before a person is consciously aware of that experience. However, the common assumption that heightened awareness leads to greater likelihood of adjustments to the hazard is only partially true (Jackson 1981; Saarinen 1982b).

Maslow's (1954) hierarchy of needs is likely to be related to awareness and the associated threshold. He states that lower level needs must be fulfilled before higher level needs are considered. In other words, particularly in the lesser developed countries, people may be more concerned with basic needs such as food and shelter rather than infrequent natural hazard events. Only if natural hazards are a priority concern is there likely to be a strong link between awareness and making adjustments to reduce the risks (Saarinen 1982b). Even in the more developed countries, Kunreuther (1978) reports that people treat such events as having a probability of occurrence sufficiently low to permit them to ignore the consequences. This is such a low priority item that people do not even reflect upon the consequences.

Both Kunreuther (1978) and Saarinen (1982b) state that knowing someone who has made an adjustment to a natural hazard can lead to increased likelihood of making that adoption. Knowing someone else making the adjustment seems to move the hazard beyond some threshold, increasing its subjective probability.

As a final point with respect to awareness, individuals tend to expose themselves to those ideas which are in accord with their interests, needs or existing attitudes. Rogers and Shoemaker (1971) term this selective exposure. They continue by stating that need generally must preceed awareness because of this selection process, although innovations or new ideas can lead to needs. Similarly, people interpret messages and experiences in terms of their existing attitudes and beliefs. Rogers and Shoemaker (1971) term this selective perception.

2.2.2.3 Perception

Mileti *et al.* (1975) define perception as an individual's understanding of the character and relevance of a hazard for self and/or community. The perception may include notions about speed of onset, scope, intensity, duration, frequency, temporal spacing, causal mechanisms and predictability. They note that hazard perception has not been a particularly powerful predictor of hazard adjustments being used.

In his early study, Saarinen (1966) found that the accuracy of hazard perception was related to direct economic relationship with the hazard; recent and intense experience with the hazard; more and recent experience with the hazard; and the objective certainty of future hazard impact. Mileti *et al.* (1975) reached similar conclusions. In general, people do not have an accurate perception of the risks associated with hazards (Saarinen 1982b). Dramatic risks such as nuclear power plant explosions tend to be overestimated, while undramatic risks such as drought tend to be underestimated.

People tend to think that hazard events will not affect them personally (Sood 1982). Some believe that having sustained damages in the past, they are unlikely to be affected in the future (Jackson 1981). Finally, Mileti *et al.* (1975) report that people have a perception of safety when they are protected from hazards by technological devices such as dams or levees (or avalanche control through the use of explosives).

2.2.2.4 Knowledge

In terms of knowledge with respect to natural hazards, the general statement may be made that it is lacking. A number of authors provide more detail. Most people do not know the character and extent of the hazard(s) for the area in which they reside and work (Mileti *et al.* 1975). Several authors have found that residents are generally unaware of the range of adjustments and relief programs open to them and tend to adopt less adjustments than the total of which they are aware (Kunreuther 1978; Jackson 1981; Rossi *et al.* 1982). People do not collect enough data to evaluate the costs and benefits of these low probability events and they locate in areas for their beneficial factors, ignoring the disaster potential (Kunreuther 1978).

2.2.2.5 Evaluation

Knowledge must be evaluated before it is applicable to decisions regarding behaviour. The time and effort required to gather and process data force people to construct a simplified model of the world. People tend to oversimplify to obtain easy solutions (Kunreuther 1978). Also, as reported by Saarinen (1982b), making decisions about risky activities is difficult. People tend to oversimplify to allow easy solutions so that strain and anxiety are reduced.

2.2.2.6 Attitudes

Gross and Niman (1975) define an attitude as a learned predispositon to respond to an object or class of objects in a consistently favorable or unfavorable way. As an example of attitudes with respect to natural hazards, many people think that the responsibility for hazard mitigation lies with the various levels of government, not the individual (McPherson and Saarinen 1977).

2.2.2.7 Behaviour

When appropriate (i.e. total losses are minimized) risk assessments are made, behavioural patterns are such that losses caused by natural hazards are markedly reduced. However, past attempts to influence the decisions and resulting behaviour of individuals have generally been unsuccessful. Haas *et al.* (1977) report that attempts to direct reconstruction to safer locational patterns in Managua, Nicaragua and Rapid City, South Dakota were failures. Regarding the sale of insurance policies for natural hazards, Kunreuther (1978) indicates that there are only a very small number of people who will purchase coverage without some outside incentive (e.g. legislation), even immediately following a major disaster. In San Francisco, few people have made any conscious preparation for the known high risk of a major earthquake (Jackson 1981). Even after a disaster, many people do not take what would seem to be attractive options such as utilizing low interest loans to the fullest extent to speed recovery (Kunreuther 1978).

To summarize, few people have taken actions to protect themselves from natural hazards (Kunreuther 1978). From an individual point of view, they are right, since the likelihood of a disaster affecting any specific individual is generally quite low. As reported by Jackson (1981), people tend to demonstrate a preference for crisis response. Any actions that people do take to protect themselves from a hazard in a particular area tend to enhance their committment to the risky area (Kiecolt and Nigg 1982).

Also, there is strong evidence that technological solutions to problems in natural hazards can initiate behaviour patterns which lead to major losses when a significant event occurs. For example, the system of levees, dams and drainage canals constructed on the delta of the Ganges-Brahmaputra River encouraged large populations to move into the area. In November of 1970, a tropical cyclone led to the death of at least 225,000 people and caused crop damage of at least \$63 million (Burton *et al.* 1978) in the area. There are often incentives (such as the financial ones of placing factories in flood zones to gain river access for shipping and water supply) which encourage behaviour that may not be appropriate with respect to natural hazards (Saarinen 1982b). Controlling avalanches in the backcountry through the use of explosives may lead to similar problems; if people begin to believe that all areas are safe from avalanche.

As a final point concerning behaviour, Sorenson and White (1980) state that the adoption of adjustments is influenced by experience, material wealth, resource use and personality, but these are not strong predictors of behaviour.

2.2.2.8 Institutional Action

There are 4 institutional actions with respect to general natural hazards which have relevance to avalanche hazard. These are warning systems, information programs, education programs and legislation (regulation).

Warning systems have been developed for a number of natural hazard events, including hurricanes, floods, earthquakes (to some extent), tornadoes, snow and avalanches (White 1974a; Brinkmann 1975; Mileti *et al.* 1975, National Academy of Sciences 1977; UNDRO 1979; Saarinen 1982a; UNDRO 1984). The warning system is composed of many interrelated processes (Mileti 1975). These are generally divided into 3 main parts:

- evaluation (detection; measurement, collation and preparation of forecast)
- dissemination (decision to warn, message content and distribution of the message)
- response (interpretation of the message and subsequent response).

Because of the large scale of these processes, they generally take place under the direction of one or more government bodies. This last process is of particular interest to this study. People may ignore warnings since they lead to decisions that are contradictory to what they already believe or are in the habit of doing (Mileti *et al.* 1975; UNDRO 1979). Festinger's (1957) theory of cognitive dissonance explains this reluctance to make decisions that would be in accord with the warning, rather than their personal beliefs.

Public information programs are intended to enhance awareness (and knowledge to some extent) of natural hazards over time as opposed to warning systems which are designed only to notify the public of impending disasters. Regulska (1982) describes how information programs make people aware of the hazard and education programs (which come to the fore only after the awareness stage) provide knowledge. Informing and educating the public is generally carried out through radio and television announcements, printed media and films and slide lectures which are commonly prepared by government agencies and private agencies such as the Red Cross. The potential of volunteers in disaster information and education programs has become more widely recognized in recent years (Regulska 1982).

Government legislation has been used to reduce the loss potential from natural hazards. Land uses have been restricted in some areas affected directly by natural hazards such as flooding, hurricanes and avalanches (e.g. White 1974a; Brinkmann 1975; Burton *et al.* 1978, Regulska 1982). Acceptable levels of risk have been legislated in some instances such as for environmental pollutants (Burton *et al.* 1978). Legislation has been enacted to set up emergency measures organizations to deal directly with disasters (UNDRO 1984).

2.3 Risk Literature

A review of the risk literature is included to give an overview of decision making under conditions of risk, such as those that may occur when backcountry skiing. Risk assessment involves a search for the best trade-off between benefit and risk. It is a balancing process in which various combinations of risks are compared and evaluated against particular gains (Whyte and Burton 1980). Gardner (1982) provides a framework which can be used to organize this section. One can identify 5 steps in a framework which may be used as a systematic approach to risk analysis. These steps comprise:

- risk identification
- risk estimation
- risk evaluation
- risk response

- risk monitoring.

This overall process of risk decision making is not necessarily an ordered sequence, since all possible combinations of steps and overlapping of steps may exist in practise (Kates 1978), but it provides a useful outline for discussion.

To prevent confusion, risk and hazard will be given definitions before proceeding. Hazard is generally thought of as a source of danger, whereas risk is viewed as the possibility or probability of loss from hazard (Whyte and Burton 1980; Gardner 1982).

With this brief overview of the risk literature, one will be able to see that decision making under conditions of risk often has suboptimal results. This could be a partial explanation of why avalanche accidents occur, even involving acknowledged experts in the field.

2.3.1 Risk Identification

Risk identification is the recognition of a hazard and the attempt to define some of its physical characteristics (Whyte and Burton 1980; Gardner 1982). This topic, for the purposes of this thesis, has been covered in sufficient detail above in the section on avalanche literature, so only the definition is provided here. Remember that risk must exceed some threshold before it is recognized. Travel by automobile may be used as an example. Intellectually, most of us understand that there is some level of risk in automobile travel. However, the level of risk is only dimly perceived because it has been with people nearly all of their lives. Daily automobile journeys are commonplace, and since accidents are relatively rare events, there is no reason for the question of risk to assume any great prominence (Sabey and Taylor 1980). A risk must be explicitly recognized before it can be estimated, evaluated, etc.

2.3.2 Risk Estimation

Risk estimation is the determination of the hazard's threat potential and its characteristics, including magnitude, spatial scale, frequency, duration and probabilities (Kates 1978; Gardner 1982). Ideally, risk estimation would appear to be a straight forward procedure, once the hazard has been identified. However, since our understanding of people, the environment and associated interrelationships is imperfect, problems arise. These problems include inaccurate estimations of risk, faulty risk perceptions and risk tolerances or attractiveness.

2.3.2.1 Accuracy of Estimation

Accurate, scientific estimates of risks are always difficult to obtain, and in some cases impossible. The very nature of the risk, particularly in low risk situations, hinders the collection of data necessary for the analysis. The scientist producing data for an assessment of risk has few, if any controls on the quality of his material. Hazards, such as avalanches, involving relatively rare and unpredictible events, are particularly difficult to describe (Council for Science and Society 1977).

Kates (1978) has outlined 3 major types of problems that exist in risk estimation: First, people may have limited experience with the event. Second, distorted assumptions are commonly used in the development of a risk estimate. Finally, there are several constraints in the cognitive process. The following points hold for people in general:

- knowledge of events is less perfect than the best scientific record
- more recent events are better known than less recent ones
- more frequent events are better appraised than those that are not
- events that have a more direct impact on everyday life and livelihood are more accurately assessed than those with more trivial outcomes.

Cognitive limitations, coupled with the anxieties generated by facing life as a gamble can cause uncertainty to be denied, risks to be distorted and statements of fact to be believed with unwarranted confidence (Slovic *et al.* 1982).

One must apppreciate the inexactness in all measures, and learn to cope with the high degree of inexactness in this particular case (Council for Science and Society 1977). The Royal Society (1983), however, argues that risk management implies the quantification of risk wherever possible. While quantification is often uncertain, it is better than making no estimate at all.

2.3.2.2 Perceptions of Risk

The influence of perception on risk estimation was alluded to above. Perceived risk refers to the combined evaluation that is made by an individual of the likelihood of an adverse event occurring in the future and its likely consequences (The Royal Society 1983). Perceived risks, particularly those of lay people, often do not reflect the real risk.

According to Slovic *et al.* (1982), in one study, experts' risk perceptions correspond closely to statistical frequencies of death. Lay peoples' risk perceptions were based in part upon frequencies of death, but there were some striking discrepancies. It appears that for lay people, the concept of risk includes qualitative aspects such as dread (e.g. bear attack) and the likelihood of a mishap being fatal. Lay people's risk perceptions are also affected by catastrophic potential. Kasper (1980) agrees that perceptions of people about risk rarely coincide with known actual risks or the best available expert projections of risk.

There are other reasons why people have inaccurate risk perceptions. Slovic *et al.* (1982) hold that perceived risk is influenced (and sometimes biased) by the imaginability and memorability of the hazard. People may, therefore, not have valid perceptions for even familiar risks. In ordinary, hazardous situations, there is a tendency to dismiss the risk with an attitude that "it can't happen to me" (Council for Science and Society 1977). This is perhaps psychologically necessary in cases of repeated exposure, voluntary or otherwise. Similarly, people reduce the anxiety generated when confronting uncertainty by denying that uncertainty (Slovic *et al.* 1982). As an example, people confronted with natural hazards often view their world as either perfectly safe or predictable enough to preclude worry. Finally, the Council for Science and Society (1977) makes the point that these subjective, commonly inaccurate, perceptions of risk often outweigh their objective, partly quantifiable, aspects in decision making.

2.3.2.3 Risk Tolerance

To further complicate the issue of risk estimation, there are specific activities in which people will tolerate higher levels of risk or perceive the level of risk as lower than it actually is. With respect to everyday situations, Otway and Pahner (1980) have found that active involvement with risk results in the risk being perceived as lower than if participation is more passive. Similarly, perceived risk associated with various leisure activities diminishes as familiarity increases (Cheron and Ritchie 1982). Finally, Rescher (1983) states that for any given level of benefit, people are prepared to tolerate a greater level of risk for activities that rate more highly in point of being:

- voluntary
- avoidable
- controllable
- familiar (i.e.; not particularly striking, memorable or shocking)
- well understood
- not dreaded
- not potentially disastrous
- remote (i.e. not immediate or near term).

Given this brief review of some of the problems that exist when estimating risk, including inaccurate estimation and faulty perceptions, the discussion may proceed to risk evaluation. The problems of risk estimation must be kept in mind when evaluating risk.

2.3.3 Risk Evaluation

Risk evaluation is the meaning attributed to the measurement of threat potential, an answer to the question: how important is the estimated risk (Kates 1978)? Even with perfect risk identification and risk estimation, risk evaluation may be imperfect, as will be demonstrated here. When making decisions under conditions of risk, Fishhoff *et al.* (1981) stress that there is no one best method for determining the most acceptable option. All approaches are decision aids — ways to enhance understanding that need not dictate choices. Only one of these methods is taken as an example here, cost benefit analysis. Before a decision is made, the results of cost benefit analysis are judged by the decision maker. A judgement is made which takes into account the acceptability of the risks. To give an example of the complexity of risk evaluations, a discussion is presented relating that acceptance of risk may be so high that some people appear to be actively seeking risk.

2.3.3.1 Cost Benefit Analysis

The analytical approaches utilized for evaluating the acceptability of risk originate from analogies to financial cost benefit risk analysis. These analogies appear generally valid for viewing risk from a societal basis, but they are not applicable to individual risk assessments. Individuals make intuitive evaluations (Starr and Whipple 1980).

Individuals utilize an implicit estimation of the benefits of a particular action in comparison to alternatives and of the risk it entails. All this is done very informally, with no attempt at precise calculation. We are guided by our own and other's experience, reasoning and guesswork, and usually cannot delay long for a detailed examination of the problem (Council for Science and Society 1977; Crouch and Wilson 1982).

Lastly, any cost benefit analysis cannot lead directly to decisions (The Royal Society 1983) which need a substantial element of value judgement. However, we must keep in mind that the use of value judgment can involve some problems.

2.3.3.2 Judgements

Definitive evidence with respect to hazards is difficult to obtain, making judgement an important facet of decision making (Slovic *et al.* 1982). However, these authors state that the products of judgment should be treated with caution. People are less than perfectly calibrated in their judgements, the bias almost invariably tending to be in the direction of overconfidence rather than in underconfidence in what we know. Such overconfidence is dangerous, indicating that people often do not realize how little they know and how much additional information is needed about the various problems and risks faced. This applies both to experts and lay people. Also, people allow the utility of outcomes to influence their assessment of likelihood and, in the extreme, search for and find psychological certainty quite unjustified externally (Slovic and Fishhoff 1980; Slovic *et al.* 1982). People also tend to behave as though they have control over chance. Langer (1980) holds that this is because people are motivated to avoid the negative consequences that accompany the perception of having no control.

Some may argue that if people have such problems as described above evaluating risk, experts should do the evaluations. However, Slovic *et al.* (1982) state that even if the experts were much better judges of risk than lay people, giving experts an exclusive franchise on hazard management would involve substituting short run efficiency for the long term effort required to create an informed citizenry.

2.3.3.3 Accepting Risks

Judgement is related to the acceptability of risks. This acceptabililty cannot be simply derived from a scientific study of quantified probabilities, costs and benefits (Council for Science and Society 1977). The human factor influences the analysis at every step. From an ethical point of view, the only sort of risk that is truly acceptable is one that is judged worthwhile (in some estimation of costs and benefits), and is incurred by a deliberate choice of its potential victims in preference to feasible alternatives. Of course these conditions do not always hold in reality.

Also of relevance here is Starr's (1972) contention that societal acceptance of risk increases with the benefits to be derived from an activity. The public appears willing to accept voluntary risks roughly 1000 times greater than involuntary exposure risks. Voluntary risks are those such as the ones incurred in leisure activities (e.g. mountain climbing), while involuntary risks are those over which a person has no control, at least in the short term (e.g. living on a river flood plain) (Kates 1978).

2.3.3.4 Risk Seekers

Acceptance of risk can increase to the point where it seems that some individuals are almost actively seeking risk. Gardner (1982) and Rescher (1983) state that part of the attraction of such recreational (and professional) activities as mountaineering, sky diving, motorcycle and car racing and helicopter skiing derives from high levels of risk. This demonstrates the complexity of some risk evaluations. Also to increase the complexity, some evidence has been found (Kates 1978; Bem 1980), although it is not entirely conclusive, that groups tend to make riskier decisions than individuals. Risk takers in endeavours such as those outlined above tend to depend heavily on skill, caution, distorted perception or luck to provide for themselves favorable personal odds not excessive by their own risk calculation (Kates 1978). This ability to reduce the risks to themselves may be part of the attraction.

2.3.4 Risk Response

After evaluating the risk, a person or organization may respond to the risk. In the case of avalanche hazard, any organized response is likely restricted to agencies such as Parks Canada.

Sabey and Taylor (1980) have done some research with respect to automobile safety, which may be applied to the case of avalanche hazard. They state that a sound knowledge of risk perceptions, attitudes, probable behaviour and expectations is most important to the success of road safety improvements, as is an understanding of the extent to which driver behaviour is likely to adapt to the changed situation and defeat the intended safety benefit.

The responses to risk which are more applicable to this thesis are discussed in the review of the avalanche hazard literature.

2.3.5 Risk Monitoring

Gardner's (1982) last step of risk monitoring is one which is sometimes ignored. With respect to avalanche hazard, a discussion of monitoring may be found in portion of the avalanche hazard literature review dealing with forecasting.

2.4 Wilderness Recreation Literature

The body of wilderness recreation literature provides some information with respect to the objectives of this thesis. The portion of this body of literature that is applicable here treats what people are seeking in wilderness recreation in potentially risky settings. To understand these people and develop appropriate management programs, one must know what it is the recreationists are seeking, or why they subject themselves to risk.

It would seem reasonable to assume that people do not participate in wilderness recreation solely to place themselves in risky situations. There must be some other benefits to be gained. Miles (1978) holds that risk can be an aside to other rewards. For example, one cannot enjoy the mountain view without the risk of passage, so the risk is taken. The benefit of the view outweighs the potential cost of being involved in an avalanche or some other accident. People go forth for such rewards and become participants in risk recreation. There is some evidence that people simply are not aware of the risk or just ignore the risk. Smutek (1981) makes this argument for the case of avalanche hazard.

There are a number of reasons why a person may consciously or unconsciously place himself in risky situations. This is not so much a death wish as an enhancement of existence through testing oneself at the edge of life (Schreyer *et al.* 1978). A number of benefits of engaging in high risk recreation have been identified, including comradeship, personal growth, self reliance, self knowledge and excitement.

Ongena (1982) uses climbing as an example of comradeship. Climbing partners struggle on the approach together, protect each other over and over during the climb, share the spectacular summit views and feelings of satisfaction and then make their way back to camp to share food and shelter. Placing this much faith and trust in another person is a very special experience, one that is generally not available in every day life. Miles (1978) concurs, stating that the personal bonds that develop with such experiences are remarkable and of inestimable value to many people.

Some people may be seeking a form of personal growth in risk recreation. According to Ongena (1982), our mechanized, technological and convenience oriented society has made it very difficult to exercise certain aspects of our total makeup. There are certain characteristics generally felt to be valued by mankind — intelligence, fitness, resourcefulness, control, courage, tenacity, judgement, responsibility and accountability. People engage in risk recreation to exercise parts of their personal selves that they do not want to atrophy. The greater the risk taken, the more of their reserves they tap and the less atrophy suffered.

Risk recreation can build one's self reliance (Miles 1978; Welton 1978). Facing a risk situation, one knows that the stakes are high and that the powers of self must be relied upon. Having confronted self and met a physical and mental challenge, a person may become more secure in their identity, more confident in themselves. In this process one can also learn more about oneself. Exposure to unfamiliar situations and trying circumstances develops self knowledge, which can only be useful (Ongena 1982). This is an inner exploration of how much one can take and generally learning about oneself.

Some people seek excitement in risk recreation. Unless a person is intermittently flushed and stirred by some exciting experience, there is apt to be a dryness of emotions or a feeling of monotony (Schreyer *et al.* 1978; Ongena 1982). This experience is not available in ordinary life routines, so many people engage in risk recreation in their leisure time to obtain the excitement necessary to maintain vitality. In like fashion, Leonard (1974) holds that for the average, reasonably well balanced person, the opportunity to take calculated risks is essential to feel fully alive.

To gain the benefits listed above, a person does not just arbitrarily place himself at risk. One first defines the goals to be obtained and then assesses the level of risk to be faced. To make an intelligent decision, one must determine whether attaining the goals is worth the danger (Meier 1978).

Finally, risk recreation can promote respect for a world which man cannot control (Miles 1978). Modern technology is so potent that it leads many people to illusions of immortality and omnipotence. Immersion in environments where one is subject to such forces of nature as weather (as in backcountry skiing) or the power of water (as in whitewater kayaking) produces respect and understanding of the world that exists beyond human control.

2.5 Relationship of this Study to the Literature

From this review of relevant literature, one will note that litle work has been done to date with regard to the backcountry skier's perception of avalanche hazard, knowledge and the related decision making process. Evidence has been presented (to a minor extent from the avalanche literature, but mainly in the natural hazards and risk literature) illustrating that people tend to make poor decisions under conditions of risk, and some of the reasons for the often poor decisions were identified. The primary goal of this thesis is to examine some of the means to improve avalanche knowledge and, hence, decisions, concentrating on the areas identified as weaknesses here.

To attain this goal, one must be aware of what the recreationist is seeking (as described in the wilderness recreation literature) and some of the present characteristics of backcountry users. The next major section of the thesis describes how data was collected to determine the backcountry skiers' perception of the avalanche hazard, avalanche knowledge levels and the effectiveness of present programs. One must be aware of the present state to have any hope of designing effective programs for the future.

3. Methodology

A chronological scheme may be used to present the series of tasks undertaken to obtain the data which form the bases of this thesis. The first step was to identify the population of winter backcountry users of Banff National Park. Next, given this population knowledge, it was possible to design an appropriate sample to be taken from the population. Third, a method of obtaining information from the sample was devised — interviews guided by the questionnaire which is contained in Appendix 1. The fourth step was to field test the data collection instruments, which were the questionnaire and the electronic trail use counters. The final 2 procedures described here are the actual data collection and the preparation of the data for analysis.

3.1 Study Population

The population considered by this study consisted of backcountry skiers in Banff National Park. For the purposes of this study, backcountry was defined as being at least 500 m from developed areas, such as townsites or downhill ski areas, or from plowed highways. For reasons outlined in the next chapter, 4 specific trails were chosen at which to conduct interviews. These were the Bow Hut, Mosquito Creek, Pipestone and Redearth Creek trails. See Figure 1.1 for the location of the trails.

No frame or list of individual skiers (such as the roll of registered voters for an election) in Banff National Park presently exists. An attempt is being made by the Visitor Services Backcountry department in Banff National Park to obtain counts of the number of users on nordic ski trails, but their database is incomplete at this time (J. Bonhomme, personal communication, 1984).

To provide partial compensation for this lack of a frame, users on the trails were counted employing a device which projects an infrared beam across the trail. Each time the beam was interrupted, an impulse was sent to an electronic counter, indicating that it should be incremented. These counts give an indication of overall trail usage, or the total population from which the sample of interviewees was taken.

3.2 Sample Design

The sample design was developed taking several factors into account, including the need to reach a broad spectrum of users; the need to ensure that there was random selection of backcountry users on the 4 trails, cost efficiency and time efficiency. In developing the design, it was assumed that all interviewing would take place between December 28, 1984 and April 8, 1985. All interviewing did take place during this period. Funds were available for 15 trips to the study area during this period.

A decision was made to do a majority of the interviewing on weekends and holidays, which are the days when the greatest numbers of people use the area. To this end, the time frame was divided into holiday (including weekends and statutary holidays) and weekday periods, as shown in Table 3.1 (columns 1 and 4 respectively). Each period was assigned a sequential number to make reference more convenient (column 2 for holiday periods and column 5 for weekday periods). Also in Table 3.1, the holiday days have been numbered sequentially (column 3) to facilitate random selection of the periods. Similarly, sequential numbers have been assigned to the weekdays (column 6). Use of the day numbers is explained below.

It was decided to allocate about 70 percent of the 15 interview periods on holidays and about 30 percent on weekdays. For each of the 15 interview periods, the first decision to be made was whether the period should be designated as a holiday or weekday period. This was done by selecting successive numbers from a random number table (Lapin 1973: p. 721). If a random number of 0, 1 or 2 was encountered, the interview period was designated as a weekday period. Otherwise, the interview period was designated as a holiday period. Column 2 of Table 3.2 illustrates the random designation of weekday and holiday periods.

Once a period had been designated as a weekday or holiday period, the specific dates were chosen, again utilizing a random number table. For holiday periods, 2 digits from the

Table 3.1 Holiday and Weekday Periods Available For Interviewing

Holiday Period (1)	Holiday Period Number (2)	Holiday Day Numbers (3)	Weekday Period (4)	Weekday Period Number (5)	Weekday Day Numbers (6)
Dec 28 - Jan 1	1	1 - 5	Jan 2 - 4	1	1 - 3
Jan 5 - 6	2	6 - 7	Jan 7 - 11	2	4 - 8
Jan 12 - 13	3	8 - 9	Jan 14 - 18	3	9 - 13
Jan 19 - 20	4	10 - 11	Jan 21 - 25	4	14 - 18
Jan 26 - 27	5	12 - 13	Jan 28 - Feb 1	5	19 - 23
Feb 2 - 3	6	14 - 15	Feb 4 - 8	6	24 - 28
Feb 9 - 10	7	16 - 17	Feb 11 - 15	7	29 - 33
Feb 16 - 17	8	18 - 19	Feb 18 - 22	8	34 - 38
Feb 23 - 24	9	20 - 21	Feb 25 - Mar 1	9	39 - 43
Mar 2 - 3	10	22 - 23	Mar 4 - 8	10	44 - 48
Mar 9 - 10	11	24 - 25	Mar 11 - 15	11	49 - 53
Mar 16 - 17	12	26 - 27	Mar 18 - 22	12	54 - 58
Mar 23 - 24	13	28 - 29	Mar 25 - 29	13	59 - 63
Mar 30 - 31	14	30 - 31	Apr 1 - 4	14	64 - 67
Apr 5 - 8	15	32 - 35			

Table 3.2 Random Selection of Interview Periods

Interview Period (1)	Period Type Decision (2)	Holiday Day Selected (3)	Holiday Period Number (4)	Weekday Day Selected (5)	Weekday Period Number (6)
1	Weekday			51	11
2	Holiday	12	5		
3	Holiday	21	9		
4	Weekday			37	8
5	Holiday	14	6		
6	Holiday	18	8		
7	Holiday	11	4		
8	Holiday	32	15		
9	Holiday	26	12		
10	Holiday	23	10		
11	Weekday			61	13
12	Weekday			25	6
13	Holiday	5	1		
14	Holiday	8	3		
15	Holiday	17	7		
*16	Holiday	24	11		
*17	Holiday	28	13		
*18	Holiday	30	14		

* Added to obtain additional interviewing days

random number table were read successively and matched to the sequential numbers for the holiday days shown in column 3 of Table 3.1. Matching by day allows the probability of selecting a period to vary in relation to the size of the period. Once a day was matched to a random number, the entire period containing that day was selected (i.e. interviews were conducted on all days of the selected period). Duplicates of dates were ignored. As an example, for interview period 2 (see Table 3.2), holiday day 12 (column 3) was obtained from the random number match. From Table 3.1, one can see that holiday day 12 is part of holiday period 5 (January 26-27). Hence, interviewing was done on January 26 and 27. For weekday periods, similar selection criteria were used. The results for the random selection of interview periods are shown in Table 3.2. Three holiday periods were added part way through the study for reasons that are discussed below.

To reduce travelling time and cost, interviewing was carried out at only 1 trail on a given day (with the exception of 2 days when there were 2 interviewers and 1 day when interviews were conducted by the same individual on 2 trails). The intent was to allocate the same number of days (weekday and holiday) for interviewing on each trail. It was not possible to follow the original schedule for 3 reasons. First, there was a delay in obtaining the electronic counters for the Pipestone trails, which did not allow interviewing to begin on that trail until February 5. Second, it became evident that if a roughly equivalent number of interviews were to be obtained for each trail to make statistical comparisons more convenient and to obtain the desired sample size for each trail, additional interviewing days would have to be allocated. Third an interviewer was not available on March 17.

From Table 3.3, all of the dates on which interviews took place may be derived. These dates are listed in Table 3.4, with the holiday dates in column 1 and the weekday dates in column 4. The following discussion explains how the original assignments of interview dates to the trails were obtained. This procedure was performed before interviewing began and an additional 3 times as the field study progressed, for the reasons outlined above.

A sequential number was allocated to each of the holiday days (column 2) and weekday days (column 5), as illustrated in Table 3.4 (Table 3.3 shows the numeric designations of the trails that are utilized in Table 3.4), to facilitate random assignment of the interview dates to

Table 3.3 Numeric Trail Designations

Trail Name	Trail Number
Bow Hut	1
Mosquito Creek	2
Pipestone	3
Redearth Creek	4

the trails. For the holiday days, 2 digits from a random number table were used to assign dates to each trail, starting with 6 days for trail 1, then 6 days for trail 2 and then 6 days for trail 3. The remaining 6 holiday days were allocated to trail 4. As an example, for trail 1 (Bow Hut), the successive random number matches could have yielded days 6 (January 12), 9 (January 20), 12 (February 2), 19 (February 24), 22 (March 9) and 28 (March 31). A similar procedure was utilized to assign 5 weekday days to each trail. The date selections and trail allocations for the dates are listed in Table 3.4. These allocations of interviewing days are listed by trail in Table 3.5. Note that these tables contain the allocations which were actually used, after being reworked 3 times to compensate for the problems outlined above.

An attempt was made to obtain a quota of 10 interviews on each interviewing day. This did not prove practical, since there were many days, particularly during the week, when it was not possible to obtain 10 interviews, since the number of trail users was too few. Users were sampled near the trail access point adjacent to the highway. All persons using the trail were interviewed, subject to constraints (e.g. already interviewing a trail user) on the interviewer's time and non-response, although it was often only possible to interview one person from each group so that lengthy delays for the group were avoided. The respondents were selected in the sequence that they were encountered by the interviewer, to eliminate selection bias on his or her part. An encounter was defined to occur when a potential respondent crossed an imaginary line on the trail near the trail access point. The method of sample selection may thus be referred to as a modified stratified multistage design.

The rationale for the choice of this design was that a probability sample was obtained and it was the one most suitable to gain the desired information from a broad spectrum of users

Table 3.4 Allocation of Trails to Interviewing Days

Holiday Day (1)	Holiday Day Number (2)	Holiday Day Trail Number (3)	Weekday Day (4)	Weekday Day Number (5)	Weekday Day Trail Number (6)
Dec 28	1	2	Feb 4	1	4
Dec 29	2	4	Feb 5	2	3
Dec 30	3	2	Feb 6	3	3
Dec 31	4	4	Feb 7	4	4
Jan 1	5	2	Feb 8	5	1
Jan 12	6	1	Feb 18	6	4
Jan 13	7	4	Feb 19	7	3
Jan 19	8	2	Feb 20	8	2
Jan 20	9	1	Feb 21	9	3
Jan 26	10	4	Feb 22	10	2
Jan 27	11	2	Mar 11	11	4
Feb 2	12	1	Mar 12	12	1
Feb 3	13	4	Mar 13	13	3
Feb 9	14	4	Mar 14	14	1
Feb 10	15	3	Mar 15	15	1
Feb 16	16	2	Mar 25	16	2
Feb 17	17	3	Mar 26	17	2
Feb 23	18	3	Mar 27	18	1
Feb 24	19	1	Mar 28	19	2
Mar 2	20	3	Mar 29	20	4
Mar 3	21	3	Apr 4	21	3
Mar 9	22	1			
Mar 10	23	2			
Mar 16	24	4			
Mar 23	25	1,2			
Mar 24	26	2,4			
Mar 30	27	2			
Mar 31	28	1			
Apr 5	29	1			
Apr 6	30	2			
Apr 7	31	1			
Apr 8	32	1,2			

in the field.

Since a sampling frame of visitors was not available, pretest results were utilized in the determination of sample size. To simplify the calculation of sample size, each trail was treated as a separate entity. The sample design, which is discussed in detail above, effectively gave a simple random sample for each trail (Emory 1976). Any deviation from a simple random sample was compensated for by calculating sample size by trail rather than for the entire

Table 3.5 Interviewing Dates for the Trails

Bow Hut (1)	Mosquito Creek (2)	Pipestone (3)	Redearth Creek (4)
Jan 12	Dec 28	Feb 5	Dec 29
Jan 20	Dec 30	Feb 6	Dec 31
Feb 2	Jan 1	Feb 10	Jan 13
Feb 8	Jan 19	Feb 17	Jan 26
Feb 24	Jan 27	Feb 19	Feb 3
Mar 9	Feb 16	Feb 21	Feb 4
Mar 12	Feb 20	Feb 23	Feb 7
Mar 14	Feb 22	Mar 2	Feb 9
Mar 15	Mar 10	Mar 3	Feb 18
Mar 23	Mar 23	Mar 13	Mar 11
Mar 27	Mar 24	Apr 4	Mar 16
Mar 31	Mar 25		Mar 24
Apr 5	Mar 26		Mar 29
Apr 7	Mar 28		
Apr 8	Mar 30		
	Apr 6		
	Apr 8		

population, resulting in a somewhat larger total sample size.

