SPATIAL AND TEMPORAL ASPECTS OF THE SNOW AVALANCHE HAZARD, GLACIER NATIONAL PARK, MONTANA, U.S.A.

David R. Butler[1]

Abstract.--Since 1910, snow avalanches in Glacier National Park have been geographically widespread and numerous. Avalanche incidences have a Park-wide distribution. Twelve people have been killed, and many more injured and/or transported by avalanches. Property damage is widespread.

INTRODUCTION

Glacier National Park, located in the Rocky Mountains of northwestern Montana, is typical of many North American alpine areas. Increasing winter usage of the Park for recreational purposes occurs in an environment where steep, glaciated terrain and heavy winter precipitation produce a high snow avalanche potential (Butler 1979, 1986). High-magnitude avalanches are known to have occurred in the past (Beals 1910, Martinelli 1984, Butler 1985, Butler and Malanson 1985a, 1985b), but National Park Service officials have not produced any compilation of the dates, locations, number and nature of avalanche accidents, injuries, and deaths. It is relatively well-known that transportation lines around the southern periphery of the Park have been vulnerable to snow-avalanche disruption, and descriptions of individual avalanche disasters have been fairly common in the local press. Unfortunately, avalanche damage to property and wildlife, and human injuries and deaths from avalanches, have not been restricted to the southern part of the Park. Questions of temporal and geographic synchroneity have also been ignored.

This paper addresses the questions and gaps of information described above. An inventory and chronology of property damage, human injury and death, and wildlife fatalities from snow avalanches have been compiled and the location of each incidence has been mapped. The inventory and chronology covers the complete Glacier National Park area, including transportation links along its southern border, for the period 1910 (the year of the establishment of the Park) to 1985.

THE STUDY AREA

An ongoing research project in Glacier National Park, Montana, U.S.A., is examining geomorphic and meteorologic differences in avalanche type and timing, west and east of the Continental Divide (fig. 1). Previous works there have examined the distribution and gross morphology of avalanche sites (Butler 1979, 1980, Butler and Malanson 1985a, 1985b), as well as meteorologic and climatologic aspects of the avalanche hazard (Beals 1910, Panebaker 1982, Martinelli 1984, Butler 1986). Dry loose snow, wet snow, and slab avalanches occur in the Park, resulting from a variety of meteorologic trigger mechanisms (Butler 1986).

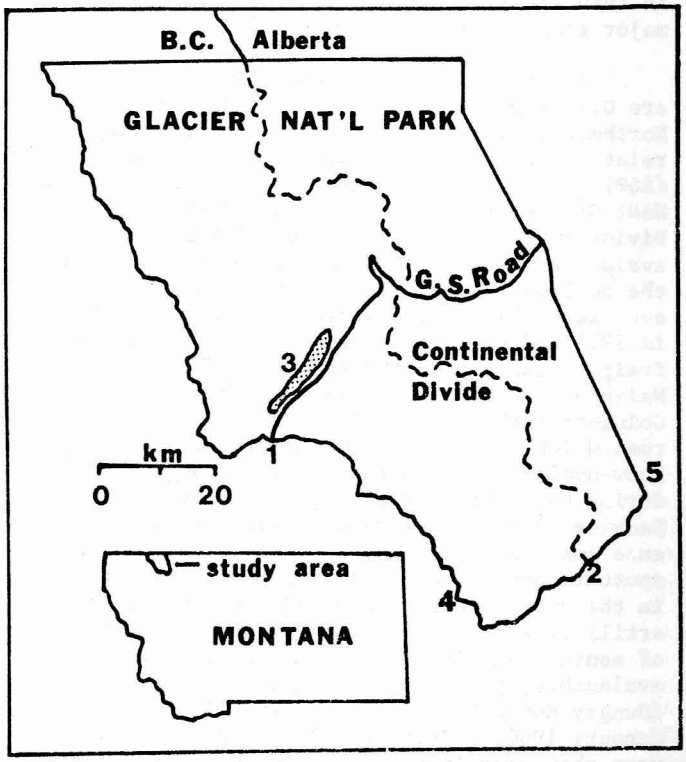

Figure 1.--Location of the study area. Numbers refer to major locations and landmarks: 1, West Glacier; 2, Summit; 3, Lake McDonald; 4, Essex; 5, East Glacier Park.

