INFLUENCES ON BACKCOUNTRY RECREATIONISTS'
RISK OF EXPOSURE
TO
SNOW AVALANCHE HAZARDS

By

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ABSTRACT

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Influences on Backcountry Recreationists' Risk of Exposure to Snow Avalanche Hazards

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Every year a large number of backcountry recreationists are caught in avalanches and statistics show the majority of avalanches that catch people are actually triggered by people. With the increasing popularity of winter recreational sports, it is safe to assume that backcountry recreationists will continue to travel into avalanche-prone terrain. To prevent further increases in avalanche accidents it is important to know if there are any factors that influence a recreationist's likelihood of being involved in an avalanche.

A web-based survey was used to investigate this problem, using a number of research hypotheses as the framework for the survey questions. Based on patterns found in background research of victim statistics and trends in avalanche education, these hypotheses focused on variables including age, gender, avalanche education, frequency in the backcountry, travel method, group dynamics, preparedness and extreme adventure goals.

Over 1400 people responded to this survey and represented a diverse group. Respondents were from all over the world, different age groups, different levels of avalanche training and used all different travel methods. Some 90% of the respondents were male but in other respects the survey appears to accurately reflect the diversity of backcountry recreationists. 448 of the respondents have witnessed or been involved in avalanche accidents, some more than once.

The analysis of the research hypotheses revealed that all variables were associated with avalanche involvement and some interesting patterns were discovered. Those participants that had the most avalanche training and were the most prepared were involved in more avalanches. This is very important as avalanche education and preparedness are intended to minimize risk. Those with intermediate levels of group dynamics and with extreme adventure goals were also involved in more avalanches.

Not all of the factors associated with involvement can be changed, but those that can, such as avalanche training, preparedness and group dynamics, can be influenced through avalanche education. Avalanche education remains the most important tool for mitigating avalanche accidents. Further research in this area can help to effectively hone avalanche education to help prevent accidents.

Table of Contents

Table of Figures

Table of Tables

Introduction

Every year an average of 152 backcountry recreationists are caught in avalanches and statistics show the majority of avalanches that catch people are actually triggered by people. The increasing popularity of winter recreational sports and improved technology, allowing people easier access to more remote locations, have led to a continual rise in avalanche fatalities over the past decade in most Rocky Mountain States (Atkins, 1998).

The victims of avalanches are a unique group because avalanches are unlike most other environmental hazards. They occur in predictable and often remote areas and are usually considered avoidable disasters. Three factors are necessary for an avalanche to occur: snow, a sufficient slope and instability within the snow pack.

To become a victim of an avalanche, a person must occupy an area where all three contributing factors are present. To access terrain of this type, most people travel using alternative methods of transportation such as skis, snowboards, snowshoes or snowmobiles, and it is normally a voluntary decision. People with the desire, the necessary equipment and the leisure time to access this terrain are the most common victims of avalanches.

There is extensive knowledge on where, when and how avalanches occur (Tremper, 2001). There are many avalanche education centers that host avalanche education seminars and classes, numerous books devoted to the awareness of these hazards and hundreds of internet sites with statistics and information regarding safe travel in the backcountry. Avalanches are very avoidable hazards. To better understand why avalanche deaths are increasing we must discover who is most at-risk from these hazards and why.

Risk is defined as the probability of an event or condition occurring (Mileti, 1999). These risks can be split into two groups, voluntary and involuntary (Smith, 2002). Involuntary risks are those in which the person has no reasonable control over the hazard, such as hurricanes or earthquakes. Voluntary risks are those in which people willingly place themselves in a situation where they may be exposed to a hazard. Risks incurred in backcountry recreation would be considered voluntary.

Voluntary risks are usually controlled by self-imposed modifications in behavior or externally-imposed controls such as changes in governmental regulations and legislation. Modifications in government could include legislation requiring training or a license in order for the person to expose themselves to a particular hazard. An example of this is the requirement to register an off-road vehicle before it is allowed on public lands. Behavioral modifications are more personal and often entail educating the person about the possible risks and how to avoid them. Because of the solitary and remote nature of backcountry recreation, it is unlikely that the government would impose legislation upon the recreational activity. This leaves behavioral modifications as the only method to control the risk inherent in backcountry recreation. In order to make proper modifications in behavior, one must first assess what factors are influencing the risk.

The risks that a backcountry recreationist encounters are the result of a number of decisions and actions. Of these factors, what governs the amount of risk each recreationist experiences? This study investigates this question by assessing travelers' levels of avalanche awareness, preparedness, recreation goals, travel methods, and decision-making processes and then comparing these factors to the travelers' level of avalanche hazard exposure. The research design involves web-based surveys. The survey web site was advertised through various means including on-line recreationist magazines, the Professional Ski Instructor's of America newsletter, web-based backcountry recreationist interest groups, local advertisements and word of mouth.

Background

The Nature of Avalanches

An avalanche is "a fall or slide of a large mass, as of snow or rock, down a mountainside" (American Heritage Dictionary, 1999). In this thesis, unless otherwise noted, the term refers to snow avalanches. Avalanches are a natural occurrence in steep, mountainous, snow-covered terrain. Snow, a sufficient slope, and instability within the snow pack are the three factors required for an avalanche to occur (Latimer, 2002).

There are different types of avalanches: loose snow avalanches and slab avalanches (Daffern, 1999). Both types of avalanches can occur in wet or dry snow. Loose snow avalanches occur in cohesionless snow. These avalanches start at one point and grow in size as they descend. They typically occur on steep slopes where gravity, due to the angle of the slope, exceeds the ability of the snow to cling together. These avalanches can be triggered by very insignificant actions. There is no definite fracture line where the avalanche started and it is not possible to identify the bed surface, or the surface on which the snow slides. Dry loose snow avalanches often occur as numerous small sluffs that can act to stabilize the snowpack. Recreationists in exposed areas can be knocked over and carried with these avalanches. Wet loose snow avalanches are often very heavy and destructive and can be very dangerous to recreationists.

In slab avalanches, a cohesive unit of snow slides on the layer beneath it (Tremper, 2001). These avalanches occur when a weak layer of snow underneath a cohesive layer fractures, allowing gravity to work on the cohesive layer, sending it sliding down the bed surface. These fractures occur when the stress on the snow pack becomes greater than the shear strength holding the layers together. The release of these avalanches can be very rapid and they often occur during or just after a storm (Daffern, 1999).

For the backcountry recreationist, slab avalanches are more hazardous than loose snow avalanches. They are usually composed of a large volume of snow that starts to move all at the same time. This action can often knock people off balance, making them more susceptible to being covered by the snow. Recreationists also easily trigger these avalanches, as it often just takes a small amount of stress on the snow pack. These factors make the dry slab avalanche the most common type to catch and kill backcountry recreationists (Tremper, 2001).

Knowledge of terrain, snow pack and weather are necessary to assess an area for avalanche risk. Avalanches typically occur on slopes ranging from 35 to 45 degrees (Tremper, 2001). Slopes less steep rarely develop conditions required for an avalanche, although they have been reported on 10-25 degree slopes. Slopes greater than 45 degrees usually do not hold snow long enough for the conditions to warrant a large slide; instead the snow slides continually, often enough to maintain stability in the remaining snowpack.

Weather plays a very important role in the creation of avalanches. Weather creates the snow pack, changes it and can add stress to it. Temperature, elevation, temperature inversions, wind, snow, humidity, radiation, and cloud cover all have significant effects on the formation and metamorphosis of the snow pack. Constant monitoring of weather and weather patterns is crucial to forecast avalanches (Tremper, 2001).

The snow pack is dynamic, which causes much of the complexity in predicting avalanches. Throughout the season the snow pack and the individual snow crystals are constantly changing under the influence of terrain and weather. Bonds form between these crystals and these bonds can be of different strengths. If weak or strong bonds cover large areas they can result in weak and strong layers within the snow pack. The weak layers increase the potential for a fracture that could result in an avalanche.

The prime conditions for avalanche occurrence are also prime conditions for most types of backcountry use. For many recreationists, the ideal slope for backcountry travel is also the slope where most avalanches are released. The fresh snow that makes for coveted backcountry runs also adds significant stress to the snow pack. Because of these issues, backcountry users must be aware of avalanche hazards and risks.

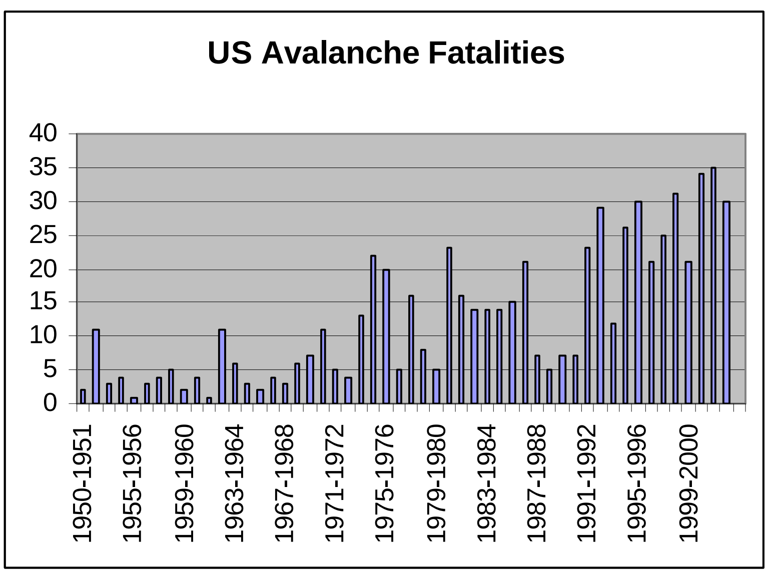
The Nature of Humans

Victim Statistics

Backcountry recreational activities have been gaining popularity and consequently backcountry use has been increasing tremendously. It is not possible to accurately estimate the population of backcountry recreationists. A study conducted by O'Gorman *et al.* (2003) attempted to estimate winter backcountry use, but found that reduced winter staff levels, the dispersed nature of the activity and the recent growth in popularity of the sport made it all but impossible to accurately estimate the population. They did find a pattern of increasing use that indicates that the use of the backcountry for recreational purposes is on the rise. Some of these indicators included the doubling of membership in the Alpine Club of Canada in the last decade and a steady and significant increase in the winter use of backcountry huts. Mountain Equipment Co-op also provided insight from retail sales showing that approximately 50% of their overall sales were winter products and sales of winter backcountry equipment have grown every year. O'Gorman *et al*. (2003) also stated that Peter Kray of *Couloir* Magazine estimates the backcountry market to be approximately 300,000 or 3% of the lift-served ski market in the U.S. He also estimates winter backcountry use at 5% of the lift-served skier population or 500,000 people.

While it is impossible to gauge the size of the population of backcountry recreationists, accurate counts are available on the number of backcountry recreationists that became victims of avalanches. A database of all avalanche fatalities in the United States is maintained by the Colorado Avalanche Information Center. The information comes from the old files of the U.S. Forest Service Westwide Data Network and the new Westwide Avalanche Network (Atkins, 1998). A summary graph of U.S. avalanche fatalities for 1950/1951 to 2002/2003 is shown in Figure 1.

Figure 1: U.S. Avalanche Fatalities



During the 1990's, there were significant increases in avalanche fatalities, a trend that has continued into the millennium (Williams, 2004b). The winter of 2001/2002 had 35 avalanche deaths, which is the greatest number of deaths in the "modern era" (post-1950). That winter was the fifth worst in 143 years of records. Now the average number of deaths per year due to avalanches is 30 (using a five year moving average). For the 1990's the yearly average was 152 people caught per year, 68 partly buried or buried, 15 injured and 22 killed. The yearly loss to property was estimated at $507, 500. Those numbers will surely increase for the decade of 2000-2010 if backcountry use continues to rise (Atkins, 1998).

The large database of information on avalanche accidents and fatalities provides ample information on user groups, accident scenarios and socio-demographic attributes of victims. However, this information regarding accidents did not include interviews or surveys of survivors. In the United States, from 1950 to 1998, 382 documented fatal avalanche accidents claimed 514 lives (Atkins, 1998). Of the fatalities, 89 percent (460) were men, and 11 percent (54) were women. The ages ranged from 6 to 66, but most fatalities were in the age group of 25-29. Most fatal accidents occurred during January and February. Colorado had the highest number of avalanche fatalities, with one-third of all U.S. avalanche deaths.

The statistics for avalanche fatalities based on user groups show that since 1950 the majority of fatalities occurred while the victims were pursuing some type of outdoor recreation. Since 1970 nine out of ten avalanche fatalities occurred while the victim was pursuing outdoor recreation activities (Tremper, 2001). Since 1980 less than one percent of avalanche fatalities have occurred within ski area boundaries on open runs or on open highways. Snowmobilers now lead the list of groups at risk, due to technological advancements in the snowmobiles that allow them to access steeper and more dangerous terrain (Atkins, 1998).

It is also important to note that these statistics may be not be completely accurate as undoubtedly not all avalanches are reported. There are likely many avalanche accidents in which no one is hurt and therefore go unreported.

Statistics show a correlation between experience level and avalanche fatalities. Atkins (1998) found that 75 percent of avalanche fatalities between 1950/51 and 1996/97 were knowledgeable seasoned backcountry recreationists. This is based on a limited sample (n = 180). A study in Canada of fatally-injured backcountry skiers concluded: ten out of every twelve fatalities were expert skiers (Tough and Butt, 1993).

Certain factors can greatly increase or reduce the chance of survival for an avalanche victim. Time is very important because the chance of survival drastically decreases as time passes (Atkins, 1998). In the first 15 minutes 86 percent of buried victims are found alive. Between 16 and 30 minutes there is a 50 percent chance of survival, and after 30 minutes the survival rate significantly diminishes.

Depth of burial also has a significant impact upon the survival rate of the buried victim. In the United States, between 1950 and 1998 there have been no survivors buried deeper than seven feet and the mean burial depth is five feet (Atkins, 1998).

The position of the victim’s head affects the survival rate. Twice as many victims buried face up survived as compared to those buried face down (Atkins, 1998). The belief is that as the snow melts from body heat, a head positioned face up will create an air pocket, whereas if the head is positioned face down an air pocket in front of the face cannot be created because the face sinks into the snow.

Because the time of burial is crucial, rescue techniques are very important (Atkins, 1998). 76 percent of victims buried with a body part protruding from the snow were rescued alive. Organized probe lines have found more victims than any other technique; however, 85 percent were recovered dead. An avalanche transceiver is the best method for quickly finding a completely buried victim, but there is no guarantee the person will be recovered alive. Avalanche rescue dogs are also capable of locating buried victims quickly, but because they are often brought to the scene long after the accident there are few live recoveries.

Victim statistics show that males between the ages of 25 and 29 are most often caught in avalanches (Atkins, 1998). It is important to understand why this user group is often the victim of avalanches. With this information, avalanche education can be honed to reduce occurrences for this demographic.

Not only are there patterns in victim statistics, but search and rescue can be placed in at-risk situations when trying to rescue those caught in avalanches (Smith, 1999). Often these rescue efforts will not continue if the accident scene is considered unsafe, but these judgment calls are not always accurate. These search and rescue workers can be hurt just attempting to reach the scene. Reducing avalanche accident occurrences will also reduce the amount of exposure to search and rescue workers.

Human Factors in Assessing and Responding to Risk

As backcountry fatalities continue to rise, significant research has been done to determine elements in common between avalanche accidents. Statistics show that the victim, or someone in the victim's party, triggers 92 percent of all fatal avalanche accidents (Atkins, 2001). These statistics point to the likelihood that many avalanche deaths are ultimately caused by human error. Many studies of victims of avalanches as well as human behavioral studies have tried to determine if this is the case, and if so, to ascertain the types of errors made and why.

Studies have been conducted to try to determine what behavioral traits are responsible for humans continually placing themselves in high-risk situations. The decision-making process behind risk-taking is very complicated. McClung (2002a) bases risk propensity, or the tendency to take risks, as a function of life experiences, not just experience with avalanches.

To determine potential risk, humans use many different mechanisms. To balance the need to make good decisions with the need to make the decisions quickly, humans often use rules of thumb, or heuristics (McCammon, 2002). In many situations these rules of thumb prove useful and reliable, but they can prove dangerous and often fatal in avalanche terrain (McCammon, 2002). Four common rules of thumb often bias the risk assessments of backcountry users: familiarity, social proof, commitment, and scarcity. Familiarity is the tendency for users to feel safer on familiar slopes. The social proof is associated with safety in numbers and the belief that if other people are using a slope then it must be safe. Commitment is the failure to notice avalanche hazards when the focus is placed on another goal, such as skiing a certain area or reaching a certain peak. Scarcity is based on the competitive nature of humans and the desire to ski certain areas if there is a feeling that the conditions are limited, such as wanting to make fresh tracks on a powder day (McCammon, 2002).

Group dynamics and communication breakdowns play significant roles in poor risk assessments. Often one or more people fail to communicate their feelings to the group; there may be incomplete communication or limited sharing of data; there may be a misunderstanding of the plan or the potential hazard; or there may be no communication at all (Fredston *et al.*, 1994).

Overconfidence of backcountry users and the belief that avalanches won't happen to them are factors which can lead to poor risk assessments. The more experienced and confident recreationists are, the more likely they are to perceive the risk to be less than it actually is (Atkins, 2001). Many recreationists are experts in their sports, but their level of avalanche experience is not comparable to their technical skills. This allows them to access dangerous avalanche terrain without being able to accurately assess the avalanche risk. It has been found that often these same types of people overestimate their avalanche skills (Fredston *et al.,* 1994). They can also become victim to negative-event feedback. Over time, runs on steep slopes that did not avalanche are remembered with positive emotions instead of being associated with avalanche danger. This positive reinforcement leads to the belief that slopes are safe when they may not be (Atkins, 2001).

These studies show the complicated nature of decision making in avalanche terrain and the tendency to depend on unreliable mechanisms for making these decisions. In many life situations experience is the best teacher and one might expect the same would hold true for traveling in avalanche terrain; however, statistics also show that large percentages of victims did have some level of formal avalanche training (McCammon, 2000).

Studies of backcountry users with different levels of avalanche training indicate avalanche training may not produce its intended result of increasing the safety of recreationists, and at times it may have negative effects. In a study of 546 avalanche accidents involving 1050 recreationists, avalanche training did not appear to decrease the level of hazard to which groups exposed themselves; groups with basic training often exposed themselves to higher levels of hazards than those with less training (McCammon, 2000). A study in Canada also shows that knowledge of the current avalanche hazard may not prevent users from taking risks (Tough and Butt, 1993). This study of backcountry ski fatalities between 1980 and 1991 found that 10 of the 12 fatalities had knowledge of the current high avalanche hazards, but still decided to travel in avalanche terrain. These studies show a need to look at avalanche education and training to determine why it may be producing negative affects.

Avalanche Education

There is a need to constantly assess and improve avalanche education, because many avalanche educators and other professionals believe it is a critical method of reducing the risk associated with backcountry travel in avalanche prone terrain (O'Gorman *et al*., 2003). In response to increasing fatalities, education efforts have also been increasing, but unfortunately the results were not always as effective as hoped (Chabot, 2002). One struggle of avalanche educators is to be able to reach and effectively teach many different types of recreationists, from human-powered skiers and snowboarders to powerful engine-driven snowmobiles. The techniques required for teaching these groups vary significantly.

