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Avalanche fatalities in the western United States: a comparison of three databases

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Abstract Reported avalanche fatalities in the United States increased markedly through the latter half of the twentieth century, a result of the increasing popularity of winter sports. Despite this increase, the literature concerning US avalanche fatalities is sparse. This paper presents a comparison of three US databases containing avalanche fatality information: *Storm Data*, the West Wide Avalanche Network (WWAN) dataset, and the National Avalanche Database (NAD). The frequency of avalanche fatalities, their temporal trends, spatial distributions, and the demographic characteristics of the victims were analyzed in each database for the years 1998–2009 for the US mountainous west. The data were then pooled to arrive at an estimate of avalanche fatality frequency in the United States for the study period. While the results indicate a considerable amount of overlap between the datasets, *Storm Data* reports fewer avalanche fatalities than both the WWAN and NAD datasets. All three datasets report a maximum of fatalities in January and display three spatial maxima: the Rocky Mountains of west-central Colorado, the intermountain region from central Utah through Idaho to west-central Montana, and the northern Cascade Ranges of Washington; however, a large void appears in the *Storm Data* records in the vicinity of the Montana maximum. These maxima result from a juxtaposition of avalanche hazard in these mountainous environments with a high concentration of winter sports activities.

Keywords Avalanches · Hazards · Fatalities · Hazard vulnerability

1 Introduction

Avalanches are flowing masses of snow that move rapidly downhill and are a prevalent threat in the mountainous regions of the western United States (Mock and Birkeland 2000;

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Birkeland and Mock 2001; Abbott 2007). Avalanches are most likely on slopes greater than 25° with sparse tree cover (McClung 2003; Grimsdottir and McClung 2006) and can be triggered by myriad stimuli, including: natural triggers such as precipitation, rapid warming, and cornice fall as well as artificial triggers such as vehicles, explosives, and humans on foot.

Avalanches cause economic losses by disrupting recreational facilities, blocking transportation routes, occasionally destroying property, and through expensive rescue efforts of stranded victims (Mock and Birkeland 2000; Birkeland and Mock 2001; Stethem et al. 2003). Additionally, avalanches pose a grave threat to persons engaged in work or recreation in mountainous regions.

Research concerning avalanche fatalities in the US is sparse. In the most extensive study, Page et al. (1999) examined in detail avalanche fatalities in the United States from 1950 to 1994. Using the National Avalanche Database (NAD), they identified 440 fatalities caused by 324 avalanche events during the study period. Avalanche deaths increased throughout the study period, particularly from 1975 to 1994, which they attributed to the increasing popularity of winter sports activities. The victims' average age was approximately 28 years and ranged from 6 to 61 years old; a vast majority of the victims were males (87%). Climbers accounted for the largest percentage of victims (25.5%), followed by backcountry skiers (22.7%), out-of-bounds skiers (10%), and snowmobilers (6.8%). Persons engaged in these activities usually travel into remote regions where avalanche hazard may not be controlled; consequently, they may be at greater risk to perish in an avalanche (Page et al. 1999). Avalanche fatalities occurred year-round, but were most common from November to April, with a maximum in February. The largest number of avalanche fatalities occurred in the state of Colorado (145), trailed by Washington (58), Alaska (53), and Utah (39).

While Page et al's (1999) findings indicated an upward trend in avalanche fatalities, it should be noted that the number of deaths decreased markedly for in-bounds skiers, drivers, and workers. This may indicate that avalanche mitigation techniques, such as use of explosives to prevent unstable snow packs and educational programs, might have a greater positive impact on these particular sub-groups of the population (Page et al. 1999).

The purpose of this research is to assess two US databases containing avalanche information, *Storm Data* and the West Wide Avalanche Network (WWAN) data available at avalanche.org, and compare them to the NAD employed in the Page et al. study. These three databases are then pooled to arrive at a "best estimate" of annual avalanche mortality in the western United States for the months October–April for the years 1998–2009. The spatiotemporal distributions of these fatalities are defined, and the demographics and activities of the victims are assessed.

2 Data

2.1 *Storm Data*

Storm Data fatality reports are compiled by National Weather Service (NWS) forecast offices from a variety of sources, including law enforcement officials, storm spotters, and from media reports (Dixon et al. 2005). These data are collected by the National Climatic Data Center (NCDC), which then makes the information available as a publication and through their website (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms).