From the pretest, it was found that the proportion of park users that were aware of the Parks Canada avalanche hazard forecast was 60 percent. Fifty percent of the trail users were assumed to find the forecast useful, to provide maximum sample size, since pretest results may have been biased in some fashion. These are 2 of the more important facets of the study. Sample size was determined using the following relationship, as derived from Lapin (1973: p. 261):

$$n = z^2 pq/d^2,$$

where the following definitions hold:

n: sample size

z: normal distribution deviate

p: proportion of population possessing attribute

q: proportion of population not possessing attribute

d: acceptable level of error .

It was assumed that it is acceptable that the population parameter is within ±0.10 of the sample proportion with 95 percent confidence. Hence,

$d = 0.10$

and $z = 1.96$.

For the proportion that were aware of the Parks Canada forecast, sample size may be computed as

$$n = (1.96)^2(0.6)(0.4)/(0.1)^2 = 92.2$$

This figure must be rounded up to 93.

For the proportion that felt the forecast was effective or useful, sample size may be computed as

$$n = (1.96)^2(0.5)(0.5)/(0.1)^2 = 96.04$$

This figure must be rounded up to 97.

The average of the 2 computed sample sizes was 95. Allowing 5 interview refusals for each trail (roughly the refusal rate in the pretest of 3 percent), gave a convenient sample size of 100 for each trail. Sample sizes were calculated using the same procedure after the survey was completed, using data from the survey. The resulting sample sizes were 26 for Bow Hut, 46 for Mosquito Creek, 51 for Pipestone and 45 for Redearth Creek.

3.3 Questionnaire Content

The questionnaire used in this study is contained in Appendix 1. This questionnaire, which was used to structure personal interviews, is divided into 6 major sections, A through F. In the following discussion of the rationale of each section (or particular question), please use the letter and number combinations (e.g. B.I.1) to refer to the questionnaire.

A number of open-ended or free-response questions are used in the questionnaire for reasons outlined by Earle and Lindell (1984). They state that free-response methods are used more appropriately earlier in the exploration of a content area or in the preliminary sections of a preliminary study. This type of question is most fruitfully used when researchers are relatively ignorant of their area of study: they simply do not know what the important questions are. Such seems to be the case today with regards to most aspects of public risk perception, especially avalanche hazard. The open-ended items allow respondents to generate their own response alternatives, including that of giving no response at all. The results produced by free-response items are controlled less by the researchers and more by the respondents.

The first major section of the questionnaire, A, is intended to elicit information specific to the interviewee's trip for that day. This specific information is important, since avalanche hazard can vary both spatially and temporally (Perla and Martinelli 1978). Data on the user's intended or actual route may give an indication of risk perception (question A.I), since to reach the destination, the respondent may be required to cross potentially hazardous terrain. Given the route and the Parks Canada avalanche hazard rating, an objective risk level can be established. Previous experience with the trail is indicated in question A.II. Summer experience is useful since one can observe the ground as a potential sliding surface for avalanches — whether it be rough (e.g. many large boulders) or smooth (e.g. grass or scree). This previous experience could provide some data on which to base risk perception and associated safety decisions. Question A.III focuses on the type of skiing the user will be doing that day, since some types may be potentially more risky than others. This provides another factor influencing objective risk. Party size (A.IV) is an indication of the number of people at risk and strength of the party. Established leadership (A.V) can be an important factor in party safety (Gallagher 1967; Perla and Martinelli 1978). The party leader is often considered to be the most experienced member of the group. The final 3 questions in section A (A.VI, A.VII and A. VIII) are intended to provide information on the length or type of trip (e.g. day or overnight) and residence.

The second portion of the questionnaire, B, deals with perception of and attitudes toward avalanches, as well as assessment of the risk of avalanches. Question B.I is intended to measure the saliency of avalanche hazard relative to other difficulties faced by backcountry travellers in winter and determine whether avalanches are considered to be a major concern.

Beginning at question B.II, the remainder of the questionnaire deals specifically with avalanches. B.II was used to determine if a person knew what an avalanche is. If the person did not, the interviewer defined an avalanche as "a mass of snow falling or sliding down a mountain" to facilitate completion of the interview. If the person was still not familiar with avalanches, the remainder of section B was skipped. Questions B.III and B.IV show awareness of the hazard frequency and magnitude. The responses to these questions could supply an indication of risk perception. It is often argued (e.g. White 1974a; Burton *et al.* 1978) that one's experience with a natural hazard is directly related to the adjustments undertaken for that hazard. Experience with avalanche hazard is measured in questions B.V and B.VI, while questions B.VII and B.VIII deal with 2 of the common adjustments to this hazard.

The final group of questions in section B; B.IX, B.X and B.XI; are intended to determine how the user evaluates the risk of avalanches for the trip that day. The perceived hazard rating supplied by the interviewee was later compared to the objective rating formulated on a daily basis by Parks Canada personnel.

The third major section of the questionnaire considers some of the management implications of protecting winter backcountry recreationists. The first question (C.I) is intended to determine what actions the user thinks Parks Canada presently takes to reduce the risks to winter travellers, providing a measure of awareness of present programs.

Next, there is a respondent evaluation of one of the programs which presently exist in Banff National Park (question C.II), the daily backcountry avalanche hazard forecast. Questions C.II.1 through C.II.3 are self-explanatory. Questions C.II.4 and C.II.5 are used to check if a person has actually obtained the Parks Canada forecast for that day, and the specific source of that information. If a hazard warning is to be effective, people must believe it (Burton *et al.* 1978). Hence, the users were asked if they thought that the Parks Canada rating was useful (question C.II.6). The purpose of question C.II.7 is to solicit user suggestions for improvement of the present avalanche hazard forecasts. The final group of questions in section C (C.III to C.VI) is intended to determine what actions the user thinks that Parks Canada should take to reduce the risks to backcountry travellers. C.III is a general open ended question, while C.IV, C.V and C.VI are more specific.

Section D is intended to provide additional information which may be used to explain differences in responses between individuals. This data is also useful in developing resource management programs. The users's experience in winter backcountry activities is measured by questions D.I through D.III. Knowledge gleaned from past experience can provide a basis on which to base decisions. Questions D.IV and D.V will be used to gain an indication of user education directly related to the avalanche hazard. Education is an explicit preparation to reduce risk levels.

Specific knowledge related to travelling safely in the backcountry is tested in questions D.VI and D.VII. Daffern (1983) argues that the ability to find a safe route is the most important skill a person travelling in avalanche prone terrain can learn. This ability was evaluated by having the respondent indicate the safest route on a line drawing (D.VI) which is representative of the study area, giving an indication of how the user makes risk assessments. The line drawing is included with the questionnaire in Appendix 1. Question D.VII is intended to measure knowledge of search and rescue techniques, since backcountry skiers must be rescued by their companions if there is to be any significant chance for survival (Williams 1975). This level of knowledge is an indicator of preparation intended to reduce risk levels.

Equipment utilized and carried by backcountry travellers may be an indication of hazard perception, preparation and knowledge level (D.VIII). This applies in particular to safety equipment carried, but may include other articles of equipment. Amount and type of clothing carried can indicate preplanning ~~for potential accidents~~ such as avalanches, injuries or equipment failures, as would comprehensive repair and first aid kits.

To describe the respondents, place them in society and to provide some predictive capabilities, socioeconomic information was collected (section E). Following the lead of Buttel (1979) and Van Liere and Dunlap (1980) in the field of environmental attitudes and Harding and Parker (1974) in the natural hazards field, data was obtained for the following variables:

occupation, age, education and sex. Examples of the probe cards for age and education are included in Appendix E. After all interviews were completed, occupational responses were categorized according to the 1980 occupational classification of Statistics Canada (1981).

The last section (F) of the questionnaire was completed after the interview, to obtain the interviewer's impression of the user. Questions F.I through F.III give a general impression of interview quality. The interviewer's assessment of the respondent's capability of dealing with avalanche hazard was recorded in question F.IV.

3.4 Pretest or Pilot Study

An initial pretest of the questionnaire was performed in the vicinity of Edmonton, Alberta. Eleven interviews were undertaken to discover any problems with the questionnaire and interview format. These respondents were selected from a local mountaineering club, persons in the Department of Geography at the University of Alberta and skiers encountered on local ski trails. Persons of varying experience levels were selected. Appropriate modifications were made to the questionnaire and interview format, followed by a second set of pretest interviews. This second set of interviews (10 people) was undertaken in Banff National Park, along the Pipestone, Mosquito Creek and Bow Hut trails. Following these interviews, the questionnaire was shortened and reworded again.

The electronic counters were thoroughly tested before being installed in the field. Testing took place in a deep freeze unit where the temperature was held continuously at -20°C so that cold sensitivity of the various components could be determined.

3.5 Data Collection

Personal interviews of users were selected as opposed to self-administered questionnaires for reasons as outlined by McGaw and Watson (1976). These are that personal interviews do not assume an interested population; have higher response rates; are more flexible; are better for complex and controversial topics; and honesty and competence of the respondent can be appraised.

If a backcountry user refused to grant an interview, a notation of the reason for the refusal was made. An attempt was then made to interview the next user encountered. Potential respondents were informed that provision of information was voluntary.

The interview day started at 0800 hours (or earlier) and continued until 1700 hours or until all skiers had returned from their trip for the day (whichever was later). The readings from the electronic counters were obtained at the start and the end of the interview day. To verify the accuracy of the electronic counters, a manual count was maintained for the entire day. The manual count also provided a reference to make adjustments to the electronic count for instances where people skied side by side (hence causing only 1 count to occur) or when people returned on a different day and/or trail than which they began the trip. Electronic counter readings were also obtained for each trail at the start and end of each holiday or weekday period when an interviewer was present.

Skiers encountered by the interviewer were generally quite interested in the survey, and the response was excellent. People did not seem to mind answering questions while they were preparing to go skiing or putting away equipment after their ski outing. The interviewer rated over 95 percent of the respondents as being very cooperative and nearly 94 percent as being very interested in the study, which are remarkable figures considering the fact that on over 22 percent of the interviewing days, the maximum temperature was less than -15°C (lowest maximum of -25°C). Of the 366 potential respondents approached by an interviewer, only 1 person declined to participate in the study. Approximately an equal number of people were interviewed on each trail with 87 interviews obtained on the Bow Hut trail, 92 at Mosquito Creek, 95 at the Pipestone trails and 91 at Redearth Creek. These totals exceeded the sample sizes calculated to obtain statistically significant results by a wide margin.

3.6 Preparation of Data for Analysis

Following data collection, the data were prepared for analysis. The questionnaire data were coded to facilitate processing by a commercial, computerized statistical package known as SPSSx. The electronic and manual counts for each trail were tabulated manually.

As evident from the questionnaire (see Appendix 1), the questions are either of closed-ended, precoded open-ended or open-ended format. The closed-ended questions, having a restricted number of responses, were coded directly from the questionnaire. The precoded open-ended questions were treated in a similar manner. Responses to the open-ended questions were placed in categories using a simplified form of content analysis following the guidelines of McGaw and Watson (1976). The relatively small sample size permitted this more time consuming processing of the richer information derived from the open-ended questions.

Total usage counts were obtained for each trail over the period in which interviews were conducted. On days when an interviewer was present, the manual count was used as the total for that day. When no interviewer was present, an adjusted electronic count was utilized. The adjustment to the electronic count was obtained for each trail by comparing manual and electronic readings when they were both available for the same time period. The overall sum of the electronic counts (taken when manual counts were available for the same period) was divided by the overall sum of the manual counts (taken when electronic counts were available for the same period). The electronic count was divided by this ratio to derive the adjusted trail use figure. Note that when calculating trail usage, a count of 1 was taken both for a person who went out and back on the same trail on the same day and for a person who went out and back on a different trail and/or day.

4. The Management Scenario — The Area and Its Users

To meet the objectives of this study, with respect to determining salience, awareness and perception of avalanche hazard, studying avalanche knowledge and guaging effectiveness of existing programs, one must have some understanding of the physical setting of the area and the nature of the people using it. In this chapter, the climatic and physiographic aspects of Banff National Park are described, as are the weather patterns for the winter of 1984-85 and the 4 ski trails selected for the study. To portray the nature of the people who ski in the park, data are presented which illustrate the number of people using the study trails, who uses the trails (in terms of occupation, age, education, sex and residence), some characteristics of the parties of skiers who use the area (party size, party leadership and overnight locations before and after the ski outing) and the type of skiing in which the people participate. Knowledge of the factors outlined in this chapter facilitates interpretation of the material presented in succeeding chapters.

4.1 Climate and Physiography of Banff National Park

The climate and physiography of Banff National Park have a major influence on the use of the area by backcountry skiers and on the risk of avalanche.

4.1.1 Climate

The climate of Banff National Park may be characterized as "cold subhumid continental" (Rheumer 1953). Generally cold temperatures and the shallow snowpack (as compared to other mountain ranges which are commonly used for recreation) can lead to extended periods of serious snow instability (Daffern 1983). Nearly all skiing in the park takes place in the subalpine and alpine ecoregions which are described by Strong and Leggat (1981). The climatic forest line (about 2100 m) is the boundary between these 2 ecoregions. The subalpine ecoregion (with a lower elevational boundary of about 1500 m) has winters which are long, snowy and cold. The overriding climatic elements which characterize the ski season in the alpine ecoregion are strong winds, long winters and higher levels of precipitation than the remainder of Alberta (Strong and Leggat 1981). More detailed information on temperature, precipitation, wind and chinooks follows.

The winters in the subalpine ecoregion are generally warmer than the prairie areas to the east. The relatively higher elevation allows escape from severe cold outbreaks of shallow Arctic air masses, and warm Pacific air masses influence this ecoregion during the winter (Strong and Leggat 1981). However, Janz and Storr (1977) report that severe Arctic outbreaks can affect the area. Long term data from the Lake Louise townsite, which is included within this ecoregion, show the following mean monthly temperatures for the winter months (Janz and Storr 1977):

- November: -8°C
- December: -12°C
- January: -16°C
- February: -10°C
- March: -7°C
- April: -1°C

Higher elevations are generally warmer (Strong and Leggat 1981), since cold air pools in the valleys. Again at the Lake Louise townsite, the long term average autumn (August to December) snowfall is 201 cm, while that for spring (January to July) is 236 cm. Snowfall generally tends to increase with elevation (Janz and Storr 1977). Topography has a major influence on winds in this area. The north-south valleys, by and large, cannot be considered to be windy, with east-west valleys having the most wind, but still not as much as areas directly east of the park. Wind speeds at the surface are reduced by the forest canopy (Janz and Storr 1977). Chinooks are infrequent in the subalpine region, although the weather pattern that brings chinooks to the prairies can moderate temperatures to some extent (Longley 1967; Strong and Leggat 1981).

Climatic data for the alpine ecoregion are limited. Mean January temperatures are generally about 3 to 4 degrees cooler than the subalpine ecoregion (Strong and Leggat 1981), with snowfalls tending to be higher (Janz and Storr 1977). The often strong winds commonly scour windward slopes bare and deposit several times the orginal depth of snow on leeward slopes (Janz and Storr 1977; Strong and Leggat 1981). These strong winds can be associated with cloud, precipitation, low temperature and whiteout conditions. Combined with wind chill, these pose a serious hazard to the backcountry traveller. Chinooks do not occur in the alpine ecoregion, and temperatures rarely, if ever, exceed 0°C during the December to February period (Strong and Leggat 1981).

4.1.2 Physiography

The rugged, high mountain landscape of Banff National Park is one of the chief attractions to backcountry skiers, along with the extended period of a reliable supply of snow for skiing. The average elevation in the area is over 2000 m, with the highest peaks reaching 2500 to 3500 m (Smith 1985). The major mountain ranges have a general northwest-southeast orientation. The ranges are separated by a series of parallel, deeply entrenched valleys, with 2 major valleys cutting eastward across the trend of the ranges. These major valleys (Bow and North Saskatchewan) tend to be quite broad with gently terraced valley floors. There is evidence of extensive valley and cirque glaciation throughout the area (McPherson 1970; Rutter 1972), although, at present, only small icefields along or near the continental divide and scattered cirque glaciers remain.

4.2 The Winter of 1984-85

During the winter of 1984-85, snow accumulation started unusually early. There were significant snowfalls in October, November and December. The height of snow on the ground by December 31, 1984 was 85 cm (compared to an average of 68 cm (Janz and Storr 1977)) in the Parks Canada snow research plot at the Lake Louise ski area. The remainder of the winter was characterized by low snowfall and high winds. Many slopes were blown clear of snow, while hard slabs of wind deposited snow developed in lee areas. Total accumulated snow only exceeded the December 31 figure by about 10 cm at any point later in the winter. Snow depth at the research plot was 90 cm (G. Irwin, personal communication, 1985) on April 1, 1985, as compared with an average of 112 cm (Janz and Storr 1977). Temperatures were generally moderate and above average, with the exception of a period from Christmas to New Year's, the last 4 days of January and the first 10 days of February when daily lows were from -30° to -35°C.

To compare the 1984-85 winter to previous winters, one may consider temperature, snowfall, wind and avalanche hazard. Temperatures were generally warmer than usual, allowing more snow consolidation. Total snowfall was only about 65 percent of normal. There was more wind than the past average, but since there was seldom any loose snow available for transport, hazardous wind slabs did not develop on lee slopes to any major extent. More detail on the avalanche hazard is presented in a succeeding chapter. In general terms, the 1984-85 winter was safer with respect to avalanche risk than the average of previous winters. All climatic data for which references were not given above and the backcountry avalanche hazard forecast were obtained from the Parks Canada wardens stationed in Lake Louise (C. Israelson, personal communicatior, 1985).

4.3 Skiing in Banff National Park

Skiers are attracted to Banff National Park for a variety of reasons. These may include the scenery, generally reliable snow conditions, the opportunity to ski in challenging terrain and the search for a wilderness experience. Both "downhill" and "cross country skiing" are available in Banff National Park. "Downhill" skiing, which is available at the Mount Norquay, Sunshine and Lake Louise commercial ski resorts, involves riding a ski lift up the slope, prior to the gravity aided descent. This form of "downhill" skiing is not within the realm of this thesis since the threat of avalanches is controlled by teams of Parks Canada wardens, and assistance is readily available in case of accidents. This study treats only "cross country skiing" in the backcountry where ski lifts and avalanche control do not exist and organized rescue teams are available only after an extended delay.

Parks Canada (1983: p. 3) recognizes 3 distinct types of cross country skiing within the park:

- **nordic skiing** is usually done close to road access points along valley bottoms and on adjacent river terraces. The terrain is often flat or gently rolling, but can also include fairly steep hills.
- **ski touring** often follows summer hiking trails which may cross high passes. It exposes skiers to many of the hazards characteristic of mountain travel in winter.
- **ski mountaineering** takes place in high alpine areas and sometimes includes glacier travel. Skiers must find their own routes and should be well prepared for extreme cold, storms, whiteouts, avalanches and crevasses.

As one can see, the level of risk from environmental factors, including avalanches, increases from the first to the last category.

4.4 Ski Trails Considered in this Study

The 4 trails selected as interview sites for this study were chosen, in consultation with Parks Canada (C. Israelson, personal communication, 1983; J. Flaa, personal communication, 1984; G. Fortin, personal communication, 1984), to provide as broad a spectrum of skiers and ski conditions as possible. These trails are Bow Hut, Mosquito Creek, Redearth Creek and the Pipestone network. The location of these trails was illustrated in Figure 1.1.

The Bow Hut trail (see Figure 4.1) is a popular access route to Bow and other huts, the Wapta Icefield and adjoining glaciers. In the view of Parks Canada (1983), it is classified as a ski mountaineering trail. To characterize the people using this trail, they likely correspond to the category of those with good avalanche knowledge and experience who concentrate their activities in avalanche areas (cf. More *et al.* 1984). Kunelius (1977) rates this trail as an

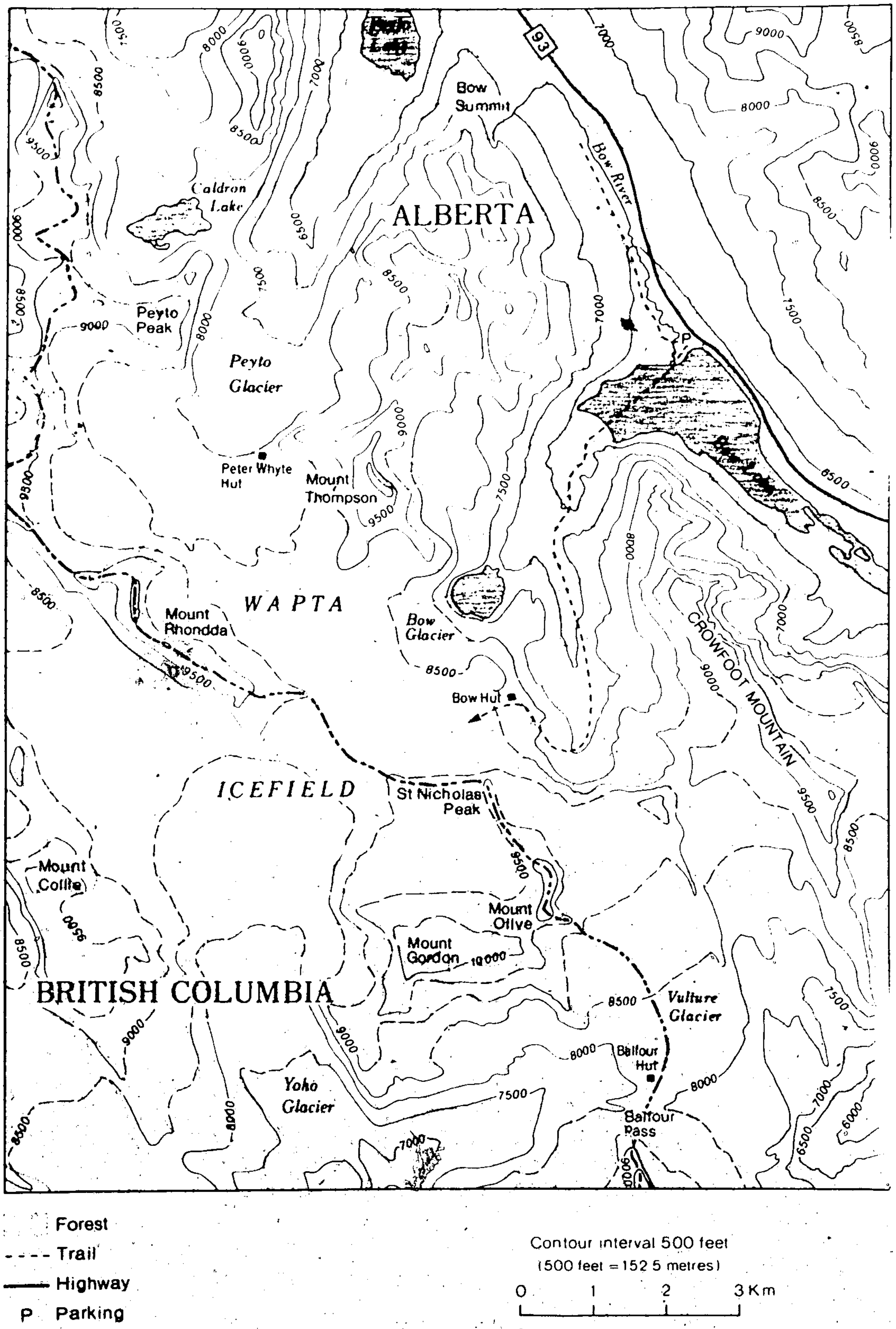

Figure 4.1 Bow Hut Trail

advanced one which can be extremely prone to avalanches. Beyond Bow Hut, crevasses in the glaciers and the potential for whiteouts represent additional dangers to the skiers.

The Mosquito Creek trail (see Figure 4.2) is one of moderate difficulty (rated intermediate by Kunelius (1977)), following the creek to the alpine meadows at its headwaters. These meadows are a popular destination for practising downhill techniques on cross country skiis (Kunelius 1977) and sightseeing. The type of skiing on this trail may be generally described as ski touring (Parks Canada 1983). The people using this trail could be represented as those who travel in avalanche areas as well as safe areas and who possess a basic awareness of avalanche danger, but have limited experience (cf. More *et al.* 1984). The popularity of this trail is enhanced by the availability of accommodation at a hostel and a campground near the trailhead and the potential for a loop trip starting from the highway at Helen Creek, ascending to Dolomite Pass and returning along Mosquito Creek. This latter route could involve some minor ski mountaineering (Parks Canada 1983).

Both the nordic and ski touring categories as described by Parks Canada (1983) exist on the Redearth Creek trail. Figure 4.3 illustrates the area of the Redearth Creek trail. This trail follows a fire road which is located 20 km west of the Banff townsite. The first 11.5 km of the trail (given a novice rating by Kunelius (1977)) are trackset on a regular basis by Parks Canada. Beyond the trackset portion of the trail, a lesser number of skiers continue to the Egypt Lake shelter (maintained by Parks Canada), Healy Pass, Shadow Lake and Gibbon Pass, trails rated at intermediate difficulty by Kunelius (1977). Skiers who used the initial portions of this trail could be represented as being those who travel on or near marked trails, are only vaguely aware of avalanche danger and prefer to stay in safe areas, while those who continued beyond the trackset section could be characterized as people who travel in avalanche areas as well as safe areas, who possess an awareness of avalanche danger, but only limited experience (cf. More *et al.* 1984).

The Pipestone network of trails is located adjacent to the Lake Louise townsite in the bottom of the Bow River valley (see Figure 4.4). This is the only area included in the study

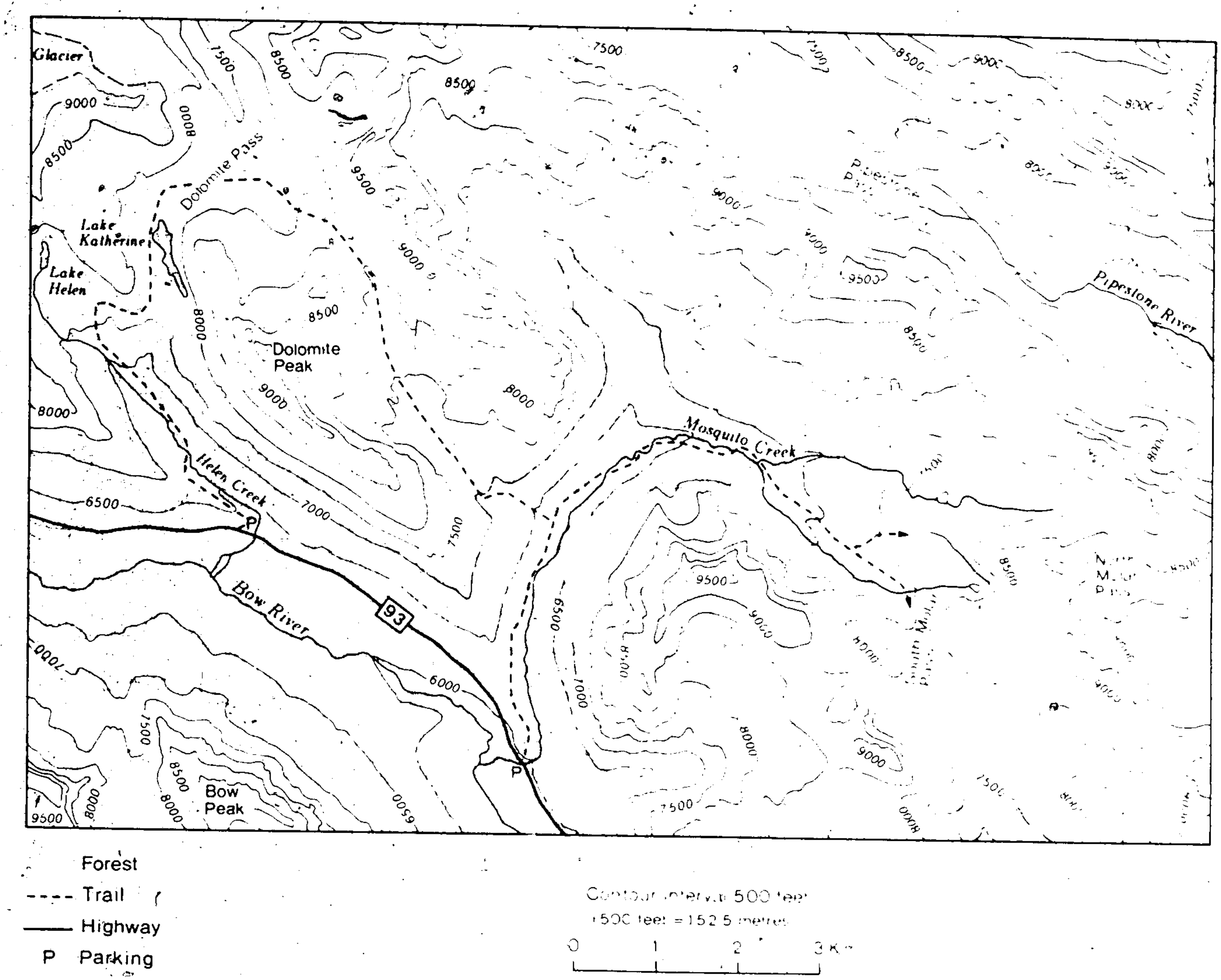

Figure 4.2 Mosquito Creek Trail

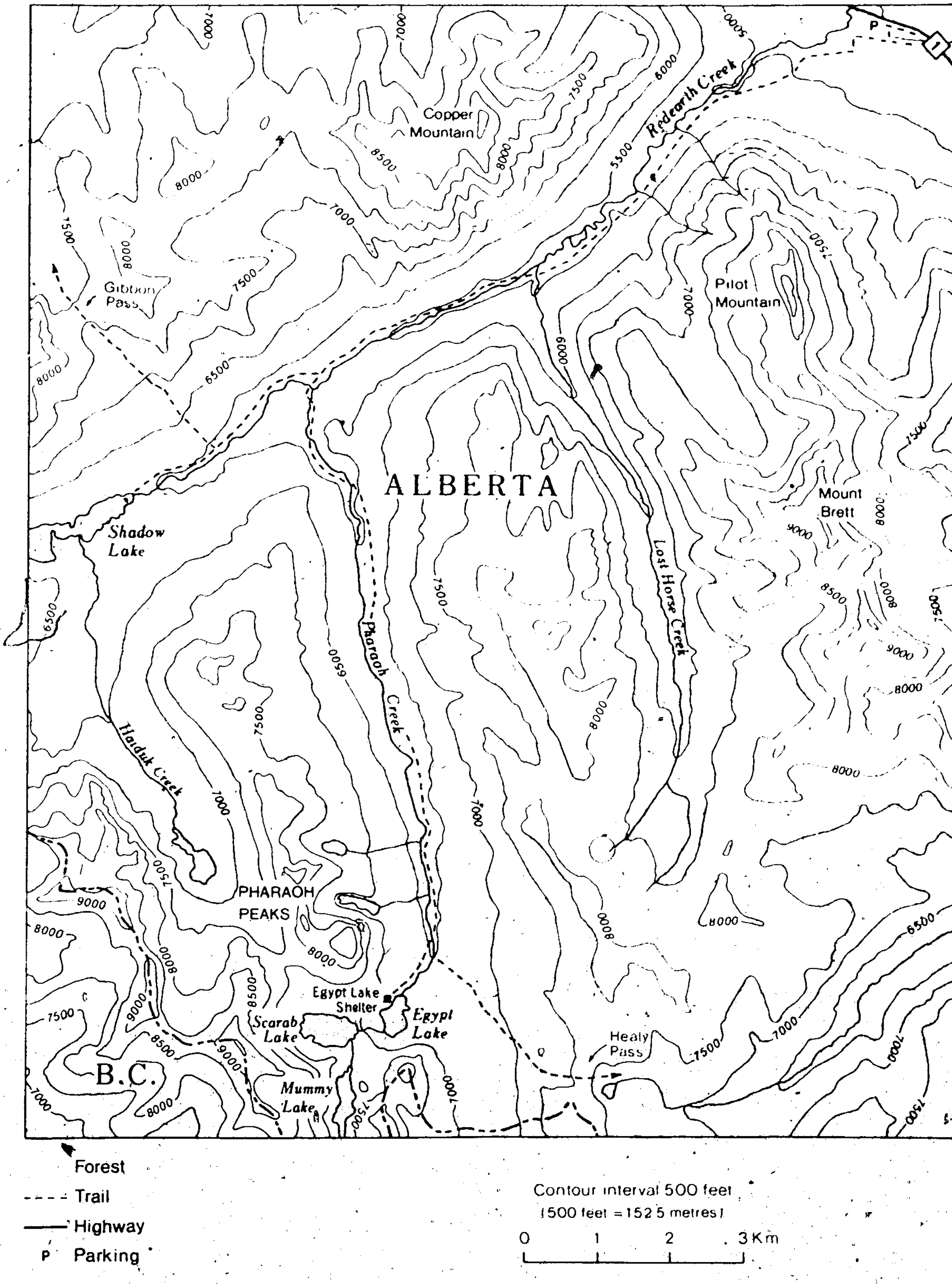

Figure 4.3 Redearth Creek Trail

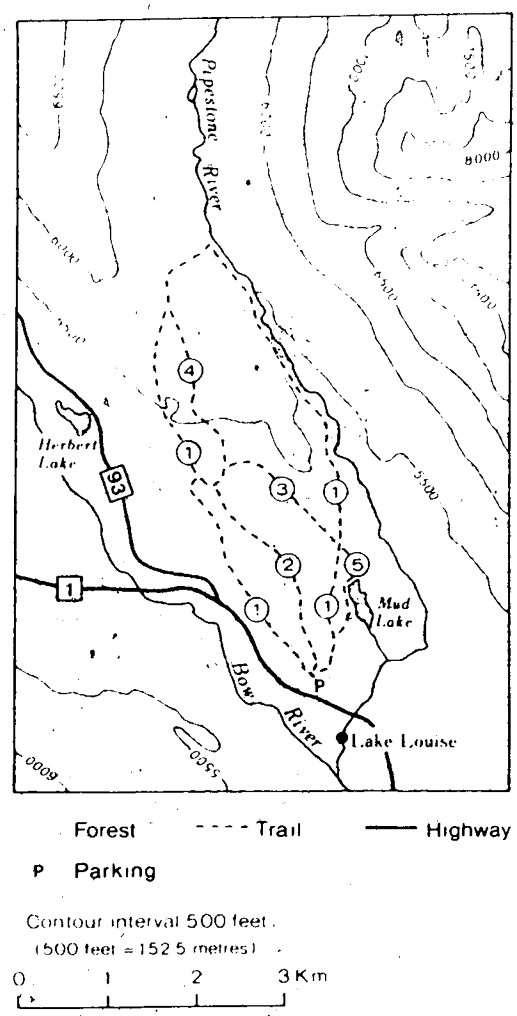

Figure 4.4 Pipestone Trail

where there is no risk of avalanches. The trails, which are trackset on a regular basis by Parks Canada, are situated within a predominantly closed forest on moderately rolling terrain suitable for beginner skiers. Commercial accommodation is available in the townsite of Lake Louise and at the nearby lake of Lake Louise. There is also a resident population at Lake Louise who utilize these trails. The skiing on the Pipestone trails would be classified as nordic by Parks Canada (1983), while More *et al.* (1984) would characterize the skiers as being those who travel on or near marked trails, are only vaguely aware of avalanche danger and would prefer to stay in safe areas.