[1]David R. Butler is Assistant Professor of Geography, University of Georgia, Athens, Georgia.

The Park area was heavily glaciated during the Pleistocene and Holocene, resulting in the spectacular alpine scenery. Most major glacial valleys of the Park are oriented northeast-southwest. Slopes above the valley bottoms are steep, often in excess of 30-40°. Large snow catchment basins occur in ravines and cirques, and on leeward slopes.

Marked differences exist in the climatic conditions on the western and eastern sides of the Park (Dightman 1967). The climate of the Park may be broadly classified as continental; however, there are distinct Pacific maritime modifications on the western slopes. Snow accumulations in the high mountain areas of the Park may exceed 280 cm/yr, produced by orographic uplifting of Pacific storms. Winds are predominantly from the west, resulting in the development of snow cornices on slopes with a southeasterly aspect (which in turn are a result of the orientation of the major glacial valleys; Butler 1979).

The major transportation links in the area are U.S. Highway Number 2 (US 2) and the Burlington Northern railroad, both of which connect the relatively isolated community of East Glacier Park (EGP) with Glacier National Park headquarters in West Glacier (fig. 1). From the Continental Divide at Summit to the hamlet of Essex, the snow-avalanche hazard from steep slopes above US2 and the railroad is especially noteworthy. A daily average of 714 vehicles used US2 through this area in 1977 and two Amtrak passenger trains and several freight trains pass through daily (Butler and Malanson 1985a). The only cross-Park road is Going-to-the-Sun Road (GS Road), a narrow two-lane road which is not kept open during winter (fig. 1). Snow-avalanche potential is high along GS Road during the period of spring snow clearance. Because of dangerous conditions, Park snow clearance operations utilize radio-equipped avalanche spotters positioned along the road. Park officials in the past have experimented with the use of artillery for blasting snow cornices, and the use of sonic booms from low-flying jets to trigger avalanches, prior to road-clearing operations (Hungry Horse News 26 April 1957, 3 May 1957, 22 January 1960, 5 February 1960). Both techniques were abandoned in the early 1960s as incongruous with Park Service philosophy.

Glacier National Park and the US2 region are a part of the Northwest Montana Avalanche Warning System (Panebaker 1985). This system provides a weekly assessment of local avalanche conditions, broadcast each Friday morning during the avalanche-prone winter and spring months. Current conditions may also be heard on local area radio, or by calling a pre-recorded message at Glacier Park headquarters;unfortunately, this is billed as a long-distance call for residents of EGP. Furthermore, Heywood and Tufnell (1985) have illustrated the problems with non-site-specific forecasts.

STUDY DESIGN AND PROCEDURES

Statistics on the time, location, and nature of snow-avalanche property damage, human impacts, and animal fatalities have been compiled for the 75-year period, 1910-1985. Data sources included Glacier National Park Ranger daily logbook entries and monthly report summaries, for the available years 1925, 1931, and 1933-1965; annual reports of the Superintendent of the Park, covering the years 1910-1926, and 1929-1932; U.S. Government monthly weather summaries, for the months December-May, 1910-1984 (Monthly Weather Review, Vols. 38-78, 1910-1950; Climatological Data, Montana, Vols. 35-61, 1923-1958; and Storm Data, Vols. 1-26, 1959-1984); unpublished letters, files, photographs, and slides on file in the Glacier National Park library; reminisces of Park historical figures (Laut 1926, Brooks 1983, Yenne 1983); information from the Montana Department of Highways; and every December through May issue, 1946-1985, of the Hungry Horse News, a local weekly newspaper published since 1946 in Columbia Falls, Montana. This newspaper (hereafter abbreviated HHN) provides local accounts of avalanche occurrences of a size or timing significant enough to affect local transportation and tourism.