All fatalities listed in *Storm Data* include the date, time, and the forecast area where the death occurred. Nearly all *Storm Data* entries are accompanied by a narrative text that gives a more detailed description of the storm event and fatalities that occurred in conjunction with the storm event (Dixon et al. 2005). The narrative text usually lists the victim's age, gender, and specific location where the fatal injury occurred (e.g., outdoors, in permanent home). The narrative also includes additional details concerning the fatality. For example, an avalanche fatality entry in *Storm Data* might state that the victim was skiing when the fatal avalanche event occurred (Table 1). Other activity categories for avalanche-related deaths mentioned in *Storm Data* include snowboarding, snowshoeing, snowmobiling, climbing, hiking, and other activity types such as workers and drivers; the latter two activity types were mentioned infrequently (Table 1).

The NWS considers any downhill snow movement an avalanche (even if a clean-up team initiates a second avalanche). These events and associated direct fatalities (people who were killed when the avalanche overtook them) are entered into *Storm Data* whenever a local NWS office receives an avalanche report via the media or an avalanche center (Peter Felsch, personal communication, 2010). Not included in *Storm Data* are indirect fatalities, which are deaths not directly attributable to the avalanche. An example of an indirect avalanche fatality is a rescue team becoming stranded in inclement conditions during the rescue attempt and subsequently perishing (Peter Felsch, personal communication, 2010).

Storm Data fatality records for "large impact events" (e.g., regional flood or tornado) are reasonably accurate (Ashley and Ashley 2008), while smaller events like lightning strikes are underreported (Curran et al. 2000; Ashley and Gilson 2009). The media are more likely to cover large, high-impact events, leading to more complete fatality records for incidents like tornadoes and hurricanes, which tend to kill more people per event, on average (Dixon et al. 2005). As the number of deaths per fatal avalanche event in the United States is relatively low (Page et al. 1999), it is possible that avalanche fatalities are under-represented in *Storm Data*.

2.2 West wide avalanche network fatality data and the national avalanche database

The WWAN is a collaborative effort by western United States avalanche centers to collect and disseminate avalanche information, which includes avalanche event reports and fatality data. The data available online through www.avalanche.org are a subset of the NAD utilized in the Page et al. (1999) study, which are maintained by the Colorado Avalanche Information Center (Janet Kellam, personal communication, 2010). These

Table 1 A qualitative summary of each database utilized in this study

Database	Years available	Demographics	Activity categories	Backcountry/out-of-bounds information
Storm Data	1993–2009	Occasionally age and gender	Included in text; ski, snowboard, snowshoe, snowmobile, climb, hike, other, unknown	Infrequently
WWAN	1998–1999 to 2009–2010	Occasionally age and gender	Ski, snowboard, snowshoe, snowmobile, climb, hike, other, unknown	Not within the database; infrequently mentioned in attached media reports
NAD	1996–2008	None	Ski, snowboard, snowshoe, snowmobile, climb, hike, other, unknown, and many assorted categories	Out-of-bounds for lift skiers but not for snowboarders; backcountry not mentioned

online data are available from the winter season of 1998 to the fall of 2009. The fatality data are organized in a manner similar to *Storm Data*. Listed for each fatality is the date and the location, which can be the closest city, or landmark.

Similar to *Storm Data,* the circumstances leading to the fatality are included in notes appended to each entry. These notes state whether the victim triggered the avalanche and the type of activity the victim was engaged in. The activity categories included in this data set are skiing, snowboarding, snowshoeing, snowmobiling, climbing, hiking, other, and unknown (Table 1). One difference between *Storm Data* and the WWAN, however, is that the WWAN sometimes includes primary source documents (for example, newspaper article or law enforcement reports) or a web link to such documents describing the incident within the event description.