4.5 Number of People Using the Study Trails

The number of people using the 4 trails was monitored over the course of the study. This monitoring, along with the interviewing, began in late December, 1984, when there was sufficient snow for cross country skiers to frequent the area on a regular basis. The skiers were counted using manual and electronic methods, as described in the methodology chapter. The trail use counts are presented in Table 4.1. The time periods for which counts were collected for each trail are as follows:

- Bow Hut — January 12, 1985 to April 8, 1985
- Mosquito Creek — December 28, 1984 to April 12, 1985
- Pipestone — February 5, 1985 to April 12, 1985
- Redearth Creek — December 29, 1984 to April 8, 1985

Total counts are presented for each trail, but since the time periods are different for each trail, they may not be directly comparable. Also for each trail, the proportion of use on weekday and holiday periods is presented.

As can be seen from Table 4.1, usage of the Bow Hut and Mosquito Creek trails was generally similar throughout the winter, with the exception of January, when usage of the Bow Hut trail is lower, even if compensation is made for the installation of the Bow Hut counter on January 12. At the beginning of the season, more people used the Redearth Creek trail than the

Table 4.1 Number of Skiers on Each Trail During Study Period

	Bow Hut	Mosquito Creek	Pipestone	Redearth Creek
December		75		19
January	114	296		592
February	325	339	544	398
March	499	517	648	521
April	121	123	70	53
Total	1059	1350	1262	1583
% Holiday	67.3	79.6	55.5	67.0
% Weekday	32.7	20.4	44.5	33.0

Bow Hut or Mosquito Creek trails, but the difference became less apparent toward the end of the season. Reasons for this could be that ski conditions after late February were better on the latter 2 trails (as a result of higher elevation, greater snowfall and somewhat lower temperatures) and the longer daylight period made excursions to those trails farther away from major population centres more attractive. The reason that the Pipestone trail receives the highest total use is greater use during weekday periods. The proximity of this trail to the Lake Louise townsite with its commercial accomodation and resident population likely accounts for the greater weekday use. Weekend use was similar to the other trails. When considering all trails, about two-thirds of the use was on weekends and statutary holidays.

The total trail use count of 5254 may not seem to represent a large number of skiers using the area, but when the many trails within Banff National Park are considered, one recognizes the large number of people who could be subject to avalanche hazard. Kunelius (1977) lists at least 72 trails in the park and one must be aware that his book does not describe all of the trails. Finally, the trail usage on these 4 trails does not fit the pattern of More *et al.* (1984), who found that about 75 percent of the skiers would use trails such as the Pipestone trail, about 20 percent trails like the Mosquito Creek trail and about 5 percent trails such the Bow Hut trail.

4.6 Who Uses the Trails

To gain an idea of some of the characteristics of the people who cross country ski in Banff National Park, data were collected with respect to 5 variables. These are occupation, age, education, sex and residence. The findings for the first 4 of these variables were used to determine if there are any differences between users of the 4 trails. Also the overall results were compared against those for the general population of Canada.

The occupations of the respondents on each trail were relatively similar (chi-square significance level greater than 0.05). However, the occupation groupings of the respondents was quite different from the overall Canadian averages (Statistics Canada 1983). The greatest variation occurred in the occupational categories for natural sciences, engineering and mathematics (28.4 percent of respondent group vs. 2.8 percent population of Canada); teaching (10.5 vs. 3.5 percent); clerical (4.3 vs. 15.5 percent); service (4.8 vs. 10.1 percent); and product fabricating, assembling and repairing (1.1 vs. 6.6 percent). Also, only 8.5 percent of the respondents were full time students, as opposed to 15.3 percent of the population of Canada (Statistics Canada 1984b). Overall, about 81 percent of the respondents had white collar jobs, as compared to only 49 percent of all Canadians. All of the above figures are for persons 15 years of age and older.

Age differences existed between the users of the trails, with the users of the Bow Hut and Mosquito Creek trails being younger, on average (significance level less than 0.05). An age difference also existed between the respondents and the population of Canada (Statistics Canada 1984a), as shown in Table 4.2. Nearly 88 percent of the respondents were between 21 and 50 years of age, while only just over 44 percent of Canadians belonged to this group.

The education level of the respondents did not vary significantly (chi-square level of significance greater than 0.05) from trail to trail. However, the education level of the respondents is much higher than that of the overall Canadian population (Statistics Canada 1984b), as shown in Figure 4.5.

Table 4.2 Age of the Respondents Compared to the Overall Canadian Population

Age	Study	Canada
< 16	0.3%	23.5%
16—20	1.1	9.0
21—25	12.9	9.5
26—30	26.1	9.0
31—35	18.1	8.2
36—40	11.0	7.0
41—45	10.4	5.6
46—50	9.3	5.0
51—55	4.4	5.0
56—60	3.0	4.7
61—65	3.0	4.1
> 65	0.3	9.3
Total	364	24889600

Chi-square = 347.2 Degrees of Freedom = 11 Significance Level < 0.05

The sex of the respondents varied significantly from trail to trail (chi-square significance level less than 0.05), with the proportion of females being greater on the Pipestone trail than on the others. However, the proportion of male respondents in the study is significantly higher than that in the overall population of Canada (75.6 vs. 49.5 percent, respectively) (Statistics Canada 1984a).

Finally, over 87 percent of the respondents were residents of Alberta or British Columbia. Of the total number of respondents, nearly 75 percent were from Calgary (50.7 percent of overall total), Edmonton, Banff, Lake Louise or Red Deer. When developing or enhancing any programs that deal with users of these backcountry areas one must realize that nearly all of these people live in relatively close proximity to Banff National Park. Also, and perhaps more importantly, the segment of the population which uses these areas generally have white collar occupations, are mostly within the 21-50 year age group, are much more highly educated than the general population of Canada and three-quarters are men.

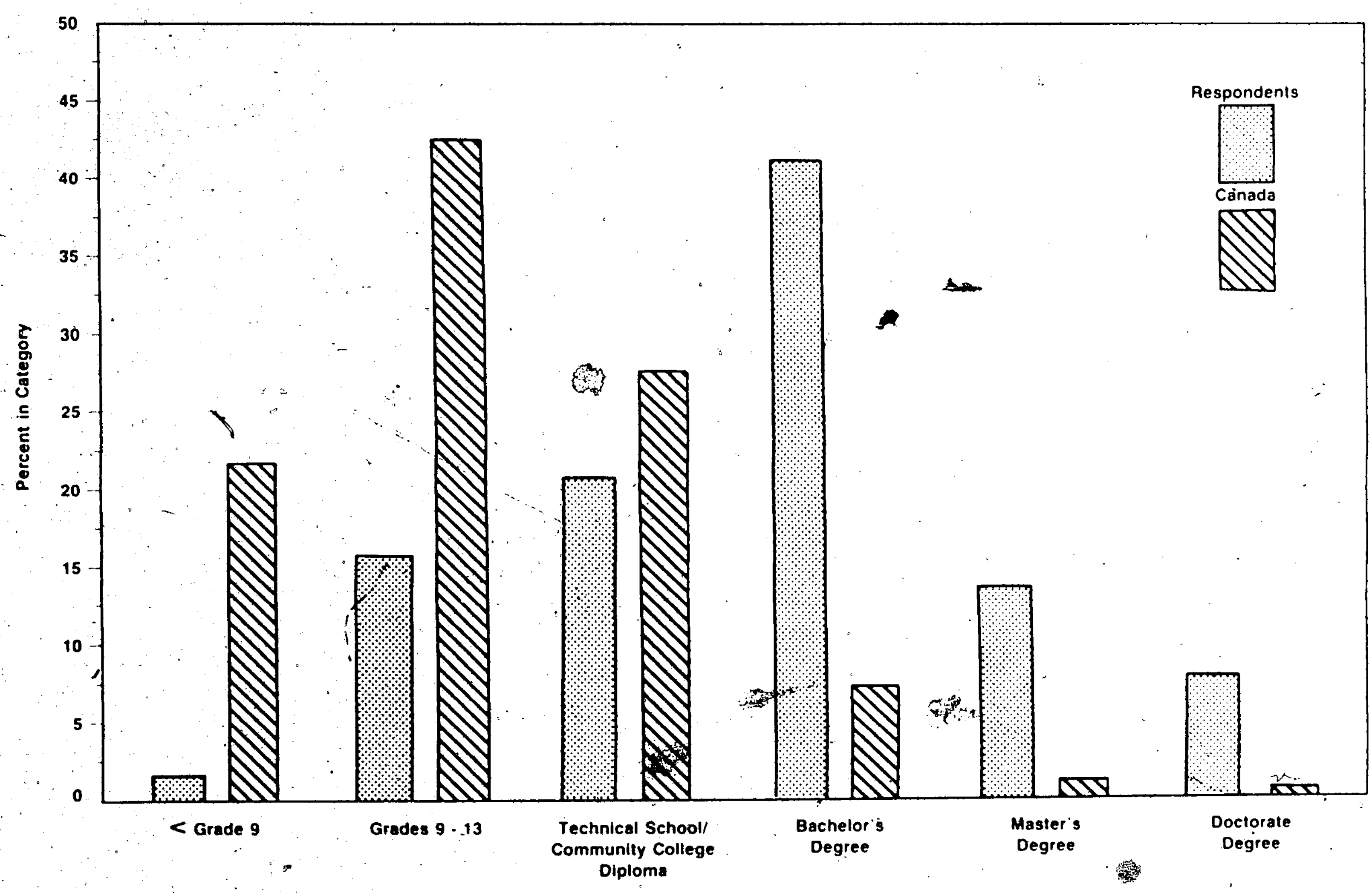

Figure 4.5 Education Levels of Respondents vs. Overall Canadian Population

4.7 Ski Party Characteristics

It is also beneficial for people developing backcountry plans to be aware of some of the characteristics of ski parties using the area. These ski parties are composed of the individuals whose attributes were discussed in the previous section. Group aspects considered in this study are party size, party leadership and overnight locations before and after the ski outing.

Parties on the Bow Hut and Mosquito Creek trails were more likely to consist of more than 2 persons than parties on the other trails (significance level less than 0.05). One may take this as an indication that a greater proportion of the parties that are mountaineering or ski touring expend more effort on trip preparation, which would be required with the increased party size. When considering all trails in aggregate, party sizes ranged from 1 to 23 skiers, with a mean of 3.5 and a median of 2. Over 45 percent of the respondents were members of a party of 2 skiers and over 80 percent of the parties had 4 or less members.

Just over 40 percent of the respondents were members of a party with a recognized leader. This figure did not vary significantly from trail to trail (chi-square level of significance greater than 0.05). Hence, any management programs aimed specifically at party leaders would reach only a minority of parties.

The locations at which the respondents stayed the night before and after the interview are associated with the trail at which the interview took place. However, it is of greater interest to consider the aggregate data here. Only slightly less than 23 percent of the respondents spent both nights outside of the park. This means that over three quarters of the cross-country skiers utilizing these trails could potentially be reached by some evening program held within the park. Almost 50 percent of the respondents spent at least 1 night in the major centres of Canmore, Banff and Lake Louise, where evening programs could be held. Programs held in Banff could potentially attract people staying in Canmore, if there was sufficient publicity. Further, a full 19 percent of the respondents spent at least 1 of the nights in the backcountry, either in a hut or camping.

4.8 Type of Skiing on the Trails

A final characteristic of the skiers that would be of interest to persons managing an area such as Banff National Park is the proportion of the skiers who participate in different types of skiing. The type of skiing in which people are engaged can give an indication of the avalanche risk they encounter. Skiers who are utilizing areas away from established trails, particularly those who are telemarking (or employing other cross country downhill techniques on open slopes) or alpine touring (on downhill skiis with hinged touring bindings) are subject to greater risk of avalanche (Daffern 1980; More *et al.* 1984).

The skiers were asked whether they would be trail skiing, off trail skiing, alpine touring or "cross country downhilling" (e.g. telemarking). It was possible for an individual skier to be participating in more than 1 type or category of skiing on the interview day. Table 4.3 shows a difference (using a chi-square test) in the risk levels among the trails in the study. Using type of skiing as a measure of avalanche risk, one can rank the trails in terms of the risk people encounter on them. The highest level of risk is encountered on the Bow Hut trail, followed by the Mosquito Creek trail, the Redearth Creek trail and the Pipestone trail.

Table 4.3 Percent of Respondents on Each Trail Engaged in Different Types of Skiing

	Bow Hut	Mosquito Creek	Pipestone	Redearth Creek
Trail Skiing	100.0%	100.0%	100.0%	100.0%
Off Trail Skiing*	81.6	55.4	5.3	16.5
Telemarking*	64.4	60.9	0.0	16.5
Alpine Touring*	9.2	1.1	0.0	0.0
Total	87	92	95	91

* Related to trail (chi-square significance level < 0.05)

4.9 Chapter Summary

From this chapter, one can gain an understanding of both the people interviewed for this study and the area in which they have chosen to ski. This understanding lays the groundwork for material presented in the succeding chapters. Interpretation of salience, awareness and perception of avalanche hazard and avalanche knowledge must take this groundwork into account, as must the evaluation and suggested enhancement of programs intended to reduce the number of avalanche accidents.

5. Salience, Awareness and Perception of Avalanche Hazard

People must be aware of the risk of avalanches and have an accurate perception of the hazard if they are to travel safely in avalanche prone terrain. Continued use of such terrain by individuals who do not have an accurate perception of the risk of avalanche is likely to lead to accidents. In this chapter, the precursors of perception will be discussed first, that is salience and awareness, followed by a presentation of the study findings concerning skier perception of avalanche hazard. Avalanche hazard must surpass some salience threshold before the skier becomes aware of it. Once a skier is aware of avalanche hazard, perceptions of it may be formed.

5.1 Salience of Avalanche Hazard

The salience (or prominence within an individual's mind) of avalanche hazard to backcountry skiers was tested by asking if they had any major concerns regarding some of the difficulties that skiers face in mountainous areas and requesting that they rank their concerns in order of importance.

Nearly 81 percent of the respondents mentioned at least 1 major concern. Of the sample subset that mentioned having a major concern, over 73 percent (or over 59 percent of all respondents) included avalanches in their list of major concerns without any prior knowledge that this study dealt with avalanches. The proportion that mentioned avalanches as a major concern was significantly greater (chi-square significance level < 0.05) on the Bow Hut and Mosquito Creek trails, where about 88 percent of those mentioning a major concern (or about 76 percent of all skiers on these 2 trails) included avalanches in their list as opposed to about 58 percent (or about 43 percent of all skiers) of the skiers on the other 2 trails. Avalanche hazard was thus more likely to surpass the salience threshold of skiers on the trails where avalanches are more likely to occur and a very large proportion of the users of the Bow Hut and Mosquito Creek trails considered avalanches to be a major concern.

On all 4 trails, avalanches were ranked first in order of importance more often than any other major concern. Overall, more than 62 percent of the respondents who mentioned a major concern ranked avalanches as being the most important of their concerns. This proportion increases to about 76 percent on the Bow Hut and Mosquito Creek trails.

From the above discussion, one can conclude avalanches are a salient major concern in the study area, especially among users of trails along which avalanches are more likely to occur.

5.2 Awareness of Avalanche Hazard

Once the salience threshold is surpassed, skiers become aware of avalanche hazard and begin to accumulate knowledge about it. In this study, consideration was given to knowledge of how often avalanches which could potentially affect people occur and the number of people killed by avalanches each year.

Respondents were asked how often they thought avalanches which could potentially affect people would occur in the Rocky Mountains of Canada over the course of the 1984-85 winter. The answers given by the respondents were divided into 4 groups, which are:

- not very often (19.6 percent of replies)
- moderately often (7.2 percent)
- quite often (66.9 percent)
- don't know (6.3 percent).

In general, the respondents rated the frequency of avalanches to be greater than the rating of "not very often" supplied by the person who is second in command of the Parks Canada avalanche hazard forecasting and control team stationed at Lake Louise (G. Irwin, personal communication, 1985). Users of the trails where there are higher levels of avalanche risk (i.e. Bow Hut and Mosquito Creek), tended to rate the frequency of avalanches which could affect people higher than the users of the other 2 trails (chi-square significance level <0.05).

Over 91 percent of the respondents were able to give an estimate of the average number of people killed by avalanches in Banff National Park each year. The median number of deaths provided by the respondents was 4 per year (average 4.5). This is somewhat greater than the 30 year average (1954-55 to 1984-85) of 0.8 death per year. Differing from all of British Columbia and Alberta taken together, where the avalanche death rate increased markedly over the past 10 years (30 year average 2.7, 10 year average 4.0), the death rate in Banff National Park over the last 10 years (1974-75 to 1984-85) remained the same as the 30 year average. Although the question posed to respondents asked specifically about avalanche deaths in Banff National Park, there is a strong similarity between the average of the responses and the 10 year average for all of British Columbia and Alberta. This similarity may be purely coincidental, however. There was no significant difference between the death rates expressed by users of the 4 different trails.

When considering the frequency of avalanches and the number of deaths caused by avalanches, one may conclude that people consider the level of risk to be higher than it is rated by an expert or available statistical frequencies, although the difference in number of deaths is not large. These results are similar to those found by Kasper (1980), Saarinen (1982b) and Slovic *et al.* (1982).

5.3 Perception of Avalanche Hazard

The preceeding discussions on salience and awareness of avalanche hazard form a natural background for this section which deals with perception of avalanche hazard. Mileti *et al.* (1975) define perception as an individual's understanding of the character and relevance of a hazard for self and/or community. One may add to this definition, stating that perception is apprehension with the mind. To determine the skier's perception of avalanche hazard, the respondents were asked to describe an avalanche, to express whether they had ever felt themselves to be in danger from an avalanche and to relate the feelings they experienced if they had been involved in an avalanche accident.

The respondents were asked for a short description of an avalanche. The descriptions given were almost exclusively factual as opposed to emotional in content. The risk of bear attack in park areas is a good example of what tends to be more of an emotional issue (e.g. Gravelines 1983). The descriptions were placed in a number of categories using content analysis. Many respondent's descriptions were subdivided into more than one category. The most commonly mentioned categories are listed below:

- snow sliding (mentioned by 81.4 percent of respondents)
- large size (22.4 percent)
- event or weakness that caused the snow to slide (16.3 percent)
- high speed (11.4 percent)
- specific avalanche attributes, such as the type of avalanche (10.8 percent)
- risk to people(6.9 percent).

Some typical examples of avalanche descriptions given by respondents are "a lot of snow that comes down quickly", "rapid downhill movement of snow" and "slab of snow coming off a hillside that is caused by a weak layer of snow".

All of the respondents were able to provide a description of an avalanche. The short descriptions collected were generally accurate, with only a very small number which contained inaccurate information, particularly on aspects such as avalanche triggering mechanisms. Only a very small proportion (less than 7 percent) described avalanches as being a risk to skiers. As a general conclusion from the avalanche descriptions, the respondents perceive avalanches to be large masses of snow which move quickly down the mountain that infrequently affect people.

The second means of examining avalanche hazard perception in this study involved asking each respondent whether he had ever considered himself to be in danger from an avalanche. A positive answer indicated that the respondent was aware of the risk posed by avalanches and had been in an area where he felt that there was some significant risk of being swept away by an avalanche. Nearly 40 percent of the respondents stated that they had perceived personal danger from an avalanche at some time in the past. The likelihood of an avalanche occurring in each instance is not known, but the important point is that the people considered themselves to be in danger from an avalanche. Of people reporting that they had been in danger from an avalanche at some time in the past, about 83 percent stated that the most recent incident had occurred in the 1980's.

From Table 5.1, it is evident that a greater proportion of the users of the Bow Hut and Mosquito Creek trails have felt that they have been in danger from avalanche at some time in the past than users of other trails. As mentioned previously, the Bow Hut and Mosquito Creek trails are the ones within the study on which avalanches are most likely to occur. Past exposure to the risk of being swept away by an avalanche certainly does not deter future use of areas where avalanches may occur. This may relate to the finding of Kiecolt and Nigg (1982) who have found that frequent experience can breed contempt of the hazard or relate to a tendency to dismiss the risk with an attitude that "it can't happen to me" (Council for Science and Society 1977; Sood 1982).

Table 5.1 Ever Personally in Avalanche Danger vs. Trail

	Bow Hut	Mosquito Creek	Redearth Creek	Pipestone	Total
Never in Danger	43.7%	50.0%	70.3%	77.7%	60.7%
Have Been in Danger	56.3	50.0	29.7	22.3	39.3
Total	87	92	91	94	364

Chi-square = 29.9 Degrees of Freedom = 3 Significance Level < 0.05

The final portion of this section deals with respondents who had been personally involved, either by being swept away by an avalanche or being a member of a party in which someone else was in an avalanche accident. These people were asked to relate their feelings about the accident just after it happened.

Only 33 people reported their feelings about being involved in an avalanche accident, with 63.6 percent indicating some negative feeling (e.g. "bad experience", "lucky to be alive", "scared" or "much power in avalanche"), 18.2 percent indicating some positive feeling (e.g. "good practise" or "confident in rescue"), 12.1 percent reflecting on some embarrassment and 6.2 percent reporting being disoriented. It seems somewhat odd to consider an avalanche as a positive experience. Instances where positive feelings were expressed would seem to have been minor accidents with little damage or loss to equipment or people.

To summarize this section on perception of avalanche hazard, several points may be made. First, skiers generally perceive avalanches as large masses of snow moving quickly down a mountain that seldom affect people. Second, experience with the risk of avalanche can breed contempt of the hazard or relate to a tendency to dismiss the risk with the attitude that "it can't happen to me". Finally, people having direct experience with an avalanche accident generally have a negative feeling about the accident, but a surprisingly large percentage related a positive feeling.

5.4 Chapter Summary

From this chapter dealing with salience, awareness and perception of avalanche hazard, several major conclusions may be drawn. First, avalanches are a salient major concern among skiers in the study area, especially among those using trails where avalanches are more likely to occur. Second, skiers tend to overrate the frequency of avalanches relative to expert opinion. Also, the skiers estimated the annual number of avalanche deaths to be slightly higher than the historical statistical frequencies. Finally, several aspects of skiers' perceptions of avalanches were discussed. Skiers tend to perceive that avalanches are large, only rarely pose a threat and are not frightening. Experience with the risk of avalanche can lead to a tendency to dismiss the risk. Direct experience with an avalanche accident generally leaves a skier with a negative feeling of the event, but a surprisingly large proportion retain positive feelings.

The skiers in the study area seem to be aware that avalanches can pose a recognizable risk, but they believe that avalanches are unlikely to pose a problem to themselves personally. Reasons for this seemingly illogical relationship have been presented by a number of authors.

Kunreuther (1978) reports that people treat such events as having a probability of occurrence sufficiently low to permit them to ignore the consequences. Saarinen (1982b) holds that people generally do not have an accurate perception of risks associated with hazards, with a tendency to underestimate undramatic risks (judging from the avalanche descriptions supplied by the respondents, they consider avalanches to be undramatic snow slides). Festinger's (1957) theory of cognitive dissonance may explain why people tend to deemphasize the risk, since this reduces stress levels. Slovic *et al.* (1982) make a similar argument. Finally, the Council for Science and Society (1977) and Sood (1982) present evidence that many people believe that accidents can happen only to other people, never to themselves.

6. Skier Avalanche Knowledge Levels

The second major objective of this study was to determine the level of avalanche knowledge possessed by the skiers, so that some estimate of their ability to make safe (i.e. no accident occurs) decisions with respect to avalanche risk could be obtained. Three major categories of avalanche knowledge indicators were utilized, including ability to assess avalanche hazard, a history of cancelling or modifying trips because of avalanche hazard and route selection ability. Since avalanche knowledge becomes important only when a skier uses an area where there is some degree of avalanche risk, this chapter is prefaced with a section dealing with avalanche risk levels on the study trails. Following the avalanche risk level material, findings with respect to the knowledge or expertise indicators are presented, including a discussion relating avalanche risk to knowledge for each of the indicators.

6.1 Avalanche Risk Levels on the Study Trails

The trails at which interviews took place were described earlier in the thesis. All of the salient features of the trails were described, with 1 important exception — avalanche risk. One of the obvious methods to distinguish among the respondents in this study is the level of avalanche risk that they faced on the day of the interview. In this section, 3 major items will be discussed:

- why the trail used on the day of the interview is a good indication of the type of trail generally used
- the avalanche risk classification scheme that was developed
- the application of the classification scheme to the study trails.

6.1.1 Trail Use Patterns With Respect to Avalanche Risk

Daffern (1981) and More *et al.* (1984) distinguish 3 different levels of recreationists based on their likelihood of exposure to the avalanche hazard. The levels are: those who are only vaguely aware of avalanches and confine their activities to marked trails and nearby areas where there is little or no avalanche risk; those with a basic awareness of avalanche danger, but limited experience who utilize both areas where avalanches may occur and areas where it is unlikely that avalanches will occur; and, lastly, those with good avalanche knowledge who concentrate their activities in avalanche prone areas. Clearly, the people in the first and last categories almost exclusively use 1 type of trail (with respect to avalanche risk). The type of trail used by those in the middle category may vary more so than for the other 2 categories, but they could be generally characterized as using trails with a moderate level of avalanche risk.

6.1.2 The Avalanche Risk Zoning Classifications

As may be expected, the avalanche risk along the trails is not constant. To simplify this classification, only factors which affect the spatial variation in avalanche risk are considered here. Three different levels of avalanche risk were identified, including:

- **no avalanche risk**: areas where the terrain is not steep enough or too heavily forested for an avalanche to occur
- **intermittent avalanche risk**: areas where there is some risk of avalanche on an intermittent basis, such as avalanche path runout zones and other slopes of moderate steepness
- **sustained avalanche risk**: areas where there can be sustained periods with a high probability of avalanches occuring, such as locations above treeline, where slope angles exceed 25°.

These categories reflect only very general levels of risk, since the probability of avalanche may vary dramatically even within very localized areas. Most areas above treeline fall into the sustained avalanche risk category, since there is no forest cover to restrict the movement of snow and small, seemingly innocuous, slopes above treeline have claimed many lives in the past (e.g., Williams and Armstrong 1984).

6.1.3 Avalanche Risk Zones on the Trails

The avalanche risk classifications have been superimposed on maps illustrating each trail. The avalanche risk classifications for the Bow Hut trail are shown in Figure 6.1, the Mosquito Creek trail in Figure 6.2, the Redearth Creek trail in Figure 6.3 and the Pipestone trail in Figure 6.4. Only the areas along the trails which were examined during the course of the study have been classified according to avalanche risk.

As skiers move from the zones of no avalanche risk to zones of sustained avalanche risk, avalanche knowledge becomes more important. For this reason, mention of the relationship between avalanche risk zones used and the knowledge indicators will be made in succeeding portions of this chapter. To facilitate subsequent discussion, the respondents were classified as having used a certain risk zone by taking the zone of maximum avalanche risk that they passed through along the way to their destination. To give 2 examples, if a person travelled to Bow Hut along the Bow Hut trail, he was assumed to have entered a zone of sustained avalanche risk, and if a person skiied along the Redearth Creek trail to where it crosses Lost Horse Creek, he was assumed to have entered a zone of intermittent avalanche risk.

6.2 Avalanche Hazard Assessment

To travel safely in avalanche prone terrain, one must know how to assess the avalanche hazard. As recommended in the literature (e.g. Perla and Martinelli 1978; Daffern 1983), Parks Canada develops ratings of the avalanche hazard based on a scientific analysis of snow strength or resistance to avalanching (snow stability). Good knowledge on which to base avalanche hazard assessments is important, since snow stability can vary dramatically over even short time periods or between 2 locations of relatively close proximity (e.g. Perla and Martinelli 1978). Hence, a route choice which may be safe under stable snow conditions (high resistance to sliding or avalanching) could be entirely unsafe under unstable snow conditions, when even the weight of a skier added to the slope may be sufficient to cause an avalanche. The change in snow stability can be caused by a number of factors (e.g. an abrupt rise in temperature