Avalanche education in North America is not standardized and there are many different types of courses one can take depending on skill level, intended outcomes and time and financial commitment. Those courses geared to outdoor professionals do not focus on the same things as those geared to the casual recreationist. Even though courses are not all geared to the same level of recreationists, all backcountry recreationists should understand the basics of recognizing avalanche terrain, contributing weather conditions, and the fundamentals of transceiver use and rescue procedures (Waag, 2002).

Traditionally, avalanche courses have spent significant amounts of time on avalanche survival, rescue procedures and practicing transceiver searches. These concepts are important, but the courses should also focus on what the statistics show to be the main cause of avalanche-related deaths – human error. More time could be spent on route-finding with topographic maps, group dynamics issues, problem solving, decision-making and conflict resolution (Spring, 1999).

Current trends in avalanche education are to specialize courses to provide the maximize benefits to the students. (Chabot, 2002). Some avalanche centers are gearing different classes towards recreationists of different sports. For example, the Gallatin National Forest Avalanche Center has varied education programs created specifically for snowmobilers (Chabot, 2002). Although these trends are improving avalanche education, they may not be keeping up with the increasing population of backcountry recreationists.

The ultimate goal of avalanche courses should be to teach students how to assess avalanche risk and to avoid it. Focusing on human factors, such as group dynamics, decision-making and problem solving could play a large role in making these courses more successful.

Backcountry recreation is a constantly evolving sport as equipment and skills improve and recreationists' goals evolve. As the sports evolve, avalanche education also needs to evolve. Avalanche educators are constantly trying to refine and improve their classes and the more the educators know about their students the better they can cater to them. It has been shown that avalanche education works, as recreationists have demonstrated saving lives while in the backcountry using skills they learned in avalanche classes (Chabot, 2002). To continue to improve avalanche education efforts avalanche research must continue. This will help to ensure that as the sport changes so will the education efforts.

Avalanche Hazard Mapping

Another possible way to mitigate the risks of hazards is to map potential hazard areas. The goal is to prevent catastrophic damage to people, animals, settlements and transportation facilities. These maps show the size, frequency and spatial extent of the danger zone of potential avalanches. Switzerland has had avalanche hazard maps since 1878, compiled from topographic maps and observations but maps for other areas are less common (Gruber and Haefner, 1995). These maps have proven very effective in mitigating the damage to property and people from large-scale avalanche cycles (Gruber and Margreth, 2001). They have shown their usefulness in mapping large areas, such as mountain towns and land-use planning techniques. Avalanche mapping for smaller areas is more difficult because as area decreases it becomes harder to forecast where avalanches will occur (McClung, 2002b).

To obtain information on avalanche potential in backcountry areas remote sensing techniques such as satellite imagery and aerial photography may be useful. Mathematical models may also be applicable in these areas. However, there are problems with all these techniques when they are applied to mountainous terrain (Gruber and Haefner, 1995). For example, the nature of the terrain can cause geometric problems, such as differences in scale, horizontal displacements and shadows. There are also problems associated with the climatic aspects such as clouds, cloud shadows, haze, snow and ice cover, and the effects of atmospheric aerosol contents (Buchroithner, 1995). Some of the solutions to these problems can not be obtained by remote sensing (Buchroithner, 1995).

In many cases, remote sensing and mapping techniques are more effective to map where each avalanche has occurred as well as the size and frequency of the event. In large-scale situations such information can be used to map where potential avalanche hazard zones are. At fine scales, such as skiable slopes, mapping is much more difficult and remote sensing may not provide the answer for the complex nature of small, localized slab avalanches.

Mathematical models also have limitations. There are uncertainties that are inherent in avalanche mapping. Small variations in the input of the avalanche starting conditions (friction coefficients) can cause large variations in the model output in terms of either runout distance or impact pressure (Barbolini and Savi, 2001). There are also uncertainties in mapping different types of avalanches. In a study in Switzerland, the models performed well for dense snow avalanches but when powder avalanches occurred there was significant underestimation in the runouts of the avalanche paths (Gruber and Margreth, 2001). The occurrence of multiple avalanches in the same path creates variability that the mathematical models are not able to predict. For example, debris left by one avalanche can cause subsequent avalanches to be deflected (Gruber and Margreth, 2001). The estimation of the fracture depth is also subject to inaccuracies. It is based upon the amount of snowfall in one storm, but the occurrence of multiple storms in a short period can have significant effects on the fracture depth (Gruber and Margreth, 2001).

New projects and research have begun to use Geographical Information Systems (GIS) to map avalanches at smaller scales using historical weather and snow pack information. Doug Scott has started a new business, AvalancheMapping.org, that focuses on creating topographic maps of avalanche prone terrain and compiling snow pack information into a usable program (Berwyn, 2004). This information is useful to recreationists, professional guides and rescue workers.

Another study used GIS and meteorological information to map the avalanche probability of known avalanche slide paths (McCollister *et al*., 2002). This study used Geographic Visualization (GVis) and Knowledge Discovery in Databases (KDD) to find patterns in the large dataset of meteorological information and associate this with geographical patterns. This method gave the researchers the ability to plug in current weather information to determine the current avalanche probability in known slide paths.

These projects show that GIS has a place in mitigating avalanche hazards to backcountry recreationists, and the utility of GIS will only continue to improve. Avalanche hazard mapping is emerging as a new industry that will likely prove useful for backcountry recreationists. New avalanche maps are in production, and new technologies are being utilized to improve avalanche prediction capabilities. This information will help to determine where avalanches are likely to occur, but it is still necessary to understand why recreationists place themselves in these areas of high risk. Therefore the focus of this thesis is on what influences recreationists' risk of exposure to avalanche accidents.

Outcomes of Background Research

With regard to backcountry recreationists, avalanche research has focused on four main areas: the study of the snow science behind the avalanches; the study of why backcountry recreationists frequently place themselves in high-risk situations; the study and review of avalanche education methods; and the study of avalanche hazard mapping techniques. This study fits into the second category, because it attempts to understand and evaluate influences on backcountry recreationists' risk of exposure to avalanche hazards.

Other studies have been conducted on this area, but they were based on victim and accident statistics. Studies such as those by Atkins (1998) and Tough and Butt (1993) have attempted to understand what influences backcountry recreationists' risk of exposure to avalanches and were performed to assess the level of experience, the amount of risk the recreationists exposed themselves to and various factors in the decision making process. Other studies on the human issues in avalanche forecasting and decision-making in avalanche terrain such as those by McClung (2002a) and McCammon (2002) were also based on patterns in avalanche accidents. Although these studies were extremely important, they were all performed retrospectively. This study makes an important contribution because it uses a survey to assess the perceptions of recreationists before they are involved in an accident.

Methodology

The purpose of this research is to determine possible influences on backcountry recreationists' risk of exposure to avalanche hazards. The background literature suggests there are patterns in the victims and eight hypotheses have been based upon these patterns. These hypotheses are:

- **One**: male recreationists are most at risk.
- **Two:** recreationists aged of 25 to 29 are most at risk.
- **Three:** recreationists on snowmobiles are most at risk.
- **Four:** recreationists with basic levels of avalanche training are more at risk.
- **Five:** those who travel most frequently in the backcountry are most at risk.
- **Six:** unprepared recreationists are more at risk.
- **Seven:** recreationists that travel in groups with unclear decision-making processes are most at risk.
- **Eight:** recreationists with goals of more extreme adventure are most at risk.

These hypotheses served as a framework for questions posed in a web-based survey that targeted all backcountry recreationists.

Website

The survey was web-based and was hosted on a personal website, www.calaboose.com. This website went live in October, 2003 and survey data were collected until the beginning of March, 2004. The website was created using basic html code for the front end and java code and a java servlet for the back end. The back end functionality loaded the survey answers into a mySQL database.

The front end consisted of four pages. The main page briefly explained the study and hosted links to all the businesses and organizations that had helped with the study. The next page was a basic consent form containing all the necessary information about the UNIVERSITY OF MONTANA, the study and those conducting the study. The third page was the actual survey. This page was a basic form complete with radio buttons, check boxes and text boxes for additional information. The final page was a confirmation page that the survey was submitted successfully. The survey is shown in Appendix A.

I created the website using a basic text editor and HTML. The mySQL database is open-source free software that I downloaded and set up. The java code, java servlet and the linking of the front end HTML website, the servlet and the database were written with the aid of a professional java developer, Fenton Travers. However, I made all changes and updates myself.

Several small problems developed related to the use of a java servlet. If the participant typed an apostrophe (’) into a text box, it would cause an error message to be returned to the participant instead of the confirmation page. However, all the answers preceding the apostrophe would all be submitted into the database. Often the participant would take the survey again, resulting in duplicates within the database. I struggled to fix this problem, and made plans to migrate the back end functionality to a PHP setup. However, time did not allow for this change to take place. As a solution, I posted a note at the top of the survey page warning participants about this problem and manually removed all duplicate entries from the database.

Sample

In order to obtain the largest possible number of participants, I added an incentive to take the survey by awarding an avalanche transceiver to one randomly chosen participant. I also advertised as extensively as possible and tried to post advertisements where recreationists from all backgrounds would observe them. By using these wide-ranging advertising techniques I believe the bias in my sample was limited.

I used three main avenues for my advertising. I created small flyers, which were left at the Trailhead, Board of Missoula, Pipestone Mountaineering, The Sports Exchange, Missoula Bicycle Works, The University of Montana's Outdoor Program, the Polaris shop on West Broadway, and the Visitor's Center at Lolo Pass. Care was taken to leave the flyers at establishments that catered to both non-motorized and motorized backcountry recreationists.

The second avenue for my advertising was through the Professional Ski Instructors of America (PSIA). This organization has a quarterly newsletter that is sent out to all its members. These members include alpine, nordic and telemark skiers as well as snowboarders. PSIA is split into nine divisions. Each division had to be contacted individually and not all divisions were able to include an article about the research in their newsletters. The Alaska, Western and Northwestern divisions did put articles in their newsletters regarding the research.

The third avenue for my advertising used web-based methods. Many online businesses, magazines and organizations agreed to host links to my websites. These online businesses included the magazines *Backcountry* Magazine, *Couloir* Magazine, *Off-Piste* Magazine, *Powder* Magazine, *The Skier's Journal*, *Snowboarder* Magazine, *Telemark Skier* and *Transworld Snowboarding* Magazine. The online businesses and organizations included EverestNews.com, Telemark Tips, The Backcountry Skier's Alliance, and AvalancheMapping.org. Another web-based method was to post information about my study and a link on various discussion forums. Information was posted on the following forums: aksnow.org, forum.baart.us, forum.powdermag.com, snowmobilenews.com, telemarkskier.com, telemarktalk.com, ultimatesnowmobiler.com and snowest.com. In many cases it was posted on these forums on more than one occasion.

In addition to the targeted survey questions described below, participants were asked where they engage in backcountry recreation. This information can be used to assess the geographic range and diversity of the survey respondents. Finally, participants were asked how they found out about the survey. These results, discussed in the data analysis section, help to show which of the advertising methods were most effective and also may shed some light on the background the participants.

Surveys

The surveys were designed to test the nine hypotheses stated above. The style of the survey was created through various discussions with professors and other individuals active in backcountry sports. No published references were consulted.

To analyze Hypothesis One, the survey included a question of the participants' gender.

To analyze Hypothesis Two the participants were asked their age.

To analyze Hypothesis Three the participants were asked what method of transportation they use in the backcountry.

To analyze Hypothesis Four the participants were asked if they had any formal avalanche training and at what level they would rate their avalanche training level (formal or informal).

To analyze Hypothesis Five the participants were asked how often they travel in the backcountry.

To analyze Hypotheses Six, Seven and Eight, multiple questions were asked. These questions were then categorized and grouped, as discussed below.

To analyze Hypothesis Six, seven questions were asked. These questions included if the participants travel with rescue gear and what types, if they practice using their rescue gear, particularly, their transceiver, if they perform snow stability tests, what types of tests they perform and where they perform them and how they determine where they are going to travel in the backcountry.

To analyze Hypothesis Seven, three questions were asked. These questions included if the participant traveled in a group, how the group made decisions and how the group travels on a slope.

To analyze Hypothesis Eight, six questions were asked. These questions included how the participants use the equipment they travel on, their goals for backcountry travel, the type of terrain they are comfortable traveling on, if they have ever traveled on terrain that made them uncomfortable, why and how often they have traveled on terrain that made them uncomfortable.

Avalanche exposure was determined based on three questions: if participants have ever witnessed or been involved in an avalanche accident, how they were involved and if they have been involved more than once.

The survey allowed the participant a choice of the best-fitting answer. In the case where not all the possible answers could be accounted for the participant was given the option of writing in an answer. These written answers were coded to fit with the rest of the data.

Limitations

The sample may not support generalizations to the larger population of backcountry recreationists because it is not a representative sample. To determine the diversity of the sample the descriptive statistics are shown in the results section. These results show that the survey was taken by a diverse group of recreationists.

Data Preparation

To prepare the survey data for analysis, all duplicate entries were removed from the database, and obvious duplicates with different emails were also removed. The database was then exported to Excel for further data reorganization. The data were reorganized so each participant occupied one row of the spreadsheet, with the columns labeled for each question. This was the proper format to prepare the data for import into the statistical software program, SPSS.

Some questions allowed participants to specify their own answers instead of or in addition to choosing from a list. These answers were coded and added to the list of choices. This included answers from the participant's method of travel in the backcountry, the participants use of snowmobiles in the backcountry, the participants goals for travel, the reason the participant found themselves traveling on terrain that made them uncomfortable, how often the participant found themselves on terrain that made them uncomfortable, the participants avalanche training level, what types of rescue gear the participant brings with them, how often the participant practices with their transceiver, what type of snow stability tests the participant performs, how the participant determines where they are going to go, how the participant and their group make group decisions, how the group travels on a slope, and how often the participant goes out into the backcountry.

Some participants filled in one of the choices for their method of travel in the backcountry and then also added information to clarify. In this case, if the participant included other methods of travel their original choice was preserved and an additional field was added to indicate if they used more than one form of transportation in the backcountry. In the case that the participant clarified their original choice, the original choice was changed to reflect this; for example, in some cases “snowboard” was changed to “splitboard”.

Categorization

Once the data were coded, answers were grouped into categories for the questions related to hypotheses six, seven, eight and nine. The following section describes the categorization process for the applicable questions.

Hypothesis Five

In order to determine if recreationists who most frequently travel in the backcountry are most at risk, the answers to this question regarding how often they travel in the backcountry were categorized into “very often”, “often”, and “not very often” (Appendix B, Table 1).

Hypothesis Six

Each of the questions related to Hypothesis Six were evaluated individually and the participants' answers categorized into "not prepared", "somewhat prepared" and "very prepared".

The first question asked if the participant carries rescue gear. The participant was given a rating of "not prepared" if they answered no (Appendix B, Table 2). Those participants who answered yes would have their preparedness rated based upon the following questions.

Those participants who answered yes to bringing rescue gear were asked what types of gear they bring. To analyze those answers, each piece of rescue gear was given a value of one and a total score was determined for each participant by summing the total amount of gear. The scores were then divided into the three categories stated above by dividing them based on equal intervals. Because a shovel, probe and transceiver are considered by most to be the bare minimum a recreationist should carry (Williams, 2004a), those recreationists who only carried two pieces of gear were considered unprepared (Table 3 in Appendix B).

The next question designed to assess the preparedness of the participant was how often they practiced transceiver searches. The categories shown in Table 4 in Appendix B were determined by assessing the relative frequency of transceiver search practices and using equal intervals to split the categories.

If the participant does not perform snow stability tests while traveling in the backcountry they were categorized as "not prepared" (Appendix B, Table 5). For those participants who do perform snow stability tests, it is important to know how many tests they perform. Tests were not weighted based upon effectiveness because different tests have different levels of reliability depending on the conditions in which they are performed and how objectively the participant performs them (Tremper, 2001). It is also important to note that one test will not give an accurate overall snow stability evaluation— it is the integration of the information from many tests and observations that allows more confidence in the stability assessment. Descriptive statistics of what types of tests were performed will be shown. For this analysis, each test performed was given a value of one and a total score was determined by summing the number of tests the participants performed. Those participants that performed more tests were considered more prepared. These categories, which were determined based on equal intervals, are shown in Appendix B, Table 6.

Those participants that performed these snow stability tests on every slope aspect they travel on were considered "very prepared", those who performed them on most, but not all slope aspects were considered "somewhat prepared" and those that did not perform them on all slope aspects were considered "not prepared" (Appendix B, Table 7).

The participants were asked how they decided where they were going to travel in the backcountry. For these answers the participant was able to check more than one method and to volunteer their own answers. Those answers considered "not prepared" did not require the participant to have any prior knowledge of the area in which they are traveling. Those answers considered "somewhat prepared" gave some type of insight as to what the terrain or conditions might be like. Those answers considered "very prepared" were a combination of these methods that allows a backcountry recreationist to be adequately prepared. This included answers such as "all of the above" or a combination of more than one “somewhat” or “not prepared” answers. (Appendix B, Table 8).

The answers for all the questions relating to hypothesis seven were grouped into one final preparedness rating prior to the analysis. To determine this final rating, each answer was given a value. “Not prepared” answers were given a value of one, “somewhat prepared” were given a value of two and “very prepared” were given a value of three. The final preparedness rating was determined by summing these values. The same three categories were used; “not prepared”, “somewhat prepared” and “very prepared” and the divisions were based on equal-intervals. Those participants with a final score between one and five were given a final preparedness rating of “not prepared”. Those with a score between six and ten were given a final rating of “somewhat prepared” and those with a score of eleven or higher were given a final rating of “very prepared”. The highest possible score was fifteen.

Hypothesis Seven

Hypothesis Seven also was also addressed by a number of different questions as stated in the Survey section above. Each of these questions was evaluated individually and the participants’ answers categorized into “poor group dynamics”, “fair group dynamics” and “good group dynamics”.

The answers to the question regarding how the group makes decisions were categorized based on the following criteria: those answers considered “poor group dynamics” were selected because there was no stated group decision-making procedures in place. In these cases it may be hard for group members to voice their opinions and feelings regarding the situation they are in.

Those answers considered “fair group dynamics” were selected because there were some decision-making procedures in place, but not every member of the group has an equal say in the final decision. The “good group dynamics” category was chosen because every member of the group had an equal say in the final decision of the group (Appendix B, Table 9).

The participants were asked how they traveled on a slope while traveling in a group. Those answers considered “poor group dynamics” were selected because there were no stated group travel procedures in place. Those answers considered “fair group dynamics” were selected because there were some travel procedures in place, but they did not state that each member of the group was being watched by the others to ensure their safety. The “good group dynamics” category was chosen because each member skied down the slopes one at a time, which is the standard procedure for travel in the backcountry (Chabot, 2002) (Appendix B, Table 10).