The WWAN data does differ from the NAD, even though the former is a subset of the latter. The NAD does not have columns containing demographic information, while this information is included in the event narrative in the online WWAN data. Similar to both *Storm Data* and the WWAN, the activity categories included in this data set are skiing, snowboarding, snowshoeing, snowmobiling, climbing, and hiking, with many additional activity categories (Table 1). This database had a category for in-bounds skiing fatalities; however, this information was not included for snowboarders or other activity types. This database also did not specify if the fatality occurred out-of-bounds or in the backcountry. Additionally, the NAD contains slope, aspect, and other physical avalanche variables for some fatalities as columns within the dataset, while this is found in the text narrative in the WWAN.

The primary source of fatality information in these two databases is the American Avalanche Association Avalanche Incident Report forms, of which there are long and short versions (http://www.avalanche.org/research/guidelines/pdf/Form_accidentshort.pdf; http://www.nwac.us/media/uploads/documents/accidents/Avalanche_Accident_long_form.pdf). Each form type has fields for the demographics of the victim, avalanche characteristics, a summary of the events sequence that led to the avalanche, and rescue information. The long form differs from the short in that there are more detailed tables for inputting weather information, the physical characteristics of the avalanche, and areas for diagrams or pictures of the avalanche.

3 Methodology

After each of the datasets was collected from their respective sources and organized, the data were pooled to make one database. This was performed to assess and estimate the total frequency of reported avalanche fatalities. The data were examined to ascertain if there were any duplicate fatalities, which was determined by examining entries in each dataset chronologically. If the date, location, demographic information (when available), and activity at the time of death were the same for entries in at least two of the three datasets, the fatality was determined to be a duplicate. It was noted what database(s) each duplicate fatality was recorded in so that the amount of overlap between the datasets could be determined.

Descriptive statistics were used to summarize the age, gender, and activity at the time of death for each victim. The fatality data were mapped in a geographic information system to delineate the spatial distribution of avalanche fatalities in the mountainous western United States. Some avalanche fatalities identified in the databases mention the specific mountain peak where the fatality occurred. In this case, latitude and longitude coordinates from Peakbagger.com (http://www.peakbagger.com/), a website for climbing enthusiasts, were

Table 2 Unmapped avalanche fatalities due to unspecific location information, but were used in the frequency tallies

Date	Season	State	Dataset
4/16/1999	1998–1999	Alaska	All
4/30/1999	1998–1999	Alaska	All
12/29/2000	2000–2001	Colorado	WWAN
2/21/2001	2000–2001	California	WWAN and NAD
2/21/2001	2000–2001	California	WWAN and NAD
12/23/2001	2001–2002	Alaska	All
4/10/2003	2002–2003	Alaska	WWAN and NAD
1/22/2004	2003–2004	Alaska	WWAN and NAD
2/26/2004	2003–2004	Utah	WWAN and NAD
12/10/2004	2004–2005	Utah	*Storm Data*
2/17/2007	2006–2007	Utah	All
1/2/2008	2007–2008	Wyoming	All
1/28/2008	2007–2008	California	WWAN
12/14/2008	2008–2009	Colorado	WWAN
12/29/2008	2008–2009	Utah	WWAN

obtained and the fatality was mapped using these coordinates. If the county where the fatality occurred was mentioned, and the mountain peak was not, then the fatality was mapped using the county seat's coordinates. If a nearby city was listed, then the fatality was mapped using the city's coordinates. Fatalities that did not have location information below the state level or location descriptions that were too vague were not mapped; however, those entries were used in the fatality count totals (Table 2).

Because of the large degree of variability in the listed location among fatality entries, a grid composed of 80 by 80 km cells was utilized, which allowed the broad geographic patterns of the data to be displayed (Ashley 2007). The resulting fatality distribution was assessed spatially to determine the factors that account for the observed distribution of avalanche fatalities.

Each fatality was grouped into one of the following category types, based on the description included with each of the databases: climbing/hiking, skiing, snowboarding, snowmobiling, snowshoeing, and unknown/other (Table 3). Climbing and hiking were combined into one category because several fatalities were recorded as hiking in one database and climbing in the other database. Helicat skiers were placed into the skiing category because there were too few of these fatalities to analyze separately. No differentiation was made between in-bounds, out-of-bounds, and backcountry deaths, because this data was not available for many of the fatalities.