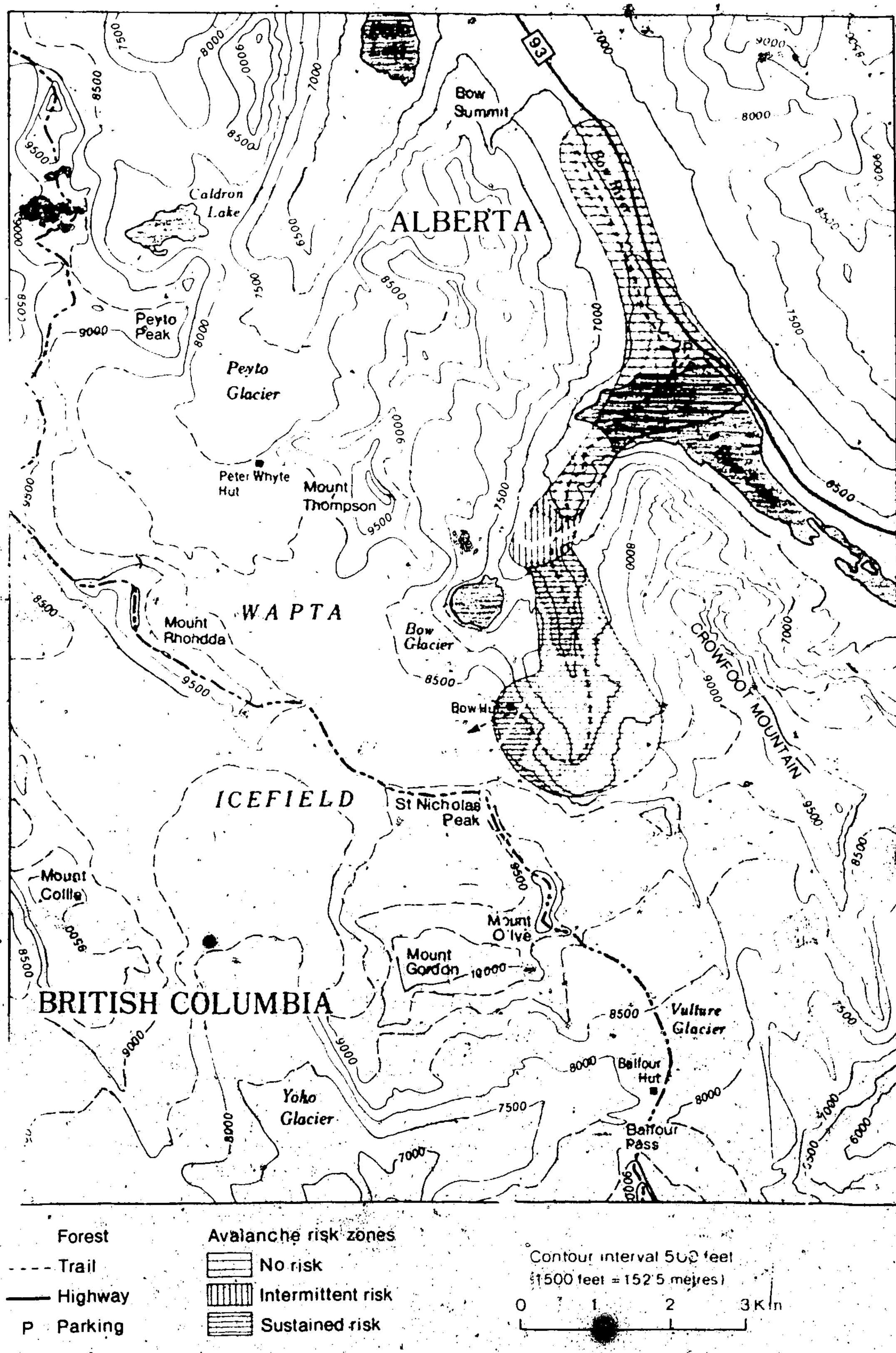

Figure 6.1 Bow Hut Trail

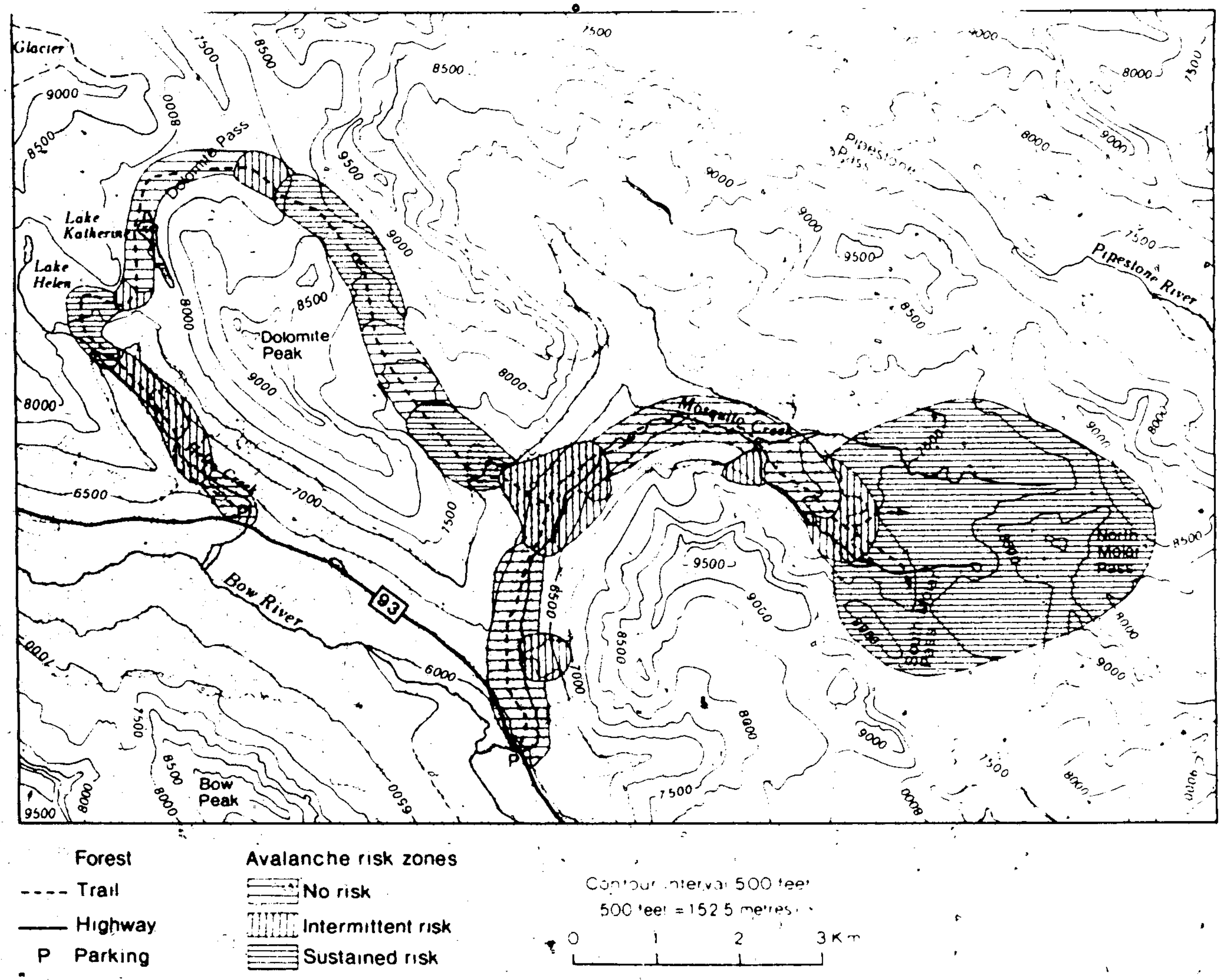

Figure 6.2 Mosquito Creek Trail

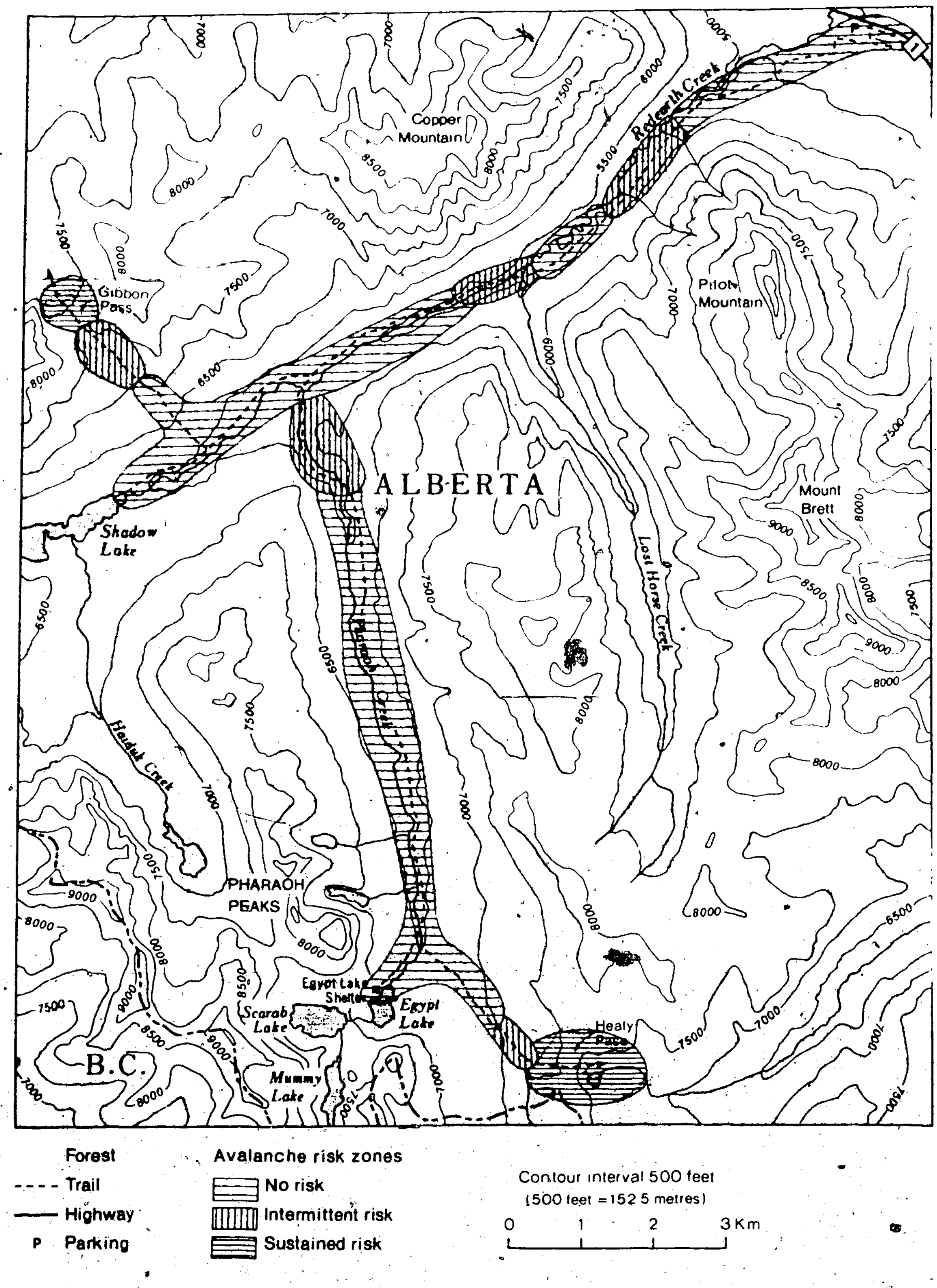

Figure 6.3 Redearth Creek Trail

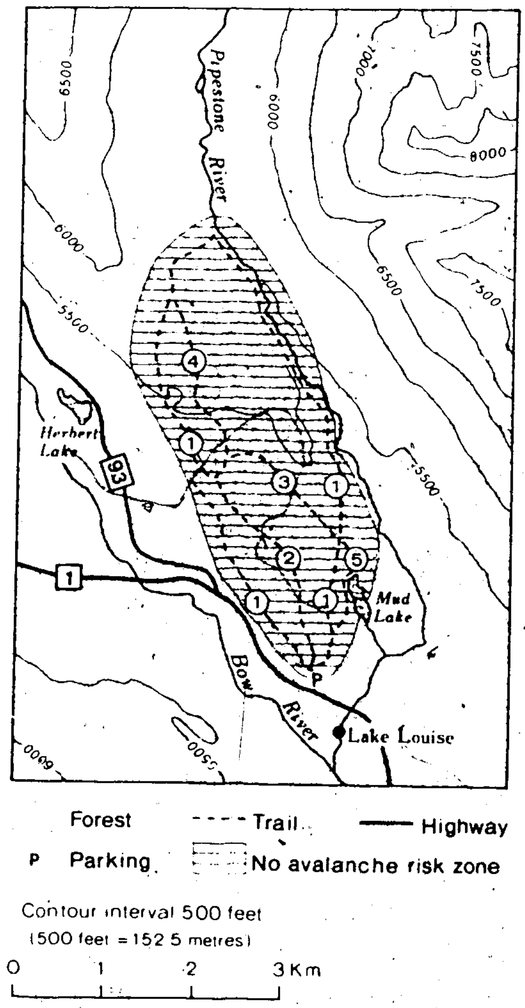

Figure 6.4 Pipestone Trail

(especially from below to above freezing) or an heavy snowfall) or a combination of several factors.

As a measure of avalanche knowledge, this indicator was obtained by asking the respondents to rate the avalanche hazard along the trail on which they were skiing on the day of the interview, and provide reasons for the rating. The response alternatives supplied to the interviewees were the avalanche hazard ratings employed by Parks Canada. Using the same rating scheme facilitates comparison. However, note that Parks Canada rates the avalanche hazard using a scientific analysis of snow stability, while the respondents may have based their rating on a number of factors, including snow stability, past trail experience, how they felt that day, various psychological factors (e.g. risk tolerance), etc.

A number of items related to assessment of avalanche hazard will be discussed in this section. First, the Parks Canada avalanche hazard rating definitions and ratings for the winter of 1984-85 will be presented, followed by a discussion of "composite" avalanche hazard ratings. Third, a comparison of the respondents' and the Parks Canada avalanche hazard ratings will be given. This is essentially a comparison of lay versus expert ratings of the hazard. Finally, the quality of the reasons given by the respondents for their avalanche hazard rating will be discussed.

6.2.1 The Parks Canada Avalanche Hazard Ratings

The backcountry avalanche hazard ratings employed by Parks Canada (as provided by Daffern (1983: p. 6)) are as follows:

- **Low avalanche hazard.** Mostly stable snow. Avalanches are unlikely except in isolated pockets on steep, snow covered open slopes and gullies. Backcountry travel is generally safe.
- **Moderate avalanche hazard.** Areas of unstable snow. Avalanches are possible on steep, snow covered open slopes and gullies. Backcountry travellers should use caution.
- **High avalanche hazard.** Mostly unstable snow. Avalanches are probable on steep,

snow covered open slopes and gullies. Backcountry travel is not recommended.

- **Extreme avalanche hazard.** Widespread areas of unstable snow. Avalanches are certain on steep, snow covered open slopes and gullies. Large, destructive avalanches are possible. Backcountry travel should be avoided.

The avalanche hazard ratings published by Parks Canada (G. Irwin, personal communication, 1985) during the study period are shown in Figure 6.5. Note that the rating did not rise above moderate to high at any time during the study. In overall terms, the snowpack was more stable during the 1984-85 winter than in previous winters. The changes in stability were not as rapid as they could have been if a major snow storm or thaw had occurred (C. Israelson, personal communication, 1985).

6.2.2 "Composite" Avalanche Hazard Ratings

Parks Canada often uses a combination of 2 avalanche hazard ratings to allow expression of differing snow stabilities at different elevations (G. Irwin, personal communication, 1985). The elevational dividing line is generally the treeline. For example, Parks Canada may rate the avalanche hazard as moderate below treeline and high above treeline. Throughout the course of this study, the rating above treeline was either the same as below treeline or 1 category above that for areas below treeline. Respondents occasionally provided composite ratings as well.

To facilitate manipulation and comparison of these ratings, the composite ratings were reduced to a single rating using the respondent's destination for the day. If the destination for the day was above treeline, the higher of the composite rating pair was the one used in all data analysis. If the destination was below treeline, the lower of the composite rating pair was the one used. This reduction to a single rating was done both for the ratings supplied by Parks Canada and the respondents. To give an example, assume that the skier rated the avalanche hazard as low to moderate and Parks Canada rated it as moderate to high that day. If the skier's destination was above treeline, then the skier's rating would be considered as moderate

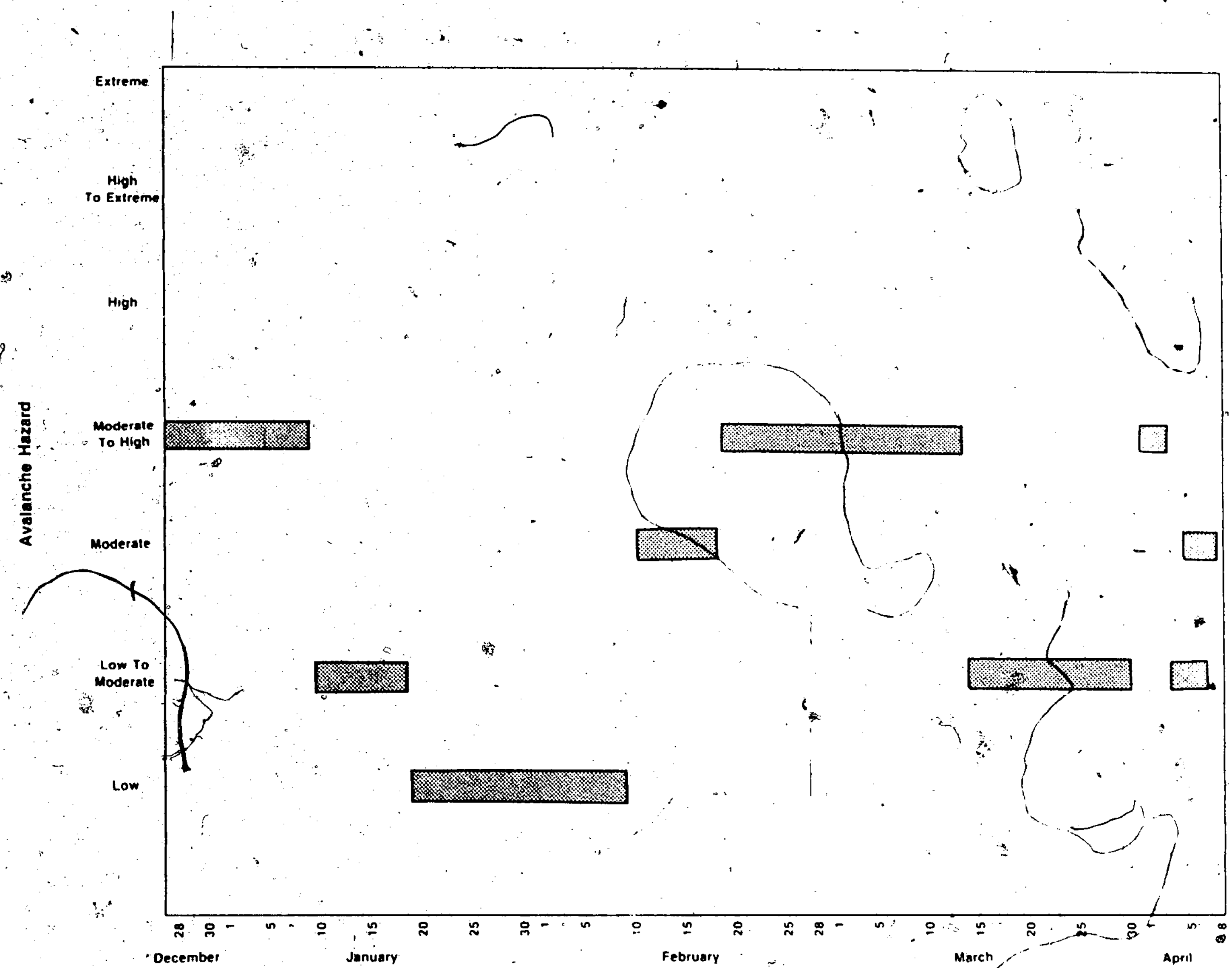

Figure 6.5 Avalanche Hazard Rating For The Winter Of 1984-1985

and that of Parks Canada as high. On the other hand, if the skier's destination was below treeline, then the skier's rating would be considered as low and that of Parks Canada as moderate.

6.2.3 Lay versus Expert Ratings of Snow Stability

Given that the avalanche hazard ratings of both the respondents ("lay people") and Parks Canada ("experts") have been reduced to a single similar scale, a comparison may be made between them. In general terms, as shown in Table 6.1, the respondents tended to rate the avalanche hazard the same as or lower than the rating of the experts from Parks Canada. However, the overall results are biased substantially by the ratings given by the users of the Pipestone trails. Over 84 percent of the respondents from this trail rated the avalanche hazard as low, likely taking terrain factors into account more than snow stability. The terrain along the Pipestone trails is relatively flat and heavily treed, making avalanches most unlikely, even during periods of extreme snow instability. Terrain was explicitly mentioned as a reason for their rating by about 50 percent of the respondents on this trail. Evidently there was some confusion among the respondents with respect to the avalanche hazard rating terminology which is used by Parks Canada with the intent of expressing snow stability or strength, not to directly relate the probability of avalanche in a given area, as believed by many respondents. Besides factors which could influence snow stability in some manner, respondents based their avalanche ratings on factors such as information from books or pamphlets, snow depth, terrain, number of people using the trail, "feelings" and presence of marked trails. The skiers certainly do not relate the avalanche hazard rating only to snow stability.

The comparisons of greatest interest here are for the trails where the terrain makes avalanches more likely than on the other trails. On the Bow Hut and Mosquito Creek trails, about one-third of the respondents rated the avalanche hazard as being lower than the rating of Parks Canada. Assuming the expert rating to be more accurate than the lay person rating, this would mean that a significant proportion of the skiers in these areas have a more risky decision

Table 6.1 Difference Between Respondent and Parks Canada Rating vs. Trail

	Bow Hut	Mosquito Creek	Redearth Creek	Pipestone	Total
Skier > Parks Canada	27.7%	19.5%	29.2%	4.5%	20.1%
Same	41.0	46.0	57.3	23.6	42.0
Skier < Parks Canada	31.3	34.5	13.5	71.9	37.9
Total	83	87	89	89	348

Chi-square=71.7 Degrees of Freedom=6 Significance Level ≤ 0.05

base, which could be more likely to lead to accidents than if the skiers, perhaps more appropriately, considered the avalanche hazard rating to be higher.

6.2.4 Quality of the Avalanche Hazard Rating and Rating Reasons

Besides rating the avalanche hazard as low, moderate, high or extreme, the respondents were asked to give a reason for their rating. The rating/reason combinations were categorized as exhibiting low, moderate or good knowledge of rating the avalanche hazard. In this section, the ranking criteria for knowledge are explained, followed by a discussion of the findings in the study both in aggregate and on a comparative basis by risk zone used.

A simple set of ranking criteria were used to rate the knowledge levels of the respondents. The knowledge level criteria were as follows:

- **low** — supplied reasons that were wrong or showed little appreciation for evaluating avalanche hazard such as "not warm enough for an avalanche to occur", "a lot of snow on the ground", "I feel good because it is a nice day" and expressions of hope that the avalanche hazard was low
- **moderate** — reasons showed partial understanding of the methods of making avalanche risk assessments such as "the snow has been stable for the last few weeks" (note that it may have become unstable in the past few days, though) and "the snow is still on the trees" (note that this is a sign of snowpack instability in some mountain ranges, but it generally has little meaning in the Canadian Rockies)

- good — good understanding of reasons for snow strength and weakness demonstrated, appropriate references to snowpack stratigraphy and influences on its strength made, such as "the recent high winds have created dangerous slab conditions", "no snow has fallen for a significant period of time", "we saw signs of recent avalanches", "we dug a snow pit", "I talked to the wardens" and "the terrain is not steep enough for avalanches to occur".

Several points may be made with regard to the relationship between the respondents' ability to rate the avalanche hazard and the level of risk that they encountered on the day of the interview. The relationship between quality of skier rated avalanche hazard reasons and level of risk encountered is shown in Table 6.2. A relatively high proportion of the users of areas where there is no avalanche risk have good knowledge with respect to rating the avalanche hazard, that is, they are generally aware that there is no avalanche risk. Users of the other 2 avalanche risk zones show knowledge increasing as risk increases, but still only about one-half of the users of the sustained risk zones have good knowledge with respect to assessing the avalanche hazard.

Table 6.2 Quality of Skier Rated Avalanche Hazard Reasons vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Low Knowledge	41.5%	44.0%	21.1%	34.2%
Moderate Knowledge	4.7	19.0	29.3	18.6
Good Knowledge	53.8	37.0	49.6	47.2
Total	106	100	133	339

Chi-square = 33.8 Degrees of Freedom = 4 Significance Level < 0.05

6.2.5 Avalanche Hazard Assessment Summary

Three major conclusions can be derived from this section on avalanche hazard assessments. First, some confusion about the avalanche hazard rating terminology employed by Parks Canada seems to exist. Perhaps an explicit rating of snow stability, as opposed to avalanche hazard, would be better. Second, along trails where the terrain is steeper and avalanches are more likely (Bow Hut and Mosquito Creek), about one-third of the respondents rated the avalanche hazard as being lower than the experts from Parks Canada. This could indicate that a significant proportion of the skiers consider the risk of avalanche to be lower than the risk calculated by experts, and hence the skiers are actually facing a greater level of risk than they perceive. Third, knowledge levels with respect to avalanche hazard ratings tend to increase as the terrain along the trails becomes steeper and avalanches become more likely. This is an encouraging trend, but there is still room for improvement, since only about 50 percent of the sustained risk zone users have good knowledge levels.

6.3 The Decision to Cancel or Modify a Ski Outing

The decision to cancel or modify a ski outing should logically be based, at least in part, on an avalanche hazard assessment. If, for example, a person considered the snowpack to be extremely unstable (i.e. high or extreme avalanche hazard), he may choose to ski on relatively flat terrain or perhaps just stay home that day. Those who have cancelled or modified a trip in the past because of avalanche hazard are likely to have greater avalanche knowledge (or ability to avoid acidents), since these actions indicate ability to recognize the risk and willingness to choose an alternative which reduces or eliminates the risk.

Just over half of the respondents reported that they had either cancelled or modified a previous trip because of the risk of avalanches. The proportion of the respondents who had cancelled a ski trip or modified their plans because of avalanche risk was closely related (chi-square level of significance less than 0.05) to the avalanche risk in the zone used. Only about 29 percent of the users of areas where there was no risk of avalanche had ever cancelled or modified their plans, while about 49 percent of those using intermittent risk areas and about 77 percent of those using sustained risk areas had. Evidently it is not uncommon for people utilizing more avalanche prone areas to modify their plans because of avalanches. Also emphasizing that plan modifications are relatively common, over 78 percent of those who had modified their plans had most recently done so since the beginning of 1983. The respondents mentioned the following modifications to their plans (the percentages are relative to the 190 persons who reported a modification, and 1 respondent may have mentioned more than 1 modification):

- go to another area (48.4%)
- modify route (25.3%)
- turn back (24.2%)
- stay (or go) home (12.6%)
- go downhill skiing (1.6%)
- wait for other people to ski the slope (0.5%).

Of the 6 different changes in plans mentioned by the respondents, only 2 show a significant variation with respect to avalanche risk zones (there is a 95 percent likelihood of the relationship existing). Users of the sustained risk zones were more likely to have mentioned modifying their route in the past (about one-third of those who used a sustained risk area and mentioned a plan modification) than users of the intermittent (about one-quarter) and no risk zones (about 6 percent). Conversely, users of the no risk zones were more likely to have mentioned staying or going home because of avalanche risk (about one-quarter of those who used a no risk zone and mentioned a plan modification) than those using intermittent (about 14 percent) or sustained risk zones (about 8 percent). These 2 relationships likely illustrate that as risk of avalanche in the area used increases, the level of confidence in one's ability to avoid avalanches increases.

6.4 Specific Route Selection

References to route selection were made in previous portions of this chapter. After assessing the avalanche hazard and deciding that it is safe to go skiing, a skier must choose a specific route to follow. Daffern (1983) argues that routefinding is the most important skill a backcountry skier who utilizes avalanche prone terrain can learn and, hence, measuring route selection ability is a good indicator of avalanche knowledge. In this study, skill at route selection was measured by having the respondents indicate the route they would take to reach the cabin shown on the diagram included in Appendix 1. Related to route selection, respondents were asked where they thought avalanches were most likely to occur on the trail they were using that day and what actions they had taken in the past when they had personally felt that they were in danger from an avalanche.

6.4.1 The Route Selection Diagram

The diagram enclosed with the questionnaire in Appendix 1 depicts an obvious avalanche slope between the skier and the cabin. About 73 percent of the respondents chose a route entirely within the trees, descending below the avalanche chute before regaining the elevation to the cabin. This is the longest and likely the safest approach to the cabin. The location of this question near the end of the questionnaire after a number of questions dealing with death and the risk of avalanches may have induced this rather conservative set of responses with few people (about 10 percent) making a direct approach to the cabin. It may have been beneficial to include this question in the first section of the questionnaire prior to any discussion of avalanches. No variables were found that would explain any variation in the route selected. The reason given for the route selection proved to be a better means of distinguishing among the respondents.

The respondents' reasons for choice of a specific route were categorized as exhibiting low, moderate or good knowledge. Criteria for placement within a specific category were as follows:

- **low**: supplied reasons that were wrong or showed little appreciation for choosing a safe route, such as "no risk of avalanche in the gully", "gully appears to be small and it would be no safer in the trees" (Stethem and Schaerer (1979, 1980) cite a number of examples where people were killed on slopes such as this) and "same risk in all areas"
- **moderate**: reasons showed partial understanding of the methods for selecting a safe

route, such as "safe, in the trees" (avalanches can flow through or initiate in treed areas (Perla and Martinelli 1978), but the likelihood of an avalanche is considerably less than in the gully), "trees indicate length of avalanche" and "trees provide protection"

- **good**: good understanding of reasons for route selection, making reference to items such as slope angle, the obvious gully which may be a terrain trap, snow strength or stability, forest cover, cornice formation above, route selections that minimize time in riskier areas and questions or inferences that the slope in question is subject to wind erosion or deposition of snow.

As shown in Table 6.3, only a small proportion (about one-quarter) of all skiers were found to have good knowledge on which to base route selection decisions. Even in sustained risk areas only about 34 percent had good knowledge. Increasing knowledge levels are evident in the progression from users of no risk to users of sustained risk areas, but still the overall knowledge levels are low. Good route selection knowledge can be critical in the sustained risk zones, particularly when snow conditions are unstable.

Table 6.3 Knowledge Level on Which Route Choice Based vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Low Knowledge	31.6%	21.9%	10.9%	20.7%
Moderate Knowledge	57.0	51.4	55.1	54.6
Good Knowledge	11.4	26.7	34.1	24.6
Total	114	105	138	357

Chi-square=26.6 Degrees of Freedom=4 Significance Level < 0.05

6.4.2 Knowledge of Avalanche Locations

To choose an appropriate route, it is helpful to know where in particular avalanches are most likely to occur. To this end, the respondents were asked if they knew where avalanches were most likely to occur on the trail they were using on the day of the interview. After an affirmative response, respondents were asked to cite the specific locations where avalanches were most likely to occur and their replies were rated to show knowledge levels as follows:

- **low**: supplied locations where avalanches would not occur (e.g. along Pipestone trails), mentioned avalanche locations that would not affect the area that the person was using (e.g. some persons using the Pipestone trail mentioned the slopes of Mount Hector which are at least 3 km north of the trail) or could not supply an answer
- **moderate**: was aware of areas where avalanches could occur, but supplied only a vague location (e.g. "steep slopes beside the trail" or "high slopes near treeline") or missed some major problem areas such as the headwall below Bow Hut
- **good**: properly identified the areas where avalanches are most likely to occur along the route they utilized. For the Bow Hut trail these include an avalanche runout zone south of the creek prior to Bow Falls, the creek canyon followed by most skiers and the headwall below Bow Hut. On the Mosquito Creek trail, the areas include 3 avalanche paths on the east and south sides of the creek and the meadows above treeline. On the Redearth Creek trail, there are 2 avalanche paths descending from Pilot Mountain, 1 from Copper Mountain just beyond the junction with Lost Horse Creek and the areas of Gibbon and Healy Pass. There are no likely avalanche locations along the Pipestone network of trails.

Over three-quarters of the respondents stated that they knew where avalanches were most likely to occur. The proportion who claimed knowledge of where avalanches were most likely to occur along the trail being used on the day of the interview tended to increase as risk increased (chi-square significance level less than 0.05). About 62 percent of no risk zone users claimed knowledge, as compared to about 71 percent of the intermittent risk zone and 91 percent of the sustained risk zone users. However, actual knowledge levels show the opposite trend, with nearly 86 percent of no risk zone users having good knowledge of where avalanches were most likely to occur, as opposed to about 38 percent of intermittent risk zone users and about 25 percent of sustained risk zone users. Evidently as avalanche risk increases, people become more overconfident in their knowledge of where avalanches are most likely to occur.

6.4.3 Past Actions in the Face of Avalanche Danger

Knowledge of appropriate route selections may also be judged by actions taken in the past. Respondents were asked if they had ever felt in danger of avalanches in the past, and if they had, what did they do? A change in route selection may be made upon realizing the present course holds at least some danger from avalanche.

Over 39 percent of the respondents felt that they had been in danger from an avalanche at some time in the past. Once aware of the risk, they related what they did, either taking some action to reduce the risk or ignoring the risk. The responses to known avalanche risk given were:

- modify route (42.7 percent of respondents who had perceived risk from avalanche)
- cross slope where risk exists — no adjustment or change made to compensate for the perceived risk (35.9 percent)
- cross slope where risk exists — after some adjustment such as proceeding 1 at a time or crossing the hazardous area quickly (22.1 percent)
- get more information on the level of risk — such as from a hasty study of the snow stratigraphy (4.6 percent).

There was no significant difference in the proportion citing different responses among users of the different avalanche risk zones.

Three of the responses mentioned seem to be rational actions for a person to take when one perceives that there is some risk of being engulfed by an avalanche. These are modifying one's route to return to what is considered to be safer terrain; deciding to cross the area of risk, but only after making some adjustment to explicitly reduce the risk from an avalanche; and getting more information to confirm or deny the original impression that one it is at risk from an avalanche. However, the large proportion (almost 36 percent) who continued in the face of risk without making any adjustment seems to indicate poor route selection decisions by a large minority of these people.

A number of reasons can be found in the literature for this seemingly anomalous behaviour of continuing in the face of avalanche danger without making any adjustments. This behaviour may be related to inexperience in hazard evaluation, as related by Smutek (1981). Alternatively, it has been found that many people feel that accidents happen only to others (Council for Science and Society 1977; Burton *et al.* 1978; Sood 1982), people ignore the risk because it causes stress (Slovic *et al.* 1982) or people exhibit a tendency to simplify decisions to reduce strain (Kunreuther 1978; Fesler 1981; Saarinen 1982b). On a slightly different tangent, Starr (1972) presents evidence that people tolerate higher levels of risk in voluntary activities (e.g. backcountry skiing) and Cheron and Ritchie (1982) hold that perceived risk decreases as familiarity with a leisure activity increases. Finally, from the conclusions of the preceeding chapter, it was found that the skiers often have an inaccurate perception of the risk. It is not possible to determine from the data available which of the above reasons explain why people maintain a route without change after perceiving an avalanche risk, but any or all of them are certainly reasonable possibilities.

6.4.4 Route Selection Summary

Three main conclusions may be derived from this section on route selection. First, route selection knowledge tended to increase with avalanche risk, but the absolute knowledge levels still leave much room for improvement. Second, the skiers were often overconfident in their knowledge of where avalanches were most likely to occur, particularly those using areas of higher avalanche risk. Finally, most people take what may be considered as reasonable actions when they perceive themselves to be at risk from avalanche, but a significant minority (about 36 percent) seem to ignore the known risk, making no adjustments to reduce it.

6.5 Chapter Summary

In this chapter, after rating the avalanche risk faced by the skiers along the trails, 3 major indicators of avalanche knowledge or expertise were discussed. Avalanche hazard assessment knowledge, history of cancelling or modifying a trip and route selection knowledge were presented as indicators of avalanche knowledge. This knowledge becomes more important as avalanche risk in the area used increases.

It was demonstrated by referring to the literature that the avalanche risk zone used on the day of the interview is a reasonable indication of the risk zone generally used by respondent. The avalanche risk classification scheme was explained and the avalanche risk zones were illustrated on maps of the study trails.

Several conclusions may be made with respect to avalanche hazard assessment knowledge. It was found that there was some confusion about the Parks Canada avalanche hazard rating terminology. On riskier trails about one-third of the respondents rated the avalanche hazard lower than Parks Canada. It was shown that ability to assess avalanche hazard generally tended to improve as the avalanche risk in the area used increased (with the exception of users of no risk zones who often realized that the terrain was not steep enough for avalanches to occur and hence considered the snow to be always unlikely to slide — i.e. stable). However, over half of the users of sustained risk areas (where it is most important to be able to assess snow stability) did not possess good knowledge of how to assess snow stability.

It was relatively common for people to modify their plans when they perceived avalanche risk. The proportion of the respondents who had cancelled or modified a trip in the past after perceiving avalanche hazard increased substantially as avalanche risk in areas used increased. Also, as areal risk level increases, the level of confidence in one's ability to avoid avalanches increases.

Finally, only a small proportion of the respondents were found to have good knowledge on which to base route selection decisions and as avalanche risk increases, people become more overconfident in their knowledge of where avalanches are most likely to occur. Also, a significant minority of the respondents report making no adjustments in the face of a known avalanche risk.

As mentioned in the introduction to this chapter, one of the objectives of this thesis is to determine the skiers' levels of avalanche knowledge. Given this review of the avalanche knowledge levels, the next chapter turns to an examination of some of the characteristics of the skiers in an attempt to determine which characteristics are most closely related to good avalanche knowledge. Awareness of these relationships will permit development of suggestions to improve management programs intended to reduce the number of avalanche accidents.

7. Examining Skier Avalanche Knowledge Levels

In the previous ~~chapter, several means~~ of measuring general avalanche knowledge were discussed. In this chapter, some of the specific characteristics of the skiers are examined to determine which characteristics are most closely related to good avalanche knowledge. These characteristics or factors to be considered include overnight backcountry use, previous trail use, past involvement with avalanches, experience, being the party leader and adjustments taken to reduce the risk of avalanches. Throughout the chapter, the relationship of each factor to the risk level in the zone used and the avalanche knowledge indicators mentioned in the previous chapter will be examined. To relate the degree of association between the knowledge indicators and the skier characteristics, when a significant relationship was found, Kendall's rank correlation coefficient, tau-b, was used. The use of Kendall's tau-b is recommended by Siegel (1956) and Blalock (1972) for ordinal (ranked) data where observations could possibly be tied on either variable (which applies here). Tau-b has values ranging from -1 (perfect negative correlation) to +1 (perfect positive correlation). A value of 0 means that there is no relationship. In the summary section of this chapter, the significant factors that relate to each knowledge indicator will be grouped together for convenience of discussion and to best illustrate the characteristics of skiers who have good avalanche knowledge.

7.1 Staying Overnight in the Backcountry

It may be hypothesized that those who have a history of camping or staying in huts (such as Bow Hut) in the backcountry in winter have superior avalanche knowledge, since these people often travel further and spend longer periods of time in the backcountry. As a measure of overnight backcountry use, respondents were asked to relate the average length of their ski trips in days for this winter (i.e. 1984-85) and last winter. To give an example of how the average trip length was derived, if a person left the highway on Saturday and returned to the highway on Sunday after spending the night camping or in a backcountry hut, the trip length would be considered as 2 days. However, if the person skied all day Saturday, returned to the highway on Saturday night, stayed at a hostel on Saturday night and then skied all day Sunday before returning home, he would be considered to have taken 2 trips each of 1 day duration. Persons who had an average trip length of greater than 1 day either this winter or last winter were considered to have stayed in the backcountry overnight.

In this section, after considering the relationship between overnight backcountry use and trail risk zones, statistically significant relationships between overnight use and the avalanche knowledge indicators will be examined.

7.1.1 The Relationship with Trail Risk Zones

There is a strong relationship between overnight backcountry use and use of the different trail risk zones, as shown in Table 7.1. The likelihood of a person staying in the backcountry overnight increases dramatically as avalanche risk along the trail in the zone used increases (from 7 percent for users of no risk zones to over 73 percent of sustained risk zone users). Only about 37 percent of all respondents had spent at least 1 night in the backcountry, but over three-quarters of these overnight users spent part of their trip on the day of the interview in a sustained risk zone.

Table 7.1 Overnight Backcountry Use vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
No Backcountry Overnight	93.0%	76.2%	26.8%	62.6%
Backcountry Overnight	7.0	23.8	73.2	37.4
Total	115	105	138	358

Chi-square = 129.3 Degrees of Freedom = 2 Significance Level < 0.05

7.1.2 Explaining Avalanche Knowledge in Terms of Overnight Backcountry Use

Statistically significant relationships were found between overnight backcountry use and all of the knowledge indicators, including avalanche hazard assessment skills, cancelling or changing plans because of avalanche risk and route selection.