The answers for all the questions relating to hypothesis seven were grouped into one final group dynamics rating prior to the analysis. To determine this final rating, “poor group dynamics” answers were given a value of one, “fair group dynamics” were given a value of two and “good group dynamics” were given a value of three. The final group dynamics rating was determined by summing these values. The same three categories were used; “poor group dynamics”, “fair group dynamics” and “good group dynamics” and the divisions were based on equal-intervals. Those participants with a final score between one and two were given a final group dynamics score of “poor group dynamics”. Those with a score of three or four were rated as “fair group dynamics” and those with a score of five or six were rated as "good group dynamics". The highest possible score was six.

Hypothesis Eight

For each of these questions related to Hypothesis Eight the participants' answers were categorized as "not extreme", "somewhat extreme" or "very extreme".

The participants were asked how they used their snowmobiles. Those answers considered "not extreme" were determined because the participant was not traveling on steep slopes. Those considered "somewhat extreme" were determined because there are no major goals or needs for extreme behavior. Those considered "very extreme" were determined because highmarking has been shown to be very dangerous and can trigger avalanches. The emergency/rescue/work category was also included in the "very extreme" category because of the potential for dangerous situations (Appendix B, Table 11).

Participants were asked what type of terrain they were most comfortable traveling on. This question assumes that the steeper the terrain, the more extreme the actions of the participant. Those answers considered "not extreme" were determined because avalanches rarely occur on shallow slopes. Those answers considered "somewhat extreme" were determined because although avalanches can occur on slopes ranging from 15 to 30 degrees, they are less likely than on slopes ranging from 35 to 45 degrees ("very extreme") (Appendix B, Table 12).

The participants were asked if they had ever traveled on terrain that made them uncomfortable, and these answers were similarly categorized. Participants that answered "no" were considered "not extreme" (Appendix B, Table 13).

Those participants that answered “yes” to traveling on terrain that made them uncomfortable were asked why they found themselves on this terrain. Those answers considered “not extreme” were determined because the participant stated they are always cautious of the terrain. Those considered “somewhat extreme” were determined because it was not the participant’s choice or desire to be on that terrain or in that situation. Those considered “very extreme” were determined because the participant knew there were possibilities the terrain was not safe but felt the goal was worth the risk (Appendix B, Table 14).

Participants were able to choose more than one answer for why they found themselves traveling on terrain that made them uncomfortable. For those that chose more than one answer, their answers were combined into one assessment. If participants’ answers included more than one category of extreme their final rating was assigned to the higher level.

Participants that had traveled on terrain that made them uncomfortable were asked how often this happened. These answers were categorized similarly. Those answers considered “not extreme” were those in which the participants rarely found themselves on terrain that made them uncomfortable. Those considered “somewhat extreme” were those in which the participants occasionally found themselves on terrain that made them uncomfortable and those considered “very extreme” were those answers in which the participant was often on terrain that made them uncomfortable (Appendix B, Table 15).

The participant was asked their goals for travel in the backcountry. Those answers considered “not extreme” were determined because motion was not an intrinsic part of those answers. Those considered “somewhat extreme” were determined because motion is involved in those answers but there are no major goals or needs for extreme behavior. Those considered “very extreme” were determined because there are stated goals or desires for the participant (Appendix B, Table 16). The guide/work category was also included in this category because of the responsibility that typically entails. This question allowed the participant to choose more than one answer to the question. The same methods stated previously for why the participants found themselves traveling on terrain that made them uncomfortable were used to combine these answers.

The answers for all the questions relating to Hypothesis Eight were grouped into one final extreme rating prior to the analysis. To determine this final rating “not extreme” answers were given a value of one, “somewhat extreme” were given a value of two and “very extreme” were given a value of three. The final extreme rating was determined by summing these values. The same three categories were used; “not extreme”, “somewhat extreme” and “very extreme” and the divisions were based on equal-intervals. Those participants with a final score between one and six were given a final extreme rating of “not extreme”. Those with a score between seven and twelve were given a final rating of “somewhat extreme” and those with a score of thirteen or higher were given a final rating of “very extreme”. The highest possible score was eighteen.

Avalanche Exposure

In order to determine what has influenced participant’s exposure to avalanche accidents it is important to know how much avalanche accident exposure each participant has had. A number of different questions were asked to determine the level of exposure each participant has had. The participants were asked if they had ever been involved in an avalanche accident, how many accidents they have been involved in and how they were involved in them. If the participant had witnessed an avalanche accident I considered them as being involved in an avalanche accident. If a participant had never been involved in an avalanche accident they were not given a rating for avalanche involvement. For those participants that were involved in avalanche accidents, if they had only witnessed an accident they were given a rating of "somewhat involved". Those participants that have been hit or caught by an avalanche, or if they had witnessed one as well as been caught by one were given a rating of "very involved" (Appendix B, Table 17).

Procedures

After the data was properly categorized it was analyzed using various statistical techniques. Descriptive statistics were performed to describe the results of each survey question. Frequencies of the answers were displayed with pie charts and bar graphs and in some cases contingency tables and x-y graphs.

After the descriptive statistics were performed the eight hypotheses were evaluated. For each hypothesis, the selected variables were subjected to contingency analysis, using two- sample chi-square tests based on whether or not the participant had been involved in an avalanche accident. This was done for all completed survey responses. The number of completed surveys varied depending on which variables were compared because not all questions needed to be answered in order to submit the survey.

A second contingency analysis was conducted for some of the hypotheses. In these cases a chi-square test was used to compare the selected variables to the participants' level of involvement in avalanche accidents.

For selected hypotheses, logistic regression analysis was used to determine which categories made statistically significant contributions to the overall pattern of results. The research hypotheses defined above were used to structure the logistic regressions in SPSS, where coefficients for alternate variable values are calculated with reference to one control value. Only those chi-square tests that were highly significant and had more than three categories were subjected to logistic regression analysis.

For certain variables, it was necessary to combine some categories in order to meet the distributional requirements of the chi-square and logistic regression tests. For Hypothesis Three, the category of "foot" was combined into "snowshoe", "nordic" was combined into telemark and "splitboard" was combined into "snowboard".

Results

Descriptive and Summary Statistics

1463 people participated in the survey. This total includes approximately 50 participants who did not complete the entire survey. In Figures 2 – 35 and Tables 1 – 23 the number of valid responses is shown.

To get a better understanding of the diversity of the sample, it is important to know where participants found out about the survey. Approximately 70 percent of the participants found out about the survey from various sites on the internet (Figure 2).

Participants found out about the survey on many different websites. The complete list of websites can be found in Appendix C, Table 1. Three websites were very effective in helping to advertise the survey: *Couloir* Magazine, TelemarkTips, and the Snowest discussion forum.

The survey participants included 138 females and 1325 males (Figure 3). The ages of the participants ranged from fifteen to sixty-five, with a mean age of 34.5 and a median age of 33. When divided into ranges, the largest proportion fell into the 25 – 29 age range (Figure 4).

Figure 2. Advertising effectiveness
(n = 1404, n = 728)

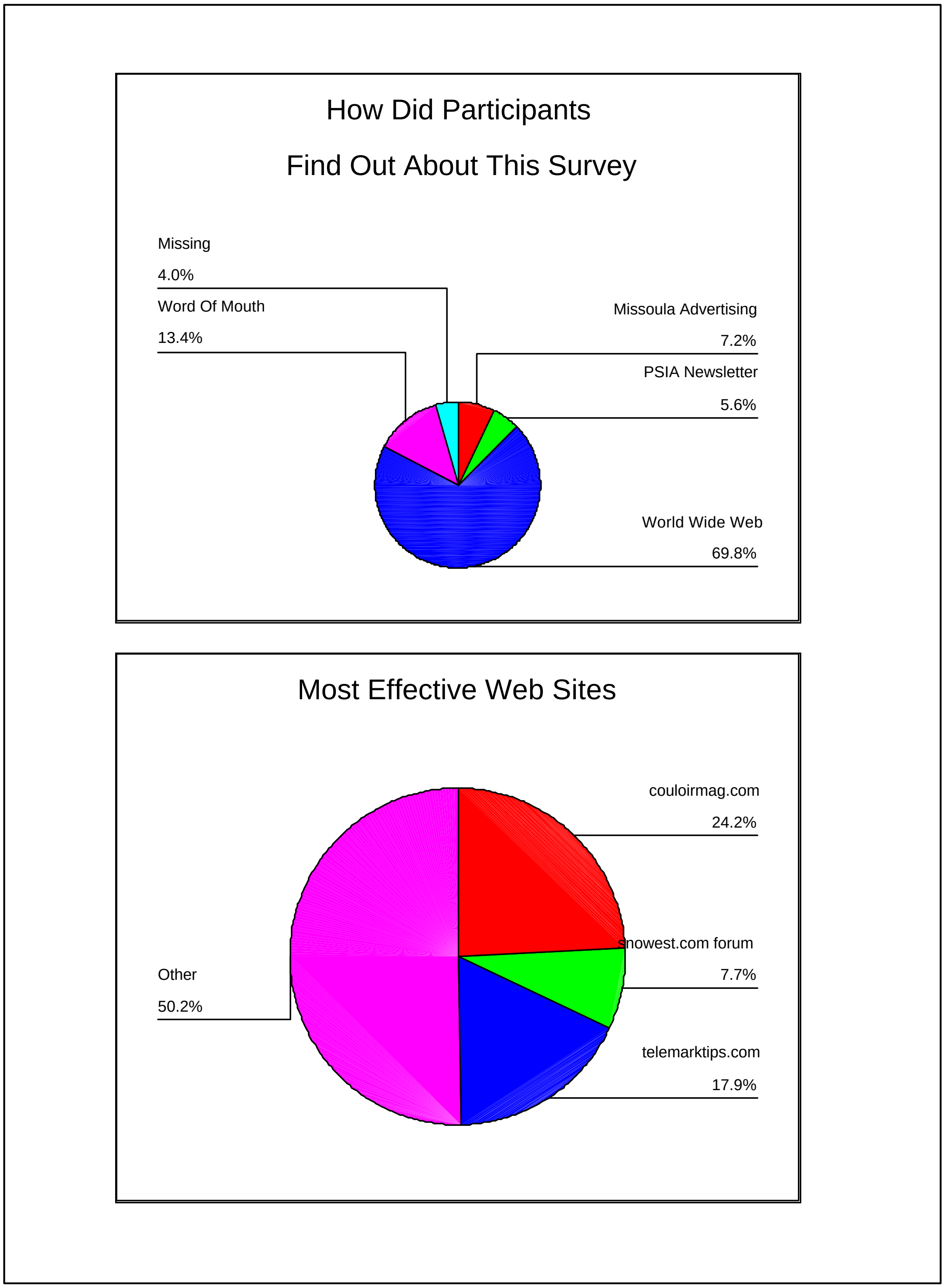


Figure 3. Participants' Gender
(n = 1463)

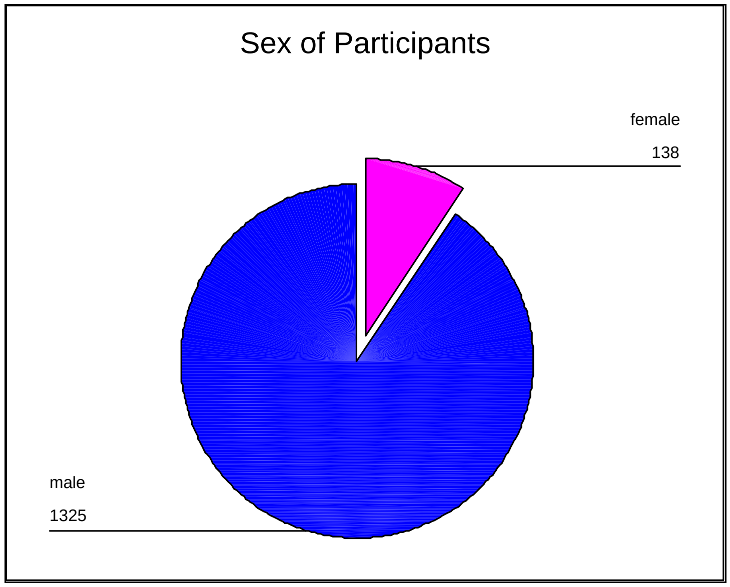
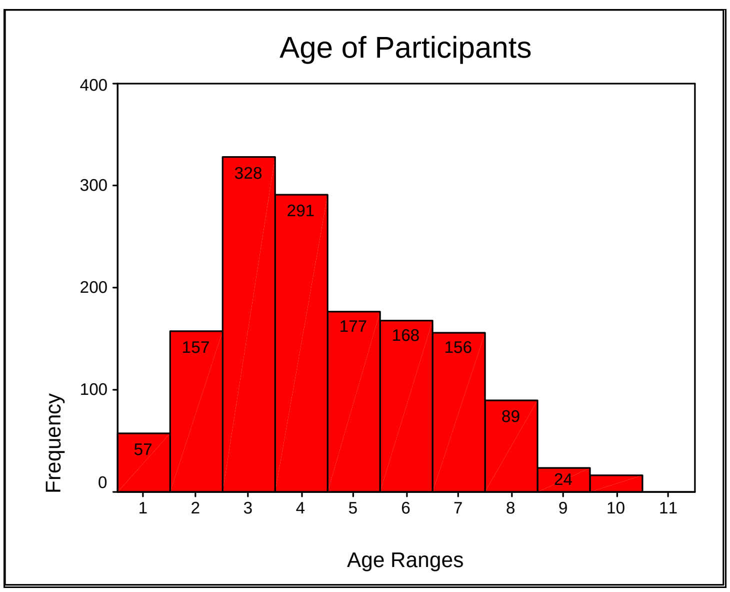


Figure 4. Age of Participants
(n = 1463)

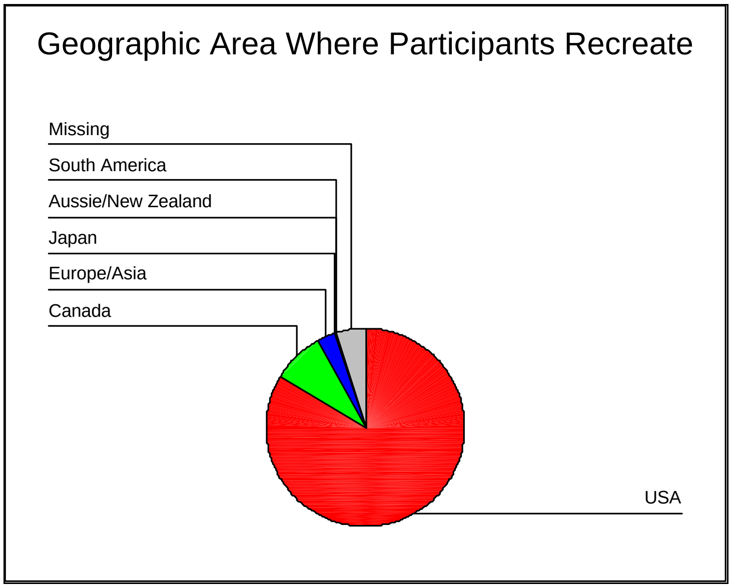


Range	Age
1	15 - 19
2	20 - 24
3	25 - 29
4	30 - 34
5	35 - 39
6	40 - 44
7	45 - 49
8	50 - 54
9	55 - 59
10	60 - 64
11	65 - 69

To determine the geographic distribution of the survey, participants were asked where they usually recreate (Figure 5). These results also help to show how far-reaching this survey was. The majority of the respondents were from North America, with 83% from the United States. Fifty respondents came from outside North America, primarily

Europe. The 1345 respondents from North America were from a large number of different states and provinces. The states with the most respondents were western states and provinces. A table of these countries, states and provinces and the number of participants from each can also be found in Appendix C.

Figure 5: Geographical Area Where Participants Usually Recreate
(n = 1395)



Country Where Participants Usually Recreate (Excluding USA & Canada)
(n = 50)

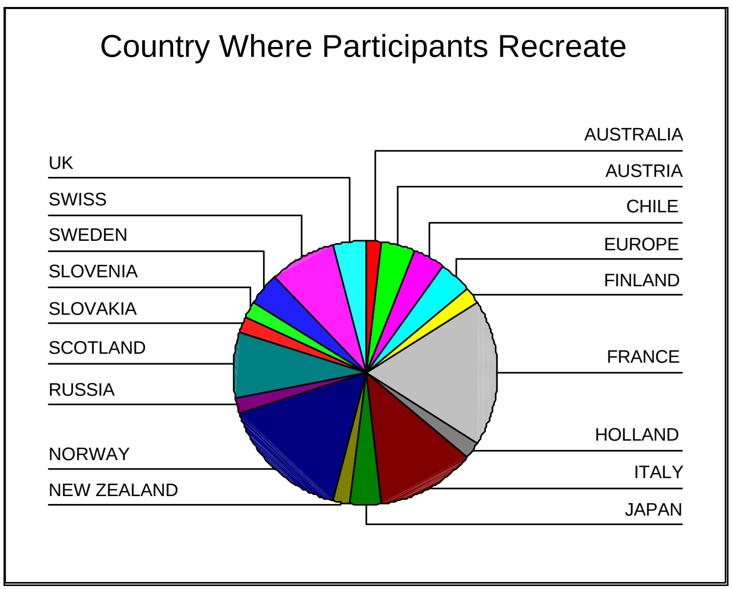
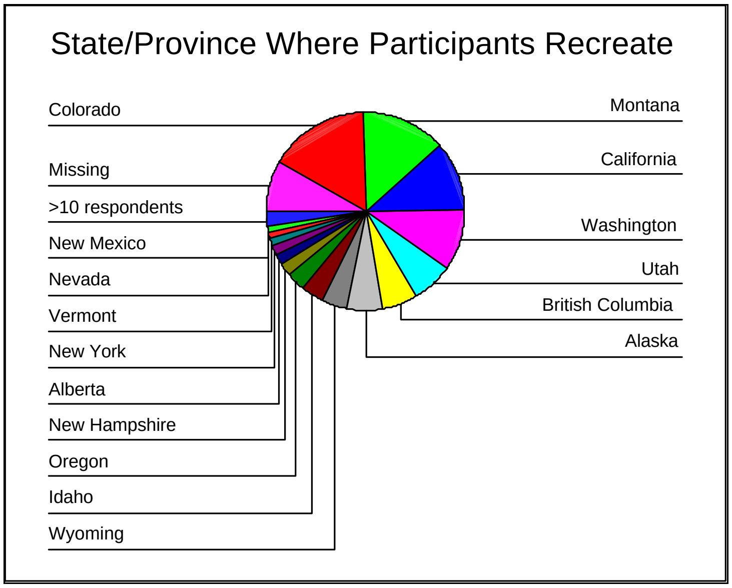


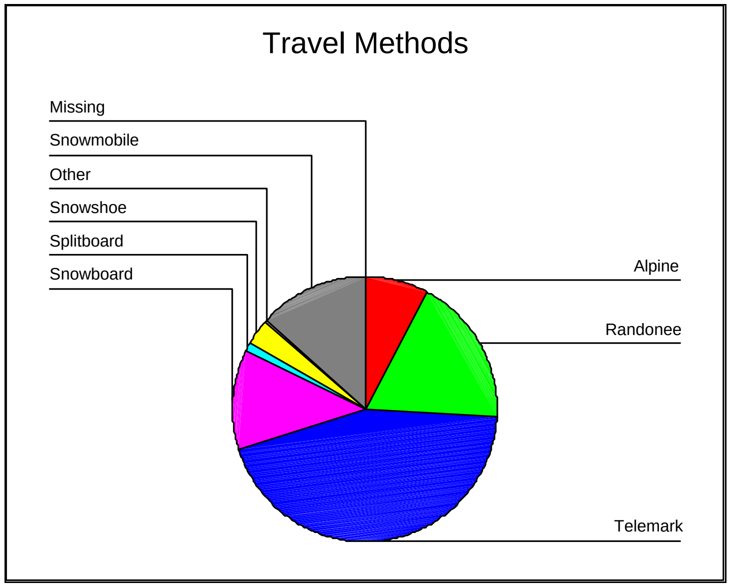
Figure 5, continued.