4 Results

4.1 Avalanche fatality frequency

Avalanche fatalities reported in three databases were identified, tallied, and assessed for the monthly period October–April from 1998–1999 to 2008–2009, in the mountainous western

Table 3 The categories utilized in this study and a brief description of each

Activity category	Description
Climbing/hiking	Mention of ice climbing, humans on foot on or off trails, rock climbing
Skiing	Explicitly stated the victim was a skier; also includes helicat skiers
Snowboarding	Explicitly stated the victim was snowboarder
Snowmobiling	Stated the victim was riding a snow machine
Snowshoeing	Explicitly stated the victim was snowshoeing
Unknown/other	No mention of any activity type; other activities types that were uncommon or did not fit into other categories (motorists, workers, people in homes, etc.)

Table 4 Annual frequency of avalanche fatalities as recorded in each individual database, and the "best estimate" derived from the pooled dataset

Season	*Storm Data*	WWAN	NAD	Pooled dataset ("best estimate")
1998–1999	25	31	29	31
1999–2000	12	20	20	21
2000–2001	18	32	33	34
2001–2002	20	31	32	33
2002–2003	7	28	28	28
2003–2004	12	21	21	21
2004–2005	13	25	25	26
2005–2006	14	23	24	24
2006–2007	11	20	20	20
2007–2008	23	35	34	36
2008–2009	6	27	15	27
Total	161	293	281	301

United States. Only six avalanche fatalities occurred in the eastern US (five in New Hampshire, one in New York) during the study period, so these were eliminated from analysis. In most seasons, the number of fatalities reported in the NAD and WWAN were nearly equal and exceeded the amount reported in *Storm Data* (Table 4). Eleven fatalities reported in December of 2008 in the WWAN were missing from the NAD, which might be attributable to a reporting delay or lag time in data compilation for the NAD.

The pooled or "best estimate" dataset yielded a total of 301 avalanche fatalities and 247 fatal avalanche events during the 11 season study period. Careful assessment of all fatality entries in each dataset revealed a considerable amount of duplicate fatalities, or overlap, between these three datasets (Fig. 1). Of the 301 "best estimate" fatalities, 154 deaths were present in all three datasets and 121 were reported in both the NAD and WWAN, but not in *Storm Data*. These 275 fatalities represented approximately 90% of the "best estimate" total. There were 21 fatalities that did not overlap (Fig. 1) and were present in only one of the databases: two in *Storm Data,* 14 in the WWAN, and five in the NAD; 11 of the 14 deaths identified only in the WWAN were from December of 2008.

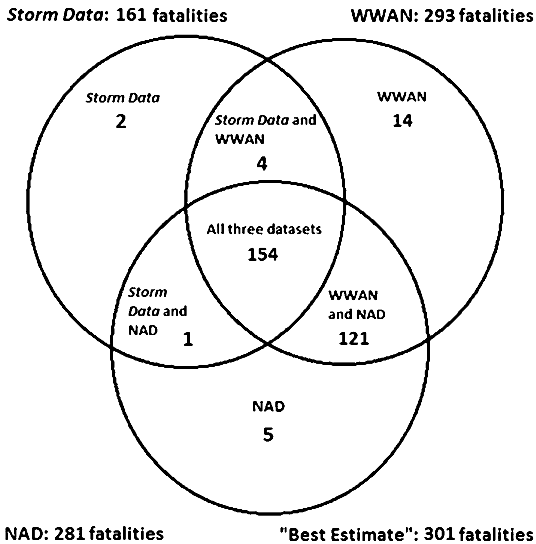

Fig. 1 The amount of overlap between the three datasets and the resultant "best estimate" of avalanche mortality for the study area and period

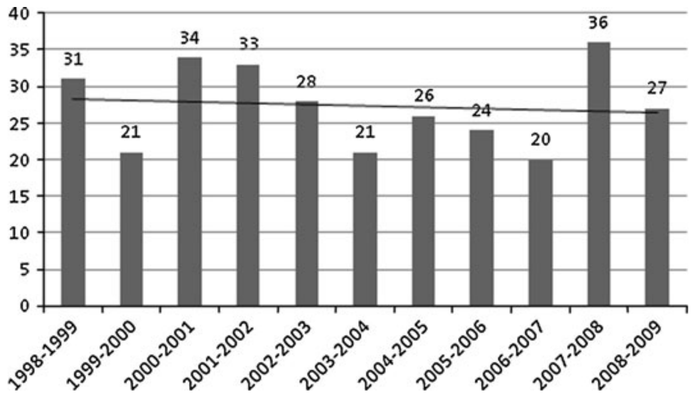

Fig. 2 The "best estimate" and trend line of seasonal avalanche fatality frequency from the pooled dataset