7.1.2.1 Avalanche Hazard Assessment

Over 80 percent of the people who had stayed overnight in the backcountry possessed moderate or good knowledge with respect to assessing avalanche hazard, as compared to about 56 percent of those who had not stayed in the backcountry overnight. The Kendall's rank correlation coefficient, tau-b, had a value of 0.18. Those who had stayed in the backcountry overnight generally had superior ability at assessing avalanche hazard, as opposed to those who had not stayed out overnight.

7.1.2.2 The Decision to Cancel or Modify a Ski Outing

Over 76 percent of the people who had stayed in the backcountry overnight had cancelled or changed their plans due to avalanche risk, as compared to only about 39 percent of those who had not camped or stayed in a backcountry hut, giving a tau-b value of 0.36. Of the 4 different plan changes mentioned by the respondents for which there was sufficient data for statistical tests to be made (i.e., go to another area, stay (or go) home, modify the route selected or turn back), only 1 has a significant relationship (significance level less than 0.05) with staying overnight in the backcountry. Of the people who reported making a change in their plans because of the risk of avalanche and had stayed in the backcountry overnight, about one-third mentioned modifying their route, as opposed to only 17 percent of those who reported making a change in their plans and who had not stayed in the backcountry overnight (tau-b value 0.18). Evidently, those who had stayed in the backcountry overnight were more likely to report modifying their route because of avalanche danger than those who had not stayed in the backcountry overnight.

7.1.2.3 Route Selection

Some significant relationships between route selection knowledge and staying overnight in the backcountry were found as well. First of all, those who had stayed in the backcountry overnight were more likely to possess good knowledge on which to base route selection decisions (over 41 percent) than those who had not stayed out overnight (less than 15 percent) (tau-b value 0.29). Second, over 87 percent of those who had stayed overnight in the backcountry claimed knowledge of where avalanches were most likely to occur along the trail being used on the day of the interview, as compared to about 68 percent of those who had not stayed out overnight (tau-b value 0.22). However, a lesser proportion of those who had stayed out overnight had good knowledge of where avalanches were likely to occur than those who had not stayed out overnight (26 percent versus 60 percent) (tau-b value -0.22). Those who stayed out overnight were more overconfident in their knowledge of most likely avalanche locations.

7.1.3 Backcountry Overnight Use Summary

To summarize this section which distinguishes people who have stayed in the backcountry overnight, several points may be made. First, those who have stayed in the backcountry overnight form the great majority (nearly three-quarters) of those who were using sustained risk zones. Parks Canada has a good opportunity to reach these people, since it is mandatory to register with Parks Canada prior to staying overnight in the backcountry. Second, overnight backcountry users have superior ability to assess avalanche hazard as compared to those who have not stayed out overnight. Third, overnight users are more likely to have cancelled or modified a ski trip because of avalanche risk and more likely to have mentioned modifying their route than non-overnight users. This suggests that overnight users are more likely to use areas where avalanches may occur and that they are willing to show respect for avalanches by modifying their route to avoid the risk. Fourth, using the reasons given for the route selection on the diagram from Appendix 1, overnight users have better knowledge on which to base route selection decisions than non-overnight users. However, overnight users tend to be overconfident in their knowledge of where avalanches are most likely to occur. This may relate to the fact overnight users generally skied in areas where there were many avalanche paths to consider (and they only mentioned a few) and they were less concerned about avalanche risk because of their superior ability to avoid it (as indicated in the test diagram question). Finally, when considering only users of sustained risk zones, there were no significant (at chi-square significance level less than 0.05) differences in any of the knowledge indicators between those who have stayed in the backcountry overnight and those who have not. Staying in the backcountry overnight is not a useful trait to distinguish risk assessment ability of those most susceptible to avalanche risk.

7.2 Previous Trail Use

Previous use of a trail can provide information on which to base decisions which affect safety with respect to avalanches. From past trips, one can be aware of wind scoured (i.e. often safer) and lee (i.e. often riskier) slopes and be familiar with the route commonly used through the area. Knowledge of potentially risky areas can also be retained from previous trips. This is particularly useful when low cloud obscures avalanche starting zones or when visibility is reduced during a storm.

In this section, the relationship between previous trail use and avalanche risk zones used will be discussed. Also, significant relationships between previous trail use and avalanche knowledge will be examined.

7.2.1 Relating Previous Trail Use and Trail Risk Zones

As shown in Table 7.2, there is a moderately strong relationship between previous use of the trail at which the interview took place and use of the different trail risk zones along the trails. Only about one-half of the people using zones where there is no risk of avalanche had used the trail previously, while about 64 percent of the users of intermittent risk zones and nearly 76 percent of sustained risk zone users mentioned previous use of the trail. Over three-quarters of the people most subject to the risk of avalanche (using sustained risk zones) were able to draw upon previous experience with the trail to make decisions with respect to avalanche risk. Cross tabulation of previous trail use and the various knowledge indicators is necessary to determine whether previous trail use has any effect on the relationship with avalanche knowledge.

Table 7.2 Previous Trail Use vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Had Not Previously Used Trail	49.6%	36.2%	24.1%	35.9%
Had Previously Used Trail	50.4	63.8	75.9	64.1
Total	115	105	137	357

Chi-square = 17.7 Degrees of Freedom = 2 Significance Level < 0.05

7.2.2 The Relationship Between Previous Trail Use and Avalanche Knowledge

Significant relationships (chi-square significance level less than 0.05) were found between previous trail use and the 3 major types of avalanche knowledge indicators considered in this thesis. These are the assessment of avalanche hazard, the decision to cancel or modify a ski outing and route selection.

7.2.2.1 Avalanche Hazard Assessment

The quality of the reasons that the respondents provided for their assessment of avalanche hazard on the day of the interview was found to be related to previous trail use (tau-b 0.13). Over 72 percent of the skiers who stated that they had used the trail previously had either moderate or good knowledge on which to base an avalanche hazard assessment, as compared to only about 52 percent of those who had not previously used the trail.

7.2.2.2 The Decision to Cancel or Modify a Ski Outing

Quite a strong relationship (tau-b 0.35) between previous trail use and a history of cancelling or modifying a ski outing was found. About 66 percent of the respondents who had previously used the trail mentioned cancelling or changing a trip in the past because of avalanche hazard, as opposed to only about 30 percent of those who had not previously used the trail. Those who had previously used the trail were either more willing to modify a trip, or skied more often in areas where it could be necessary to modify a trip.

The relationship between previous trail use and history of trip modification also exists when considering only those who entered areas where avalanches are most likely — sustained risk zones. Of this group, nearly 85 percent of the people who had previously used the trail reported previously cancelling or modifying a trip, as compared to only about 55 percent of those who had not previously used the trail (tau-b 0.31).

7.2.2.3 Route Selection

Two of the indicators of route selection knowledge (the test diagram and claimed knowledge of avalanche locations) showed a significant relationship with previous trail use when considering the respondents in aggregate, while 2 different indicators of route selection knowledge (2 actions taken after avalanche risk was perceived — modify the route and cross the slope without making an adjustment) were significantly related with trail use when considering only users of sustained risk zones.

When considering the respondents in aggregate, there was a weak (tau-b 0.13), but still significant, relationship between previous trail use and route selection knowledge as measured by the reasons given for the route selection on the diagram from Appendix . A greater proportion of those who had previously used the trail (about 28 percent) had good route selection knowledge than those who had not previously used the trail (about 18 percent). There was a much stronger relationship (tau-b 0.42) between previous trail use and claimed knowledge of where avalanches were most likely to occur, with nearly 89 percent of those who had previously used the trail claiming knowledge, as compared to about 51 percent of those who had not previously used the trail.

When considering only the group for which route selection is most critical, that is, the users of the sustained risk zones, moderately strong relationships were found between previous trail use and 2 of the actions that respondents related taking after perceiving some risk from an avalanche in the past. First, those who had previously used the trail (about one-third of them) were much less likely (tau-b -0.28) to report modifying their route when they perceived some risk from avalanche than those who had not previously used the trail (over 69 percent). Perhaps those who had previously used the trail were more confident in their route selection ability. Second, those who had previously used the trail were much more likely (tau-b 0.31) to report crossing a slope in the face of perceived avalanche risk (nearly 47 percent) without making any adjustment than those who had not previously used the trail (about 8 percent). This second relationship provides additional evidence that those who had previously used the trail were more confident in their route selection ability, and make riskier decisions.

7.2.3 Previous Trail Use Summary

A number of general points may be made with regard to previous trail use. First, about 64 percent of the respondents had previously used the trail on which the interview took place. The likelihood that a person had previously used the trail increased as the risk of avalanche in the zone used on the day of the interview increased. For example, a person who entered a sustained avalanche risk zone on the day of the interview was more likely to have previously used the trail than a person who entered only a no risk zone. Second, people who had previously used the trail generally had a superior ability at assessing avalanche hazard, as compared to those who had not. Third, there was a greater likelihood of reporting previous cancellations or modifications of previous ski outing among those who had previously used the trail than among those who had not. This indicates that a greater willingness to modify a trip, or, perhaps more likely, a history of skiing more often in areas where it could be necessary to modify a trip.

Lastly, several facts should be mentioned with regard to route selection. When considering all respondents, those who mentioned previously using the trail had increased ability at route selection and a greater claimed knowledge of most likely avalanche locations than those who were using the trail for the first time (but actual knowledge levels were not significantly different). When consideration is given only to users of the sustained risk zones, those who had used the trail in the past were less likely to modify their route in the face of perceived avalanche danger and more likely to cross a slope even after avalanche risk has been perceived without making any adjustment than those who had not previously used the trail. Generally speaking, those who had previously used the trail were more confident in their route selection ability than those who had not, and made riskier decisions. There may be some basis for this increased confidence, with 1 reason being superior ability at assessing avalanche hazard. These people certainly showed a willingness to modify trips when necessary.

7.3 Past Involvement with Avalanches

Saarinen (1982b) argues that prior experience with a disaster is related in some manner with prepardness level or ability to deal with the hazard. In this section, an indicator of past involvement with avalanches will be examined. Material for this indicator was collected by asking the respondent whether he or any of his acquaintances had ever been involved in an avalanche accident. Following a general discussion on avalanche involvement, the relationship between avalanche involvement and avalanche knowledge will be examined.

7.3.1 A General Look at Avalanche Involvement

A rather large proportion (over 38 percent) of the respondents claimed that they or an acquaintance had been involved in an avalanche accident, that is, being swept downhill by an avalanche. Even only those who had been personally involved in an avalanche accident comprised nearly 11 percent of the skiers interviewed. This surprisingly large proportion of the respondents who had personally been involved in an avalanche accident would seem to indicate that many avalanche accidents do not result in a fatality. There have been only 81 deaths caused by avalanche among these participating in a recreational activity (excluding snowmobiling) during the past 30 years in British Columbia and Alberta (see Figure 2.1).

A significant relationship exists between the trail risk zones used on the day of the interview and avalanche involvement. From Table 7.3, which illustrates the relationship between avalanche involvement and risk zone used, it is evident that as avalanche risk increases, the likelihood of previous involvement increases. About 25 percent of the users of no risk zones have a history of previous involvement. The proportion increases to over 56 percent in the sustained risk zones. One may conclude that past involvement with avalanches does not deter use of zones where avalanches are most likely to occur.

Table 7.3 Respondent or Acquaintance Involved in Avalanche vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
No Involvement	74.8%	71.4%	43.5%	61.7%
Involvement	25.2	28.6	56.5	38.3
Total	115	105	138	358

Chi-square = 31.9 Degrees of Freedom = 4 Significance Level $\leq$ 0.05

7.3.2 Explaining Avalanche Knowledge in Terms of Avalanche Involvement

- Previous avalanche involvment has statistically significant relationships (probability of relationship existing greater than 95 percent) with all of the avalanche knowledge indicators addressed in this study (avalanche hazard assessement, cancelling or modifying a trip and route selection).

7.3.2.1 Avalanche Hazard Assessment

Persons with a previous history of avalanche involvement are more likely (tau-b 0.24) to have good knowledge with respect to assessing avalanche hazard (over 59 percent) than those with no previous avalanche accident experience (only 39 percent of these people were rated as having good knowledge with respect to assessing avalanche hazard).

When considering only users of the sustained risk zones, where ability to assess avalanche hazard is most important, a slightly stronger relationship exists (tau-b 0.31) with a greater proportion of those with a history of accident involvement having good knowledge (over 61 percent) and a lesser proportion of those without any involvement having good knowledge (less than 35 percent).

7.3.2.2 The Decision to Cancel or Modify a Ski Outing

Those with a history of avalanche involvement were certainly more likely (tau-b 0.35) to have cancelled or modified a trip in the past because of avalanche risk than those with no avalanche accident involvement (about 75 percent versus about 39 percent). Having made such trip modifications in the past, these people are likely to modify future trips if the avalanche risk is too high. Similar relationships exist when considering only those who used sustained risk areas (tau-b 0.30).

Those with a history of cancelling or modifying a trip were asked what changes they had made to their plans. About twice as many of those who had a history of avalanche accident involvement reported modifying their route because of avalanche risk than those with no previous accident involvement (tau-b 0.21). Those with previous accident experience appear to be somewhat more willing to modify their route because of avalanche risk. Again, the same sort of relationship exists where including only users of the sustained risk zones in the analysis (tau-b 0.26).

7.3.2.3 Route Selection

Significant relationships exist between previous exposure to avalanche accidents and all of the indicators used for route selection knowledge. These indicators fall into 3 different groups, which are an assessment based on the reasons given for the route selection on the diagram from Appendix 1, knowledge of most likely avalanche locations along the route taken on the day of the interview and actions taken when avalanche risk was perceived in the past.

Persons with a previous history of avalanche accident involvement were more likely to have good route selection knowledge than those without this experience (tau-b 0.27). About 40 percent of those with previous accident involvement were rated as having good route selection knowledge on the basis of their reasons for choosing their route on the test diagram, as opposed to only 15 percent of those with no previous accident involvement. The relationship is nearly identical when only sustained risk zone users are considered (tau-b 0.26).

Respondents with previous avalanche accident involvement were somewhat more likely (tau-b 0.13) than others to claim knowledge of where avalanches were most likely to occur along the trail, but their actual avalanche location knowledge was only very marginally better (tau-b 0.06). This indicates some overconfidence in knowledge of most likely avalanche locations by those with previous accident experience. In contrast, among users of the sustained risk zones, the knowledge levels of those with accident experience was actually better (tau-b 0.22).

Finally, when considering the actions taken by the respondents after perceiving some risk of an avalanche occurring, some surprising results were derived. After perceiving avalanche risk, those previously involved in an avalanche accident were less likely (tau-b -0.18) to modify their route (this decision was likely made on the trail, as opposed to the decision to cancel or modify a trip, which was probably made before leaving the highway, or at least not after specifically perceiving immediate risk from an avalanche), and more likely to report crossing a suspect slope without making any adjustment to reduce the risk (tau-b 0.21). These relatively strong relationships are in direct contrast to previous findings reported in the literature. For example, workers such as Burton *et al.* (1978) and Saarinen (1982b) have found that people with prior natural hazards experience are more likely to adopt adjustments. Perhaps as suggested by the Council for Science and Society (1977), people feel that accidents cannot happen to themselves, particularly if they have already been associated with that type of accident (Jackson 1981).

7.3.3 Summary of Past Avalanche Involvement

To summarize this section, a number of statements may be made about those who have a history of being personally involved in an avalanche accident or knowing someone else who has been in such an accident. First, a surprisingly large proportion (over 38 percent) of the respondents have either personally been or had an acquaintance involved in an avalanche accident. From this, one may conclude that many avalanche accidents do not result in fatalities. Second, the majority of those with past avalanche accident experience use areas where there is at least some risk of an avalanche — past involvement apparently does not deter future use of avalanche prone areas.

The following points may be made about people who have past avalanche accident experience, as compared to those who lack that experience:

- they have generally better avalanche hazard assessment skills
- they are more likely to have modified a trip in the past, which may be due to the fact that they more often use areas of higher avalanche risk
- they have better route selection knowledge
- they are more likely to overestimate their knowledge of most likely avalanche locations (except users of sustained risk zones, who do have superior knowledge)
- when they perceive avalanche risk, they are more likely to keep going along the same route without making any adjustment.

The first 3 points are similar to the findings of Burton *et al.* (1978) and Saarinen (1982b) from the field of natural hazards, but the last 2 points are definitely in contradiction to the findings of these authors. The explanation could be that people may accept higher known risk levels in these voluntary activities.(Rescher 1983).

7.4 Experience

Prior to any detailed study, one would think that a backcountry skier's experience level would have a major effect on avalanche knowledge, with those having more experience having greater knowledge. To test this assumption, a 4 part discussion dealing with experience is presented here. The individual parts include:

- the derivation of an experience indicator
- some of the survey results for experience
- relating experience and avalanche risk in the zone used
- relating experience to avalanche knowledge.

7.4.1 Deriving an Experience Indicator

To obtain a measure of experience, the number of years that a person has been involved in winter recreation in mountainous areas is insufficient. There must be some consideration of the number of times per season that a person participates in these activities. Ideally, the proportion of the outings which took place in avalanche prone terrain should be known as well, but this factor was not obtained in the study. A measure of experience was derived for the purposes of this study by taking the product of the term number of years of participation and the term given by the average number of days spent in mountainous backcountry areas for the winters of 1983-84 and 1984-85. Hence, if a person had participated in winter recreation in mountainous areas for the last 10 years, and had spent an average of 10 days per winter over the last 2 winters in the mountainous backcountry, he would have an experience factor of 100, which equates very roughly to 100 days of skiing. These are approximately the median figures for all of the respondents. To compensate for the fact that the respondent may have been interviewed prior to the end of the 1984-85 winter, the number of days for that season were adjusted. It was assumed that the ski season lasted from December 1, 1984 to April 30, 1985 and that the person would ski, on average, the same number of days per month after the interview as prior to the interview.

7.4.2 Experience Levels of Skiers Surveyed

The estimates for the total number of experience days of the respondents were surprisingly high (see Table 7.4). The median figure was 100.3 days, with the average being 240.7 days. The average number of backcountry skiing days in mountainous areas for the last 2 seasons was 19.2. Evidently, many people have made a significant committment in time and money (equipment and transportation) to the sport. Also, over 37 percent of the respondents have gone on a trip of 2 or more days where they camped or stayed in a backcountry hut over the past 2 winters. More experienced people are more likely to have taken overnight trips.

Table 7.4 Experience in Days of the Respondents

Days	Count	Percent	Cumulative Percent
0 - 19	65	17.8	17.8
20 - 39	31	8.5	26.3
40 - 59	35	9.6	35.9
60 - 79	23	6.3	42.2
80 - 99	27	7.4	49.6
00 - 199	66	18.1	67.7
200 - 299	43	11.8	79.5
300 - 399	19	5.2	84.7
400 - 499	15	4.1	88.8
500 - 749	19	5.2	94.0
750 - 999	6	1.6	95.6
1000 - 1999	11	3.0	98.6
2000 - 2999	2	0.5	99.2
3000 - 3999	1	0.3	99.5
4000 - 4999	2	0.5	100.0
Total	365	100.0	

7.4.3 Experience Levels in the Different Risk Zones Used

To compare experience to level of risk encountered by terrain, the median number of experience days was used as a dividing line. As shown in Table 7.5, people utilizing areas where there can be sustained periods of high avalanche risk are likely to be more experienced. A similar relationship holds when the average number of experience days is used as the dividing line, but the differences, though still significant, are not quite as pronounced.

Table 7.5 Number of Experience Days vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
< 100 days	64.2%	53.3%	33.3%	48.7%
> 100 days	35.8	46.7	66.7	51.3
Total	106	105	138	349
Chi-square = 24.1	Degrees of Freedom = 2		Significance Level < 0.05	

7.4.4 Relating Experience to Avalanche Hazard Knowledge

Similar to the previous factors discussed, experience was found to have statistically significant relationships with all 3 of the avalanche knowledge indicators considered in this study (avalanche hazard assessment, cancelling or modifying a trip and route selection).

7.4.4.1 Avalanche Hazard Assessment

When using quality of the reasons given for the avalanche hazard rating supplied by the respondents as an indicator of ability to assess avalanche hazard, a generally positive relationship (tau-b 0.18) was found between experience and avalanche hazard assessment ability. About 34 percent of those with from 0 to 49 days of experience had good knowledge, as did about 45 percent of the 50 to 99 day group, about 58 percent of the 100 to 199 day group, 61 percent of the 200 to 399 day group and about 45 percent of the over 400 day group. No reason for the knowledge drop in the most experienced group was found in analyzing the data collected, but as illustrated later in this chapter, experience is not one of the most important factors with respect to making decisions under conditions of risk. Finally, no significant relationship was found between these 2 variables when considering only users of the sustained risk zones.

7.4.4.2 The Decision to Cancel or Modify a Trip

Persons with greater experience were more likely to have cancelled or modified a ski trip in the past than those with lesser experience (tau-b 0.37). Only about 19 percent of those in the 0 to 49 day experience group had made such a change, as opposed to about 64 percent of the 50 to 199 day group and about 73 percent of the over 200 day group. One explanation for the increasing likelihood of changing a trip due to avalanche risk with increasing experience may be only that participating in more trips increases the probability of having to change at least 1 trip. Similar to above, there was no significant relationship between these 2 variables when considering only users of the sustained risk zones.

7.4.4.3 Route Selection

Significant relationships were found between experience and all 3 indicators used for route selection ability. First, persons with greater experience were more likely to give better reasons for the route chosen on the diagram from Appendix (tau-b 0.21). Only about 14 percent of those in the 0 to 49 day experience group were classified as having good knowledge or which to base route selection decisions. This figure increased gradually to over 39 percent in the over 400 day experience group. An even stronger positive relationship exists when considering only the sustained risk zone users (tau-b 0.31).

Second, claimed knowledge of most likely avalanche locations along the trail used on the day of the interview certainly increased with experience (tau-b 0.25), from 57 percent of the 0-49 day experience group to about 88 percent of the most experienced group. However, actual avalanche location knowledge did not show such a clear trend, with the least experienced group having about the same knowledge level as the most experienced group (tau-b 0.08), although among users of sustained risk zones actual knowledge does increase with experience (tau-b 0.22). Some degree of overconfidence must come with experience, at least among the general skier population.

Finally, a significant relationship was found between experience and actions taken when risk from avalanche was perceived by the respondents. This relationship existed only among sustained risk zone users, where it was found that more experienced skiers were less likely to relate crossing a slope after making an adjustment when avalanche risk is suspected than those with lesser experience (tau-b -0.29). Unfortunately, no significant relationship was found to tell what they were more likely to do, but they could have modified their route to avoid areas where avalanche risk was perceived or continued without making any adjustment.

7.4.5 Experience Summary

In this section, several aspects of skier experience were presented. First, the derivation of an indicator for skier experience was explained. Second, it was noted that the skiers interviewed had a generally high level of experience. Evidently, many people have made a significant committment of both time and money (in terms of equipment and transportation) to the sport. Third, the following observations may be made about those who have greater experience levels, as compared to those with lesser experience:

- they are more likely to use areas of greater avalanche risk
- they have superior avalanche hazard assessment skills
- it is more likely that they have cancelled or modified a trip in the past (remember that they have had more opportunities to do so)
- they have better route selection ability
- they are overconfident in their knowledge of most likely avalanche locations (except solely the users of the sustained risk areas)
- when considering only users of sustained risk areas, they are less likely to cross a slope

where avalanche risk is suspected after making some adjustment to the risk.

7.5 Being the Party Leader

Daffern (1983) and Wilkinson (1983) recognize that the leader can have a significant influence on the safety of the party, particularly in large groups. For this reason, analysis of the interview data was performed to determine whether party leaders had better avalanche knowledge than non-leaders. Bearing in mind that parties were no more likely to have a recognized leader in any of the 3 risk zones, the avalanche knowledge of the leaders will be discussed, in terms of avalanche hazard assessment, the decision to cancel or modify a trip and route selection.

The ability of trip leaders to assess avalanche hazard could not be distinguished from that of non-leaders.

Trip leaders were somewhat more likely to have cancelled or modified a trip in the past than non-leaders. About 63 percent of leaders had made such a change, as compared to about 50 percent of the rest of the skiers. Trip leaders have, at least to a marginal extent (tau-b 0.12), been more conservative in their decisions.

With respect to route selection, the only significant relationship showed trip leaders to be more likely to claim knowledge of avalanche locations than non-leaders (tau-b 0.16). About 87 percent of leaders claimed to have this knowledge, as opposed to less than 72 percent of the non-leaders. However, there was no significant difference between actual knowledge of the 2 groups, demonstrating some overconfidence of leaders in their knowledge. Finally, when considering only users of the sustained risk zones, party leaders tended to be somewhat more conservative than others in their route selections after perceiving some risk from avalanche. Party leaders were more likely (tau-b 0.32) to report modifying their route after perceiving avalanche risk (65 percent) than non-leaders (about 30 percent) and less likely (tau-b -0.24) to mention crossing a slope where avalanche risk is suspected without making any adjustment (20 percent) than non-leaders (over 46 percent).

To summarize this section on party leaders, several salient points may be made. First, the likelihood of ski parties having a recognized leader is not related to the avalanche risk encountered. For example, ski parties using sustained risk zones are no more or no less likely to have a recognized leader than parties using no or intermittent risk zones. Second, trip leaders are no better at making avalanche hazard assessments than non-leaders. Third, trip leaders are more likely to have cancelled or modified a trip in the past than non-leaders. As a fourth point, trip leaders exhibit some overconfidence in their knowledge of most likely avalanche locations. Finally, when considering only users of sustained risk zones, party leaders tend to be more conservative in route selection after avalanche risk is perceived than non-leaders. Overall, party leaders generally have no better or worse knowledge than non-leaders, but they have a tendency to be slightly more conservative in their decisions.

7.6 Adjustments to Reduce the Risk of Avalanches

A number of adjustments may be made by an individual to reduce the risk of avalanches to himself. In the interviews, the respondents were queried about a number of major adjustments which they could have made. People may take avalanche awareness courses or read books on the subject to enhance their ability to travel safely in avalanche prone terrain. Preparation for a trip may include acquiring and carrying specific items of equipment, along with obtaining information with respect to avalanche hazard immediately prior to or during the early stages of a trip before potentially hazardous conditions are encountered. Each of these 4 adjustments are discussed in this section.

7.6.1 Avalanche Safety Courses

People can enhance their ability to travel safely in avalanche prone terrain by taking avalanche safety courses or seminars, subject to the proviso that such courses must be supplemented by field experience in the company of knowledgeable persons. There will be 2 major portions in this discussion of avalanche safety courses, which are a presentation of the responses given with respect to courses taken and an examination of the impact of taking such courses on avalanche knowledge.

7.6.1.1 Survey Results with Respect to Avalanche Safety Courses

Table 7.6 shows the relationship between taking an avalanche safety course and risk rating in the area the respondent was using. The attribute of taking a course or attending a seminar is related to the risk rating of the area. A greater proportion (about 62 percent) of the individuals using areas where there can be sustained high risk of avalanche have taken a course than those in the other rating categories (about 35 percent). However, there is a large proportion (nearly 49 percent) of the people using areas where avalanches may occur (including the intermittent risk category) that have not taken an avalanche safety course. Even of those who have taken courses (considering all respondents here), over 40 percent have taken courses with a total duration (for all courses taken) of 2 days or less, where only a minimal amount of material could be covered. As a positive note, on an aggregate basis, the mean number of days spent attending courses was 5.3 and the median was 4.0. Evidently, at least some people are making a significant investment in time and possibly money to improve their training in this field. Almost 68 percent of the respondents taking courses had taken their most recent course in the 1980's. Some people mentioned taking as many as 3 avalanche safety courses in their lifetime.

These courses or seminars were sponsored and taught by a wide variety of institutions and individuals. To give an example of this variety, the 162 respondents who had taken such a course reported 68 different course sources. The most commonly mentioned courses were made available by the following organizations or individuals (with number of respondents taking the course in parentheses):

- Alpine Club of Canada (17)
- Canadian Ski Patrol Systems (15)
- City of Calgary (13)
- British Columbia Institute of Technology (11)

Table 7.6 Taking of Avalanche Safety Courses vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Not Taken Course	67.8%	61.9%	38.4%	54.7%
Taken Course	32.2	38.1	61.6	45.3
Total	115	105	138	358

Chi-square = 25.0 Degrees of Freedom = 2 Significance Level < 0.05

- University of Calgary (10)
- Al Schaeffer (10)
- Parks Canada (10)
- Blue Lake Centre (9)
- Tony Daffern (8).

7.6.1.2 The Impact of Avalanche Safety Courses on Avalanche Knowledge

Taking avalanche safety courses was found to have a significant effect (95 percent probability of relationship existing) on all 3 of the major types of avalanche knowledge indicators discussed in this thesis.

Respondents who had taken an avalanche safety course were better able (tau-b 0.22) than those who had not to supply valid reasons for their rating of the avalanche hazard or snow stability on the day of their trip. Over 57 percent of those who had taken a course were rated as having good hazard assessment knowledge, as compared to only 38 percent of those who had not taken a course. A similar relationship exists when considering only users of the sustained avalanche risk zones (tau-b 0.21).

When considering the respondents both in aggregate and solely those using the sustained risk areas, a much greater proportion of those who had taken an avalanche safety course had cancelled or modified a trip in the past because of avalanche risk than those who had not taken a course. In aggregate (sustained risk area responses were similar, with tau-b of 0.37), over three-quarters of those who had taken a course had changed trip plans in the past, while less than 35 percent of those who had not taken a course had changed their plans (tau-b 0.41). Taking a course seems to increase one's propensity to make plan modifications because of avalanche risk.

Route selection knowledge was also affected by taking avalanche safety courses. Significant relationships were found between course taking and route selection knowledge rated by the reasons for the route selected on the diagram from Appendix 1, knowledge of most likely avalanche locations and actions taken when avalanche risk was perceived.

About 36 percent of those who had taken a course were rated as having good route selection knowledge based on the diagram question in the interview, as compared to about 15 percent of those who had not taken a course (tau-b 0.24). Even though course takers ranked higher, there is still much room for improvement in route selection ability. No significant relationship was found where considering only sustained risk zone users.

As seems to be the trend for the characteristics discussed thus far, those who had taken a course were more likely to claim knowledge (tau-b 0.26) of most likely avalanche locations along the trail used on the day of the interview (about 88 percent) than those who had not taken a course (about 65 percent), but their actual knowledge levels were only very marginally better (tau-b 0.02) than non-takers of courses. No significant relationships for this overestimation of their knowledge were found solely for users of sustained risk zones.

Finally, a significant relationship was found with 1 of the actions taken after skiers had previously perceived risk from an avalanche. Skiers who had taken a course were much less likely (tau-b -0.40) to cross a slope where avalanche risk was suspected after making some adjustment (about 10 percent of course takers fell into this category) than those who had not taken such a course (about 46 percent). Course takers must have placed more faith in their route selection ability, either by crossing the slope without making an adjustment or just modifying their route to avoid the area where avalanche risk is perceived. Similar results were derived for users of sustained risk zones (tau-b -0.38).

7.6.1.3 Avalanche Safety Course Summary

Speaking in general terms, the taking of avalanche safety courses evidently can have a significant positive impact on avalanche knowledge. Several specific conclusions may be derived from this section as well. First, as avalanche risk in the area used increases, the likelihood of people using the area having taken a course increases. However, nearly half of the people using areas where avalanches can occur have not taken a course. Further, even though over 40 percent of the course takers attended courses of 2 days or less in duration, the mean number of days spent at courses was 5.3. Finally, the following points may be made when comparing people who have taken a course to those who have not:

- they are better able to assess avalanche hazard
- they are more likely to have cancelled or modified a trip in the past, thus showing increased willingness to change the trip if conditions are inappropriate
- they have better route selection knowledge, but there is still much room for improvement
- they overestimate their knowledge of most likely avalanche locations
- they are less likely to cross a slope where they suspect avalanche risk after making an adjustment, which may indicate increased confidence in their route selection ability.

7.6.2 Reading of Material Dealing With Avalanches

In addition to taking courses, a skier can enhance his knowledge of avalanche safety by reading books and other material. In this section, the survey results with respect to reading of material dealing with avalanches will be presented, followed by an examination of whether reading such material has any effect on avalanche knowledge.

7.6.2.1 Survey Results for Reading of Avalanche Material

Besides pamphlets, newspapers and magazines, the respondents reported reading 22 different books which dealt wholly or partially with avalanches. These books include Seligman (1936), Fraser (1966), LaChapelle (1969, 1979), MacInnes (1972), Tejada-Flores and Steck (1972), Ferber (1974), Williams (1975), Kunelius (1977), Chouinard (1978), Perla and Martinelli (1978), Tejada-Flores (1981) and Daffern (1983), along with several others in foreign languages and a few manuals published by organizations such as the Canadian Ski Patrol Systems and the British Columbia Institute of Technology.

Since a number of these publications treat avalanches only as an aside, the books were categorized as dealing specifically with avalanches or being general books. Those categorized as specific avalanche books included Seligman (1936), Fraser (1966), LaChapelle (1969, 1979), Williams (1975), Perla and Martinelli (1978), Daffern (1983), Canadian Ski Patrol Systems manuals, a Japanese language book and a British Columbia Institute of Technology manual. Pamphlets, magazines and newspapers were placed in the general category. A person is likely to learn more about travelling safely through avalanche prone terrain by reading a specific avalanche publication. Also, a greater interest in the subject and a desire to learn more about it is shown by reading the specific books. Table 7.7 illustrates the reading of books related to the level of risk in the zone which the respondent used on the day of the interview. A greater proportion of those using the sustained risk areas (about 56 percent) than the intermittent (less than 28 percent) or no risk (13 percent) areas have read at least 1 specific avalanche book.

7.6.2.2 The Effect of Reading on Avalanche Knowledge

Reading of material dealing with avalanches was found to be related to all 3 of the major avalanche knowledge indicators discussed in this thesis, which are assessing avalanche hazard, cancelling or modifying a trip and route selection (probability of relationship existing greater than 95 percent).

Table 7.7 Reading of Avalanche Material vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
No Material Read	29.6%	21.2%	8.8%	19.1%
Only General Material Read	57.4	51.0	35.8	47.2
Specific Book(s) Read	13.0	27.9	55.5	33.7
Total	115	104	137	356

Chi-square = 53.0   Degrees of Freedom = 4   Significance Level < 0.05

It was found that reading of avalanche material had a major impact on avalanche hazard assessment ability (which was judged by the quality of the reasons supplied by the respondent for his avalanche hazard rating on the day of the interview). Only about 29 percent of those who had read no material dealing with avalanches were rated as having good snow stability assessment knowledge, as compared to about 39 percent of those who had read general material and over 66 percent of those who had read specific avalanche books (tau-b 0.33). A similar, although somewhat weaker (tau-b 0.29), relationship was found when considering only users of sustained risk areas.