The location of every reported incidence of human victimization and/or property damage was plotted on a Park map (fig. 2). The month and year of occurrence of all incidences of human victimization, property damage, and wildlife death by avalanches were recorded and categorized. Years with high number of avalanche incidences were noted, and a series of maps was generated on which the distribution of large avalanche events during major avalanche winters was plotted. One such map, for the winter of 1938-1939, is included here as representative (fig. 3). The complete series is available on request from the author.

Property damage statistics were organized into categories. Impacts to human life were categorized by activity during avalanche encounter. Because of the non-specific nature of some historical data (for example, simply reporting that "several" people were involved in an avalanche accident), the human incidence figures are regarded as a minimum. The data on human impact, property damage, and wildlife death were tabulated by month to determine if monthly concentrations of the avalanche hazard exist.

RESULTS

Major Avalanche Winters: Distribution and Inventory

Since 1910, snow avalanches in Glacier National Park have been geographically widespread and especially numerous in the winters of 1909-1910, 1912-1913, 1924-1925, 1928-1929, 1932-1933, 1935-1936, 1938-1939, 1944-1945, 1948-1949, 1949-1950, 1951-1952, 1953-1954, 1955-1956, 1956-1957, 1962-1963, 1971-1972, 1974-1975, 1978-1979, and 1981-1982. This chronology is derived from the data set