If the 301 fatalities within the pooled dataset are construed as the best estimate of avalanche mortality in the mountainous western United States during the study period, this represents a seasonal average of approximately 27.4 deaths. The 45-year period (1950–1994) analyzed by Page et al. (1999) yielded an annual average of nearly 10 fatalities, with the mean increasing to nearly 16 fatalities for the last 20 years of their study period. The higher annual mean reported in this study and the increased number of avalanche fatalities in the latter part of the Page et al. study likely results from increased levels of winter sport participation (Deibert et al. 1998) and better data collection procedures (Gall et al. 2009). While our period of study was too limited to make definitive conclusions in regard to the temporal trends of avalanche fatalities, the pooled dataset displayed a statistically insignificant downward trend (Fig. 2). The steady increase in fatalities found in the Page et al. study and the slight downward trend in our study suggests avalanche fatalities reached a peak in the mid to late 1990s and have begun to decline. However,

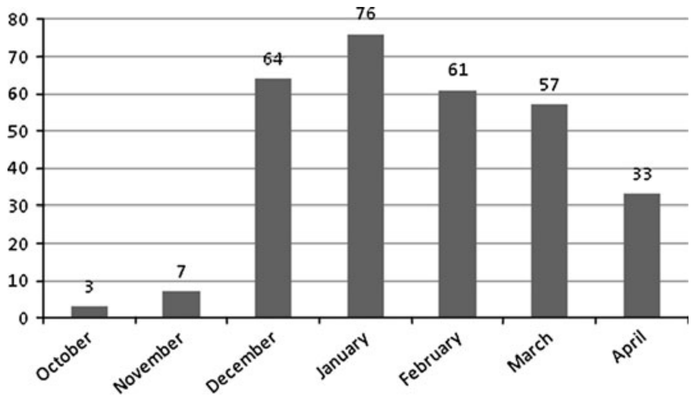

Fig. 3 Monthly frequency of avalanche fatalities from the pooled, or "best estimate", dataset

more research is needed to determine the long-term variability of avalanche fatalities and the specific factors that influence the mortality trend.

The 301 reported fatalities occurred in conjunction with 247 fatal avalanche events, a mean of 1.2 deaths per fatal event, which is similar to the results obtained by Page et al. (1999). The deadliest reported event during the period of record was an avalanche near Turnagain Pass, Alaska in March 1999 that killed six snowmobilers. There were variations in the mean number of avalanche deaths for each dataset, with a yearly average of 14.6 for *Storm Data,* 26.6 for the WWAN, and 25.5 for the NAD. During the 11-year study period, *Storm Data* missed 140 fatalities reported in the NAD and the WWAN—an underreporting percentage of 46.5%.

Fatalities were relatively low through the months of October and November, then sharply increased in the month of December (Fig. 3). Avalanche fatalities reached a peak in the month of January, steadily declined through February and March, and became less frequent in April. The December and January avalanche fatality maximum occurs during the peak months for winter sport participation in western states (Page et al. 1999). The December/January maximum reported in these three databases differs from the February peak reported in the Page et al. study.

4.2 Demographics of avalanche victims

Demographic information was available for a considerable number of entries in the WWAN and *Storm Data,* but was not contained within the NAD dataset file. Several entries within the NAD had a link to a media report (that sometimes stated the victim's demographic information), but there were too few of these to assess the demographic information within this particular dataset.

Of the 161 (293) fatalities reported in *Storm Data* (WWAN), 119 (203) included the victim's age. The mean age for fatalities listed in *Storm Data* (WWAN) was 31.5 (32.3) years of age, which is comparable to the few prior avalanche fatality studies conducted in the US and Canada (Page et al. 1999; Boyd et al. 2009). These results might imply that younger people might take greater risks while engaged in winter sports activities, or a greater number of younger people participate in these activities than older individuals (Abu-Laban 1991; Ferrera et al. 1999).