States and Provinces Where Participants Usually Recreate (North America) (n = 1343)



The participants in the survey used a number of different methods of travel as Figure 6 shows. The largest proportion (44%) of participants used telemark ski equipment as their primary travel method. Other methods that were used by the participants include snowmobiles, snowshoes, splitboards, snowboards alpine skis and randonee skis. This chart does not include those secondary methods used by some participants because not all participants volunteered a secondary method and this information was not used for analysis.

Figure 6: Preferred Travel Methods of the Participants
(n = 1462)



Travel Methods	Frequency	Percent
telemark	648	44.3
randonee	265	18.1
snowmobile	194	13.3
snowboard	177	12.1
alpine	112	7.7
snowshoe	46	3.1
splitboard	16	1.1
nordic	3	< 1
foot	1	< 1
Totals	1462	

Participants were asked if they had any formal avalanche training (Figure 7) and to rate their level of avalanche training (Figure 8), including formal and informal training. A cross-tabulation of this information (Table 1) shows the levels of avalanche training the participants felt they had compared with whether they had had any formal training. This analysis shows that of those participants that have not had any formal avalanche training, the majority feel they have a rudimentary awareness of the hazard, which was one of the levels of avalanche training they were able to select. For those participants that have had formal training, many report that they have had multiple trainings over several years, plus several years or more of backcountry experience. This group is closely followed by those who have had a one to two day minimum avalanche course.

Figure 7: Do Participants Have Formal Avalanche Training
(n = 1443)

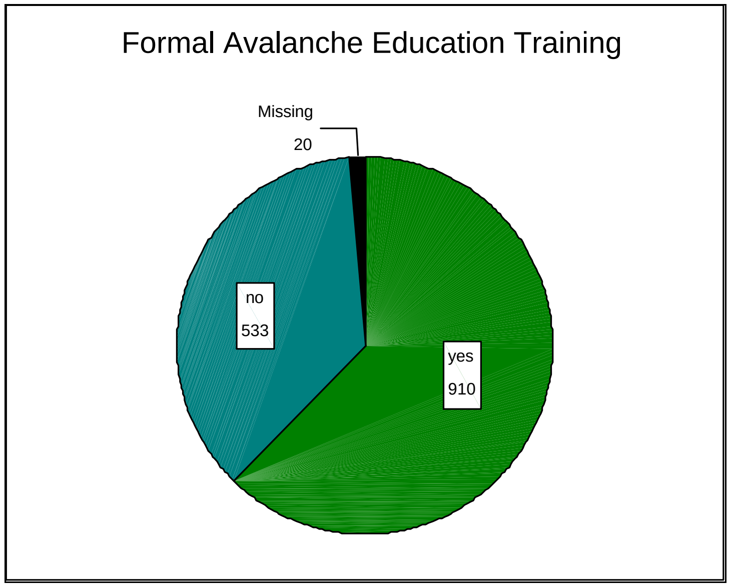


Figure 8: Self-Assessed Avalanche Training Level
(n = 1440)

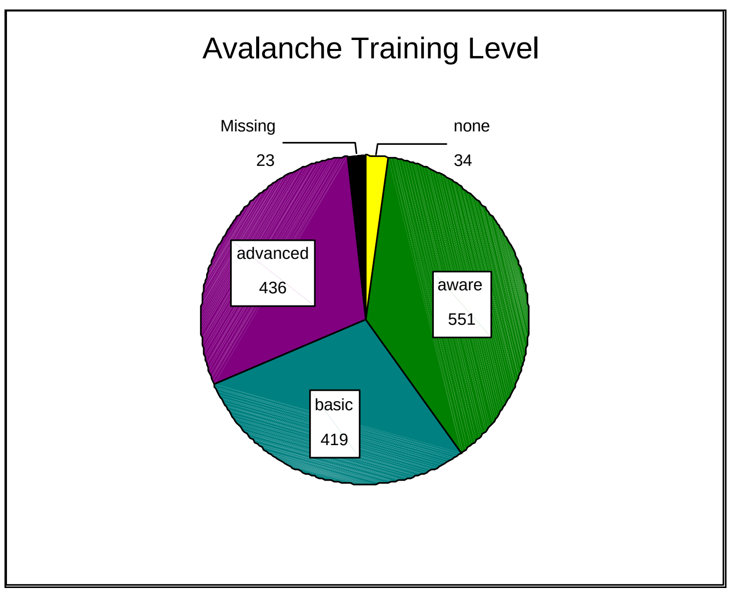


Table 1: Cross Tabulation of Formal Training vs. Training Level

Self-Assessed Training Level							
			none	aware	basic	advanced	Total
Formal Avalanche Training	yes	Count	0	125	379	405	909
		Percent	0%	14%	42%	45%	
	no	Count	34	426	40	31	531
		Percent	6%	80%	8%	6%	
Total			34	551	419	436	1440
Percent			2%	38%	29%	30%	

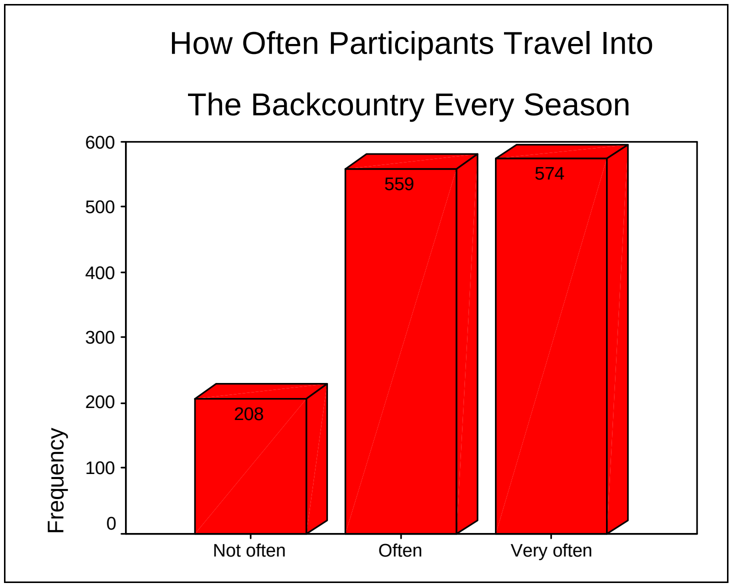
Contingency tables and chi-square tests were also run to help get a better understanding of the data set. Males and females were similar in the proportions of respondents with rudimentary or no awareness, basic training, and advanced training (Table 2).

Table 2: Gender vs. Training Level

Self-Assessed Training Level						
		none	aware	basic	advanced	Total
Female	Count	5	60	39	32	136
	Percent	4%	44%	28%	24%	
Male	Count	29	491	380	404	1304
	Percent	2%	38%	29%	31%	
Total		34	551	419	436	1440
Percent		2%	38%	29%	30%	

Participants were asked how often they traveled into the backcountry every season (Figure 9). Approximately 39 percent (574) of the participants went out into the backcountry "very often", meaning they went out every weekend or more. The next largest group of 38 percent (559) went into the backcountry "often", or once or twice a month. Finally, the smallest group of 14 percent (208) were those participants who went into the backcountry "not often", or less than once or twice a season.

Figure 9: How Often Do Participants Travel into the Backcountry
(n = 1341)



A contingency table (Table 3) shows that males go into the backcountry more often than females, and the association between these variables is statistically significant according to a chi-square test.

Table 3: Gender vs. Frequency in the Backcountry

How Often Does Participant Go Into the Backcountry					
		Not Often	Often	Very Often	Total
Female	Count	28	48	43	119
	Percent	24%	40%	36%	
Male	Count	180	511	531	1222
	Percent	15%	42%	43%	
Total		208	559	574	1341
Percent		15%	42%	43%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.827	2	0.033
N of Valid Cases	1341		

Chi-square analysis of the participant's avalanche training versus their frequency in the backcountry shows that those with advanced training go out into the backcountry much more frequently than those with less avalanche training. This association is highly statistically significant (Table 4).

Table 4: Training Level vs. Frequency in the Backcountry

How Often Does Participant Go Into the Backcountry						
			Not Often	Often	Very Often	Total
Participant's Rating of their Avalanche Training Level	none	Count	14	9	6	29
		Percent	48%	31%	21%	
	aware	Count	127	239	149	515
		Percent	25%	46%	29%	
	basic	Count	54	195	143	392
		Percent	14%	50%	36%	
	advanced	Count	13	116	276	405
		Percent	3%	29%	68%	
Total			208	559	574	1341
Percent			15%	42%	43%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	205.22	6	0.000
N of Valid Cases	1341		

The participants were asked a series of questions designed to determine how prepared they were when they went into the backcountry. Approximately 90% reported that they carry rescue gear (Figure 10). Those participants were asked what types of rescue gear they brought (Figure 11). The most commonly used types of rescue gear include a transceiver, shovel and probe.

Those participants that bring transceivers into the backcountry were asked how often they performed practice transceiver searches (Figure 12). Some participants clarified that they practiced a few times a season, so this was added to the possible choices. Few responded that they practiced all the time (3 %) or never (>1%). A large number of participants (32%) responded that they practiced once at the beginning of the season. Approximately 25% responded that they practice a few times a month, 14%

responded that they practiced less than once a year and 7% responded that they practice a few times a season.

Figure 10: Do Participants Bring Rescue Gear into the Backcountry
(n = 1422)

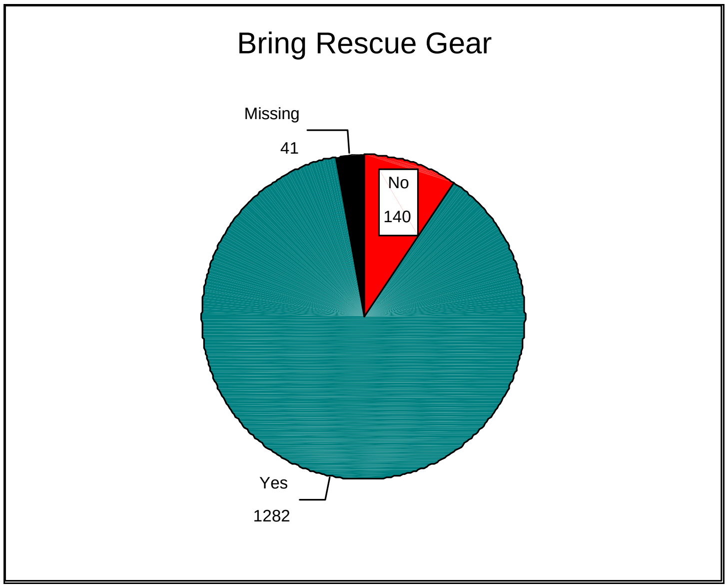


Figure 11: What Types of Rescue Gear Participants Bring into the Backcountry
(n = 4276; multiple answers permitted)

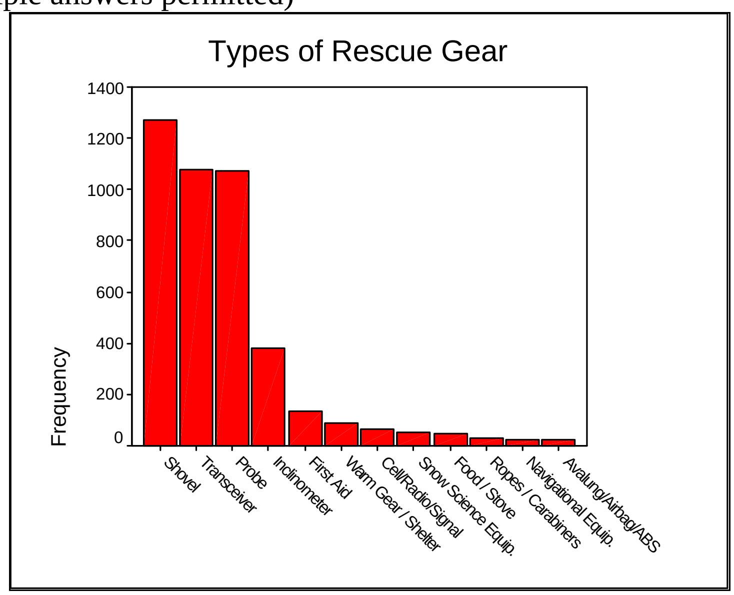
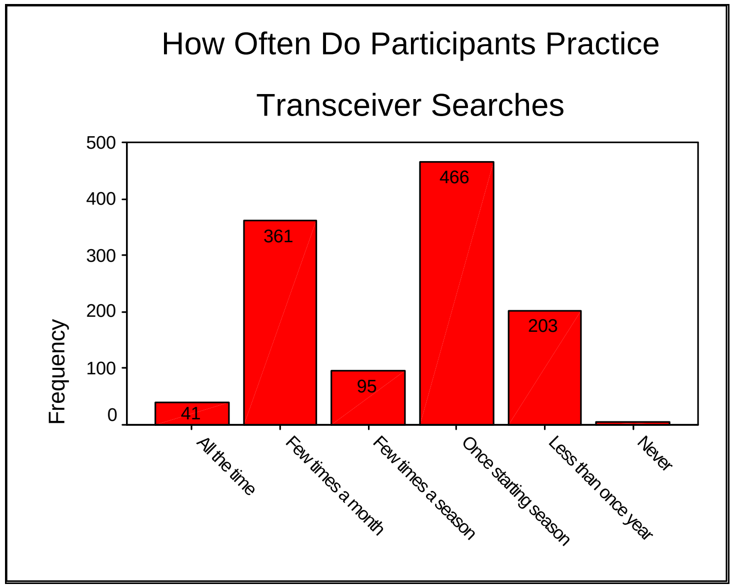
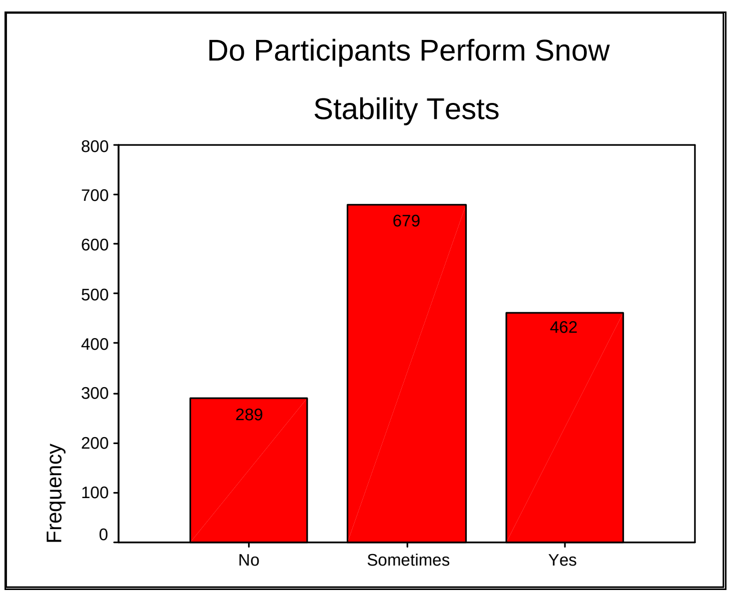


Figure 12: How Often Do Participants Perform Practice Transceiver Searches
(n = 1170)



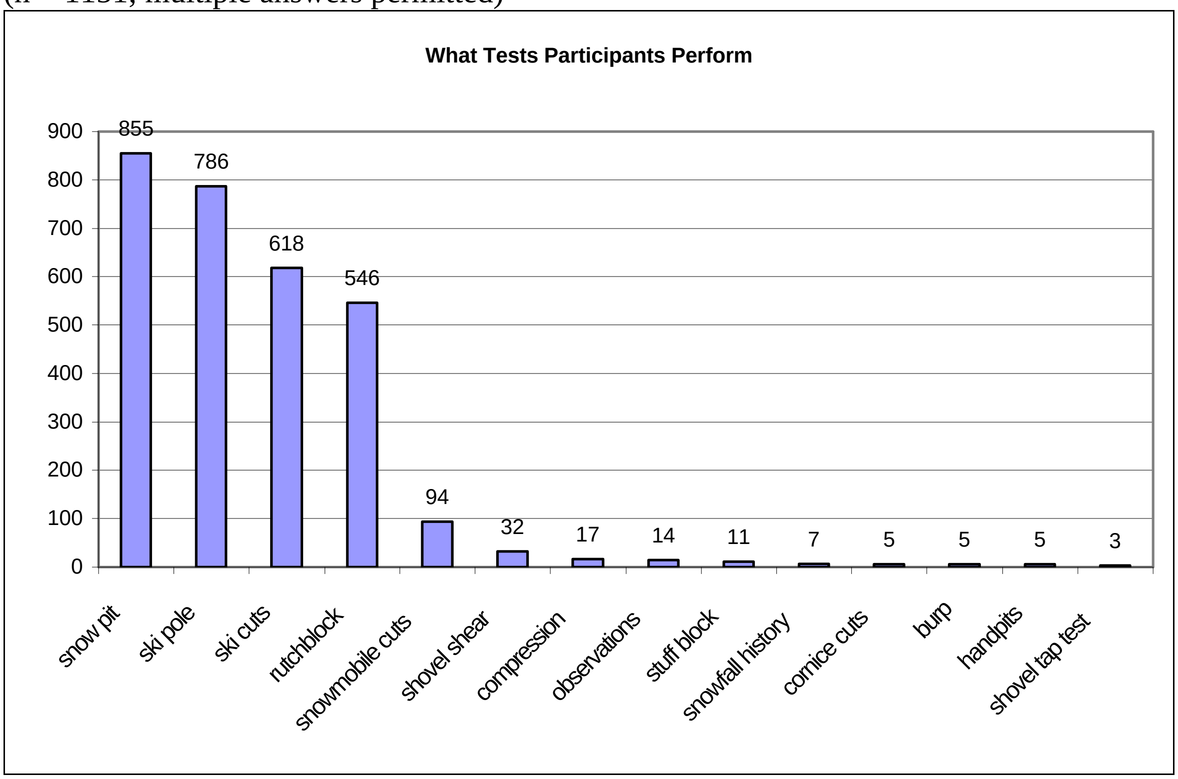
Participants were asked if they performed snow stability tests in the backcountry (Figure 13). These results approximated a normal curve, with 20 percent of the respondents not performing tests, 46 percent performing them sometimes and 32 percent performing them all the time.