Respondents who had read avalanche material were also more likely (tau-b 0.42) to have cancelled a trip or changed their plans because of avalanche hazard in the past. Over 84 percent of those who had read a specific avalanche book had made such a trip change in the past, which is a much greater proportion than those who had read only general avalanche material (about 42 percent) or none at all (about 28 percent). Reading of avalanche material, particularly specific books, evidently has a major impact on people's willingness to change their plans because of avalanche risk, or alternatively, their awareness that avalanche risk levels should be considered when making the final decision to go or not to go along a specific route. Among users of the sustained risk zones, a similar relationship exists as well (tau-b 0.30).

Two indicators of route selection capability were found to be significantly related to reading of avalanche material. These are route selection ability as rated by the reasons supplied for the route selected on the diagram from Appendix 1 and knowledge of where avalanches are most likely to occur on the trail used on the day of the interview.

In terms of knowledge on which the route selection was based, only about 11 percent of those who had read no material were rated as having good route selection knowledge, as compared to about 16 percent of those who had read general material and nearly 45 percent of those who had read specific books (tau-b 0.32). Reading of avalanche material certainly improves route selection ability, since only about 10 percent of those who had read specific books were rated as having low route selection knowledge, much less than the 38 percent of those who had read no material.

In the same vein as the previous factors discussed, those who had read avalanche material, particularly specific books, were much more likely to claim knowledge (tau-b 0.33) of most likely avalanche locations along the trail they were using that day, but their actual knowledge levels were marginally worse (tau-b -0.07). Overconfidence in knowledge of specific avalanche locations seems to be common among those who are otherwise more knowledgeable.

Similar to the aggregate of the people surveyed, those who used sustained risk areas showed increasing route selection ability with reading of avalanche material (tau-b 0.24), but there was no overconfidence in knowledge of most likely avalanche locations by readers of avalanche material — they actually did have somewhat better knowledge (tau-b 0.24).

7.6.2.3 Summary for Reading of Avalanche Material

Of the factors discussed to this stage in the chapter, reading of avalanche material appears to be among those having the greatest positive influence on ability to make decisions under conditions of avalanche risk. Several specific summary points may be made about reading of material dealing with avalanches. First, the respondents reported reading a wide variety of publications. The books most commonly reported as being read were those of Perla and Martinelli (1978) (read by 21 percent of those reading some publications) and Daffern (1983) (read by 27.5 percent of those reading some publications). Second, a scheme was presented by which the material read could be ranked as to the amount of detail contained. Third, as avalanche risk in the zone used increased, reading of avalanche material increased, although still only just over half of the users of sustained risk zones had read specific avalanche material. There is some room here to encourage people, particularly those using sustained risk areas to read more detailed publications. Finally, reading of avalanche material affected the indicators of avalanche knowledge as follows:

- had a major positive impact on avalanche hazard assessment capability
- led to increased awareness of need and willingness to cancel or modify a trip when avalanche risk is high
- improved route selection ability
- led to some overconfidence in knowledge of most likely avalanche locations, except exclusively among users of sustained risk zones where reading of such material was related to increased knowledge.

7.6.3 Safety Equipment Carried by the Skiers

Various items of equipment can be carried and utilized by skiers to reduce the risk of being caught in an avalanche and to increase the efficacy of any party self rescue in the case of an avalanche accident. Several other items should be carried on any backcountry trip regardless of the avalanche risk. One must bear in mind that carrying equipment does not necessarily mean that one knows how to use it. Experience, along with knowledge, are required to make effective use of the equipment. In this section, the survey results with respect to equipment carried will be discussed, followed by the relationships between carrying equipment and avalanche knowledge.

7.6.3.1 Survey Results on Equipment Carried

Survey results with respect to carrying various types of equipment are presented here. The types of equipment considered include those for snow study, avalanche rescue, and general emergencies. An aggregate of avalanche rescue and general emergency equipment, termed being well equipped, is considered as well.

Snow study equipment can be useful when attempting to predict snow stability (Perla 1978b; Daffern 1983). Some items that can easily be carried in the backcountry include a snow crystal plate, a magnifier and a clinometer. The magnifier is used in conjunction with the crystal plate to study snow stratigraphy as described by Perla and Martinelli (1978). Slope angles may be measured using a clinometer as suggested by Perla (1978b) and Daffern (1983). From the snow stratigraphy analysis, a person with appropriate education and experience can estimate the maximum angle of slope on which it is safe to ski. However, almost none of the respondents carried this snow study equipment. Only 2.2 percent carried a crystal plate and magnifier, 1.9 percent carried a clinometer and only 0.9 percent carried both. Evidently people prefer skiing to digging holes in the snow.

The obvious and best method of reducing the risk of avalanche is to choose a safe route (Williams and Armstrong 1984). However, there is a chance that one can make a route finding mistake in avalanche prone terrain. According to a number of experts (e.g. Kunelius 1977; Daffern 1983; Williams and Armstrong 1984), all parties travelling in these areas should carry avalanche rescue beacons, shovels and probes (either sectional probes carried in the pack or ski poles which join together to form a probe) to facilitate self rescue. Each person should have an avalanche rescue beacon and ideally everyone should carry a shovel and a probe to guard against the case that the individuals carrying the shovel and/or probe are caught in an avalanche. Use of all 3 items is important to minimize the time taken for rescue, since there is often little time to effect a live rescue. Williams and Armstrong (1984), based on a study of avalanche accidents in the United States between 1950 and 1982, have found that only 50 percent of persons completely buried by an avalanche can survive longer than 30 minutes. From Table 7.8, one can see that persons travelling in areas where there can be sustained periods of high avalanche risk are more likely to carry these 3 items of equipment than those travelling in areas of lesser risk, but still only about 41 percent had all 3 items among members of the party (and all 3 items were not necessarily carried by each person). Indeed, over 20 percent of the respondents' parties carried no avalanche rescue equipment at all in areas of sustained high avalanche risk.

Table 7.8 Carrying of Avalanche Rescue Equipment vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
No Equipment	80.9%	70.5%	20.3%	54.5%
1 Item	6.1	9.5	18.8	12.0
2 Items	7.0	11.4	20.3	13.4
3 Items	6.1	8.6	40.6	20.1
Total	115	105	138	358

Chi-square = 114.2 Degrees of Freedom = 6 Significance Level < 0.05

In the opinion of many experts (Kunelius 1977; Tejada-Flores 1981; Parks Canada 1983; Wilkinson 1983), parties utilizing backcountry areas should carry 3 other items in case of emergencies, regardless of whether avalanche terrain is encountered (although these items can also be useful in the case of an avalanche accident). These items are warm extra clothing, a first aid kit and a repair kit. It is evident from Table 7.9 that these items are commonly carried by people utilizing areas where there can be sustained periods of high avalanche risk, with people utilizing areas of lower avalanche risk being less well prepared for equipment failures, injuries and unplanned stops.

As is obvious from the above discussion, any well equipped party travelling in avalanche prone terrain should carry all 3 items of avalanche rescue equipment and all 3 items of emergency equipment. As shown in Table 7.10, only a small proportion of the respondents' parties could be classified as being well equipped, although those travelling in areas where there can be sustained periods of high avalanche risk are more likely to be well equipped (i.e. carry all 6 items).

Table 7.9 Carrying of Emergency Equipment vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
0 or 1 Item	49.6%	27.6%	5.8%	26.3%
2 Items	17.4	21.0	14.5	17.3
3 Items	33.0	51.4	79.7	56.4
Total	115	105.	138	358

Chi-square=72.2 Degrees of Freedom=4 Significance Level <. 0.05

Table 7.10 Whether Party is Well Equipped vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total.
Not Well Equipped	94.8%	91.4%	60.9%	80.7%
Well Equipped	5.2	8.6	39.1	19.3
Total	115	105	138	358

Chi-square=57.3 Degrees of Freedom=2 Significance Level < 0.05

7.6.3.2 The Relationship Between Carrying Safety Equipment and Avalanche Knowledge

Carrying of avalanche rescue and emergency equipment, along with being well equipped, were found to be significantly related to all 3 indicators of avalanche knowledge mentioned in this thesis, that is, avalanche hazard assessment ability, history of cancelling or modifying a trip because of avalanche risk and route selection skills.

Avalanche hazard assessment skills were found to be positively related to carrying safety equipment. Only about 36 percent of those who carried no avalanche rescue equipment were rated as having good avalanche hazard assessment knowledge, a percentage much lower than for those who carried all 3 items of avalanche safety equipment (over 63 percent). The tau-b value for carrying avalanche rescue equipment is 0.28. In terms of carrying emergency equipment, about 31 percent of those who carried none or only 1 item were rated as having good knowledge, as compared to nearly 56 percent of those who carried all 3 items (tau-b 0.26). Lastly, about 43 percent of individuals who were not well equipped were found to have good knowledge, as opposed to over 63 percent of those who were well equipped (tau-b 0.21). The sole significant relationship when considering only those who used the sustained risk zones was for being well equipped (tau-b 0.20).

The likelihood of a person having cancelled or modified a trip in the past increases with the amount of safety equipment carried. Only about 34 percent of those who carried no avalanche rescue equipment had cancelled or changed a trip, while nearly 84 percent of those who carried all 3 items of avalanche rescue equipment had (tau-b 0.41). Similarly, only about 21 percent of those who carried no or only 1 item of emergency equipment had cancelled or changed a trip, relative to 70 percent of those who carried all 3 emergency items (tau-b 0.40). Finally, about 45 percent of those who were not well equipped had cancelled or changed a trip, as compared to nearly 86 percent of those who were well equipped (tau-b 0.32). Similar relationships existed when considering only users of the sustained risk zones, with tau-b values of 0.20 (avalanche rescue equipment), 0.20 (emergency equipment) and 0.19 (being well equipped). The only significant relationship found between any plan change because of avalanche risk and safety equipment carried was in the aggregate data between modifying one's route and being well equipped. Here, about 21 percent of those who were not well equipped reported modifying their route because they thought the avalanche hazard was too high and about 36 percent of well equipped persons had modified their route (tau-b 0.16).

Finally, significant relationships were found between carrying of safety equipment and 2 of the indicators of route selection ability. These are route selection knowledge as rated from the reasons given for the route selected on the diagram from Appendix 1 and knowledge of most likely avalanche locations.

With respect to route selection knowledge, only about 16 percent of those who carried no avalanche rescue equipment were rated as having good knowledge, as compared to nearly 48 percent of those who carried all 3 items (tau-b 0.26). Carrying emergency equipment was related to route selection knowledge as well, with only about 12 percent of those who carried no emergency equipment or only 1 item having good route selection knowledge, relative to about 35 percent of those who carried all 3 items having good knowledge (tau-b 0.27). Finally, only about 18 percent of those who were not well equipped had good knowledge, as opposed to one-half of those who were well equipped (tau-b 0.26). Route selection knowledge levels, both for the aggregate of all respondents (which was presented above) and solely for users of the sustained risk zones, were higher for those who carried the various items of safety equipment. For users of the sustained risk zones, the tau-b values were 0.19 (avalanche rescue equipment), 0.21 (emergency equipment) and 0.27 (well equipped).

With reference to knowledge of most likely avalanche locations, only 63 percent of those who carred no avalanche rescue equipment claimed knowledge, while 89 percent of the people that carried all 3 items of avalanche rescue equipment did so (tau-b 0.28). Similar proportions were found for claimed knowledge of most likely avalanche locations for both carrying of emergency equipment (tau-b 0.26) and being well equipped (tau-b 0.18). Overconfidence in their knowledge of most likely avalanche locations was found for respondents scoring highly in all 3 factors. This overconfidence was not evident when considering only users of the sustained risk areas for any of the factors. In fact, as number of items of emergency equipment carried increased, actual knowledge of most likely avalanche locations increased for this group (tau-b 0.26) and there was a greater probability that well equipped users of the sustained risk zones had greater actual knowledge of most likely avalanche locations than those who were not well equipped (tau-b 0.21).

7.6.3.3 Safety Equipment Summary

Those who have made the effort to acquire and carry the various items of safety equipment generally have better avalanche knowledge than those who carry little or no safety equipment. Carrying of safety equipment is likely a more obvious reflection of only 1 of the decisions made by these more knowledgeable people. A few specific points may be made in summarizing this section which provide support for this general statement.

First, only a very small proportion of the respondents carried snow study equipment. People could be encouraged to obtain such equipment and learn to apply information which may be obtained by using the equipment to enhance their decisions with respect to avalanche safety. Second, people generally carried more items of avalanche rescue equipment as risk in the zone used increased, although still only a minority (about 41 percent) of those who used sustained risk zones carried all 3 of the items generally accepted by experts as being required for a speedy, effective rescue. Third, people generally carried more items of emergency equipment as risk in the zone used increased. Fourth, only a small proportion of the respondents using any of the risk zones were considered to be well equipped, but the proportion of those who were well equipped did increase as risk in the zone used increased.

Finally, as all 3 of the factors considered here (carrying of avalanche rescue and emergency equipment, along with being well equipped) increased, the following statements may be made:

- avalanche hazard assessment skills increased
- the likelihood of having cancelled or modified a trip in the past because of avalanche hazard increased
- route selection skills increased
- overconfidence in knowledge of most likely avalanche locations increased, except among users of sustained risk zones where actual knowledge increased.

7.6.4 Obtaining Information With Respect to the Avalanche Hazard

The respondents were asked whether they or members of their party usually obtained information or made observations regarding the risk of avalanches in the area before taking or soon after the start of a ski trip. In this section, a summary of the survey responses to this question is presented, followed by an analysis of whether those who obtain some form of information have better avalanche knowledge.

7.6.4.1 Obtaining Avalanche Hazard Information

As may be observed in Table 7.11, a surprisingly large proportion (over 77 percent) of the respondents, especially among users of the low and intermittent risk zones, stated that they generally obtained information about avalanche risk in the area that they intended to use. There was a trend of increasing likelihood of obtaining such information as risk in the zone used increased, however. While recognizing that the proportion of the respondents who stated that they generally obtained information may be exaggerated to some extent because of desire to depict themselves as being knowledgeable, it is interesting to examine in greater detail the type of information obtained and the source of that information.

Table 7.11 Acquisition of Information About Avalanches vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
No Information Obtained	37.4%	21.9%	10.9%	22.7%
Information Obtained	62.6	78.1	89.1	77.3
Total	115	105	137	357

Chi-square = 25.0   Degrees of Freedom = 2   Significance Level < 0.05

The respondents reported obtaining a number of different types of information, all of which could be useful inputs to decisions made about avalanche risk. These information types and the proportion of the respondents that mentioned each one are as follows (with the percentages relative to the 134 respondents who mentioned an information type):

- Parks Canada avalanche hazard report (31.3 percent)
- weather forecast (21.6 percent)
- visual observation (18.7 percent)
- snow pit or other stability test (17.9 percent)
- snow or ski report (15.7 percent)

- recent weather trend (11.9 percent)
- history of weather conditions which affect snow stability throughout the winter (7.5 percent)
- all other information types not separately mentioned (10.4 percent).

Only a small proportion of all respondents (about 17 percent of the total of 365 respondents) stated that they actually went to the effort to make their own observations with respect to the risk of avalanches. A respondent was considered to have made observations with respect to avalanche conditions if he reported digging a snow pit (or making some other test of snow stability), making visual observations (such as observing recent avalanche activity or noticing which slopes have been heavily laden with wind blown snow), reliance on past experience on that trail (e.g. remembering the safe route through the area or remembering prominent areas of avalanche danger or maintaining a history of weather conditions that may affect snow stability throughout the winter. From Table 7.12, it is evident that as avalanche risk in the zone used increases, the likelihood of a respondent making his own observations increases.

Table 7.12 Reported Making of Observations vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Did Not Make Observations	97.3%	82.8%	71.7%	83.2%
Did Make Observations	2.6	17.1	28.2	16.8
Total	115	105	138	358

Chi-square=29.6 Degrees of Freedom=2 Significance Level < 0.05

Besides mentioning the type of information obtained, respondents cited the sources of their information. Nearly all of the sources cited would have useful information available with respect to the risk of avalanches. The information sources and the proportion of the respondents that mentioned each one are as follows (with the percentages relative to the 249 respondents who mentioned an information source):

- Parks Canada wardens (58.6 percent)
- telephone recording (9.6 percent)
- Parks Canada Banff information centre (8.8 percent)
- commercial radio stations (8.4 percent)
- friends (8.0 percent)
- other skiers (2.8 percent)
- trail guides or other publications (2.0 percent)
- cable television information program (1.6 percent)
- topographic maps (1.6 percent)
- other information sources not separately mentioned (12.0 percent).

The very high proportion that mentioned the Parks Canada wardens as an information source may be a result of the highly educated skiers seeking information from those who they perceive to be most knowledgeable.

It is informative to relate the 5 most popular information sources mentioned to the risk zones used by the skiers, as shown in Table 7.13. The likelihood of people contacting the Parks Canada warden service increases substantially as avalanche risk in the zone used increases. When considering all of the respondents, about 40 percent reported that they generally contacted one of the park warden offices before their trips.

Skiers can obtain information on current avalanche hazard conditions from a telephone recording which is updated by Parks Canada as conditions change. Not surprisingly, the proportion that utilize this service increases in direct relation to the avalanche risk in the zone used, as shown in Table 7.13.

From Table 7.13, one may infer that people utilizing no or intermittent risk areas are the ones most likely to stop at the Parks Canada Banff information centre, probably to obtain general trail information rather than specific avalanche information. A number of respondents using the sustained risk areas reported that the information centre was a poor

Table 7.13 Proportion Using Information Source vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Parks Canada Wardens •	46.3%	52.1%	71.0%	58.8%
Telephone Recording •	3.0	7.0	15.0	9.4
Parks Canada Info Center •	14.9	12.7	2.8	9.0
Commercial Radio Stations	10.4	9.9	5.6	8.2
Friends •	3.0	4.2	13.1	7.8
Total	67	71	107	245

• Response dependent on risk level (Chi-square level of significance < 0.05)

source of avalanche information because of a lack of knowledgeable staff.

There is no significant difference in using commercial radio stations as an information source among users of the different trail risk zones. Parks Canada supplies their avalanche hazard forecast to a number of stations in Calgary and Edmonton, but it is commonly broadcast only on the Banff and Canmore stations.

Only about 8 percent of the respondents who supplied an information source stated that they obtained information from their friends, but there was a significant difference among users of the different avalanche risk zones. People using the sustained risk areas were more likely to obtain information from their friends (see Table 7.13).

7.6.4.2 Relating Obtaining of Information to Avalanche Knowledge

Significant relationships were found between obtaining information with respect to the avalanche hazard and all 3 of the major avalanche knowledge indicators discussed in this thesis.

Respondents who reported obtaining information were better able than those who had not to supply valid reasons for their rating of the avalanche hazard on the day of their trip. Over 53 percent of those who had obtained information were rated as having good hazard assessment knowledge, as compared to only 25 percent of those who had not obtained any information (tau-b 0.26). A similar relationship exists when considering only users of the sustained avalanche risk zones (tau-b 0.18).

A greater proportion of those who had obtained information had cancelled or modified a trip in the past because of avalanche risk than those who obtained no information. Over 62 percent of those who had obtained information reported changing trip plans in the past, while only about 21 percent of those who had not obtained information mentioned changing their plans (tau-b 0.35). Those who make the effort to obtain information about the avalanche risk are generally more likely to be willing to modify their plans under conditions of high avalanche risk. However, no significant relationship was found between obtaining information and plan changes among users of the sustained risk zones.

Route selection knowledge was also related to obtaining of information about avalanches. Significant relationships were found between obtaining information and route selection knowledge rated by the reasons for the route selected on the diagram from Appendix 1 and knowledge of most likely avalanche locations. Only the former relationship was found to be significant among users of the sustained risk zones.

About 30 percent of those who had obtained avalanche information were rated as having good route selection knowledge based on the diagram question in the interview, as compared to about 7 percent of those who had not obtained information (tau-b 0.25). The relationship was weaker among users of the sustained risk zones, with a tau-b value of 0.19). Although those who obtained information ranked higher, there is still much room for improvement in route selection ability.

Finally, over 83 percent of those who had reported obtaining information claimed knowledge of most likely avalanche locations along the trail used on the day of the interview, with about 48 percent of those who had not obtained any information claiming such knowledge (tau-b 0.35). Only about 45 percent of those who had obtained information were rated as actually having good knowledge, as compared to about 48 percent of those who had not obtained information (tau-b 0.02). Those who had obtained avalanche information overestimated their knowledge of the most likely avalanche locations.

7.6.4.3 Obtaining Avalanche Information Summary

A number of points may be made to summarize this section on obtaining of information about avalanche hazard. First, and of greatest importance, a surprisingly large proportion (over 77 percent) of the respondents claimed that they regularly obtained information prior to ski trips. Even assuming that the respondents were only attempting to impress the interviewer with their knowledge, a great majority of the respondents were aware of where they could obtain information and what type of information to ask for. Also, the likelihood of respondents obtaining information increased in direct relation to trail risk in the zone used. Second, the probability of respondents making their own avalanche risk observations was directly related to avalanche risk in the zone used, but only about 17 percent of all respondents reported making their own observations. Third, a high proportion of the respondents (40 percent) specifically mentioned the Parks Canada warden service as a good information source. Fourth, a number of respondents reported that the Parks Canada Banff information centre was a poor source of avalanche information because of a lack of knowledgeable staff.

Finally, those who reported obtaining avalanche information as compared to those who did not may be characterized as follows:

- had superior avalanche hazard assessment skills
- were more likely to have cancelled or modifed a trip in the pst
- had superior route selection knowledge, although there is still much room for improvement
- were overconfident in their knowledge of most likely avalanche locations.

7.7 Chapter Summary

The summary for this chapter, in which a number of factors were examined in an attempt to identify the characteristics of skiers which are likely to be related to good avalanche knowledge, may be divided into 3 major portions. First, since avalanche knowledge becomes important only when some degree of avalanche risk exists, a brief summary of the material dealing with avalanche risk levels faced will be presented. Second, for each of the avalanche knowledge indicators introduced in the previous chapter, significant relationships with the factors which were discussed in this chapter will be identified, along with a measure of the degree of the relationship. Finally, the factors which were most characteristic of those with good avalanche knowledge will be outlined.

7.7.1 Relating Avalanche Risk Faced to Avalanche Knowledge

Generally as risk level in the zone used by the respondents increased, there was a corresponding increase in avalanche knowledge. This is an encouraging trend. The skiers themselves seem to select trails or areas which are best suited to their level of avalanche knowledge. For example, those with little or no avalanche knowledge generally used areas where there was no risk of avalanche and those with the highest levels of avalanche knowledge generally used the sustained avalanche risk areas. This differs from other hazards, such as earthquakes, floods and hurricanes where knowledge levels are only randomly associated with risk exposure, perhaps because of the large areas affected by these other hazards as compared to avalanches (Burton *et al.* 1978).

However, even when considering only the users of the sustained risk zones (those with the highest knowledge levels), over half of these people were not rated as having generally good knowledge on which to base their risk assessments. This is an area which definitely needs to be addressed by any programs which have the goal of reducing the number of avalanche accidents. This deficiency in avalanche knowledge has been identified by a number of authors, including Co[illegible]he (1977), Fesler (1981), Smutek (1981), More *et al.* (1984) and Williams and Armstrong

(1984). In the remainder of this summary, some of the characteristics of those with the best avalanche knowledge are identified. Knowing these characteristics will allow development of programs better suited to reduce this deficiency in knowledge.

7.7.2 Summarizing the Significant Relationships

To facilitate identification of the factors which were most characteristic of those with good avalanche knowledge, for each of the knowledge indicators mentioned in the previous chapter, factors which were significantly related will be outlined, along with a measure of the degree of the association, tau-b. As before, the avalanche knowlege indicators will will be discussed in 3 groups — avalanche hazard assessment, the decision to cancel or modify a trip and route selection. For each knowledge indicator, relationships will be discussed both for the aggregate data and when considering only users of the sustained risk zones, where decisions made with respect to avalanches have the greatest importance.

7.7.2.1 Avalanche Hazard Assessment

Relationships were found between avalanche hazard assessment knowledge and a number of the factors discussed in this chapter. These are listed below for the aggregate data in order of Kendall rank correlation coefficient, tau-b, with the tau-b values in parentheses:

- reading of material dealing with avalanches (0.33)
- carrying of avalanche rescue equipment (0.28)
- carrying of emergency equipment (0.26)
- obtaining avalanche information (0.26)
- previous avalanche involvement (0.24)
- taking of avalanche safety courses (0.22)
- being well equipped (0.21)
- overnight backcountry use (0.18)
- experience (0.18)

- previous trail use (0.13).

As can be seen from the tau-b values, all of these relationships are as one would expect, that is, as the factor increased, avalanche hazard assessment knowledge increased. When considering only the users of the sustained risk zones, relationships were found between hazard assessment knowledge and a lesser number of factors. Again, the factors are listed in order of tau-b:

- previous avalanche involvement (0.31)
- reading of avalanche material (0.29)
- taking of avalanche safety courses (0.21)
- being well equipped (0.20)
- obtaining avalanche information (0.18).

These tau-b values are crudely similar to those for the entire group of respondents.

7.7.2.2 Cancellation or Modification of Trips

A number of factors were found to be related to a history of cancelling or modifying a trip because of avalanche risk. When considering all respondents, the related factors were as follows, listed in order of tau-b value:

- reading of avalanche material (0.42)
- taking of avalanche safety courses (0.41)
- carrying of avalanche rescue equipment (0.41)
- carrying of emergency equipment (0.40)
- experience (0.37)
- overnight backcountry use (0.36)
- previous avalanche involvement (0.35)
- previous trail use (0.35)
- obtaining avalanche information (0.35)
- being well equipped (0.32)
- being the party leader (0.12).

When considering only users of the sustained risk zones, relationships were found between cancelling or modifying a trip and the following factors:

- taking of avalanche safety courses (0.37)
- previous trail use (0.31)
- reading of avalanche material (0.30)
- previous avalanche involvement (0.30)
- carrying of emergency equipment (0.20)
- carrying of avalanche rescue equipment (0.20)
- being well equipped (0.19).

The respondents reported taking a number of alternative actions when they cancelled or modified a trip. Of these actions, only modifying the intended route was significantly related to any of the factors. For all respondents, these factors are:

- previous avalanche involvment (0.21)
- overnight backcountry use (0.18)
- being well equipped (0.16).

Among those who used the sustained risk zones, the only significant relationship was with previous avalanche involvement (tau-b value of 0.26).

7.7.2.3 Route Selection

The last category of avalanche knowledge indicators considered in this thesis is route selection. Significant relationships were found between a number of factors and route selection knowledge rated by the reasons for the route selected on the test diagram from Appendix 1, knowledge of most likely avalanche locations and actions taken when avalanche risk was perceived.

Test diagram route selection knowledge was found to be related to many of the factors discussed in this chapter. When considering the respondents in aggregate, these factors are:

- reading of avalanche material (0.32)

- overnight backcountry use (0.29)
- carrying of emergency equipment (0.27)
- previous avalanche involvement (0.27)
- being well equipped (0.26)
- carrying of avalanche rescue equipment (0.26)
- obtaining avalanche information (0.25)
- taking of avalanche safety courses (0.24)
- experience (0.21)
- previous trail use (0.13).

A lesser number of factors were found to be significantly related to test diagram route knowledge when considering only users of sustained risk areas. These are:

- experience (0.31)
- being well equipped (0.27)
- previous avalanche involvement (0.26)
- reading of avalanche material (0.24)
- carrying of emergency equipment (0.21)
- carrying of avalanche rescue equipment (0.19)
- obtaining of avalanche information (0.19).

These tau-b values are roughly the same as those for the respondents in aggregate, except that experience seems to play a greater role in route choices when considering only persons using sustained risk areas.

There are 2 indicators of knowledge of most likely avalanche locations — claimed and actual. All of the factors mentioned in this chapter are related to claimed avalanche location knowledge when considering the respondents in aggregate. The tau-b values are as follows:

- previous trail use (0.42)
- obtaining of avalanche information (0.35)

- reading of avalanche material (0.33)
- carrying of avalanche rescue equipment (0.28)
- taking of avalanche safety courses (0.26)
- carrying of emergency equipment (0.26)
- experience (0.25)
- overnight backcountry use (0.22)
- being well equipped (0.18)
- being the party leader (0.16)
- previous avalanche involvement (0.13).

The tau-b values for actual knowledge (for the aggregate of respondents) are either near 0, or strongly negative in the case of overnight backcountry use, indicating substantial overconfidence in knowledge of locations where avalanches are most likely to occur for persons who are otherwise considered to be more knowledgeable than others with lesser factor scores.

This relationship reverses itself when considering [illegible] users of sustained risk areas. There are no significant relationships between the factors and claimed knowledge, but the following were found for actual knowledge:

- carrying of emergency equipment (0.26)
- reading of avalanche material (0.24)
- previous avalanche involvement (0.22)
- experience (0.22)
- being well equipped (0.21).

The overconfidence in knowledge of most likely avalanche locations was replaced by an actual increase in knowledge among users of the sustained risk zones.

Three of the actions taken when avalanche risk was perceived were significantly related to at least one of the skier characteristics. When considering the respondents in aggregate, 1 characteristic is related to each of the 3 actions. The tau-b value when relating modifying one's route to previous avalanche involvment is -0.18, indicating that those with previous avalanche experience were less likely to modify their route when avalanche danger was perceived. Previous avalanche involvement was also related to the action of crossing a slope where avalanche risk was suspected without making any adjustment (tau-b 0.21). Finally, those who took avalanche safety courses were less likely to cross a slope when avalanche risk was suspected after making some adjustment (tau-b -0.40).

When considering only users of the sustained risk zones, 2 factors are related to each of the actions. These are (with the action first and the factor second):

- modify plan when avalanche risk was perceived
  - being the party leader (0.32)
  - previous trail use (-0.28)
- cross a slope where avalanche risk was suspected without making an adjustment
  - previous trail use (0.31)
  - being the party leader (-0.24)
- cross a slope where avalanche risk was suspected only after making some adjustment
  - experience (-0.29)
  - taking of avalanche safety courses (-0.38).

7.7.2.4 Comparing the Relationships Found to the Literature

Nearly all of the relationships presented above between avalanche knowledge and the factors follow the trends that one would expect after reviewing the natural hazards literature. That is, as familiarity, experience and adjustments taken toward avalanche hazard increase, generally so does avalanche knowledge. The tau-b values were somewhat low, but the large number of relationships with most of the avalanche knowledge indicators provides confidence that the results obtained are not spurious. Similar findings have been reported in the natural hazards literature by writers such as Saarinen (1966, 1982b), Jackson and Mukerjee (1974), Mileti *et al.* (1975), McPherson and Saarinen (1977), Burton *et al.* (1978), Kunreuther (1978), and Kiecolt and Nigg (1982).

However, there were some notable exceptions to what one would expect to find after reading such literature, both for the respondents in aggregate and when considering only those respondents who used sustained risk zones.

First, when considering the respondents in aggregate, several exceptions to past findings in the natural hazards literature were identified. These exceptions include overconfidence in knowledge of most likely avalanche locations, not modifying one's route when avalanche danger was perceived, crossing slopes where avalanche risk was suspected without making any adjustment and not crossing a suspect slope after making some adjustment. Contrary to what one would expect from the natural hazards literature (e.g., Burton *et al.* (1978); Saarinen (1982b)), as familiarity, experience and adjustments taken toward avalanche hazard increase, the knowledge of most likely avalanche locations does not increase. Such overconfidence in knowledge has been reported in the risk literature by Slovic *et al.* (1982). This overconfidence may also be a reflection of risk tolerance by these more knowledgeable people who consider avalanches to be an avoidable, familiar, well understood, not dreaded and a remote event, as reported by Rescher (1983). Similar statements may be made about the other 3 anomalous relationships.

Second, 4 exceptions to what would be expected from the results found in the natural hazards literature were identified when considering only those who used sustained risk zones. Those with previous trail experience were less likely to modify their plans in the face of perceived avalanche danger and were more likely to cross a slope where avalanche risk was suspected without making any adjustment than those lacking previous experience on the trail. The most experienced people were least likely to cross a slope where avalanche risk was suspected after making an adjustment as were those who had taken avalanche safety courses.

Evidently there are some differences between people's characteristics relative to avalanches and natural hazards in general. As reported by Lev (1978) and Williams and

Armstrong (1984), it is not uncommon for people who are considered experienced, knowledgeable and cautious mountainers to be caught in avalanches, and some people view risk as essential to the enjoyment of the sport (Miles 1978; Schreyer *et al.* 1978; Ward 1980; Ongena 1982).

7.7.3 Factors Most Related to Good Avalanche Knowledge

From an examination of the relationships and the Kendall's tau-b values (the correlation coefficient) which were presented above, one can identify the factors that were most characteristic of those with good avalanche knowledge. To simplify the factor identification, only the tau-b values from the 3 major knowledge indicators were considered. These are assessments of avalanche hazard, a history of cancelling or modifying a trip because of avalanche hazard and route selection knowledge as determined from the reasons given for the route selection on the test diagram from Appendix 1. The factors identified as the best indicators of avalanche knowledge are:

- reading of material dealing with avalanches
- previous avalanche involvement (either personal or acquaintance)
- taking of avalanche safety courses
- being well equipped
- obtaining avalanche information.

Those with the higher ratings in these factors would generally have the best avalanche knowledge, and would generally be best able to make decisions which would minimize the number of avalanche accidents.

Education, in terms of reading avalanche material and taking avalanche courses, appears to be the most important predictor of avalanche knowledge. From educational material, one learns the need for being well equipped and the need to obtain as much information as possible about avalanche risk. There is also a close relationship between education and previous avalanche involvement. Those who have a history of previous avalanche involvement are more likely to have read avalanche material and taken avalanche safety courses than those without the experience (significance level less than 0.05). This study provides concrete evidence supporting the recent trend toward supplying information to and educating backcountry skiers (e.g., More *et al.* 1984; Valla 1984).

Experience, in terms of winter backcountry use, was conspicuously absent as a good predictor of avalanche knowledge, except in a few cases when considering only respondents who were utilizing sustained risk areas. This is not to say that experience is useless with respect to avalanche safety, but rather that if an experienced person is to have the ability to make good decisions with respect to avalanches, 1 or more of the 5 predictor factors mentioned above will likely be present as well. Evidently experience is useful only when supplemented by education and preparation for any potential problems.

8. Managing Avalanche Hazard

The primary goal of any management program dealing with avalanche hazard should be to reduce the number of avalanche accidents that occur or to eliminate them entirely. One obvious way to attain this goal is to prevent people from using areas where avalanches could take place through strict enforcement of legislation which denied access to such locations. However, this solution is not a reasonable one, both from the point of view of enforcement logistics and desires of backcountry skiers. Any management programs devised must allow generally free access to backcountry areas (Hendee *et al.* 1978; McAvoy and Dustin 1981), while attempting to meet the challenge of reducing the number of avalanche accidents.