The gender of the victim was reported in 128 (264) out of 161 (293) cases in *Storm Data* (WWAN), or approximately 80% (90%) of the entries. Similar to the Page et al. (1999) study, a very high percentage of the victims in both datasets were male, with 88.2 and 93.1% in *Storm Data* and WWAN, respectively. The high percentage of male avalanche fatalities may stem from greater risk-taking behavior on the part of males (Byrnes et al. 1999), or simply that more males participate in winter sports activities (Deibert et al. 1998; Skokan et al. 2003).

4.3 Analysis of activity

Each dataset included a field stating the activity the victim was engaged in at the time of their death. This field was used to determine what activity group perished more often in avalanche events. Skiing and snowmobiling constitute the bulk of the 301 fatalities identified in the pooled dataset, with 79 and 121 deaths, respectively (Fig. 4). The number of recreational backcountry users has increased greatly in recent years, with more skiers and snowmobilers entering potentially uncontrolled avalanche territory (Stethem et al. 2003).

Snowmobiling fatalities decreased slightly throughout the study period, in contrast with recent Canadian research (Stethem et al. 2003). However, there was a considerable amount of annual variability (Fig. 5), with a maximum of 19 deaths in 2001–2002 and a minimum of four in 2004–2005. Despite the slight decrease throughout the study period, snowmobiling-related deaths accounted for approximately 40% of avalanche fatalities in the pooled dataset. In the 2002–2003 season, 60% of avalanche fatalities in British Columbia involved snowmobilers (Stethem et al. 2003). Two factors account for the high percentage of snowmobiling avalanche fatalities. The number of people accessing the backcountry has increased greatly in recent years, and modern equipment allows for easier access to alpine terrain that was once difficult to traverse (Stethem et al. 2003; Silverton et al. 2007, 2009). Additionally, we hypothesize that the weight of snowmobile can potentially trigger avalanches.

A study by Silverton et al. (2009) of 353 US winter sports participants gauged avalanche hazard perception by activity, including 46 snowmobilers. The results suggested that snowmobilers underestimated backcountry avalanche hazards more often than participants in other winter sports (with the exception of snowshoers), such as snowboarders and skiers. Additionally, snowmobilers, showshoers, out-of-bounds skiers and out-of-bounds snowboarders utilized “minimum safety practices” (partner, transceiver, and

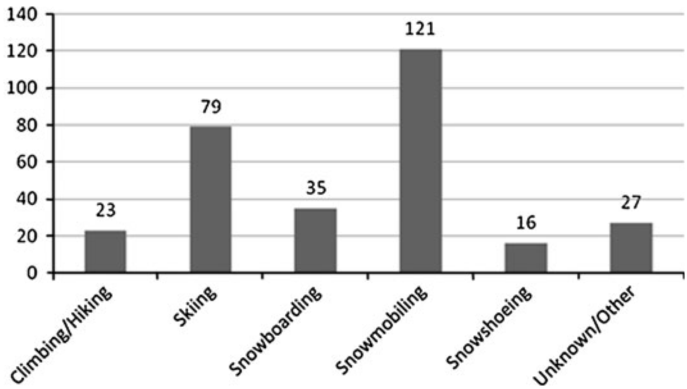

Fig. 4 Avalanche deaths stratified by activity at the time of death for the 301 fatalities of the pooled, “best estimate” dataset

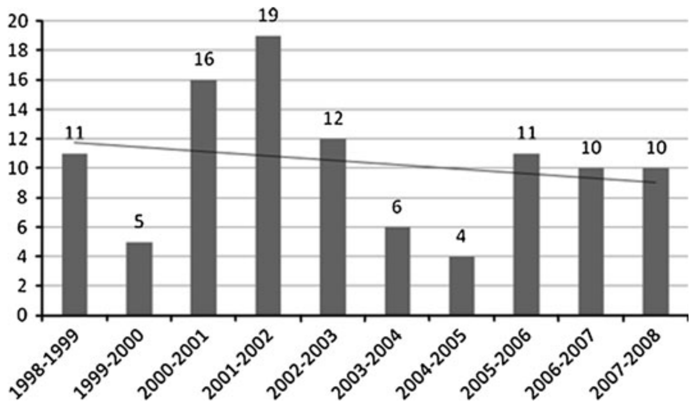

Fig. 5 Annual frequency of snowmobiling-related avalanche fatalities from the pooled, "best estimate" dataset

shovel) less often than skiers and snowboarders (Silverton et al. 2007). Targeted avalanche awareness education programs should be enacted to help remedy the decreased level of avalanche hazard awareness among participants of these recreational activities.