Figure 13: Do Participants Perform Snow Stability Tests
(n = 1430)



Those participants that do perform snow stability tests performed many different types (Figure 14). The majority of the participants dug snow pits (74%) and a large number of respondents also performed ski pole tests (68%). Other tests were also performed by many of the respondents including ski cuts (54%), rutchblock tests (47%), snowmobile cuts (8%), shovel shear tests (3%), compression tests (1%), observations (1%), stuff block tests (>1%), snowfall history records (>1%), cornice cuts (>1%), the "burp the baby" test (>1%), handpits (>1%) and shovel tap tests (>1%).

Figure 14: What Types of Snow Stability Tests Do Participants Perform
(n = 1151; multiple answers permitted)



A cross tabulation of the tests performed versus the training level of the participant is shown in Table 5, and a cross tabulation of the preparedness level in terms of snow stability tests versus the training level is shown in Table 6. These tables show that those with higher levels of avalanche training perform more stability tests than those with lower training levels and they are also more prepared.

Table 5: Snow Stability Tests Performed vs. Participant's Training Level

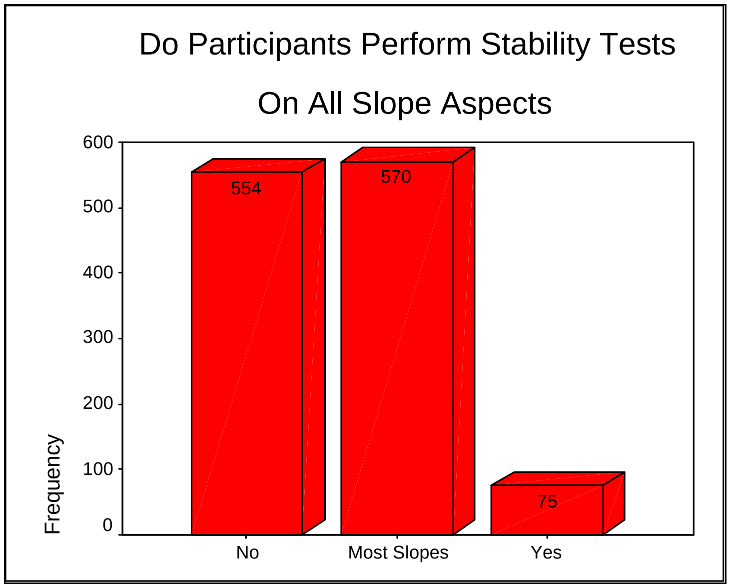
	no	aware	basic	advanced	totals
snowfall history	0	3	2	2	7
cornice cuts	0	1	1	3	5
shovel tap test	0	0	0	3	3
burp	0	1	0	4	5
handpits	0	0	0	5	5
snow	1	7	10	7	25
observations	0	5	1	8	14
ski	3	13	16	10	42
stuff block	0	0	0	11	11
compression	0	0	1	16	17
snowmobile cuts	3	30	16	20	69
shovel shear	0	0	5	27	32
rutchblock	1	67	199	279	546
ski cuts	1	109	178	288	576
ski pole	4	189	258	335	786
snow pit	3	176	305	371	855
Totals	16	601	992	1389	**2998**

Table 6: Preparedness Level (snow stability tests) vs. Training Level

Participant's Rating of Their Avalanche Training Level							
			None	Aware	Basic	Advanced	Total
How Prepared	not	Count	32	467	219	120	838
		Percent	4%	56%	26%	14%	
Is Participant In Terms of	somewhat	Count	2	80	196	273	551
		Percent	<1%	15%	36%	49%	
Snow Stability Tests	very	Count	0	0	3	41	44
		Percent	0%	0%	7%	93%	
Total			34	547	418	434	1433
Percent			2%	38%	29%	30%	

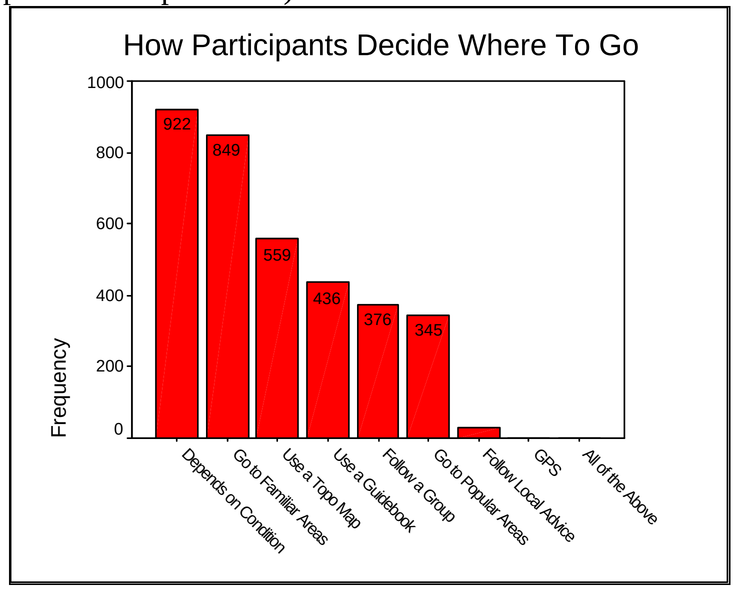
Of those participants that performed snow stability tests, only 5 percent stated they always performed tests on all slopes (Figure 15). Approximately 38 percent of the participants performed stability tests on all slopes and 39 percent performed them on most slopes.

Figure 15: Do Participants Perform Snow Stability Tests on All Slope Aspects (n = 1199)



Participants were able to choose more than one answer regarding the question of how they determined where they were going to travel in the backcountry. They could also specify other methods than the ones available to choose from. The majority of participants (65%) stated they determine where to travel based on the current conditions (Figure 16). Another very large group (58%) go to familiar areas, 39 percent stated they used a topographic map to choose their route, while 31 percent of the respondents used a guidebook. A smaller number follow a group (26%) or go to popular areas and follow tracks (24%). A few respondents specified that they follow local advice (2%) or use a GPS (>1%). For this question, participants were able to check more than one method so counts are very large for the different answers.

Figure 16: How Do Participants Determine Where to Travel in the Backcountry (n = 1429; multiple answers permitted)



These questions assessing how prepared the participants were when they went into the backcountry were then categorized using the methods stated above and grouped to determine a final preparedness rating for each participant (Figure 17). This rating is used in future analysis of the participants' preparedness. Over half of the respondents were "somewhat prepared" (57%), followed by those that were "very prepared" (28%). Only a small number of respondents were "not prepared" (12%).

The majority of the participants (60%) travel in a group when recreating in the backcountry (Figure 18). The next largest group (37%) travel in a group as well as alone. Only one percent of participants responded that they travel alone in the backcountry at all times.

Figure 17: Participants' Preparedness Rating
(n = 1438)

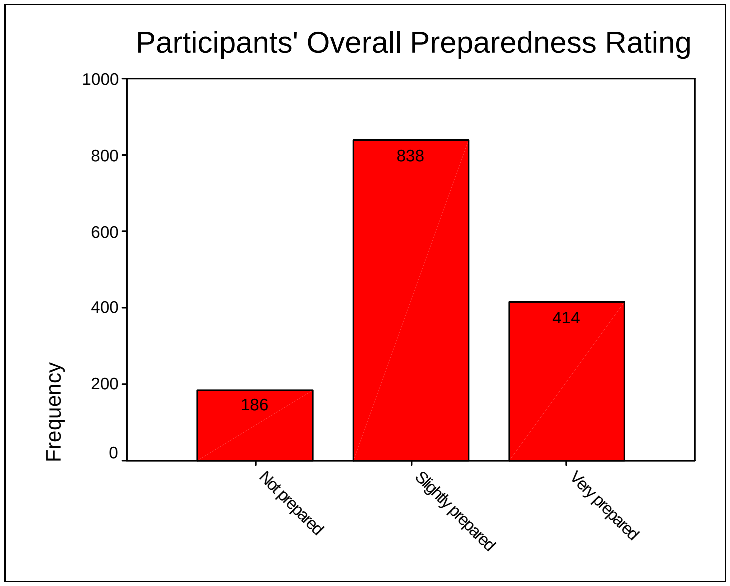
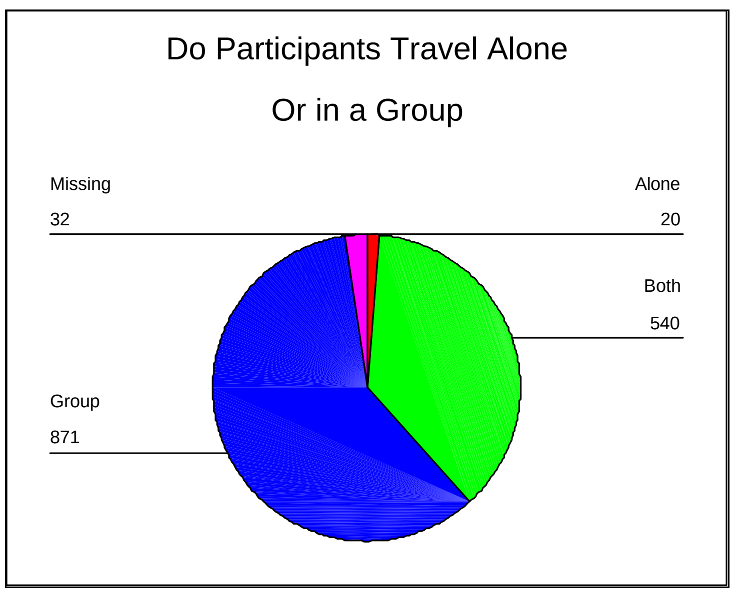


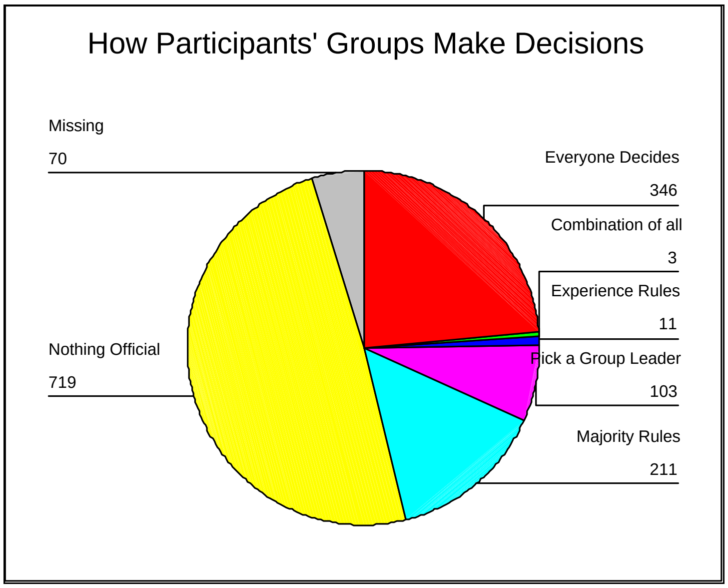
Figure 18: Do Participants Travel Alone or in a Group
(n = 1431)



Of those participants that traveled in a group, the largest share did not have any official methods in place for making group decisions (49%) (Figure 19). The next largest group of respondents stated that all members of the party made the decision together

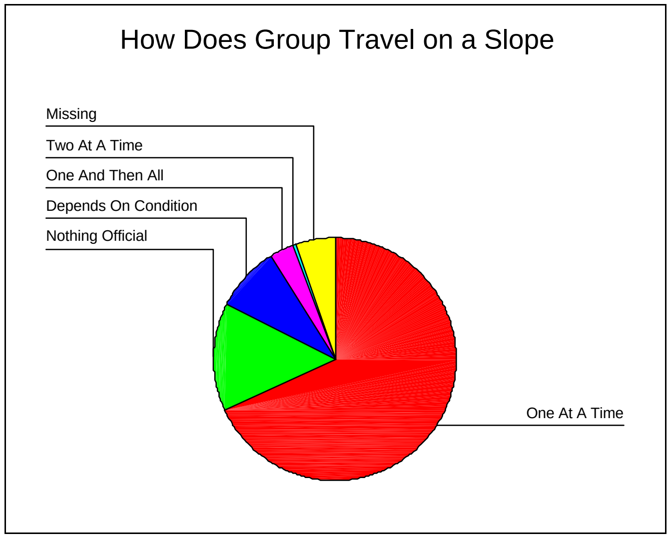
(24%), followed by those who made decisions based on the majority (14%), those that elected a group leader (7%), those that let those with the most experience make the final decisions (>1%) and those that used a combination of all these methods (>1%).

Figure 19: How Do Participants' Groups Make Decisions
(n = 1393)



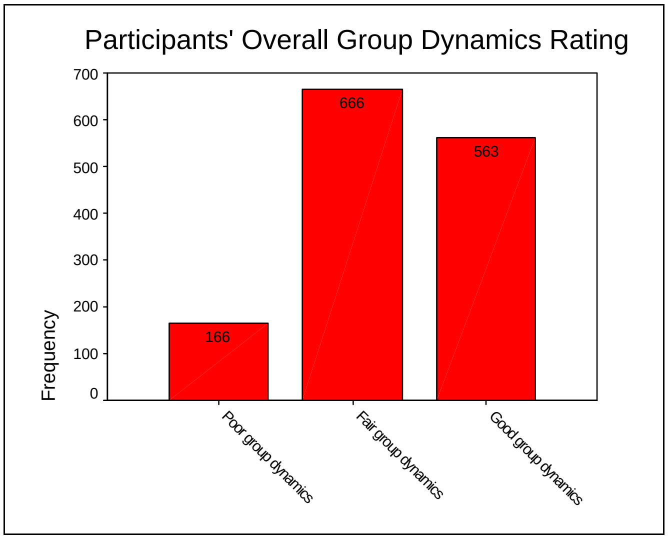
The majority of the participants that traveled in groups traveled one at a time down slopes (68%), followed by those groups that had no official method for traveling down the slopes (15%), those that made their travel decisions based on the conditions (9%), those that let one person go first and then everyone went at their leisure (3%) and those that went two at a time (>1%) (Figure 20).

Figure 20: How Does The Group Travel on a Slope
(n = 1384)



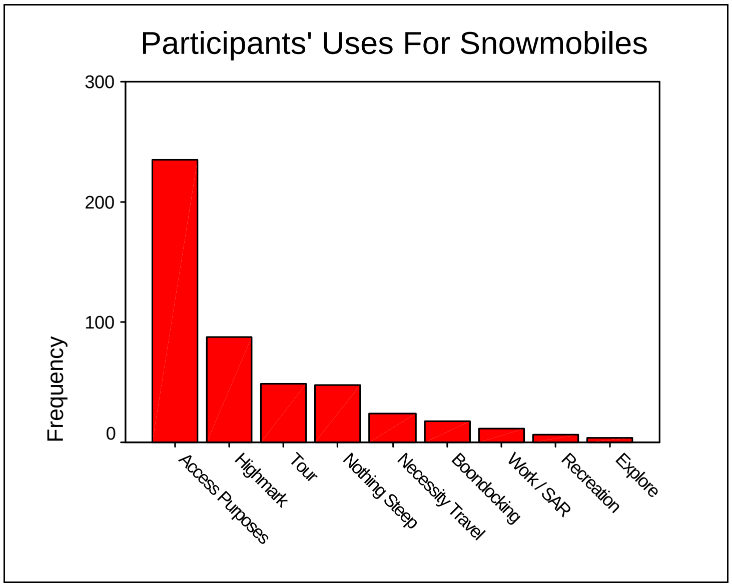
These questions assessing the quality of the participants' group dynamics were then categorized using the methods stated above and grouped to determine a final group dynamics rating for each participant (Figure 21). This rating is used in the next chapter to test the hypothesis that participants' group dynamics are associated with the likelihood of avalanche involvement. The largest group of participants had "fair group dynamics" (46%). A slightly smaller group had "good group dynamics" (39%) and the smallest category had "poor group dynamics" (11%).

Figure 21: Final Group Dynamics Rating
(n = 1395)



Participants were asked a series of question to assess the extremity of their goals for adventure in the backcountry. Uses for snowmobiles were an important component in evaluating the recreationists' adventure goals (Figure 22). Respondents were able to choose more than one answer for this question, and because questions were not blocked out based on previous answers, they were also able to respond to this question even if snowmobiles were not their primary method of travel. "Access purposes" was the largest group (49%) including many recreationists who had a primary method of travel other than snowmobiles but still used snowmobiles for access. Other choices included in the survey included highmarking (18%), touring (10%), traveling on slopes, but nothing that steep (10%) and necessity travel (5%). The participants were also able to specify other uses, with contributed answers including boondocking (4%), work and search and rescue (2%), recreation (1%) and exploring (>1%).

Figure 22: Purpose for Riding Snowmobiles
(n = 480; multiple answers permitted)

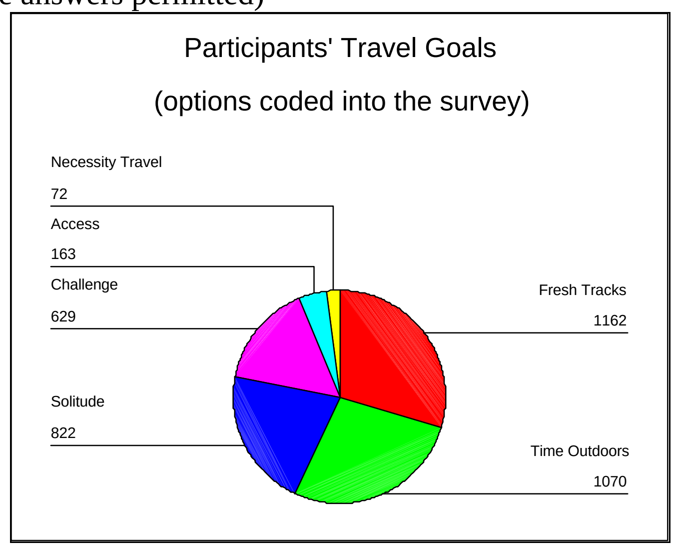


All the participants were asked what their goals were for traveling in the backcountry (Table 7). Participants were able to choose more than one goal, hence the large number of responses. The table shows all answers, including those that the participants wrote into the "other" section. The pie chart shows those answers as they were coded into the survey (Figure 23). The largest category of participants responded that "fresh tracks" was a travel goal (80%). Large numbers of participants also specified their travel goals as "time outdoors" (73%), "solitude" (56%), "challenge" (43%), "access purposes" (11%), and "necessity travel" (5%). Smaller numbers of participants specified other goals such as "exercise", "work" and "search and rescue", "recreation", "money", "film/photography", to "explore" and "snow science".