Parks Canada is the management agency responsible for the area of Banff National Park, the location of this study. Several programs have been instituted by Parks Canada in an attempt to meet the goal of reducing the number of avalanche accidents in the park. The programs, particularly the backcountry avalanche hazard forecast, will be critically reviewed in this chapter. In the first section of the chapter, avalanche hazard will be compared to other hazards to demonstrate some of the differences required in programs dealing with avalanche hazard as compared to other hazards. Second, to give a better understanding of the Parks Canada avalanche hazard management programs, a history of their development will be supplied. Third, the survey results with respect to the present Parks Canada programs will be presented. Finally, based on the survey results with respect to the programs, material from the previous chapters and appropriate literature references, methods of improving Parks Canada's programs will be suggested.

8.1 Avalanches Compared to Other Natural Hazards

Like other natural hazards, avalanches involve interaction between the human use system and the geophysical event (White 1974b). However, there are some differences between avalanches and other natural hazards which affect the way in which they are managed. Ferber (1974) provides a schema which may be used to distinguish the important differences between avalanches and other hazards. In this schema, 2 divisions of hazards are identified — objective hazards and subjective hazards.

The objective hazards include all natural processes which exist or operate inevitably, whether or not man is involved. Darkness, storms, floods, earthquakes, hurricances, avalanches, whiteouts and all such impersonal factors fall into this category. Herein lies the similarity of avalanches with other hazards.

The difference lies in the subjective aspects of the hazards. These arise from human error. Accidents always have both objective and subjective causes—neither alone is sufficient (Ferber 1974). For example, a snow slope which is weakening through natural processes to avalanche tomorrow may be triggered today by a skier. For natural hazards in general, most people are ignorant of the character and extent of the hazard(s) for the area in which they reside and work on a permanent basis (Miles *et al.* 1975), while many think that the responsibility for hazard mitigation lies with the various levels of government, not the individual (McPherson and Saarinen 1977). The difference between avalanches and other natural hazards lies in the exposure to the hazard. One is seen as a mandatory, permanent exposure to obtain life essentials such as employment and residence, while the other is an optional, temporary exposure in search of recreation. The former is perceived as being much closer to an objective hazard or "act of God" over which an individual has no control (only governments have the resources to do so), whereas the exposure in the latter instance is totally controlled by the individual in his search for recreation. People can resent what they see as government intervention in their recreational activities (Hendee *et al.* 1978; McAvoy and Dustin 1981). Recreationists often seek some fulfillment in overcoming these subjective hazards (e.g. inexperience, poor judgement, poor route choice, poor physical conditions, and inappropriate equipment) using only their own resources (Meier 1978; Miles 1978; Ongena 1982). Hence, as mentioned previously, management programs must seek only to aid the recreationist, not direct him.

8.2 A History of the Parks Canada Programs

Parks Canada has implemented several programs intended to reduce the number of accidents incurred by winter backcountry users. The aim has been mainly to provide information and to provide assistance in cases of emergency. Foremost among the programs is the backcountry avalanche hazard forecast. Others include the search and rescue program, user discretionary safety permits and provision of advice by knowledgeable staff. The material for this section was derived from interviews and correspondence with the Parks Canada Public Safety Supervisor in the Lake Louise area (C. Israelson, personal communication, 1984).

The backcountry avalanche hazard forecast program was initiated during the winter of 1981—82. Prior to the initiation of this program, the warden service provided generalized avalanche hazard information on an informal basis. Information was only available on an "as requested" basis except for press releases during periods of extreme avalanche hazard and occasional radio interviews.

With increased backcountry use in the 1970's and early 1980's, these procedures proved inadequate. It became evident that in winter many more backcountry users were killed by avalanches than any other cause. A number of fatal accidents which occurred in and near Banff National Park in February of 1981 pointed out the need for a formal program.

During the summer of 1981, a well coordinated, high profile public awareness and information program was developed. Arrangements were made to develop a backcountry avalanche hazard forecast on a daily basis which would be distributed by telex to radio and television stations, newspapers, helicopter skiing operations, highway maintenance staff, the Canadian Ski Patrol System, and Parks Canada warden service and information outlets.

At present, warden service personnel who develop the avalanche hazard forecasts at the 3 alpine ski areas in Banff National Park confer each afternoon. Following these daily discussions, forecasters at the Lake Louise ski area generate a backcountry forecast and distribute the hazard information via telex to the locations described above. The Banff information centre, warden offices and recorder telephones are contacted by telephone to update the hazard message, so that all outlets receive the same message. Backcountry patrols are dispatched to collect snowpack information, observe avalanche activity and verify the hazard forecast.

No significant changes to the backcountry avalanche hazard forecast program are anticipated in the near future. There are indications that the program is well received by the public, as will be mentioned in succeeding portions of the chapter.

A number of warden service personnel have undertaken specialized training for backcountry search and rescue operations. They are prepared to search for lost persons and rescue those who have suffered injury. Trained dogs, helicopters and various other equipment are available for use in search and rescue operations. Unfortunately, victims of avalanches may die before being reached by the search and rescue personnel, because of the time delays involved in backcountry users contacting the warden service after the accident and subsequent transit time. However, victims have been rescued alive under favorable burial conditions when rescue crews received prompt notification.

Backcountry users may voluntarily obtain safety permits for their trip. Their anticipated route and timing along the route are indicated on the permit, which can facilitate search and rescue operations if the people do not return by the designated date and time.

Parks Canada personnel are available, particularly knowledgeable members of the warden service, to provide advice to backcountry travellers upon request. They may recommend safe and enjoyable areas, while providing detailed information on potentially hazardous areas.

Of the 4 programs discussed above which are intended to reduce the level of risk encountered by winter backcountry travellers, the backcountry avalanche hazard forecast, in conjunction with the provision of advice, is the most important. The ultimate aim is to prevent accidents before they happen, not react to them after they occur as in the safety permit and search and rescue programs. However, there is still a need for the latter 2 programs, to reduce losses when accidents do occur.

8.3 Respondent Knowledge, Opinions and Suggestions with Respect to Parks Canada Programs

In this study, the respondents' knowledge, opinions, and suggestions with respect to Parks Canada programs were tested, particularly with respect to the backcountry avalanche hazard forecast. First, respondents were asked which programs they were aware of that were intended to reduce risks to backcountry skiers, followed by a more detailed set of questions treating the avalanche hazard forecast. Finally, respondents were asked their advice on what Parks Canada could do in the future, besides the present avalanche hazard forecast program, to reduce the number of avalanche accidents.

8.3.1 Awareness of Parks Canada Programs

The respondents were posed the question of whether they were aware of any actions that Parks Canada takes to reduce the risks to backcountry skiers. Ninety-four percent of the respondents were aware of at least 1 action. All of the programs presently implemented by Parks Canada were mentioned by at least 1 person. Comments on the respondent's replies were provided by a member of the warden service in Lake Louise (G. Irwin, personal communication, 1985). The responses may be divided into 3 categories: those dealing in the safety, information and services.

8.3.1.1 Safety Programs

The safety category may be considered in 4 parts: responses dealing with avalanche control, those treating programs to increase the probability that people get in and out of the backcountry safely, those dealing with risk reduction on trails and those dealing with trail signs. First, over 30 percent of the respondents mentioned some form of avalanche control through the use of explosives. Parks Canada controls avalanches only at the 3 alpine ski areas and along highways, but there is no avalanche control in the backcountry, as suggested by over 26 percent of the respondents.

Second, the respondents mentioned 6 different actions they thought that Parks Canada takes to increase the probability that people get in and out of the backcountry safely. The proportion of respondents mentioning each action is listed in parentheses below:

- safety registration (15.1%)
- search and rescue (14.0%)
- trail patrols (6.0%)
- self registration facility at trail heads (0.5%)
- ensure that people take appropriate equipment (0.3%)
- nightly check of parking lots (0.3%).

Parks Canada does not take any of the latter 3 actions and patrols trails only on an intermittent basis.

Third, to reduce risk on trails, respondents stated that Parks Canada closes trails (4.4%), provides huts for shelter (1.4%), places campsites in low risk areas (0.3%) and routes trails in areas where there is low avalanche risk (1.6%). Parks Canada does not close trails, but it does provide some huts and place designated campsites in low risk areas. Only a small number of marked and advertised trails (such as the Pipestone trails) are routed in areas of low avalanche risk.

Finally, trail signs such as distance markers (7.9%) and avalanche hazard zone markers (10.7%) were mentioned by the respondents. The avalanche hazard zone marker signs along trails were tried in the past by Parks Canada and were discontinued. Trail distance markers are installed at some trail junctions solely for summer use, so any benefit to skiers is purely coincidental.

8.3.1.2 Information Programs

Parks Canada operates a number of programs intended to inform the backcountry skier. The respondents mentioned aspects of information dissemination, research and public education.

All of information dissemination actions mentioned do exist, with the exception of posting the avalanche hazard forecast at the trail head, and only small number of trails are graded with respect to difficulty. The information dissemination actions mentioned are as follows, with the proportion of the respondents mentioning each in parentheses:

- backcountry avalanche hazard forecast (27.9%)
- information from wardens (25.5%)
- information centre provides trail and risk information (14.5%)
- provide information to the media (4.1%)
- provide weather reports (3.0%)
- grade trails as to level of difficulty (1.6%)
- post the avalanche hazard at the trail head (1.4%)
- provide information at the park gate (1.1%)
- promote the use of marked trails and tell people the risks associated with not using marked trails (0.8%)
- warn people of the risks associated with wildlife (0.3%).

The fact that the wardens do research on avalanches and other risks was mentioned by 11.5 percent of the respondents.

Three forms of public education were mentioned by the respondents, with only the first one being commonly offered by Parks Canada. The three forms are:

- publications such books and pamphlets (8.8%)
- education of skiers— e.g. courses, seminars, interpretive programs (3.3%)
- public avalanche awareness presentations (0.3%).

8.3.1.3 Services Provided by Parks Canada

The respondents mentioned several services provided by Parks Canada to backcountry skiers. These are:

- packing and grooming of trails (6.3%)
- law enforcement (0.8%)
- surveying the public to find the best way to serve them (0.5%)
- highway plowing (0.3%)

- providing support to crosscountry ski patrols (0.3%).

Parks Canada does pack and groom some trails, provide law enforcement and plow the highways, but it provides only marginal support for cross country ski patrols and only occasionally surveys the public.

8.3.1.4 Program Awareness Summary

Speaking in general terms, most respondents were able to identify at least 1 action taken by Parks Canada to reduce the risks to backcountry skiers. Apparently respondent awareness of Parks Canada programs is not exceptionally good, though. Under 28 percent mentioned the backcountry avalanche hazard forecast, the program most directed toward avalanche safety. A somewhat larger proportion, 40 percent, were aware that Parks Canada provides information to skiers, but many people were cognizant only of a general information source, as opposed to a specific one for information about hazards. A lower proportion of the respondents were aware of the safety registration and rescue programs, in line with the lower profile of these programs. Finally, a large proportion of the respondents (over 36 percent) mentioned programs which do not exist, particularly avalanche control in the backcountry and avalanche signs on the trails. These mistaken impressions may relate to the extensive, readily visible, avalanche control programs at the 3 alpine ski resorts in Banff National Park, and the presence of avalanche warning signs along the highways and at the alpine ski areas.

8.3.2 Parks Canada's Backcountry Avalanche Hazard Forecast

The backcountry avalanche hazard forecast is one of the major services with the goal of increasing the safety of backcountry skiers provided by Parks Canada. Since it has one of the highest program profiles and is a readily identifiable entity, it was chosen as the specific program for which to test respondent awareness and opinions and to obtain suggestions for improvement.

A number of questions about the avalanche hazard forecast were posed to the respondents. First, the interviewees were asked if they were aware of the forecast and if they knew where to get it. Next, a question was posed as to whether the forecast was usually obtained. To check this response, respondents were asked to provide the Parks Canada avalanche hazard rating for that day and the source of that rating. Finally, the respondents were asked whether they thought the Parks Canada avalanche hazard forecast was useful and how they thought that this program could be improved.

8.3.2.1 Awareness of the Avalanche Hazard Forecast

Over 71 percent of the respondents were aware of the Parks Canada avalanche hazard forecast and over 68 percent of them were familiar with at least 1 location where it could be obtained, although less than 28 percent mentioned the program without any specific prompting. As shown in Table 8.1, a greater proportion of the people using the sustained risk areas were aware of the forecast than those using lower risk areas. A similar situation exists with respect to knowledge of forecast dissemination locations. Over 86 percent of the people who have the greatest need for or can benefit most from the forecast (i.e. sustained risk zone users) know at least 1 location where it is available.

Table 8.1 Aware of Avalanche Hazard Forecast vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Not Aware of Forecast	42.6%	34.3%	10.9%	27.9%
Aware of Forecast	57.4	65.7	89.1	72.1
Total	115	105	138	358

Chi-square=34.4 Degrees of Freedom=2 Significance Level < 0.05

The most common sources of the avalanche hazard forecast cited by the respondents were, in order of the proportion of all respondents aware of that source, are:

- park wardens (49.3%)
-

- telephone recording (28.8%)
- Banff information centre (20.0%)
- radio (13.7%)
- alpine ski areas (9.0%).

Some differences were found with respect to knowledge of the information sources between users of different trail risk categories. Over 75 percent of the users of sustained risk areas were aware that the avalanche hazard forecast could be obtained from park wardens, as opposed to less than 35 percent of the users of no risk areas. A similar relationship exists for users of the telephone recorded message, with figures of 42 and 14 percent respectively. There was no significant difference between users of the different risk categories with respect to awareness of availability at the information centre, but there were significant differences in the final 2 categories. A greater proportion of the users of the no risk areas (20 percent) mentioned availability of the forecast on the radio than users of sustained risk areas (7 percent). This difference may reflect a guess on the part of the users of no risk areas who expected that such information should be available on the radio. Actually, it is not commonly available on the radio. Finally, more users of the sustained risk areas (15 percent) were aware of the availability of the forecast from the avalanche research stations at the alpine ski areas than those who were using areas where there was no avalanche risk (5 percent).

8.3.2.2 Obtaining the Avalanche Hazard Forecast

When considering all of the respondents, only about 33 percent replied that they usually obtained the Parks Canada avalanche hazard forecast prior to going out on a trip. As may be seen from Table 8.2, there are significant differences between the different risk categories in terms of checking the forecast. Over half of the users of sustained risk areas stated that they usually obtained the forecast. Of interest is the row presenting replies from people who said they generally checked the forecast only if they considered the conditions to be hazardous. These replies lead one to consider the relationship between checking the forecast and the avalanche hazard rating for the day as provided by the respondent.

Table 8.2 Usually Check Avalanche Forecast vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Do Not Check	75.7%	65.7%	34.1%	56.7%
Do Check	13.0	26.7	53.6	32.7
Check Only If Hazardous	11.3	7.6	12.3	10.6
Total	115	105	138	358

Chi-square = 55.8 Degrees of Freedom = 4 Significance Level < 0.05

A significant relationship exists (significance level less than 0.05) between these 2 variables, with less than 40 percent of the people who rated the avalanche hazard as low obtaining the forecast and nearly 60 percent of those who supplied a high or extreme rating getting the forecast. This would seem to indicate a salience threshold level below which avalanches are not a risk worth the consideration or effort expenditure to reduce. As shown in a previous chapter, just under 40 percent of the people using sustained avalanche risk areas tend to underrate the avalanche hazard, and so are less likely to check the Parks Canada forecast which would correct their erroneous avalanche risk perception.

The avalanche hazard rating given by respondents who said that they had checked the Parks Canada avalanche hazard forecast on that day was compared against the actual Parks Canada forecast. Just over 60 percent of the respondents gave the same rating as Parks Canada, with only just under 10 percent giving a higher rating than Parks Canada. A full 30 percent of the respondents supplied a lower rating than Parks Canada. When considering level of risk by zone, there was only random variation in the responses above and below the Parks Canada rating in the no and intermittent risk categories, but skiers who use sustained risk areas were more likely to give a lower rating than Parks Canada as opposed to a higher rating with a probability of greater than 0.999 (using the binomial test suggested by Siegel (1956)). Thirty-six percent of the users of sustained risk areas who obtained the Parks Canada forecast underestimated the risk, while only 4 percent overestimated the risk. These discrepancies are of even greater interest, since the persons stated that they had obtained the Parks Canada forecast, and still understated the risk level.

For the people who did obtain the Parks Canada avalanche hazard forecast, the most common sources of the information were:

- park wardens (62.1%)
- telephone recording (15.2%)
- Banff information centre (9.1%).

Over 97 percent of the respondents thought that the Parks Canada avalanche hazard forecast was a useful service. Even if they did not personally use the service, they may have thought that other people using riskier areas or persons with less skill at making decisions with respect to avalanches would benefit from it.

8.3.2.3 Improving the Avalanche Hazard Forecast Program

The suggestions made by the respondents with respect to improving Parks Canada's avalanche information program may be divided into 5 major categories. These are as follows (with the proportion of the respondents making that category of suggestion in parentheses):

- improve forecast dissemination (28.2%)
- improve highway and trail signs (17.9%)
- improve forecast development (10.1%)
- improve skier education (4.5%)
- improve registration, regulation and protection (1.7%).

In the category of improving forecast dissemination, the most commonly mentioned suggestions were to improve publicity and make the program more well known, provide access to the forecast at hotels, make the information more accessible and visible, provide pamphlets (like the present bear pamphlets) at the park entrance, broadcast the avalanche hazard forecast with the alpine ski report, put the forecast on Calgary radio stations and provide more avalanche information in the newspapers.

The 2 suggestions most commonly made with regard to signs were to provide a sign similar to the present fire hazard sign (listing low, moderate, high and extreme with an appropriate indication of the current hazard rating) at the park entrance, exits from the townsites of Banff and Lake Louise and access points to the Banff-Jasper Highway; and provide the avalanche hazard forecast at trail heads.

To improve the avalanche hazard forecast development, skiers suggested making the information more specific for localized areas, doing more research on the avalanche hazard in more areas and eliminating the tendency (at least as it is perceived by the skiers) to exaggerate the risk. With respect to skier education, the most common suggestion was to provide programs to allow skiers to increase their knowledge base. Parks Canada presently relies on the private sector to fulfil this role (G. Irwin, personal communication, 1985).

In the last category, no suggestion was made more than once. The suggestions could be classified as those dealing with the safety registration system, trail patrols and mandatory usage of avalanche beacons.

To summarize the discussion on the respondent's suggestions to improve Parks Canada's backcountry avalanche information program, it appears that skiers would appreciate improved access to more detailed information than is presently readily available.

8.3.2.4 Backcountry Avalanche Hazard Forecast Summary

The backcountry avalanche hazard forecast is one of the major services with the goal of increasing the safety of backcountry skiers provided by Parks Canada. Overall, about 70 percent of the respondents were aware of the forecast and knew where to get it. A greater proportion (over 86 percent) of the sustained risk zone users knew where to get the forecast than users of the other risk zones. Sources from which the forecast were most commonly obtained include, in order of popularity: warden offices, the telephone recording and the the Banff information centre. Of all respondents, about one-third stated that they usually obtained the forecast (54 percent of sustained risk zone users). Respondents were more inclined to get the forecast if they personally considered the avalanche hazard to be high. Even after getting the Parks Canada forecast, about 30 percent of these people rated the avalanche hazard as lower than Parks Canada. This figure increased when considering only users of the sustained risk zones. Finally, over 97 percent of the respondents thought that the avalanche hazard forecast was useful, but most felt that there should be improved access to more detailed information than is presently available.

8.3.3 Possible Future Accident Likelihood Reduction Programs

The respondents were asked several questions in an attempt to determine how they thought Parks Canada could further reduce the likelihood of accident to backcountry skiers. The first question dealt with suggested ways to reduce general risks to backcountry skiers, other than specifically the avalanche information program. The other 2 questions dealt with broadcasting the avalanche hazard forecast on the Parks Canada radio station at the Canmore entrance to Banff National Park and closure of trails when the avalanche hazard is high.

8.3.3.1 Suggested Means to Reduce General Risks

Almost 85 percent of the respondents provided some suggestion as to what, besides the avalanche information program, Parks Canada could do or should do to reduce the general risks to backcountry skiers. The suggestions were categorized as listed below (with the proportion of the respondents mentioning an entry in each category in parentheses):

- nothing (30.2%)
- give more information of the general type (21.2%)
- improve trail signs, particularly junction and distance markers (9.5%)
- increase the number and scope of regulations treating backcountry use (7.8%)
- implement a number of safety precautions (6.7%)
- provide educational courses (6.4%)

- improve trail construction and maintenance (5.3%)
- use the media more often (5.3%)
- hut comments (5.0%).

As evidenced by the large proportion of the respondents who held that Parks Canada should do nothing else to reduce the risk to backcountry skiers, either the people feel that Parks Canada is doing enough already, the people feel that the risks are too low to be worth considering or the people are actively seeking risk.

As noted in the previous section, a substantial proportion of the skiers see Parks Canada as a major information source. Suggestions for improvement of the information program included providing more information about trails, providing lists of equipment requirements, providing general education, increasing people's awareness of potential dangers in the backcountry and encouraging backcountry users to be responsible for themselves.

A number of suggestions were made with respect to regulation of backcountry skiers. There was some mention of stricter registration procedures that emphasized equipment and knowledge requirements, along with trail closures during periods of high avalanche risk. However, those who held these opinions were out numbered by nearly a factor of 4 by those who felt that Parks Canada should do nothing.

The safety precaution most often mentioned was regular patrols of ski trails. Others included avalanche control, nightly check of parking lots and provision of telephones at trailheads.

All of the other categories are generally self explanatory, with the exception of hut comments. A number of skiers proposed having primitive warmup shelters along the more popular trails, while others advocated more huts, particularly in areas where can be a high risk of being caught in a storm or a need to stay overnight for some other reason (e.g. areas like the Wapta Icefield). In contrast, other people argued that present huts should be removed, since they act as a magnet attracting people with lower skill levels than should be using the area. Access routes to the huts may be avalanche prone or significant problems could arise if the hut is not reached by nightfall and appropriate camping equipment is not carried.

8.3.3.2 Broadcasting the Avalanche Hazard Forecast

The warden service in Banff National Park has proposed broadcasting the avalanche hazard forecast on the Parks Canada radio at the Canmore entrance to the park in the past, but so far permission has not been granted by Parks Canada upper management (C. Israelson, personal communication, 1984). This radio station, which has a range of about 5 km, is used to broadcast a continuously repeating recording of pertinent information about the park to people as they pass through the gate.

Assuming that the avalanche hazard forecast is to be broadcast on this radio station, people must listen to the station to receive the information. Only 28 percent of the respondents stated that they occasionally listened to this station, with over 40 percent never listening and over 31 percent who were not aware that the station existed. If the forecast was broadcast by the station, a greater proportion of the skiers must made aware of its availability for it to be effective. One method, as suggested by several respondents, would be to place a sign by the highway advertising that the forecast is available on this station.

The responses in favor of broadcasting the backcountry avalanche hazard forecast on this station nearly neached 90 percent of the total. The skiers also supplied information as to why the forecast should or should not be broadcast, according to their response.

The responses given by those who felt that the forecast should be broadcast were grouped into 5 categories. These categories are as follows (with the proportion of all respondents giving a reply which fits into each category in parentheses):

- reach more people than other methods of forecast dissemination and make more people aware of the risk (42.5%)
- ease of access to the information (26.0%)
- a good service for Parks Canada to provide (18.6%)

- suggestions of how best to implement placing the forecast on the station (3.0%)
- citing of benefits to Parks Canada (2.5%).

The last 2 categories require additional explanation. Implementation suggestions included having a highway sign advertising the fact that the forecast is available on the station, giving priority to the forecast with respect to other information on the broadcasts during weekend and holiday periods and emphasizing the forecast when avalanche conditions are particularly risky. Benefits to Parks Canada included a reduced need to bother the wardens, a low cost method of providing the information and ease of including the forecast in the repeating broadcast.

Responses that fit into 4 categories were supplied by those who felt that the forecast should not be broadcast. These categories are arguments that (proportion of total number of respondents making that argument in parentheses):

- the broadcast would not reach many people (5.2%)
- other sources are better (4.4%)
- skiers should make their own decision (0.8%)
- may cost too much (0.5%).

The category contents are obvious, perhaps with the exception of other sources being better. Other sources would include the warden offices, the Banff information centre, the telephone recording, a sign and commercial radio stations. It is of interest to note that significantly less of the persons using sustained risk areas than other areas (including only those arguing against the broadcast) thought that the broadcast would not reach many people, while significantly more of the sustained risk areas users thought that other sources were better (chi-square level of significance less than 0.05).

8.3.3.3 Trail Closures

One obvious method of reducing the risk of avalanche accident to backcountry skiers is to close the trails when the risk of avalanches is high. Over 60 percent of the respondents felt that this is a good method of protecting skiers, as shown in Table 8.3.

However, notice the significant difference between users of sustained risk areas as opposed to the lower risk areas. Those most subject to the risk of avalanche were least in favor of trail closures. Also, those who had taken an avalanche safety course or read avalanche safety material were generally against closing trails. Hence, one may argue that only those who lack the skills to make their own decisions desire to have Parks Canada decide whether it is safe to use a trail.

Table 8.3 Should Parks Canada Close Trails vs. Risk Zone Used

	No Risk	Intermittent Risk	Sustained Risk	Total
Should Not Close	22.6%	22.1%	67.9%	39.9%
Should Close	77.4	77.9	32.1	60.1
Total	115	104	137	356

Chi-square = 72.8 Degrees of Freedom = 2 Significance Level < 0.05

The respondents provided reasons to support their answer of whether or not Parks Canada should close trails if the risk of avalanche is high. Those who were against closing trails gave reasons which were grouped into the following categories, with the proportion of the total number of respondents giving a reason in that category in parentheses:

- the decision with respect to using an area should be based on the knowledge of the individual who should make his own choice (22.7%)
- Parks Canada should help people make their own decisions, not make the decisions for them (14.5%)
- people resent impositions on their freedom and it would be difficult to accurately judge which trails to close when (8.8%)
- people would still use the trails in spite of the closure (4.9%).

Reasons given in support of trail closure were:

- to protect people (50.4%)

- benefits to Parks Canada such as a reduced requirement for avalanche rescues (8.2%).

Some of those in support of closing trails (7.7% of all respondents) also gave suggestions for trail closure policies, such as closing trails only if the risk is extremely high, closing only those specific trails where the risk is high and providing the closure reasons on the sign at the trailhead.

8.3.3.4 Possible Future Programs Summary

Three possible future means of reducing the likelihood of avalanche accidents were mentioned in this section.

First, general risk reduction suggestions included doing nothing (indicating that people were satisified with the present level of service or did not want to have any programs imposed upon them) and providing improved information services with regard to trails, equipment required, education or knowledge levels required, increasing danger awareness and encouraging people to be responsible for their own actions.

Second, the comments with regard to broadcasting the avalanche hazard forecast on the Parks Canada radio station at the Canmore park entrance may be summarized. Only 28 percent of the respondents listened to the station on an occasional basis. Over 90 percent of the respondents were in favor of the broadcast, citing reasons such as making more people aware of the risk, ease of access and being the type of service that Parks Canada should provide. Those against the broadcast felt that it would not reach many people and other sources would be better.

Third, several points were made about trail closures during periods of high avalanche risk. Overall, over 60 percent of the respondents favored closing the trails when required; but this proportion was found to be only about 32 percent of sustained risk zone users. Generally only those who lacked the skills to make their own decisions promoted closing trails. Those supplying reasons against trail closures wanted to make their own decisions, resented imposed decisions and saw Parks Canada's role as one of helping people to make decisions. Most respondents in favor of closing trails felt that people should be protected from their own decisions and that Parks Canada would have to do fewer rescues.

8.3.4 A Summary of Skier Opinion on Parks Canada's Programs

To summarize this section on skier opinion of Parks Canada's programs, the respondents had an overall favorable opinion of Parks Canada's programs. Respondents were generally aware that Parks Canada takes actions to reduce the likelihood of avalanche accidents to backcountry skiers, but often were not cognizant of specific programs. With respect to the backcountry avalanche hazard forecast, about 70 percent of the respondents were aware of it and knew where it could be obtained. The park warden offices were the most commonly mentioned places to get the forecast. Note that over 87 percent of the skiers were from Alberta or British Columbia, and thus were likely to be aware of the wardens and their role. Only about one third of the respondents said that they usually get the forecast and there is a tendency to obtain the forecast only if the respondent personally considers the avalanche risk to be high. Over 97 percent of the respondents stated that the avalanche hazard forecast was a useful service, and most suggested improvements dealt with improving access to a more detailed forecast.

Several suggestions may be made about potential future initiatives. In terms of reducing general risks to backcountry skiers, the respondents generally felt that no new steps should be taken with the exception of improving information services. There was general support for broadcasting the avalanche hazard forecast or the Parks Canada radio station, but some means of making people aware of this service would have to be devised. Over 60 percent of the respondents favored trail closures because of high avalanche risk, but the majority of the closure supporters tended to be users of no or intermittent risk areas who had low knowledge levels.

8.4 Some Methods to Improve Parks Canada's Programs

Based on the survey results with respect to the present Parks Canada programs, material from the previous chapters and appropriate literature references, methods of enhancing Parks Canada's programs may be suggested. This section will be arranged in 5 major portions. First, the problem to be resolved is reviewed briefly along with some of the reasons for its existence. Second, consideration will be given to what can be done about the problem. Third, weaknesses of the present programs dealing with the problem will be reviewed. Fourth, a solution to the problem using a structure suggested in the literature will be presented. Finally, specific details will be given about 2 of the proposed means of reducing avalanche accidents — trail head signs and a ski information centre.

8.4.1 The Problem Facing Parks Canada

Clearly the fundamental problem which Parks Canada faces (at least relative to the issues of this thesis) in Banff National Park is avalanche accidents. There are a number of reasons why this problem exists, both physical and human.

The 2 major physical reasons are climate and physiography. The generally cold winters with small amounts of snowfall (relative to other mountain ranges commonly used by backcountry skiers) result in a shallow snow pack which can be quite unstable for long periods of time (Daffern 1983). The rugged high mountain landscape (which attracts skiers in the first place) provides slopes of sufficient steepness for avalanches to occur in many of the locations commonly used by backcountry skiers.

There are 3 primary human reasons for avalanche accidents which have been illustrated in this thesis. First, skiers feel that avalanches only infrequently affect people, and any people that are affected will not be themselves. Second, there is much room for improvement in people's knowledge and ability to make decisions with respect to avalanches — even among users of sustained avalanche risk zones. Third, there is some evidence of avalanche risk tolerance or even what may appear to be risk seeking in this recreational activity.

8.4.2 What Can Be Done About the Avalanche Accident Problem

At first glance, it would seem that the avalanche accident problem may be resolved by dealing with either or both of the reasons for its existence. Here it will be demonstrated that the physical reasons for the problem cannot be resolved, while the human reasons for the problem may potentially be removed.

There are several brief reasons why the physical reasons for the problem cannot be resolved. First the physiography cannot be changed to make it safe because of the immensity of such a project (i.e. level the mountains) is beyond comprehension, and such a solution is totally at odds with the Parks Canada's mandate of preservation and would destroy the natural beauty sought by the park users (Sax 1980). The technology to change the climate does not exist, and the desirability of changing the climate is most questionable in any event. It is not practical to control avalanches in the backcountry (e.g. with explosives) because of the large areas involved, relatively light usage in any 1 specific area, cost, and the fact that artificial control could lead to a false sense of security. As an example, losses have ocurred because of artificial flood control leading to a false sense of security among residents and industries along rivers (Gardner 1982).

The human reasons for the avalanche accident problem may be addressed, however. Programs may be devised to make people aware that avalanches can affect people (i.e. themselves); to improve people's knowledge and decision making ability with respect to avalanche risk; and to make people aware of their levels of risk tolerance so that they can explicitly choose the level of risk that they face. Those designing solutions to the human problems must be cognizant of what people are seeking in this form of wilderness risk recreation; that is, comradeship, personal growth, self reliance, self knowledge and excitement (Leonard 1974; Hendee *et al.* 1978; Meier 1978; Miles 1978; Schreyer *et al.* 1978; Welton 1978; Ongena 1982). From evidence presented in this and preceeding chapters, one may conclude that the best solution is to educate the skiers (with books and safety courses), provide them with easily accessible, detailed information and let them make their own decisions.

8.4.3 Problems with the Present Parks Canada Programs

There are some problems with the present Parks Canada programs with respect to distributing detailed information and educating the skiers. If one knows where and who to ask, Parks Canada staff can provide a wealth of excellent information such as the avalanche hazard forecast, detailed data used to derive the forecast, detailed advice on almost any topic, pamphlets and other publications, snow and ski conditions for specific areas and the weather forecast. From the results of the survey, it is evident that many people are aware of these information sources, but comparatively few people make use of such information. Reasons why people often do not get the information that they should have to improve their knowledge base and subsequent decisions include:

- inconvenient access to the information
- all detailed information is not available from 1 central source
- lack of confidence in the knowledge level of the staff at the Banff information centre
- people who are not familiar with the park often do not know where information is available
- some people believe that Parks Canada staff exaggerate the risks.

One final problem with the Parks Canada programs is that they do not directly address the human reasons which may lead to avalanche accidents, particularly the lack of knowledge and ability to make safe decisions with respect to avalanches.

8.4.4 A Suggested Solution to the Problem

The primary goal here is to reduce the number of avalanche accidents. It has been shown that the best way to do this is to educate skiers. Skiers may be educated by providing them with information. Sood (1982) provides an outline which may be followed to communicate this information. Even though Sood's work was intended to apply to natural hazards in general, it may be tailored specifically for avalanche hazard:

Sood (1982) holds that there are several reasons why public information programs are justified. First, the public wants and is willing to accept additional information on natural hazards (supported by data from this study as well). Second, with the rapid information change that presently exists, such programs can keep people up to date. Third, these programs can correct faulty perceptions and increase public knowledge. Fourth, they can be accomplished on a low budget and finally, there are examples of such programs being successful in the past.

These public information programs should consist of 3 stages, according to Sood (1982). The goal of the first stage is to catch people's attention. In the second stage of the campaign, the goals should be to increase the saliency of avalanche hazard issues, enhance the audience's involvement in these issues and induce skiers to help in formulating feasible avalanche hazard mitigation strategies. Behaviour change of the skiers (to reduce the number of avalanche accidents) would be the goal of the third stage.

A more detailed discussion of the 3 major stages follows. Remember that even when the second stage has begun, the first stage is continued. This also applies to the first and second stages once the third stage has begun. In this way, additional people can be reached, while the repetition provides reinforcement and the confirmation sought by the earlier adopters.

The 3 stages could be based on 4 interrelated means of getting information to the public. These are:

- use of the news media to make people aware of the avalanche problem and some of the means to combat it
- involvement of the skiing public in devising means of reducing the number of avalanche accidents
- establishment of a ski information centre which is well advertised and has very convenient access
- trail head signs at commonly used trails to reach people who have not used the ski information centre.

8.4.4.1 Stage One

Within the first stage itself, there are several distinct phases. First, one must set the goals for the entire campaign. Next, information about the target groups must be obtained. Finally, the message must be prepared and delivered.

Goal setting is simply the process of determining the aims of the campaign. This is a simple description, but the process can involve a substantial amount of effort. The goal of reducing the number of avalanche accidents by educating (e.g. books and courses) the public has already been mentioned.