4.4 Spatial analysis of avalanche fatality data

The pooled "best estimate" dataset was used to delimit the spatial distribution of avalanche fatalities in the conterminous western United States for the study period. Three spatial maxima were identified (Fig. 6): the Rocky Mountains of west-central Colorado; the second in the intermountain region, from Idaho and western Montana south into Utah; and a third in the Cascades of Washington, east of Seattle. These maxima are chiefly the result of the high concentration of winter sports activities in these mountainous, avalanche-prone regions (Page et al. 1999; Mock and Birkeland 2000). Alaskan avalanche fatalities have a maximum in the northern region of the Kenai Peninsula, near the city of Anchorage (Fig. 7).

Storm Data underreported avalanche fatalities in the vicinity of the Idaho-Montana border (not illustrated). This is partially accounted for by *Storm Data's* routine undercounting of atmospheric hazard-related fatalities (Curran et al. 2000; Ashley 2007; Ashley and Black 2008). It was hypothesized that there might be NWS office-to-office variability in the *Storm Data* collection process. However, weather forecast offices follow a *Storm Data* preparation guide (Mandt 2007) and use a newspaper clipping service to identify avalanche fatalities, and this process is similar for all weather forecast offices (John Livingston, personal communication, 2010). It was also hypothesized that an avalanche fatality needed to occur in conjunction with a winter storm to be included in *Storm Data,* which could also account for its underreporting of avalanche deaths. However, all avalanche events and fatalities that are identified by weather forecast offices are reported (John Livingston, personal communication, 2010).

5 Conclusions

This study presented an analysis of avalanche fatalities in the western United States for the cool seasons 1998–99 through 2008–09. Three databases containing avalanche fatality data

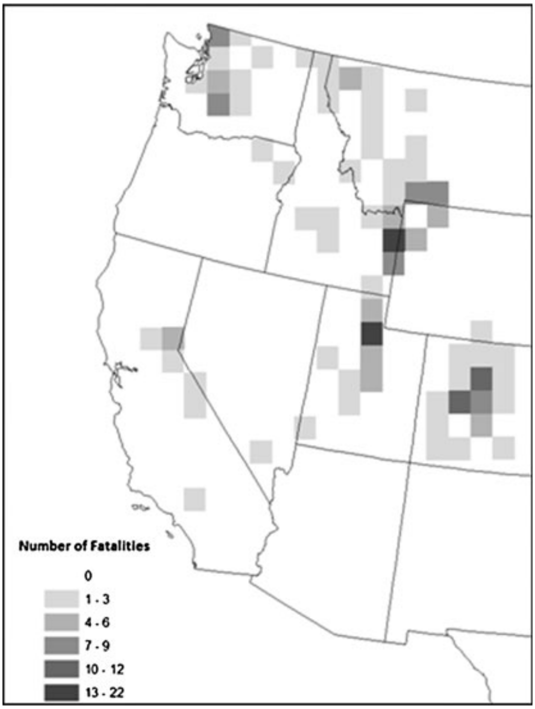

Fig. 6 The spatial distribution of avalanche fatalities in the western conterminous United States from 1998–1999 to 2008–2009 using the pooled, "best estimate" dataset. Approximately 15 of the 301 fatalities identified in our pooled dataset do not contain mountain peak, county, or municipality location information and therefore cannot be mapped. These "missing" fatalities are listed in Table 1