Table 7. Participants' Travel Goals
(n = 1456)

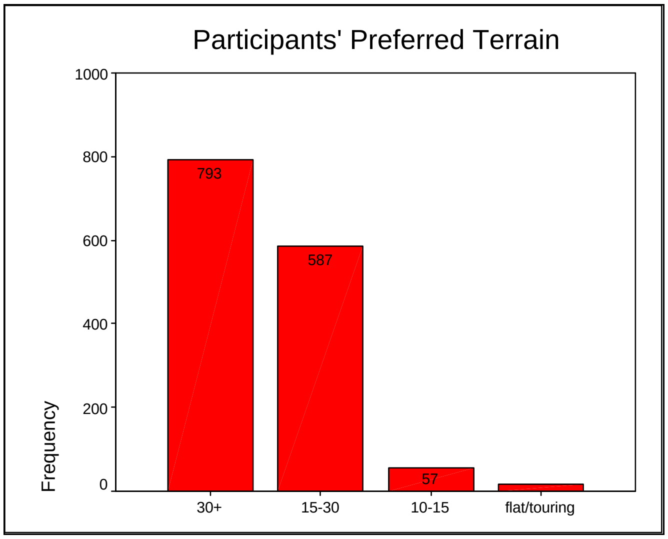
Travel Goals	Frequency
Fresh Tracks	1162
Time Outdoors	1070
Solitude	822
Challenge	629
Access	163
Necessity Travel	72
Exercise	19
Guide/Work/SAR	9
All of the Above	7
Recreation	5
Money	4
Film	4
Explore	3
Snow Science	2
Total	3971

Figure 23. Participants' Travel Goals
(n = 1456; multiple answers permitted)



A large number of participants (54%) responded that they preferred to recreate on terrain that had a slope of 30 degrees or more (Figure 24). The next largest group of respondents preferred terrain with a 15 to 30 degree slope (40%), followed by those who preferred 10 to 15 degree slopes (4%) and flat terrain (1%).

Figure 24: Participants' Preferred Terrain
(n = 1455)



Ninety percent of participants responded that they have traveled on terrain that made them uncomfortable (Figure 25). Reasons why respondents were uncomfortable include "Necessary" (55%), "To challenge yourself" (25%), "Unintentional" (24%), "Following others" (22%) and others (7%) (Figure 26) (numbers total more than 100% because multiple answers were allowed).

Figure 25: Has Participant Traveled on Terrain that Made them Uncomfortable
(n = 1456)

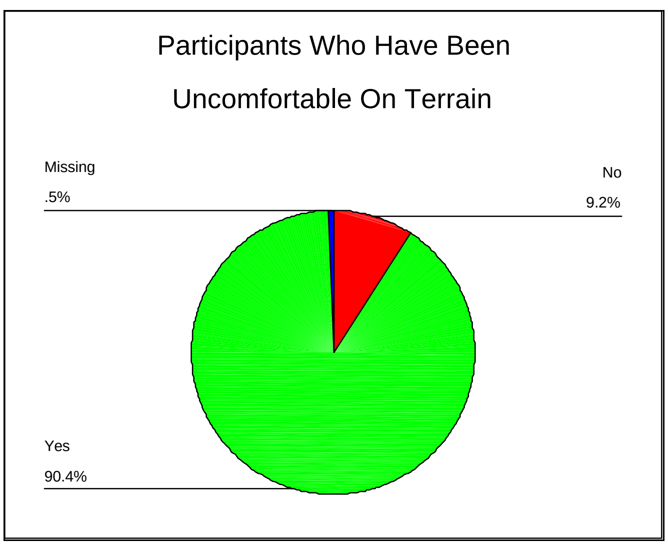
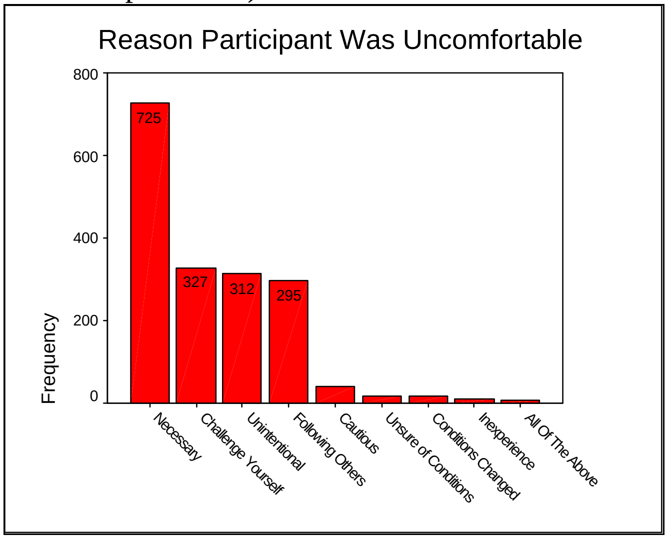


Figure 26: Why Participants Traveled on Terrain that Made them Uncomfortable (n = 1313; multiple answers permitted)



Those participants who stated that they had traveled on terrain that made them uncomfortable were also asked how often that happens (Figure 27). 54% of respondents were uncomfortable on the terrain they were traveling on once or twice a season, 26% were uncomfortable once or twice in their life, and 17% were uncomfortable frequently. For this analysis, participants that specified that they were uncomfortable once every few years were grouped with those that stated they were uncomfortable once or twice in their lives.

The questions designed to assess the extremity of the participants' adventure goals were categorized using the methods stated above and grouped to determine a final extreme rating for each participant that is used in future analysis of the participants' goals of extreme adventure (Figure 28). The largest group of participants was categorized as "somewhat extreme" (47%), followed by those that were "very extreme" (43%) and "not extreme" (9%).

Figure 27: How Often Participant Travels on Terrain That Makes Them Uncomfortable
(n = 1268)

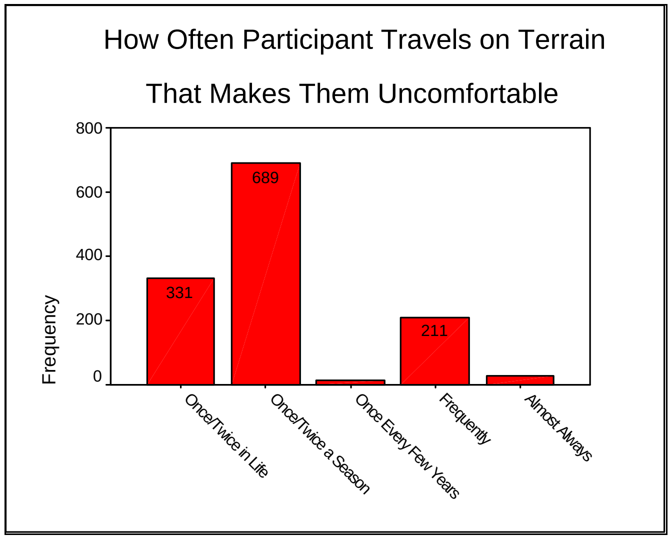
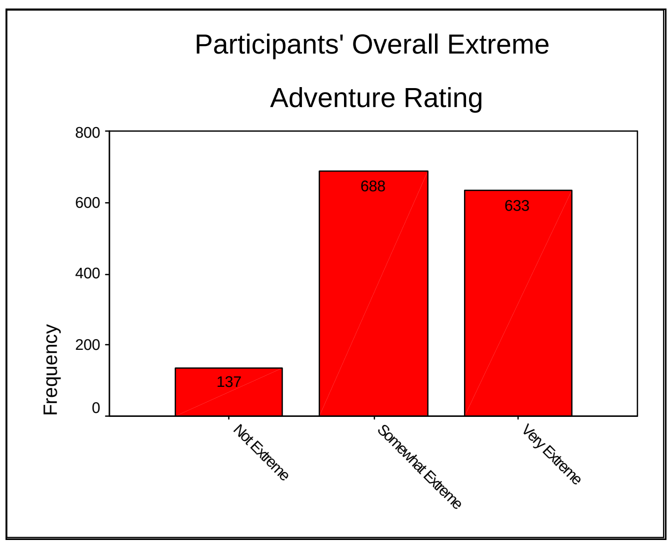
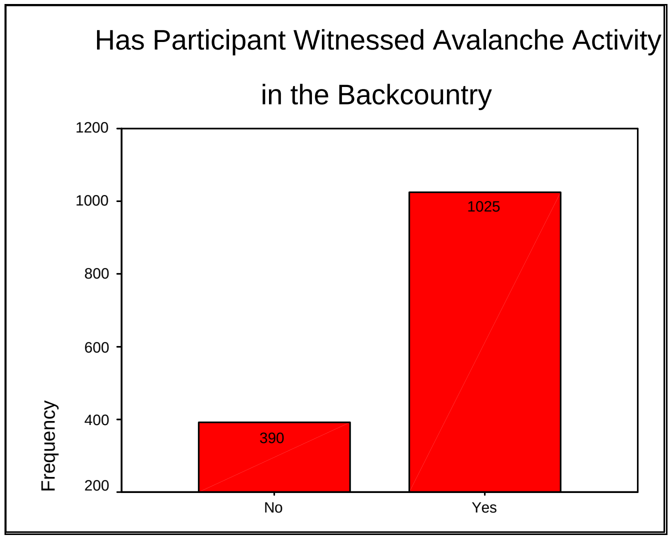


Figure 28: Final Extreme Adventure Rating
(n = 1458)



Participants were asked a series of questions to determine how much avalanche exposure they have had. These questions included whether they have ever witnessed avalanche activity in the backcountry (Figure 29), if they have ever been involved in an avalanche accident (Figure 30) and if they have, in what capacity (Figure 31).

Figure 29: Has Participant Ever Witnessed Avalanche Activity
(n = 1415)



Over half of the participants (1025) have witnessed avalanche activity in the backcountry and about 32 percent of the total respondents have been involved in an avalanche accident in some way. When specifying how they were involved in the avalanche accident, participants were able to choose more than one answer to account for multiple accidents. Of those participants that have been involved in avalanche accidents, the largest group were witnesses to avalanches, but 22 percent of the total respondents have actually been hit by an avalanche and 16 percent of the total respondents have been involved more than once (Figure 32).

These questions regarding what type of exposure the participant has had to avalanches were used to formulate an overall avalanche exposure rating for participants that have been involved in avalanche accidents (Figure 33). This rating was used for further analysis of the eight hypotheses. The methods for creating this rating were discussed above in the Data Categorization section. Of those participants that have been involved in avalanche accidents in some capacity, the largest group were “very involved” (20%), followed by those who were “somewhat involved” (11%).

Figure 30: Has Participant Been Involved in and Avalanche Accident
(n = 1413)

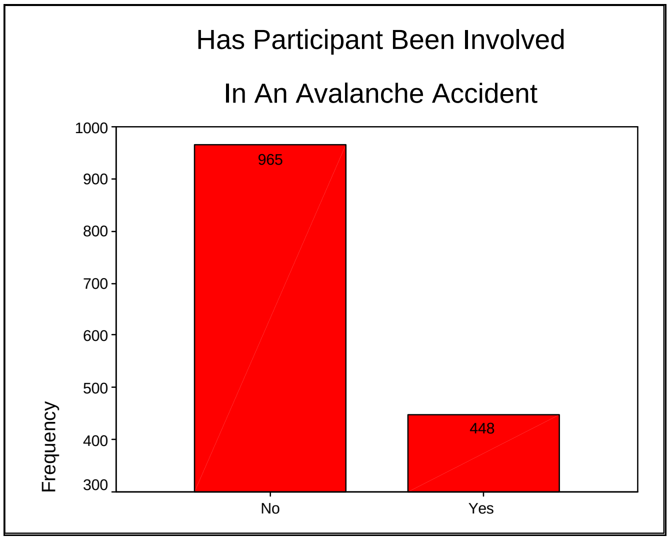


Figure 31: In What Capacity was Participant Involved in Avalanche Accident
(n = 587; multiple answers permitted)

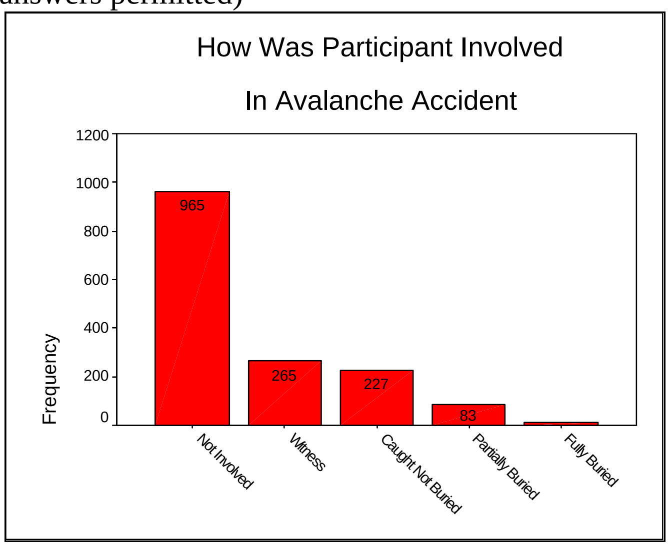


Figure 32: Has Participant Been Involved in More than One Avalanche Accident
(n = 601)

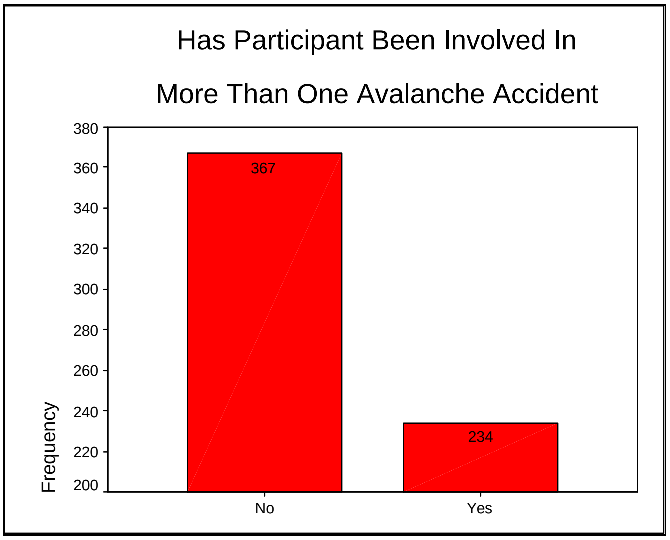
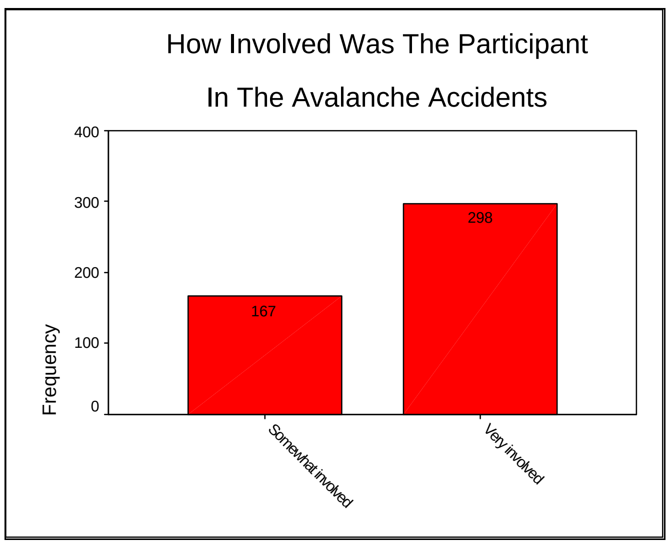


Figure 33: Overall Avalanche Involvement Rating (involved participants)
(n = 465)



Hypothesis Testing of Avalanche Involvement

Of all that responded to this survey, 31 percent were involved in avalanche accidents. Of those that were involved in accidents 11 percent were "somewhat involved" and 20 percent were "very involved".

Hypothesis One

Hypothesis one states that male recreationists are more at risk than female recreationists. Twenty-two of the female participants in this survey (16% of the total number of females) have been involved in an avalanche accident in some way, compared to 443 of the male participants (33% of the total). A chi-square test shows that there is a statistically significant association between gender and the involvement of the recreationists in an avalanche accident (Table 8).

Table 8. Gender vs. Avalanche Accident Involvement

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
Gender	Female	Count	22	110	132
		Percent	17%	83%	
	Male	Count	443	838	1281
		Percent	35%	65%	
	Total		465	948	1413
	Percent		33%	67%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.397	1	0.000
N of Valid Cases	1413		

A chi-square test run to determine if there was any association between the level of avalanche involvement of those participants who had been involved in an accident and gender found that there is a statistically significant association (Table 9). The contingency table shows that females have higher than expected counts for "somewhat involved" and lower than expected counts for "very involved". Males have lower than expected counts for "somewhat involved" and higher than expected counts for "very involved". This supports the previous analyses and shows that males are more likely to have higher levels of involvement in avalanche accidents.

Table 9: Gender vs. Involvement Level

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
Gender	female	Count	14	8	22
		Percent	64%	36%	
	male	Count	153	290	443
		Percent	35%	65%	
Total			167	298	465
Percent			36%	64%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.711	1	0.005
N of Valid Cases	465		

Hypothesis Two

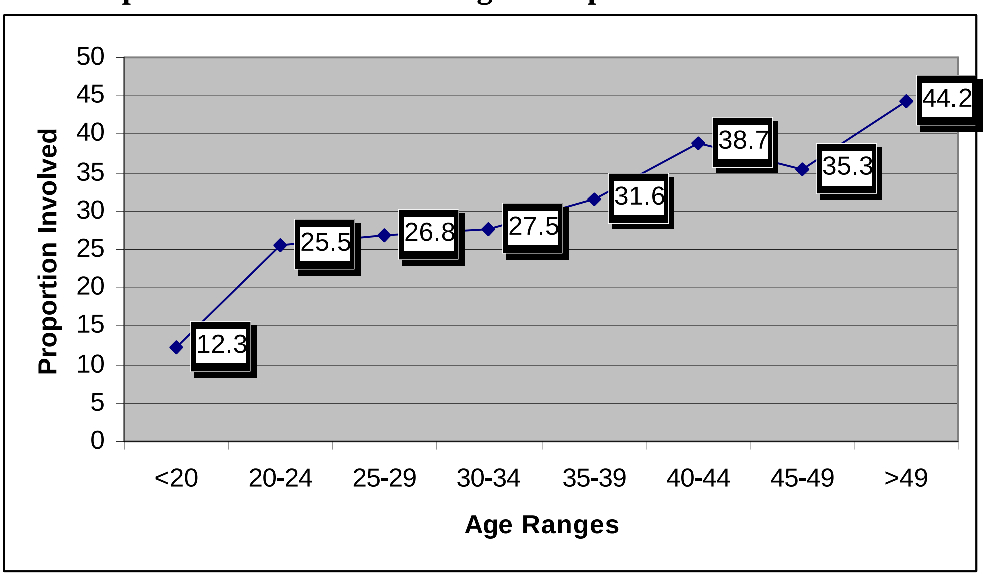
Hypothesis two states that recreationists between the ages of 25 and 29 are at more risk of avalanche exposure. A chi-square test shows that there is a statistically significant association between age group and involvement in an avalanche accident (Table 10). With seven degrees of freedom, the chi-square statistic of 28.269 is highly significant ($p < .001$). However, the research hypothesis that participants between the ages of 25 and 29 were most at risk was not supported by the contingency table. This table showed that all age groups younger than 34 have lower than expected values for avalanche involvement. It is actually the older age groups (35 and higher) that have higher proportions of avalanche accident involvement (Table 11).