When designing the campaign, it must be kept in mind that most people find most information campaigns irrelevant (Dervin 1981), not surpassing their awareness threshold. This factor must be compensated for by tailoring the messages for the specific target audience(s). Precampaign audience analyses such as sample surveys are a must, as are pilot tests of alternative sources, appeals and styles with small samples of the intended audience (Atkin 1981). One cannot rely on the organizational leaders' grasp of public opinion, since it is seldom accurate (Milbrath 1980). All portions of this campaign must be directed toward backcountry skiers who were found to be highly educated and often highly dedicated to the sport.

Saarinen (1966) and Mileti *et al.* (1975) state that the best time to start an information campaign is immediately after the occurrence of a hazard event, such as an avalanche accident. At this point in time, the hazard has likely surpassed the population's awareness threshold. This relates to the work of Saarinen (1982b), who has found that the greater the perceived risk of a hazardous event in the near future, the greater the likelihood of mitigation adoption. Sood (1982) relates another aspect of timing. Campaigns should be arranged to coincide their peak with the beginning of the danger season for hazards that are cyclical in time such as avalanches and continue at a lower level throughout the risk season.

Sood (1982) recommends the use of televison and other visual media in the first stage. They are capable of transmitting large quantities of data and television has been found to be the most credible news medium. The ski information centre could be advertised on such media. One must select message sources perceived as credible by the audience (such as the person in charge of avalanche safety programs or the head of the ski information centre), particularly dynamic spokesmen who attract attention to the message. The quality of the presentation (especially entertaining style) should be emphasized as well as the quantity (Atkin 1981). Finally, message repetition is powerful since people tend to think the problem is more serious if they hear about it often (Nigg 1982; Sood 1982). People can also be made aware of the avalanche problem through the use of the ski information centre and trail head signs. Skiers may be enticed into the ski information centre with the thought of enquiring about ski conditions or the weather forecast (if the centre is in a location where little effort is required to reach it, such as near the east Banff National Park entrance) and become aware of avalanches from information obtained there. Also posting of the avalanche hazard at trail heads (along with posting sources of additional information—e.g. the ski information centre) would increase awareness.

8.4.4.2 Stage Two

Once people are aware of the campaign, it is time to get them involved in the second stage. It is at this stage that an attempt is made to correct the deficiencies in knowledge and decision making skills noted earlier. The major factors in the second stage are interpersonal communication, printed material and community involvement.

Starting in the second stage, Sood (1982) holds that complete reliance on the mass media to disseminate information is likely to be ineffective. The use of interpersonal communication, especially at the ski information centre, in conjunction with mass media can substantially enhance the beneficial results. After some audience involvement in the issue has been generated, printed material is particularly effective (Sood 1982). Printed material, such as pamphlets which are already available, could be distributed at the ski information centre.

Tapping into existing organizational and interpersonal resources such as outdoor clubs in communities such as Calgary, Edmonton, Red Deer and Banff and having them form a volunteer, grassroots organization to help disseminate the main messages of the awareness campaign forms a major portion of the second part of the campaign (Sood 1982). Regulska (1982) (and a number of survey respondents) also recommends promoting awareness in schools. Rogers and Shoemaker (1971) and Rossi *et al.* (1982) hold that at least some effort should be concentrated on the elite section of the target group (e.g. outdoor store staff, outdoor club leaders). Other people may emulate the elite.

The advantages of volunteer involvement are that more people can be reached at a lower cost; the program is likely to be more persuasive if the public itself helps to develop and implement the campaign on a local basis; and the program can be self-perpetuating since the local people are working to protect their own interests (Regulska 1982). Volunteers could provide input to programs, build displays for the ski information centre, aid in erection of the trail head signs and patrol trails (perhaps in cooperation with the Canadian Ski Patrol Systems nordic division). This participation could lend more credence to the Parks Canada programs in the minds of the recreational skiers. A further advantage of this public involvement system has been identified by Kunreuther (1978). People who know someone who has made an adjustment are more likely to make similar adjustments. The major disadvantage of the public involvement program is that it is difficult to sustain enthusiasm in these projects related to relatively infrequent phenomena such as avalanche accidents, but people can be made to recognize that the threat of avalanches is never far away.

8.4.4.3 Stage Three

As stated earlier, the major goal of stage 3 is to change individual behaviour. Sood (1982) argues that this persuasion process involves not so much changing one's opinion, but rather changing one's perception of the issue or object in question. Perception change is accomplished through the use of scientific announcements. Studies have found that announcements based on scientific conclusions are considered to be the most credible and the most likely to be remembered (Nigg 1982). These scientific announcements may also be used to help people in the evaluation process. In other words, people should be given the steps which may be used in reaching a conclusion easily, along with the conclusion they will reach. This will offset the problems with evaluation noted earlier. Much of stage 3 would be acomplished at the ski information centre where interpretitive slide-sound shows, static displays and knowledgeable staff would make people aware of the benefits of avalanche education, and where it could be obtained.

8.4.5 Specific Details on Trail Head Signs and the Ski Information Centre

Some specific details about the 2 most significant aspects of the public information program are presented here. The ski information centre will be considered first, followed by the trail head signs.

The proposed ski information centre would be located near the east entrance of Banff National Park. Most skiers enter Banff National Park through this entrance. This location was suggested by the overwhelming response in favor of broadcasting the avalanche hazard forecast on the radio station that presently exists at the gate. Many of the respondents stated that they would use such information sources if they were readily available. From the results of the survey, it would seem best to staff this centre with people who are intimately familiar with the backcountry and potential hazards. The respondents definitely favored obtaining information from members of the warden service, so perhaps this could be an extension of the warden service safety programs. Staff and displays should be of high quality, since the highly educated skiers would quickly recognize information that was incomplete or of insufficient detail.

The following should be made available at this centre (all of them exist already, but this would bring them all together in 1 location):

- detailed avalanche hazard forecast and advice (make empirical data and evaluations available to the skiers so that they may better evaluate the risks that they are exposing themselves to (Gardner 1982))

- ski trail conditions and advice
- weather forecast
- pamphlets dealing with avalanches and other aspects of backcountry safety
- backcountry permits for overnight use, hut use and safety registration
- interpretive slide-sound shows and static displays that illustrate the importance of education to safe travel in the mountains
- listing of private firms that offer avalanche courses
- collection of avalanche safety books and other relevant reading material dealing with safety in the mountains offered for sale.

People would most likely be attracted to the centre by the first 5 points, but while at the centre there is a high probability of the interpretive material influencing people to become aware of avalanche risk and the need to learn more about avalanches. Volunteers from local outdoor clubs could aid in the development of this interpretive material to ensure that the information would be more relevant to the skiers. This centre should be open daily for longer periods of time than usual office hours, particularly on weekends to meet the needs of skiers enterin[g the] park late at night planning to begin skiing early the next day. To compensate for people entering the park other than at the east entrance, similar facilities could be located at entrances to adjacent national parks and information could be shared among them using some communication link such as telex or some other form of computer controlled arrangement.

The trail head signs would be placed at commonly used trails. Couche (1977) recommends the use of such signs, as did a number of the survey respondents. The signs would contain, at a minimum, the avalanche hazard forecast (which would have to be changed daily) and the location where additional information may be obtained — the ski information centre. The avalanche hazard forecast could be useful as a warning against trail use during periods of high avalanche risk to people who lack the requisite knowledge to make their own decision.

Skiers would also appreciate a topographic map illustrating the usual route taken by skiers using the trail and other pertinent information. Skiers certainly made use of such maps where they were available at the Pipestone and Redearth Creek trails. Volunteer help could also be used to aid in design and installation of these signs. These signs would provide information to people who do not use the ski information centre.

As a concluding note, the ski information centre and the trail head signs could easily be adapted for summer use as well, as information sources for hikers and climbers.

9. Conclusion and Recommendations

In concluding this thesis, it is appropriate to return to the 3 major objectives outlined in the introduction. The first objective was to determine the skiers' perceptions of the avalanche hazard, while the second was to determine the levels of avalanche knowledge possessed by the skiers and identify characteristics of the skiers related to avalanche knowledge or ability to make avalanche risk assessments. The last objective was to evaluate the effectiveness of present Parks Canada programs treating avalanche hazard and provide suggestions to improve the programs. From the discussions relating to these 3 objectives, it is evident that avalanches differ from other natural hazards in some important ways.

9.1 The First Objective

With respect to the first objective, several major conclusions may be made. First, avalanches are a salient major concern among skiers in the study area, especially among those using areas where avalanches were most likely to occur. Second, skiers tend to overrate the frequency of avalanches relative to expert opinion. Also, the skiers estimated the annual number of avalanche deaths to be slightly higher than the historical statistical frequencies. Finally, several aspects of skiers' perceptions of avalanches were discussed. Skiers tend to perceive that avalanches are a large phenomenon that only rarely pose a threat. Experience with the risk of avalanche can lead to a tendency to dismiss the risk. Direct experience with an avalanche accident generally leaves a skier with a negative feeling of the event, but a surprisingly large proportion retain positive feelings.

The skiers in the study area seem to be aware that avalanches can pose a recognizable risk, but they believe that avalanches are unlikely to pose a problem to themselves personally. Reasons for this seemingly illogical relationship have been presented by a number of authors. Kunreuther (1978) reports that people treat such events as having a probability of occurrence sufficiently low to permit them to ignore the consequences. Saarinen (1982b) holds that people generally do not have an accurate perception of risks associated with hazards, with a tendency to underestimate undramatic risks (judging from the avalanche descriptions supplied by the respondents, they consider avalanches to be undramatic snow slides). Festinger's (1957) theory of cognitive dissonance may explain why people tend to deémphasize the risk, since this reduces stress levels. Slovic *et al.* (1982) make a similar argument. Finally, the Council for Science and Society (1977) and Sood (1982) present evidence that many people believe that accidents can happen only to other people, never to themselves.

9.2 The Second Objective

To fulfil the second objective, several different indicators of avalanche knowledge were identified. These dealt with assessing avalanche hazard, the decision to cancel or modify a trip and route selection. On an overall basis, the avalanche knowledge level of the respondents was poor, but it did improve as avalanche risk faced on the day of the interview increased. This section concludes with a comparison of the knowledge results from this study to those found in the literature, and a review of the skier characteristics which were found to be most closely related to avalanche knowledge.

Several conclusions may be stated with respect to avalanche hazard assessment knowledge. It was found that there was some confusion about the Parks Canada avalanche hazard rating terminology. On riskier trails about one-third of the respondents rated the avalanche hazard lower than Parks Canada. It was shown that ability to assess avalanche hazard generally tended to improve as the avalanche risk in the area used increased (with the exception of users of no risk zones who often realized that the terrain was not steep enough for avalanches to occur and hence considered the snow to be always unlikely to slide — i.e. stable). However, over half of the users of sustained risk areas (where it is most important to be able to assess avalanche hazard) did not possess good knowledge of how to assess avalanche hazard.

It was relatively common for people to modify their plans when they perceived avalanche risk. The proportion of the respondents who had cancelled or modified a trip in the past after perceiving avalanche hazard increased substantially as avalanche risk in areas used increased. Also, as areal risk level increases, the level of confidence in one's ability to avoid avalanches increases.

Finally, only a small proportion of the respondents were found to have good knowledge on which to base route selection decisions and as avalanche risk increases, people become more overconfident in their knowledge of where avalanches are most likely to occur. Also, a significant minority of the respondents report making no adjustments in the face of a known avalanche risk.

Generally as risk level in the zone used by the respondents increased, there was a corresponding increase in avalanche knowledge. This is an encouraging trend. The skiers themselves seem to select trails or areas which are best suited to their level of avalanche knowledge. For example, those with little or no avalanche knowledge generally used areas where there was no risk of avalanche and those with the highest levels of avalanche knowledge generally used the sustained avalanche risk areas. This differs from other hazards, such as earthquakes, floods and hurricanes where knowledge levels are only randomly associated with risk exposure, perhaps because of the large areas affected by these other hazards as compared to avalanches (Burton *et al.* 1978).

However, even when considering only the users of the sustained risk zones (those with the highest knowledge levels), over half of these people were not rated as having generally good knowledge on which to base their risk assessments. This is an area which definitely needs to be addressed by any programs which have the goal of reducing the number of avalanche accidents. This deficiency in avalanche knowledge has been identified by a number of authors, including Couche (1977), Fesler (1981), Smutek (1981), More *et al.* (1984) and Williams and Armstrong (1984).

Nearly all of the relationships found between avalanche knowledge and the skier' characteristics follow the trends that one would expect after reviewing the natural hazards literature. That is, as familiarity, experience and adjustments taken toward avalanche hazard increase, generally so does avalanche knowledge. The tau-b values were somewhat low, but the large number of relationships with most of the avalanche knowledge indicators provides confidence that the results obtained are not spurious. Similar findings have been reported in the natural hazards literature by writers such as Saarinen (1966, 1982b), Jackson and Mukerjee (1974), Mileti *et al.* (1975), McPherson and Saarinen (1977), Burton *et al.* (1978), Kunreuther (1978), and Kiecolt and Nigg (1982).

However, there were some notable exceptions to what one would expect to find after reading such literature, both for the respondents in aggregate and when considering only those respondents who used sustained risk zones.

First, when considering the respondents in aggregate, several exceptions to past findings in the natural hazards literature were identified. These exceptions include overconfidence in knowledge of most likely avalanche locations, not modifying one's route when avalanche danger was perceived, crossing slopes where avalanche risk was suspected without making any adjustment and not crossing a suspect slope after making some adjustment. Contrary to what one would expect from the natural hazards literature (e.g., Burton *et al.* (1978); Saarinen (1982b)), as familiarity, experience and adjustments taken toward avalanche hazard increase, the knowledge of most likely avalanche locations does not increase. Such overconfidence in knowledge has been reported in the risk literature by Slovic *et al.* (1982). This overconfidence may also be a reflection of risk tolerance by these more knowledgeable people who consider avalanches to be an avoidable, familiar, well understood, not dreaded and a remote event, as reported by Rescher (1983). Similar statements may be made about the other 3 anomalous relationships.

Second, 4 exceptions to what would be expected from the results found in the natural hazards literature were identified when considering only those who used sustained risk zones. Those with previous trail experience were less likely to modify their plans in the face of perceived avalanche danger and were more likely to cross a slope where avalanche risk was suspected without making any adjustment than those lacking previous experience on the trail. The most experienced people were least likely to cross a slope where avalanche risk was suspected after making an adjustment as were those who had taken avalanche safety courses.

Evidently there are some differences between peoples' characteristics relative to avalanches and natural hazards in general. As reported by Lev (1978) and Williams and Armstrong (1984), it is not uncommon for people who are considered experienced, knowledgeable and cautious mountaineers to be caught in avalanches, and some people view risk as essential to the enjoyment of the sport (Miles 1978; Schreyer *et al.* 1978; Ward 1980; Ongena 1982).

After this brief review of avalanche knowledge levels and comparison of the results of this study to the literature, the discussion may now turn to an examination of some of the characteristics of the skiers to show which characteristics are most closely related to good avalanche knowledge. Five factors were identified which were strongly related to the indicators of avalanche knowledge. These were:

- reading of material dealing with avalanches
- previous avalanche involvement (either personal or acquaintance)
- taking of avalanche safety courses
- being well equipped
- obtaining avalanche information.

Those with the higher ratings in these characteristics would generally have the best avalanche knowledge and would generally be best able to make decisions which would minimize the number of avalanche accidents.

Education, in terms of reading avalanche material and taking avalanche courses, appears to be the most important predictor of avalanche knowledge. From educational material, one learns the need for being well equipped and the need to obtain as much information as possible about avalanche risk. There is also a close relationship between education and previous avalanche involvement. Those who have a history of previous avalanche involvement are more likely to have read avalanche material and taken avalanche safety courses than those without the experience (significance level less than 0.05). This study provides concrete evidence supporting the recent trend toward supplying information to and educating backcountry skiers (e.g. Daffern 1981, 1983; Gallagher 1981; Valla 1980, 1984; More *et al.* 1984).

9.3 The Third Objective

In meeting the third objective, the chapter which assesses the effectiveness of present Parks Canada programs treating avalanche hazard and makes suggestions for program improvement, particularly the portion presenting methods to enhance Parks Canada's programs, is actually a summary of all material presented in this thesis. The highlights of this chapter presented here include a summary of skier opinion of the Parks Canada programs, some of the primary reasons for avalanche accidents (which may be addressed by the programs suggested here), some of the problems with the present Parks Canada programs and a summary of the suggestions to improve the programs and reduce the number of avalanche accidents.

The respondents had an overall favorable opinion of Parks Canada's programs. They were generally aware that Parks Canada takes actions to reduce the subjective risks to backcountry skiers, but often were not cognizant of specific programs. With respect to the backcountry avalanche hazard forecast, about 70 percent of the respondents were aware of it and knew where it could be obtained. The park warden offices were the most commonly mentioned places to get the forecast. Note that over 87 percent of the skiers were from Alberta or British Columbia, and thus were likely to be aware of the wardens and their role. Only about one third of the respondents said that they usually get the forecast and there is a tendency to obtain the forecast only if the respondent personally considers the avalanche risk to be high. Over 97 percent of the skiers stated that the avalanche hazard forecast was a useful service, and most suggested improvements dealt with improving access to a more detailed forecast.

Several suggestions may be made about potential future initiatives. In terms of reducing general risks to backcountry skiers, the respondents generally felt that no new steps should be taken with the exception of improving information services. There was general support for broadcasting the avalanche hazard forecast or the Parks Canada radio station, but some means of making people aware of this service would have to be devised. Over 60 percent of the respondents favored trail closures because of high avalanche risk, but the majority of the closure supporters tended to be users of no or intermittent risk areas who had low knowledge levels.

There are 3 primary human reasons for avalanche accidents which have been illustrated in this thesis. First, skiers feel that avalanches only infrequently affect people, and any people that are affected will not be themselves. Second, there is much room for improvement in people's knowledge and ability to make decisions with respect to avalanches — even among users of sustained avalanche risk zones. Third, there is some evidence of avalanche risk tolerance or even what may appear to be risk seeking in this recreational activity.

There are some problems with the present Parks Canada programs with respect to distribution of detailed information and educating the skiers. If one knows where and who to ask, Parks Canada staff can provide a wealth of excellent information such as the avalanche hazard forecast, detailed data used to derive the forecast, detailed advice on almost any topic, pamphlets and other publications, snow and ski conditions for specific areas and the weather forecast. From the results of the survey, it is evident that many people are aware of these information sources, but comparatively few people make use of such information. Reasons why people often do not get the information that they should have to improve their decisions include:

- inconvenient access to the information
- all detailed information is not available from 1 central source
- lack of confidence in the knowledge level of the staff at the Banff information centre
- people who are not familiar with the park often do not know where information is available
- some people believe that Parks Canada staff will exaggerate risks.

One final problem with the Parks Canada programs is that they do not directly address the human reasons which may lead to avalanche accidents, particularly the lack of knowledge and ability to make safe decisions with respect to avalanches.

Some specific details about the 2 most significant aspects of the public information program suggested in this study with the intent of addressing the reasons for avalanche accidents and some of the problems with the present Parks Canada programs are presented here. The ski information centre will be considered first, followed by the trailhead signs.

The proposed ski information centre would be located near the east entrance of Banff National Park. Most skiers enter Banff National Park through this entrance. This location was suggested by the overwhelming response in favor of broadcasting the avalanche hazard forecast on the radio station that presently exists at the gate. This ski information centre should be advertised in the local media (e.g. television, radio and newspapers), to make more people aware of its existence. Many of the respondents stated that they would use such an information sources if they were aware of it. From the results of the survey, it would seem best to staff this centre with people who are intimately familiar with the backcountry and potential hazards. The respondents definitely favored obtaining information from members of the warden service, so perhaps this could be an extension of the warden service safety programs. Staff and displays should be of high quality, since the highly educated skiers would quickly recognize information that was incomplete or of insufficient detail.

The following should be made available at this centre (all of them exist already, but this would bring them all together in 1 location):

- detailed avalanche hazard forecast and advice (make empirical data and evaluations available to the skiers so that they may better evaluate the risks that they are exposing themselves to (Gardner 1982))
- ski trail conditions and advice
- weather forecast
- pamphlets dealing with avalanches and other aspects of backcountry safety
- backcountry permits for overnight use, hut use and safety registration

- interpretive slide-sound shows and static displays that illustrate the importance of education to safe travel in the mountains
- listing of private firms that offer avalanche courses
- collection of avalanche safety books and other relevant reading material dealing with safety in the mountains offered for sale.

People would most likely be attracted to the centre by the first 5 points, but while at the centre there is a high probability of the interpretive material influencing people to become aware of avalanche risk and the need to learn more about avalanches. Volunteers from local outdoor clubs could aid in the development of this interpretive material to ensure that information will be more relevant to the skiers. This centre should be open daily for longer periods of time than usual office hours, particularly on weekends to meet the needs of skiers entering the park late at night planning to begin skiing early the next day. To compensate for people entering the park other than at the east entrance, similar facilities could be located at entrances to adjacent national parks and information could be shared among them using some communication link such as telex or some other form of computer controlled arrangement.

The trail head signs would be placed at commonly used trails. Couche (1977) recommends the use of such signs, as did a number of the survey respondents. The signs would contain, at a minimum, the avalanche hazard forecast (which would have to be changed daily) and the location where additional information may be obtained — the ski information centre. The avalanche hazard forecast could be useful as a warning against trail use during periods of high avalanche risk to people who lack the requisite knowledge to make their own decision. Skiers would also appreciate a topographic map illustrating the usual route taken by skiers using the trail and other pertinent information. Skiers certainly made use of such maps where they were available at the Pipestone and Redearth Creek trails. Volunteer help could also be used to aid in design and installation of these signs. These signs would provide information to people who do not use the ski information centre.

9.4 Avalanches Compared to Other Natural Hazards

Finally, it has been shown that there are some important differences between avalanches and other natural hazards, particularly when considering avalanche hazard management. For natural hazards in general, most people are ignorant of the character and extent of the hazard(s) for the area in which they reside and work on a permanent basis (Mileti *et al.* 1975), while many think that the responsibility for hazard mitigation lies with the various levels of government, not the individual (McPherson and Saarinen 1977). In contrast, exposure to avalanches is on a temporary, recreational basis. It has been shown here that people tend to choose the level of avalanche risk to which they expose themselves in direct relation to their avalanche knowledge. Generally as avalanche risk faced increases, skiers make a greater effort to learn more about protecting themselves. People are self-motivated, since this is a voluntary, recreational activity from which they gain much pleasure. Management programs must take into account this evidence that people using avalanche prone areas, particularly the riskier areas, want to learn more about the hazard and will seek out information. Programs such as a ski information centre and trailhead signs are likely to attract their attention and voluntary participation.

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Appendix 1: Questionnaire Used in the Study

Skier Perception of Avalanche Hazard

Location ____________________________ Interviewer ____________________________
Date ____________________________ Time ____________________________

Hi, I am from the University of Alberta. With the approval of the local management agency, Parks Canada, we are conducting a survey of winter recreation use in this national park. The survey results will be used as a basis for suggested improvements to present winter recreation management programs. I would be grateful if you would be kind enough to voluntarily answer some questions. Your responses will remain anonymous.

A. *First, I would like to ask a few questions about your trip today.*

I. Where are you planning to go during your ski trip along this trail today? (Where did you go)?

II. Have you ever been on this trail before?
   1. No.
   2. Yes.
      a) How many times in winter?
      b) How many times in summer?

III. What type of skiing are you (were you) doing today? More than one type may apply to you. Are (were) you:
   1. Trail skiing.
   2. Off-trail skiing.
   3. "Cross country downhilling" or telemarking.
   4. Alpine touring.

IV. How many people are in your party?

V. Does your party have a recognized leader?
   1. No.
   2. Yes.
      a) Are you the leader?
         i) No.
         ii) Yes.

VI. Do you live in Alberta or British Columbia?
   1. No.
      a) What province or state do you live in? (Record country if not Canada or USA.)

   2. Yes.
      a) What is the name of your home city or town.

VII. At what city, town or other location did you stay last night?

VIII. At what city, town or other location are you staying tonight?

B. *The next group of questions deals with some of the difficulties skiers face in mountainous areas.*

I. Do you have any major concerns when skiing at this time of year?
   1. No.
   2. Yes.
      a) What are they?

      b) Which is the most important of your concerns? (Mark 1 beside it.)
      c) What would you say is your second greatest worry? (Mark 2 beside it.)

Avalanches have been identified as a possible risk in some areas of the mountains. I would like to ask some questions to get your ideas about them.

II. Could you give me a short description of an avalanche? (If person does not know, describe it as a mass of snow falling or sliding down a mountain and go to C).

III. How often do you think avalanches which could potentially affect people will occur here in the Rockies over the course of this winter?

IV. Would you be able to give an estimate of, on average, how many people are killed by avalanches in Banff National Park each year?
   1. No.
   2. Yes.

a) How many?

V. Have you or any of your acquaintances ever been involved in an avalanche accident?
1. No.
2. Yes.
a) Personally.
i) What year was that?
ii) Can you tell me what happened?

iii) How did you feel?

b) Acquaintance.
i) What year was that?

VI. Have you ever felt that you personally were in danger from an avalanche?
1. No.
2. Yes.
a) What year was that?
b) Where?
c) What did you do?

VII. Have you ever cancelled a trip or changed your plans because you thought the avalanche hazard was too high?
1. No.
2. Yes.
a) Was that before or after you left home?
i) Before.
What year was that?
What changes did you make in your plans?

ii) After.
What year was that?
What changes did you make in your plans?

VIII. Before taking or soon after the start of a ski trip, do you or a member of your party obtain any information or make observations regarding the risk of avalanches in the area?
1. No.
2. Yes.
a) What type of information do you obtain?

b) Where do you get it?

IX. Do you know where avalanches are most likely to occur on this trail?
  1. No.
  2. Yes.
    a) Where?

X. At what level would you rate the avalanche hazard on this trail today? Would you rate it as:
  1. Low.
  2. Moderate.
  3. High.
  4. Extreme.

XI. Why have you rated the avalanche hazard at this level?

C. *Now, I would like to ask you a few questions about the role of Parks Canada in winter recreation management.*

I. Are you aware of any actions that Parks Canada takes to reduce the risks to backcountry skiers?
  1. No.
  2. Yes.
    a) Which ones?

II. Parks Canada provides a backcountry avalanche hazard forecast on a daily basis.
  1. Have you heard of it?
    a) No. (Go to question C.II.6)

b) Yes.

2. Do you know where to get it?
   a) No.
   b) Yes.
      i) Parks Canada Warden.
      ii) Parks Canada information outlet.
      iii) Downhill ski area.
      iv) Radio.
      v) Friends.
      vi) Weather station
      vii) Telephone recording.
      viii) Newspaper.
      ix) Television.
      x) Other (specify).

3. Do you or a member of your party usually check the avalanche hazard forecast before going out on a trip?
   a) No. (Go to question C.II.6.)
   b) Yes.
4. At what level does Parks Canada rate the avalanche hazard as today? (If respondent does not know, go to question C.II.6.)

5. How did you learn what today's rating is?
   a) Parks Canada Warden.
   b) Parks Canada information outlet.
   c) Downhill ski area.
   d) Radio.
   e) Friends.
   f) Weather station
   g) Telephone recording.
   h) Newspaper.
   i) Television.
   j) Other (specify).

6. Do you think that the Parks Canada rating is (would be) useful?
   a) No.
   b) Yes.
7. Do you think there are any ways that Parks Canada could improve their avalanche information program?
   a) No.
   b) Yes.
      i) How?

III. What other things, besides the avalanche information program, could Parks Canada do to reduce the general risks to backcountry skiers?

IV. Do you ever listen to the short range radio station located at the Canmore park entrance?
1. No.
2. No, never heard of it.
3. Yes.

V. Should the avalanche hazard forecast be broadcast on this radio station.
1. No.
   a) Why?
2. Yes.
   a) Why?

VI. Should Parks Canada close trails when the avalanche risk to backcountry travellers is high?
1. No.
   a) Why?
2. Yes.
   a) Why?

D. *Now, I would like to just ask a few questions about your recreational background.*

I. How many years have you been involved in winter recreation activities in mountainous areas?

II. How many days have you been in the backcountry within the mountains this winter? In

this survey, I define backcountry as areas at least 500 m from developed areas, such as Banff townsite and the downhill ski areas, or from plowed roads.
1. What is the average length of any such outing or trip in days?

III. About how days were you in the backcountry in mountainous areas last winter?
1. What was the average length, in days, of these trips?

IV. Have you taken courses or attended lectures that relate to avalanche safety.
1. No.
2. Yes. Would you happen to remember the sponsoring agency, the length of the course and the year that you took the course?

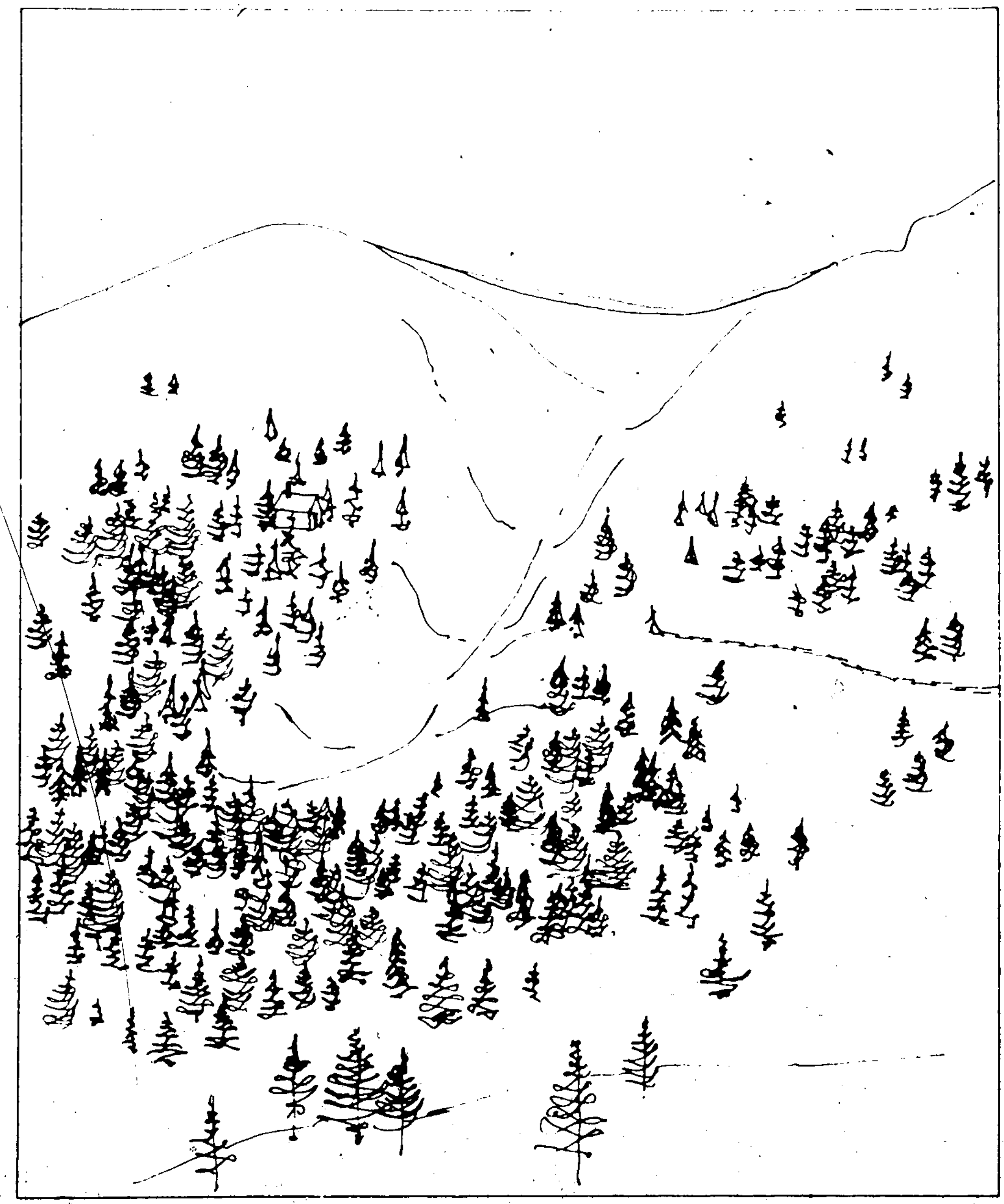
Sponsoring agency	Length of course	When (year)

V. Have you read any books or pamphlets on avalanche safety?
1. No.
2. Yes. Would you happen to remember the title, the author and the year that you read the book or pamphlet?

Title	Author	When (year)

VI. Given a situation such as the one on the diagram, could you please indicate the route you would take to the cabin if the avalanche hazard rating was moderate. (Indicate skier and cabin on diagram.) (Interviewer draw route on diagram.)
1. Why did you choose this route?

VII. If you were a member of a group of 4 skiers and 1 of the other group members was caught in an avalanche and totally buried, what would you do?



VIII. What safety equipment do you or your party usually carry in the backcountry. (Use observation to answer as many of these as possible, especially those marked with an •.)
1. None.
2. •Shovel.
3. Collapsible probe.
4. •Ski poles that may be joined to form a probe.
5. Avalanche cord.
6. Avalanche rescue beacon.
7. Crystal plate and magnifier.
8. Clinometer to measure slope angle.
9. •Amount and type of clothing (suitable for long stops?)
10. Repair kit.
11. First aid kit.
12. Other equipment. (Specify)

E. *That just about covers everything, except for a few facts about yourself. Could I ask some very general personal questions? If you do not like a question, just do not answer it.*

I. What is your occupation?
II. Could you please indicate the age group to which you belong? (Show respondent probe card.)
III. Which group best represents the highest level of education which you obtained? (Show respondent probe card.)
IV. Sex. (Observation)
1. Male.
2. Female.

Thank you for your time and cooperation. You have been very helpful.

Time taken for interview ____________________

F. *Interviewer Impression of User (To be completed after interview)*

I. Was respondent
1. very cooperative?
2. somewhat cooperative?
3. not cooperative?

II. Was respondent
1. well informed?
2. somewhat informed?

3. not informed?

III. Was respondent

1. very interested?
2. somewhat interested?
3. not interested?

IV. Was respondent

1. well prepared to deal with avalanche hazard?
2. somewhat prepared to deal with avalanche hazard?
3. not prepared to deal with avalanche hazard?

The probe cards contained the following:

Age

A. 15 years or less
B. 16 — 20 years
C. 21 — 25 years
D. 26 — 30 years
E. 31 — 35 years
F. 36 — 40 years
G. 41 — 45 years
H. 46 — 50 years
I. 51 — 55 years
J. 56 — 60 years
K. 61 — 65 years
L. Over 65 years

Education

A. Primary School (Grades 1 — 8)
B. High School (Grades 9 — 12 (13))
C. Technical School or Community College
D. Bachelor's Degree
E. Master's Degree
F. Doctorate Degree