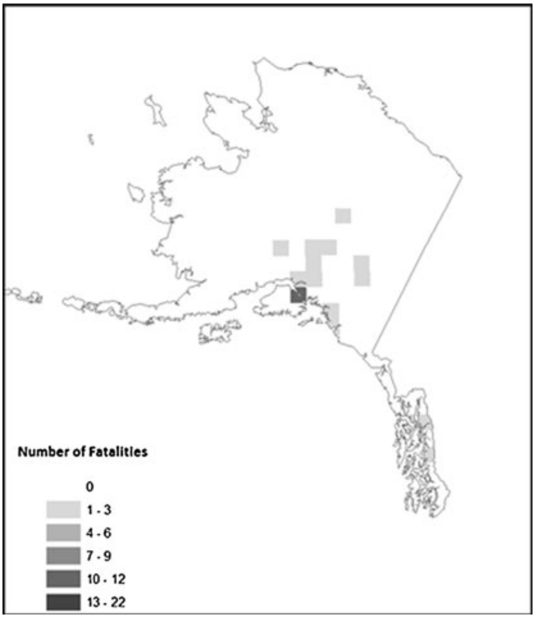

Fig. 7 Same as in Fig. 6, except for Alaskan avalanche fatalities

(*Storm Data,* WWAN, NAD) were obtained, assessed, and pooled to create a "best estimate" of avalanche mortality for the study area/period. The pooled dataset yielded an annual average of approximately 27 fatalities, with a peak in January. Two consistencies with previous avalanche research were identified, namely the higher level of male vulnerability, as well as higher numbers of skiing and snowmobiling fatalities compared to other activity types.

While these datasets are constructed and presented in similar ways, each would be useful to researchers in different fields. Researchers seeking to assess the physical characteristics of avalanches would find the WWAN and NAD to be more useful datasets, as they include variables such as slope, aspect, and avalanche distance for some fatalities, while *Storm Data* rarely includes these data. While the NAD presents these data in column format and the WWAN includes these as part of the narrative text, the WWAN is more accessible as it is available freely online.

If a *Storm Data* fatality occurred during or immediately following a storm event, a description of meteorological variables was included in the narrative text. The NAD has columns for the weather at the time of the rescue attempt (temperature, precipitation, average wind, and sky cover) and the previous 24-h weather (precipitation and average wind), but this information was not listed for all entries. Additionally, the results show that *Storm Data* underreports the number of avalanche fatalities.

The juxtaposition of avalanche prevalence in mountainous regions in the western United States and the increasing popularity of winter sports activities have led to an increase in avalanche fatalities since the 1950s. This makes it imperative to record the most accurate tallies possible for avalanche deaths. There are several improvements that can be incorporated into these databases to make them more accessible and accurate. The first improvement is better communication between the three agencies maintaining these databases. While the WWAN and the NAD contained many overlapping fatalities, *Storm Data* was missing a considerable percentage of the fatalities listed in the two former databases. Since NWS offices seek to record all avalanche fatalities reported to them from avalanche centers (Peter Felsch, personal communication, 2010), this might indicate inefficient interagency communication of these data. Gall et al. (2009) posited the creation of a centralized database for all hazard-related losses in the United States. One solution based on the previous idea is the creation of a single, centralized agency that reports all avalanche-related deaths.

Accuracy and comparability of these databases can be further increased through the adoption of standardized activity categories, which are absent on the Avalanche Incident Report forms. While most of the categories in these databases were qualitatively similar, there were inconsistencies in reporting climbing and hiking deaths. If standardized categories are not formulated, a specific decision-making process should be developed and applied to ensure that climbing and hiking fatalities are classified consistently between the three databases (or in the event a centralized avalanche database is created, one database).

The NAD has specific fields for in-bounds and out-of-bounds lift skiers, but does not have this information for other activity categories; it also does not have information stating if the fatality occurred in the backcountry. Additionally, *Storm Data* and WWAN often do not explicitly state if the fatality occurred in-bounds, out-of-bounds or in the backcountry. Listing this information in a specific field will make it more accessible. Furthermore, one avalanche fatality study (Boyd et al. 2009) utilized a classification scheme in which skiers and snowboarders were grouped into a single category. While the databases utilized skiing and snowboarding as separate categories, more research could be done to determine if the differences between these activities are significant enough to warrant two categories.

The number of people participating in recreational winter sports activities has increased considerably in recent years. Therefore, long-term, accessible records for these data, coupled with research that gauges perception of avalanche hazards, could help to mitigate these deadly events.

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