Table 10. Age vs. Avalanche Accident Involvement

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
Ranges Of Participant's Ages	< 20	Count	11	43	54
		Percent	20%	80%	
	20-24	Count	40	111	151
		Percent	26%	74%	
	25-29	Count	91	231	322
		Percent	28%	72%	
	30-34	Count	85	196	281
		Percent	30%	70%	
	35-39	Count	57	112	169
		Percent	34%	66%	
	40-44	Count	67	92	159
		Percent	42%	58%	
	45-49	Count	56	96	152
		Percent	37%	63%	
	>49	Count	58	67	125
		Percent	46%	54%	
Total			465	948	1413
Percent					

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	28.269	7	0.000
N of Valid Cases	1413		

Figure 34: Proportion Involvement vs. Age Groups



A logistic regression using the 25 to 29 age group as a reference value reinforces the findings of the chi-square test (Appendix D, Table 1). The "greater than 49" age group had the most statistically significant association with avalanche accident involvement, with a significance value of $p < .001$. This group was most likely to have been involved in an avalanche accident. The 40-44 age group also had a highly significant rate of avalanche involvement compared to the 25-29 year-olds ($p = .002$), while respondents younger than 20 were less involved ($p = .230$).

A chi-square test to test for a significant association between the age ranges and the participants' level of involvement found that there was not a statistically significant association (Table 11).

Table 11: Age Ranges vs. Level of Avalanche Involvement

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
Ranges Of Participant's Ages	< 20	Count	6	5	11
		Percent	55%	45%	
	20-24	Count	15	25	40
		Percent	38%	62%	
	25-29	Count	37	54	91
		Percent	41%	59%	
	30-34	Count	27	58	85
		Percent	32%	68%	
	35-39	Count	23	34	57
		Percent	40%	60%	
	40-44	Count	22	45	67
		Percent	33%	67%	
	45-49	Count	19	37	56
		Percent	34%	66%	
	>49	Count	18	40	58
		Percent	31%	69%	
Total			167	298	465
Percent			36%	64%	

Table 11, continued.

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.688	7	0.698
N of Valid Cases	465		

<u>Hypothesis Three</u>

Hypothesis three states that recreationists on snowmobiles are the most at risk of avalanche involvement (Figure 48). A chi-square test, with seven degrees of freedom, resulted in a highly significant chi-square statistic of 22.728 ($p < .001$) (Table 12). Those participants on randonee skis had the largest difference between the observed and expected values for those participants that had been involved in an avalanche accident, with 38.0% involved in avalanche accidents compared to 32.9% for all respondents. Telemark skiers followed the randonee skiers with 35.3%. This indicates that snowmobiles were not the most at risk of exposure to avalanches, but it is in fact the randonee and telemark skiers. Snowshoers had the lowest counts for being involved in an avalanche accident with only 13.6%.

Table 12: Travel Method vs. Avalanche Accident Involvement
(splitboard, nordic, and foot have been combined as described in procedures above)

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
Travel Method	alpine	Count	34	77	111
		Percent	31%	69%	
	randonee	Count	97	158	255
		Percent	38%	62%	
	snowboard	Count	41	146	187
		Percent	22%	78%	
	snowmobile	Count	66	125	191
		Percent	35%	65%	
	snowshoe	Count	6	38	44
		Percent	14%	86%	
	telemark	Count	220	404	624
		Percent	35%	65%	
Total			464	948	1412
Percent			33%	67%	

Table 12, continued.

Chi-Square Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.728	5	0.000
N of Valid Cases	1412		

To further investigate these chi-square results, a logistic regression was run using snowmobilers as a reference value (Appendix D, Table 2). The results of this test show that statistically, the rates of avalanche involvement for alpine, randonee and telemark travel methods are not significantly different from the snowmobilers. The snowboarders and snowshoers, however, are significantly different and when compared with the snowmobilers they are less likely to be involved in an avalanche accident.

The final phase of the analysis is based on the level of involvement. Snowshoers were left out of this analysis because of the small number of them that have been involved in avalanches. They were not combined into another group because of the very different nature of the travel method. Comparing the participants' travel method to their level of involvement in avalanche accidents resulted in a chi-square statistic of 12.037 which is statistically significant ($p = .017$) (Table 13). This contingency table shows that alpine and randonee skiers had higher than expected counts for being "very involved" in avalanche accidents. Snowmobilers and telemark skiers had lower than expected counts for being "very involved" in avalanche accidents.

Table 13: Travel Method vs. Involvement Level of Involved Participants

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
Travel Method	alpine	Count	6	28	34
		Percent	18%	82%	
	randonee	Count	26	71	97
		Percent	27%	73%	
	snowboard	Count	15	26	41
		Percent	37%	63%	
	snowmobile	Count	30	36	66
		Percent	45%	55%	
	telemark	Count	86	134	220
		Percent	39%	61%	
Total			163	295	458
Percent			36%	64%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.037	4	0.017
N of Valid Cases	458		

Hypothesis Four

Hypothesis four states that those recreationists with basic levels of avalanche training are more at risk. For analysis of this hypothesis, the categories of "no training" and a "basic awareness" of the hazard have been combined into the basic awareness category. This facilitates contingency analysis by ensuring all categories have similar numbers of participants. It also seems safe to assume that all respondents must have some awareness of the hazard or they would not have taken the survey.

A chi-square test found a highly significant association ($p < .001$) between the participant's training level and involvement in an avalanche accident (Table 14). Approximately 61 percent of participants with advanced levels of training were involved in avalanches. Those with minimal awareness of the hazard and basic avalanche training were involved in fewer avalanche accidents (17 percent and 27 percent, respectively).

Table 14: Avalanche Training Level vs. Avalanche Accident Involvement

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
Participant's Rating of Their Avalanche Training Level	aware	Count	98	481	579
		Percent	17%	83%	
	basic	Count	109	301	410
		Percent	27%	73%	
	advanced	Count	258	166	424
		Percent	61%	39%	
Total			465	948	1413
Percent			33%	67%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	224.334	2	0.000
N of Valid Cases	1413		

Further analysis with a logistic regression using those with basic training levels as a reference value (Appendix D, Table 3) supported the findings of the chi-square test and show that statistically, those with a rudimentary awareness of avalanche hazards are different when compared with those with a basic awareness, and they are involved in fewer than expected avalanche accidents. Those with advanced training are also statistically different when compared to those with basic training and are involved in more than expected avalanche accidents.

Recreationists' level of training is also strongly associated with their level of involvement in avalanche accidents and their level of avalanche training (Table 15). These results showed that those participants that had been involved in avalanche accidents and had advanced avalanche training had higher than expected counts for being "very involved" in avalanche accidents. The other levels of avalanche training all had lower than expected counts.

Table 15: Training Level of Involved Participants vs. Level of Involvement

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
Participant's Rating of Their Avalanche Training Level	aware	Count	49	49	98
		Percent	50%	50%	
	basic	Count	45	64	109
		Percent	41%	59%	
	advanced	Count	73	185	258
		Percent	28%	72%	
Total			167	298	465
Percent			36%	64%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.322	2	0.000
N of Valid Cases	465		

A logistic regression test with basic training levels as a reference value supports the findings of the chi-square test and shows that statistically, those with a rudimentary awareness of avalanche hazards were not different when compared with those with a basic awareness (Appendix D, Table 4). Those with advanced training are statistically different when compared to those with basic training and are involved in more extreme levels of avalanche accidents than expected.

Hypothesis Five

Hypothesis five states that recreationists who most frequently travel in the backcountry are more at risk of increased avalanche exposure. Not surprisingly, the contingency analysis (Table 16) shows a highly significant association between these variables. This supports the hypothesis that those participants that spend more time in the backcountry are more at risk of avalanche exposure.

Table 16: Frequency in Backcountry vs. Avalanche Accident Involvement

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
How Often Does Participant Travel Into The Backcountry	not often	Count	36	172	208
		Percent	8%	82%	
	often	Count	142	415	557
		Percent	25%	75%	
	very often	Count	271	303	574
		Percent	47%	53%	
Total			449	890	1339
Percent			34%	66%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	88.912	2	0.000
N of Valid Cases	1339		

Further analysis shows a very strong association between frequency of travel in the backcountry and level of involvement in avalanche accidents. The contingency table shows that those participants that spend the most time in the backcountry had higher than expected counts for being "very involved" in avalanche accidents, while those participants who were in the backcountry "often" and "not often" had lower than expected counts for being "very involved" in avalanche accidents (Table 17).

Table 17: Frequency in Backcountry of Involved Participants vs. Involvement Level

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
How Often Does Participant Travel Into The Backcountry	not often	Count	15	21	36
		Percent	42%	58%	
	often	Count	66	76	142
		Percent	46%	54%	
	very often	Count	78	193	271
		Percent	29%	71%	
Total			159	290	449
Percent			35%	65%	

Table 17, continued.

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.427	2	0.001
N of Valid Cases	449		

Hypothesis Six

Hypothesis six states that unprepared recreationists are more at risk. A chi-square test shows that there is a highly significant association between the participant's preparedness rating and their involvement in an avalanche (Table 18). The contingency table reveals that those recreationists that are "not prepared" and "somewhat prepared" actually have lower than expected counts, contrary to the expectations of the hypothesis. Those recreationists that are "very prepared" have higher than expected counts for avalanche accident involvement.

Table 18: Preparedness Rating vs. Avalanche Accident Involvement

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
Overall Preparedness Rating	not prepared	Count	22	157	179
		Percent	12%	88%	
	somewhat prepared	Count	244	585	829
		Percent	29%	71%	
	very prepared	Count	199	206	405
		Percent	49%	51%	
Total			465	948	1413
Percent			33%	67%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	87.302	2	0.000
N of Valid Cases	1413		

Considering only those recreationists who have been involved in avalanche accidents, a chi-square comparison of their preparedness level to their level of involvement in avalanche accidents determined that there was no statistically significant association (p = .179) (Table 19).

Table 19: Preparedness Rating vs. Level of Involvement

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
Overall Preparedness Rating	not prepared	Count	9	13	22
		Percent	41%	59%	
	somewhat prepared	Count	96	148	244
		Percent	39%	61%	
	very prepared	Count	62	137	199
		Percent	31%	69%	
Total			167	298	465
Percent			36%	64%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.443	2	0.179
N of Valid Cases	465		

<u>Hypothesis Seven</u>

Hypothesis seven states that recreationists that travel in groups with unclear decision-making processes are most at risk. A chi-square test shows that there is a highly significant association (p<.001) between the participants' group dynamics rating and their avalanche involvement (Table 20). The contingency table shows that those with "fair group dynamics" had a larger than expected rate of involvement (38 percent) in avalanche accidents. Contrary to the hypothesis, those participants with "poor" and "good" group dynamics had lower than expected rates (19 percent and 32 percent, respectively).

Table 20: Group Dynamics Rating vs. Avalanche Accident Involvement

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
Overall Group Dynamics Rating	poor group dynamics	Count	30	129	159
		Percent	19%	81%	
	fair group dynamics	Count	251	410	661
		Percent	38%	62%	
	good group dynamics	Count	175	386	561
		Percent	31%	69%	
Total			456	925	1381
Percent			33%	67%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.575	2	0.000
N of Valid Cases	1381		

Considering only those recreationists who have been involved in avalanche accidents and comparing their group dynamics score to their level of involvement in avalanche accidents with a chi-square test, no statistically significant association was discovered (p = .309) (Table 21).

Table 21: Group Dynamics Rating vs. Level of Involvement

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
Overall Group Dynamics Rating	poor group dynamics	Count	8	22	30
		Percent	27%	73%	
	fair group dynamics	Count	86	165	251
		Percent	34%	66%	
	good group dynamics	Count	69	106	175
		Percent	39%	61%	
Total			163	293	456
Percent			36%	64%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.35	2	0.309
N of Valid Cases	456		

Hypothesis Eight

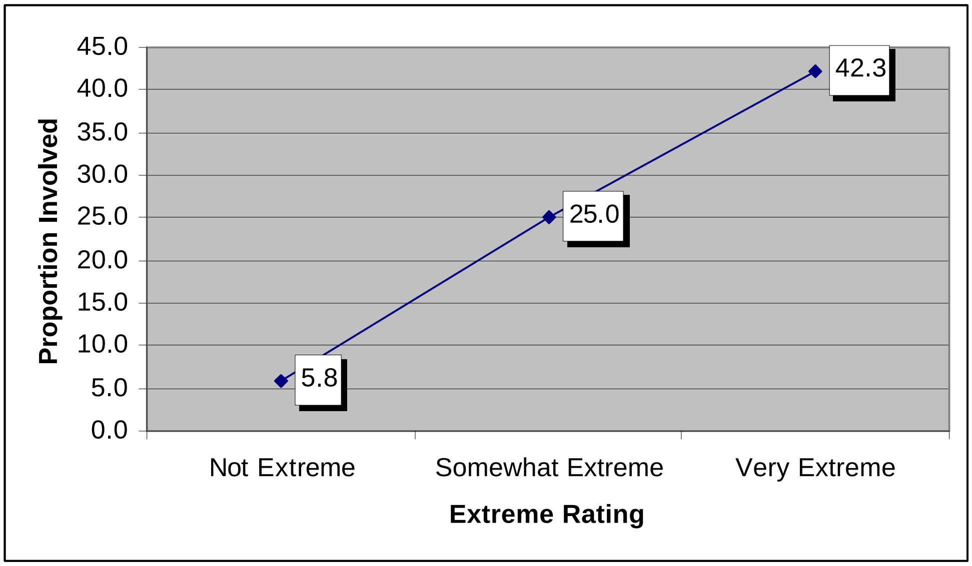
Hypothesis eight states that recreationists with goals of more extreme adventure are most at risk. A chi-square test shows that there is a highly significant association between the participants' extreme rating and if they had been involved in an avalanche accident (Table 22). The contingency table shows, that as expected, those participants with a "very extreme" rating had higher than expected counts for being involved in an avalanche accident. Also as expected, those participants with "not extreme" and "extreme" ratings had lower than expected counts for being involved in an avalanche accident. Those participants categorized as "very extreme" also have higher proportions of avalanche accident involvement (Figure 35).

Table 22: Participants' Extreme Rating vs. Avalanche Accident Involvement

Have Participants Been Involved in an Avalanche Accident					
			Yes	No	Total
Overall Extreme Rating	not extreme	Count	9	112	121
		Percent	7%	93%	
	somewhat extreme	Count	177	491	668
		Percent	26%	74%	
	very extreme	Count	279	345	624
		Percent	45%	55%	
Total			465	948	1413
Percent			33%	67%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	87.363	2	0.000
N of Valid Cases	1413		

Figure 35: Proportion Involvement vs. Extreme Rating



For the second phase of the analysis, a chi-square test was performed on only those recreationists who have been involved in avalanche accidents. This test showed a statistically significant association between those recreationists' level of involvement in avalanche accidents and their extreme rating (p = .025) (Table 23). Those participants with a "very extreme" rating had higher than expected counts for being "very involved" in avalanche accidents.

Table 23: Extreme Rating of Involved Participants vs. Level of Involvement

Participants' Level of Involvement in Avalanche Accidents					
			Somewhat Involved	Very Involved	Total
Overall Extreme Rating	not extreme	Count	6	3	9
		Percent	66%	34%	
	somewhat extreme	Count	72	105	177
		Percent	41%	59%	
	very extreme	Count	89	190	279
		Percent	32%	68%	
Total			167	298	465
Percent			36%	64%	

Chi-Square Test			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.397	2	0.025
N of Valid Cases	465		

Discussion

This web-based project had an incredible response rate, which was probably due to effective advertising and the ease of taking an on-line survey at leisure and wherever internet access is available. I also believe that the ubiquitous nature of the internet greatly helped to diversify my sample: participants were from all over the world, all different age groups, different training levels and different ability levels. Diversity was evidently lacking in the male to female ratio, but I feel this proportion does reflect, to some degree, the actual proportion of the population of backcountry recreationists. The large sample size and diversity of this sample helps to relieve any bias associated with the data set.

Descriptive Statistics

The descriptive statistics revealed some interesting relationships between avalanche education or training and other associated factors such as preparedness and snow stability tests. Those recreationists who considered themselves to have higher levels of avalanche training also had formal avalanche training. These results imply that formal avalanche training gives backcountry recreationists a much higher confidence in their level of avalanche training.

Formal avalanche training typically teaches recreationists how to assess snow stability through various tests of the snow pack. This training also often involves training in how to use transceivers and other rescue gear. One would assume that recreationists with higher levels of avalanche training would recognize the importance of these tests and perform more of them more often, this assumption was supported by the research. However, most participants only perform a few different tests and those with lower levels of avalanche training perform smaller numbers of tests. The descriptive statistics also reveal that most participants are "not prepared" and few are "very prepared" based on the categorization of snow stability tests.

Hypothesis One

The data analysis supports the hypothesis that males are more likely to be involved in avalanches. A significantly higher proportion of males have been involved in an avalanche (35 percent, compared to 17 percent of females), and among those involved, males were more likely to have been caught and/or buried. This is also supported by studies of victim statistics. Between the winters of 1950/51 and 1996/97, 89 percent of avalanche victims were males (Atkins, 1998).

Hypothesis Two

The data analysis determined that there was an association between the age of the participants and their involvement in an avalanche, but there was no statistically significant association between age groups and those that were caught and/or buried. The research did not support the hypothesis as stated; these results showed that it was the older age groups that were more likely to have been involved in avalanches.

One limitation of this research is that the participants were not asked to specify what age they were when they were involved in the accidents. Victim statistics do show that most avalanche victims are between the ages of 25 and 29 (Atkins, 1998), so it is possible that many of the respondents in this survey were involved in avalanches when they were that age but were lucky enough to survive. As recreationists get older it is likely they have spent more time in the backcountry and therefore in avalanche-prone terrain so the findings that older recreationists have been involved in more avalanches makes sense.

Hypothesis Three

The data analysis determined that there is a significant association between the participant's travel method and involvement in avalanches, but it did not support the hypothesis that those on snowmobiles were involved in more avalanches. It was actually the randonee and telemark skiers that were involved in more accidents, while snowshoers and snowboarders were the safest compared to the snowmobilers. A reason for this could be the nature of the travel methods. Randonee and telemark skis are designed for backcountry travel and therefore these travel methods are more efficient for traveling in the backcountry than snowboards or snowshoes. This could allow the recreationists on this equipment to cover more terrain and potentially be exposed to more avalanche prone terrain.

An association was also found between the participant's travel method and their level of exposure but once again the research hypothesis was not supported: it was the alpine and randonee skiers that had higher levels of involvement. Victim statistics show that the activity that has had the most deaths in recent years is snowmobiling (Atkins, 1998), but this trend was not reflected by this survey. This could be due in part to the way that most snowmobilers found out about the survey, which was from on-line snowmobiling forums. These snowmobilers may be more aware of avalanche hazards and therefore more cautious. This could represent a bias in the sample.

Hypothesis Four

This research determined that there is a significant association between the participants' training level and their involvement in avalanche accidents, but in contrast to my research hypothesis, those with basic levels of training were not involved in more avalanche accidents than expected. Ironically, it was those participants with advanced levels of training that were involved in the most avalanche accidents, and who also had the highest levels of involvement in avalanche accidents.

Other research also supports these findings; victim statistics show that approximately 75 percent of all the victims had avalanche awareness training, and the greater the experience and training, the higher the rate of avalanche fatalities (Atkins, 1998, 2001). Unfortunately, avalanche training alone does not seem to prevent recreationists from taking risks (McClung 2000a).

Hypothesis Five

The data analysis supported the hypothesis that those participants who spend the most time in the backcountry are involved in more avalanches and among those involved, those who spent the most time in the backcountry were more likely to have been caught and/or buried. These results are not surprising as one would expect that those who are in the backcountry most often, and therefore most often in avalanche-prone terrain, would be involved in the most accidents.

Hypothesis Six

Contrary to the hypothesis, data analysis determined that those recreationists that were "very prepared" were involved in the most avalanche accidents. Among recreationists who have been involved in avalanches, preparedness level did not affect their degree of involvement in these accidents.

These results are not as unexpected as they may seem. Studies show that most victims killed in avalanches were competent winter adventurers (Atkins, 2001), which this preparedness level reflects. Those people with the most experience are those that often take the greatest risks (Fredston *et al*., 1994) and these experienced recreationists are often very prepared for the hazards they encounter. Unfortunately, the knowledge that they are going to be taking risks and the resulting preparations cannot always protect them from getting involved in avalanche accidents.

Hypothesis Seven

I hypothesized that recreationists with “poor group” dynamics would be most often involved in avalanches; actually, the data analysis determined that it was those with “fair group dynamics” that were involved in the most avalanche accidents. Among those that were involved in avalanches there was no statistically significant association between the group dynamics rating and their level of involvement.

This could be explained by the fact that those with “poor group dynamics” may not go into the backcountry often enough to have needed to develop better group dynamics, resulting in a lower rate of exposure to avalanche hazards. Those with “good group dynamics” on the other hand, may go into the backcountry more frequently and have consequently developed group dynamic skills to better aid them in navigating avalanche-prone areas. Those with “fair group dynamics” may lack experience but may still find themselves in avalanche prone areas with no effective methods to make group decisions. This situation could cause them to be involved in more avalanche accidents.

Hypothesis Eight

As the hypothesis proposed, data analysis determined that those participants with extreme adventure goals were involved in more avalanche accidents, and among those involved, those with extreme adventure goals were more likely to be caught and/or buried.

Victim statistics also support this hypothesis and while it may be hard to assess what exactly the recreationist was doing at the time that the avalanche was triggered, it has been found that many victims relied on mitigation measures to reduce their risk as opposed to entirely avoiding the hazards (McCammon, 2000). This behavior is not uncommon for those with extreme adventure goals as this research shows that many of those recreationists with a high extreme adventure rating were also more prepared.

Conclusion

This project set out to address the question: What influences backcountry recreationists' risk of exposure to avalanche accidents? The data and analysis show that there are a number of independent variables that influence the risk. Some of these variables have a statistically stronger association and play a greater role in determining risk than others. Moreover, some of these variables can be changed, while others cannot.

For the variables that can be changed, such as participants' avalanche training level, preparedness and group dynamics, I would recommend the continued use of avalanche education to try to influence participants' likelihood of avalanche accident involvement.

Unfortunately, the analysis presented here indicates that avalanche education and avalanche training are not currently reducing the number of avalanche accidents, as one would hope. Avalanche training courses should be frequently revised using information such as this study. For example, courses could use these data to stress the role of good group dynamics and give specific examples of ways to improve communication and group behavior. Further research into avalanche training, including recreationists' perceptions of their own ability to assess avalanche risk as well as their preparedness could give a better understanding of why these variables are associated with higher avalanche accident involvement.

A complicated finding of this research is that although avalanche education is considered the best method for preventing avalanche accidents (O'Gorman *et al.,* 2003), it was found that those with the most training were involved in the most accidents.

Analysis of participants' preparedness yielded similar results; those that were more prepared were involved in more accidents. I do not believe that this indicates avalanche training has negative effects, rather I think it shows that those that take the most risks also prepare and train themselves appropriately for the hazard.

Undoubtedly, avalanche education needs constant improvements and further research in this area would be very beneficial. Possible improvements could include changes in how risk assessment is taught, to improve understanding of when and where avalanches occur. This could be done by focusing more on snow pack assessments and route finding and focusing on what the snow pack looked like in areas that slid as well as areas that did not. Multi-media approaches could also be useful including video clips of avalanches and audio clips of telltale warning signs.

Limitations and Recommendations

There are several important questions that my survey methodology did not accurately address. As noted in the Discussion, my questions did not elicit the age of the participants when they were caught in the avalanches. This information could potentially change the results of Hypothesis Two and it would be useful in more accurately determining which age groups are at greatest risk.

Another important area of questions would be when recreationists began to acquire formal avalanche education training, whether they started getting this training before or after being involved in an avalanche accident, and whether they have been involved in any avalanche accidents since getting this training. These questions would help to more accurately determine how well avalanche education is preventing avalanche accidents.

Appendix A

Sample Survey

Please check all that apply

In the backcountry, how do you usually travel?

- ☐ Alpine Ski
- ☐ Snowboard
- ☐ Snowmobile
- ☐ Snowshoe
- ☐ Telemark Ski

Other ______

If you snowmobile, what do you usually use it for?

- ☐ Tour
- ☐ Travel up slopes, but nothing that steep
- ☐ Highmark
- ☐ Use it for access purposes, and ski/snowboard/etc. once you get there

Other ______

What are your goals for travel in the backcountry?

- ☐ Solitude
- ☐ Get fresh tracks
- ☐ Ski steep, challenging terrain
- ☐ Spend time outdoors

Other ______

What type of terrain do you prefer to recreate on?

- Flat/touring
- Up to 15 degree slopes (steepness of most mountain roads)
- Up to 30 degree slopes (intermediate to advanced at a ski area)
- 30 degrees and up (most black diamond trails range from 30-40 degrees)

Have you ever traveled on terrain that made you uncomfortable?

Yes No

If you answered yes, what was the reason?

- You were following others in your group
- You were not sure of where you were going and ended up somewhere less than desirable
- You thought it would be good to challenge yourself
- It was necessary for where you wanted to go

Other

If you answered yes, how often would you say this happens?

- Once or twice in your life
- Once or twice a season
- Frequently, but not every time you go out
- Almost every time you go out

Other

Have you ever taken any avalanche training?

Yes No

How would you rate your training level?

- No training or awareness
- Rudimentary awareness of the hazard
- 1-2 Day avalanche course minimum
- Multiple trainings over several years, plus several years or more of backcountry experience

Other

When you travel in the backcountry do you bring rescue gear?

Yes No

If you answered yes, what do you usually bring?

- Transceiver
- Probe
- Shovel

Other

If you bring a transceiver, how often do you practice transceiver searches?

- Less than once a year
- Once at the beginning of the season
- A few times a month
- All the time, I'm addicted!!

When you travel in the backcountry, do you perform snow stability tests?

- Yes
- Sometimes
- No

If you answered yes or sometimes, what tests do you usually perform?

- Ski pole poking as you go
- Dig snow pit
- Rutchblock test
- Ski cuts

Other

If you perform these tests, do you perform them on each slope aspect you travel on?

- Yes
- No
- Not every slope, but most

When you travel in the backcountry how do you determine where you are going to go?

- ☐ Pick a route before with a topo map
- ☐ Use a guidebook
- ☐ Travel in familiar areas
- ☐ Travel with a group and follow them
- ☐ Go to popular areas and follow the established trails
- ☐ Dependent upon daily conditions and visual assessments

Other ______

When you travel in the backcountry how do you travel?

- ○ Alone
- ○ In a group
- ○ A little bit of both

If you travel in a group, how do you usually make group decisions?

- ○ Elect a group leader
- ○ Majority rules
- ○ If one doesn't want to go, no one goes
- ○ Nothing that official

Other ______

If you travel in a group, how do you travel on a slope?

- ☐ One at a time
- ☐ If one makes it alright, then everyone goes at their leisure
- ☐ Nothing official, everyone goes at their leisure

Other ______

Have you ever witnessed avalanche activity while you were in the backcountry?

☐ Yes ☐ No

If you answered yes, did you alter your travel plans because of it?

☐ Yes ☐ Not every time ☐ No

Have you ever been involved in an avalanche accident?

- ☐ No
- ☐ Witness
- ☐ Caught but not buried
- ☐ Caught and partially buried
- ☐ Caught and fully buried

If you answered yes, have you been involved more than once?

☐ Yes ☐ No

How old are you? ______

☐ **Male** ☐ **Female**

Where do you usually recreate? State/Province Country

How often do you go into the backcountry every season?

- Once or twice a season
- Once or twice a month
- Just about every weekend
- I spend more time out there than at home

Other

Email

(this will only be used for contact purposes if you win the transceiver)

How did you find out about this survey?

- PSIA
- Missoula Advertising
- Word of Mouth

Other website
Other

Comments??

Appendix B

Data Categorization

Table 1. Frequency in backcountry

How often do you travel in the backcountry?	
Answer	**Category**
once or twice a season	not very often
once or twice a month	often
every weekend	very often
all the time	very often

Table 2. Rescue Gear

When you travel in the backcountry do you bring rescue/safety gear?	
Answer	**Category**
no	not prepared
yes	determined in next question

Table 3. Types of Rescue Gear

If you answered yes, what do you usually bring?	
Answer	**Category**
0 to 2 types of rescue gear	not prepared
3 to 5 types of rescue gear	somewhat prepared
6 to 8 types of rescue gear	very prepared

Table 4. Transceiver Practice Frequency

If you bring a transceiver, how often do you practice transceiver searches?	
Answer	**Category**
never	not prepared
less than once a year	not prepared
once beginning of the season	somewhat prepared
few times a season	somewhat prepared
few times a month	very prepared
all the time	very prepared

Table 5. Perform Snow Stability Tests

When you travel in the backcountry, do you perform snow stability tests?	
Answer	**Category**
no	not prepared
sometimes	determined in next question
yes	determined in next question

Table 6. How Many Stability Tests

If you answered yes, or sometimes, what tests do you usually perform?	
Answer	**Category**
0 to 2 types of stability tests	not prepared
3 to 4 types of stability tests	somewhat prepared
5 to 7 types of stability tests	very prepared

Table 7. Stability Tests on Different Aspects

If you perform snow stability tests, do you perform them on every aspect you travel on?	
Answer	**Category**
no	not prepared
not every slope but most	somewhat prepared
yes	very prepared

Table 8. Travel Planning

When you travel in the backcountry, how do you decide where you are going to go?	
Answer	**Category**
follow a group	not prepared
follow tracks	not prepared
GPS	not prepared
use a guidebook	somewhat prepared
familiar areas	somewhat prepared
dependent on conditions	somewhat prepared
based on local advice	somewhat prepared
topographic map	somewhat prepared
all of the above	very prepared

Table 9. Group Decision-Making Processes

If you travel in a group, how do you usually make group decisions?	
Answer	**Category**
nothing official	poor group dynamics
pick a group leader	fair group dynamics
combination	fair group dynamics
majority rules	fair group dynamics
experience rules	fair group dynamics
everyone decides	good group dynamics

Table 10. Group Slope Travel

If you travel in a group, how do you travel on a slope?	
Answer	**Category**
nothing official	poor group dynamics
depends on instance	fair group dynamics
one and then all	fair group dynamics
two at a time	fair group dynamics
one at a time	good group dynamics

Table 11. Snowmobile Use

If you use a snowmobile, what do you usually use it for?	
Answer	**Category**
tour	not extreme
travel up slopes, but nothing steep	not extreme
access purposes	somewhat extreme
necessity travel	somewhat extreme
explore	somewhat extreme
recreation	somewhat extreme
boondocking	somewhat extreme
emergency/rescue/work	very extreme
highmark	very extreme

Table 12. Terrain

What type of terrain are you most comfortable traveling on?	
Answer	**Category**
flat/touring	not extreme
10 to 15 degrees	not extreme
15 to 30 degrees	somewhat extreme
30 + degrees	very extreme

Table 13. Uncomfortable On Terrain

Have you ever traveled on terrain that made you uncomfortable?	
Answer	**Category**
no	not extreme
yes	determined in next question

Table 14. Uncomfortable On Terrain Reason

If you have been on terrain that made you uncomfortable, what was the reason?	
Answer	**Category**
exhibit caution at all times	not extreme
unintentional	somewhat extreme
following others	somewhat extreme
conditions changed	somewhat extreme
inexperience	somewhat extreme
unsure of conditions	very extreme
necessary	very extreme
challenge	very extreme
all of the above	very extreme

Table 15. Frequency on Uncomfortable Terrain

How often do you find yourself on terrain that makes you uncomfortable?	
Answer	**Category**
once or twice in part's life	not extreme
once every few years	not extreme
once or twice a season	somewhat extreme
frequently	very extreme
almost always	very extreme

Table 16. Travel Goals

What are your goals for travel in the backcountry?	
Answer	**Category**
solitude	not extreme
time outdoors	not extreme
film	not extreme
money (cheap)	not extreme
snow science	not extreme
necessity travel	somewhat extreme
access	somewhat extreme
recreation	somewhat extreme
ski	somewhat extreme
exercise	somewhat extreme
explore	somewhat extreme
get fresh tracks	very extreme
challenge	very extreme
guide/work	very extreme
all of the above	very extreme

Table 17. Involvement Level for Participants Who Have Been Involved in and Avalanche Accident

Involvement Level for Participants Who Have Been Involved in and Accident	
Answer	**Category**
witnessed an accident	somewhat involved
witnessed an accident and been caught in an avalanche	very involved
Been caught in one avalanche	very involved
been caught in two or more avalanches	very involved

Appendix C

Tables and Figures

Table 1: Websites

Websites	Frequency	Percent
adn website	1	0.1
assa website	1	0.4
compatriotsnowboards.com	1	0.1
life-link	1	0.1
Mountaineering Club of Alaska	1	0.1
NATO	1	0.1
ski reports	1	0.1
sledheads homepage	1	0.1
teletrax	1	0.1
tetongravity.com	1	0.1
transworldsnowboarding.com	1	0.1
Anchorage Daily News	2	0.2
backcountrymagazine.com	2	0.2
ultimatesnowmobiler.com	2	0.2
theskiersjournal.com	3	0.3
snowmobilenews.com	4	0.4
snowboarder.com	5	0.5
snowmobileforum.com	8	0.8
aksnow.org	9	0.9
internet search	10	1.0
telemarktalk.com	12	1.2
telemarkskier.com	22	2.2
forum.baart.us	31	3.1
earnyourturns.com	34	3.4
powdermag.com	35	3.5
snowboardermag.com	38	3.8
offpistemag.com	50	5.0
snowest.com	112	11.1
telemarktips.com	262	26.0
couloirmag.com	354	35.2
Total	**1006**	**100**

Table 2: Country Participant Recreates In.

Country	Frequency	Percent
Austrailia	1	0.1
Finland	1	0.1
Holland	1	0.1
New Zealand	1	0.1
Russia	1	0.1
Slovakia	1	0.1
Slovenia	1	0.1
Austria	2	0.1
Chile	2	0.1
Europe	2	0.1
Japan	2	0.1
Sweden	2	0.1
United Kingdom	2	0.1
Scotland	4	0.3
Switzerland	4	0.3
Italy	6	0.4
Norway	8	0.6
France	9	0.6
Canada	123	8.8
United States	1222	87.6
Total	1395	100

Table 3: State/Provice Participant Recreates In.

State/Province	Frequency	Percent
Colorado	241	17.945
Montana	199	14.818
California	164	12.211
Washington	146	10.871
Utah	99	7.372
British Columbia	86	6.404
Alaska	84	6.255
Wyoming	62	4.617
Idaho	53	3.946
Oregon	45	3.351
New Hampshire	33	2.457
Alberta	25	1.862
New York	22	1.638
Vermont	19	1.415
Nevada	15	1.117
New Mexico	10	0.745
Minnesota	6	0.447
Massechusetts	5	0.372
Maine	4	0.298
Michigan	4	0.298
Quebec	4	0.298
Yukon	3	0.223
New Jersey	2	0.149
Pennslyvania	2	0.149
Wisconsin	2	0.149
West Virginia	2	0.149
Arizona	1	0.074
North Carolina	1	0.074
Nebraska	1	0.074
Nova Scotia	1	0.074
Ontario	1	0.074
Virginia	1	0.074
Total	1343	100

Appendix D

Table 1. Logistic Regression: Age Range vs. Avalanche Accident Involvement

Logistic Regression							
		B	S.E.	Wald	df	Sig.	Exp(B)
Age Ranges Of Participant's	25-29 (ref. value)			27.690	7	0.000	
	<20	0.432	0.360	1.439	1	0.230	1.540
	20-24	0.089	0.222	0.161	1	0.688	1.093
	30-34	-0.096	0.179	0.287	1	0.592	0.908
	35-39	-0.256	0.204	1.570	1	0.210	0.774
	40-44	-0.614	0.203	9.184	1	0.002	0.541
	45-49	-0.393	0.209	3.535	1	0.060	0.675
	>49	-0.787	0.218	13.054	1	0.000	0.455
	Constant	0.932	0.124	56.652	1	0.000	2.538

Table 2. Logistic Regression: Travel Method vs. Avalanche Accident Involvement

Logistic Regression							
		B	S.E.	Wald	df	Sig.	Exp(B)
Travel Method (splitboard, nordic and foot combined as described in Procedures	snowmobile (ref. value)			21.594	5	0.001	
	alpine	0.179	0.256	0.488	1	0.485	1.196
	randonee	-0.151	0.199	0.571	1	0.450	0.860
	snowboard	0.631	0.233	7.329	1	0.007	1.880
	snowshoe	1.206	0.465	6.737	1	0.009	3.341
	telemark	-0.031	0.174	0.032	1	0.859	0.970
	Constant	0.639	0.152	17.618	1	0.000	1.894

Table 3. Logistic Regression: Training Level vs. Avalanche Accident Involvement

Logistic Regression							
		B	S.E.	Wald	df	Sig.	Exp(B)
Participant's Avalanche Training Rating Level	basic (ref. value)			202.917	2	0.000	
	aware	0.575	0.157	13.343	1	0.000	1.777
	advanced	-1.457	0.150	94.750	1	0.000	0.233
	constant	1.016	0.112	82.564	1	0.000	2.761

Table 4. Logistic Regression: Training Level of Those Involved vs. Level of Avalanche Accident Involvement

Logistic Regression							
		B	S.E.	Wald	df	Sig.	Exp(B)
Participant's Avalanche Training Rating Level	basic (ref. value)			15.986	2	0	
	aware	-0.352	0.28	1.577	1	0.209	0.703
	advanced	0.578	0.239	5.86	1	0.015	1.782
	constant	0.352	0.195	3.278	1	0.07	1.422

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