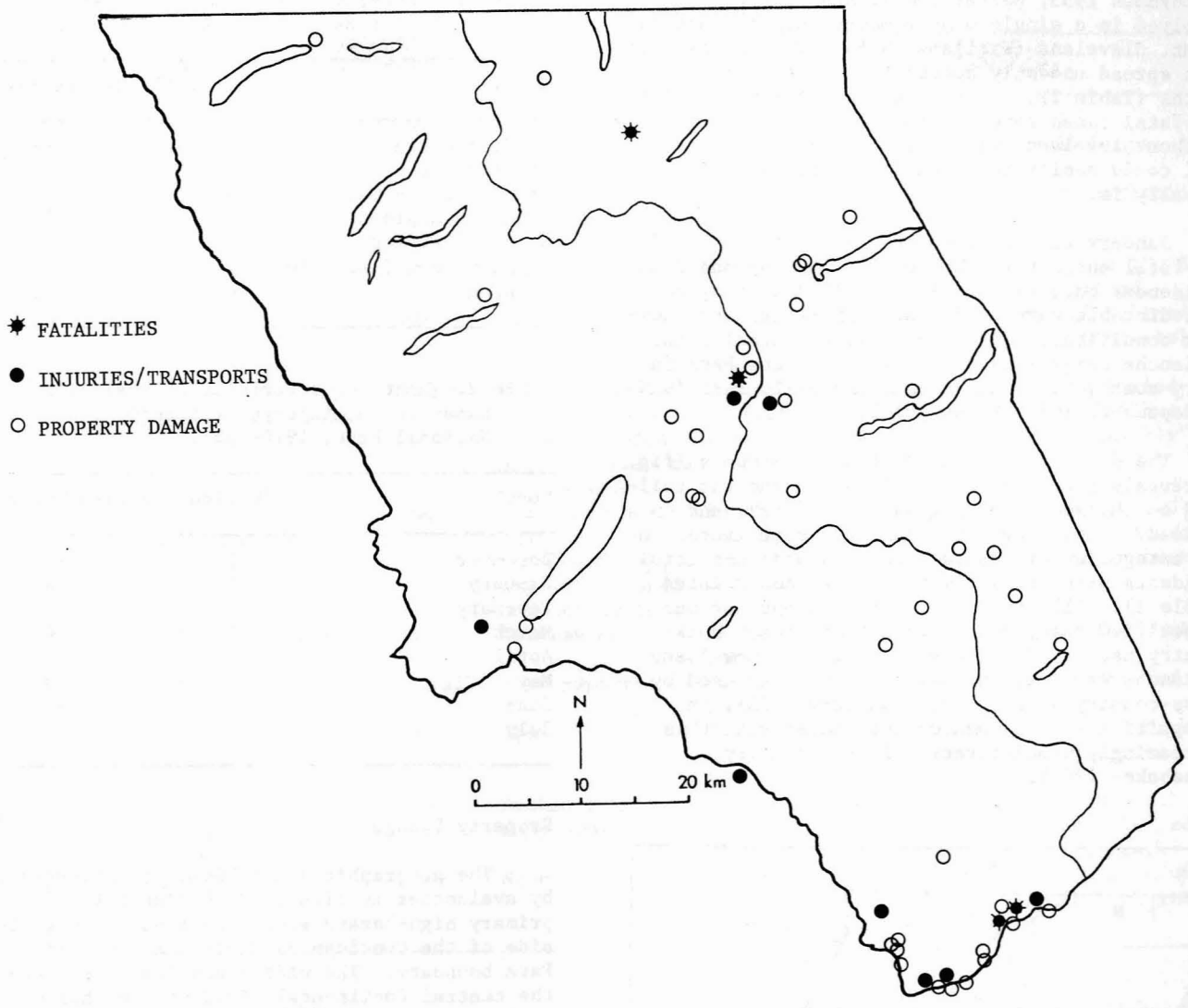

Figure 2.--Locations of snow avalanche accidents in Glacier National Park, 1910-1985. Map does not show one unspecified location of a burial incident, and six unspecified locations of property damage along U.S. Highway 2.

cited above, and also from tree-ring records extracted from damaged conifers along the margins of Park avalanche paths with little or no historical documentation (Butler 1979, 1985, 1986, Butler and Malanson 1985a, 1985b).

The plotting of the location of avalanche incidences by winter reveals both the Park-wide distribution of the hazard, and the Park-wide synchroneity of major avalanche winters (e.g., fig. 3). Microclimatic conditions, although probably responsible for differences in the types of snow avalanches at specific sites west and east of the Continental Divide, do not overcome the effects of regional circulation patterns which result in winters with synchronous, widespread avalanches. A prime example of widespread and synchronous avalanching occurred on 13-14 February 1979, when "just about every place in the park that can avalanche has avalanched yesterday and today" (Great Falls Tribune, 14 February 1979, p. 1).

Human Impact

Twelve people have been killed by avalanches during the period of study. The locations of these disasters (fig. 2), each a multiple-victim event, reveal that avalanche fatalities have occurred across the Park, west and east of the Continental Divide. Of those killed (Table 1), five were involved in rail transportation along the southern Park boundary (Beals 1910, Atkinson and Atkinson 1985), two were clearing snow from GS Road

(Anonymous 1953, Walter 1983), and five were involved in a single winter mountaineering accident on Mt. Cleveland (Williams 1975). The deaths have been spread unevenly across the winter and spring months (Table 2). An examination of some specific non-fatal cases reveals the incredible good fortune of those involved (Table 3); clearly, the fatality toll could easily be double or triple what it actually is.

January has produced the greatest number of non-fatal encounters (Table 2). The May and July incidences occurred on GS Road, illustrating the unpredictable nature of mountain weather and snowpack conditions. With such unstable conditions, avalanche hazards exist somewhere in the Park in every month, including summer and early fall (HHN 18 September 1985, Payne 1918).

The distribution of non-fatal accidents (fig. 2) reveals a concentration along US2 and the railroad on the southern margins of the Park, and on GS Road. This geographic pattern is reflected in the categories of mountain terrain use; non-fatal accidents were primarily transportation-related (Table 1). All other accidents, except for one unspecified case, were a result of winter backcountry usage. Park Service officials now issue avalanche warnings for backcountry areas used by cross-country skiers (HHN 5 January 1978), in recognition of the hazards associated with this increasingly popular recreational activity (Panebaker 1985).

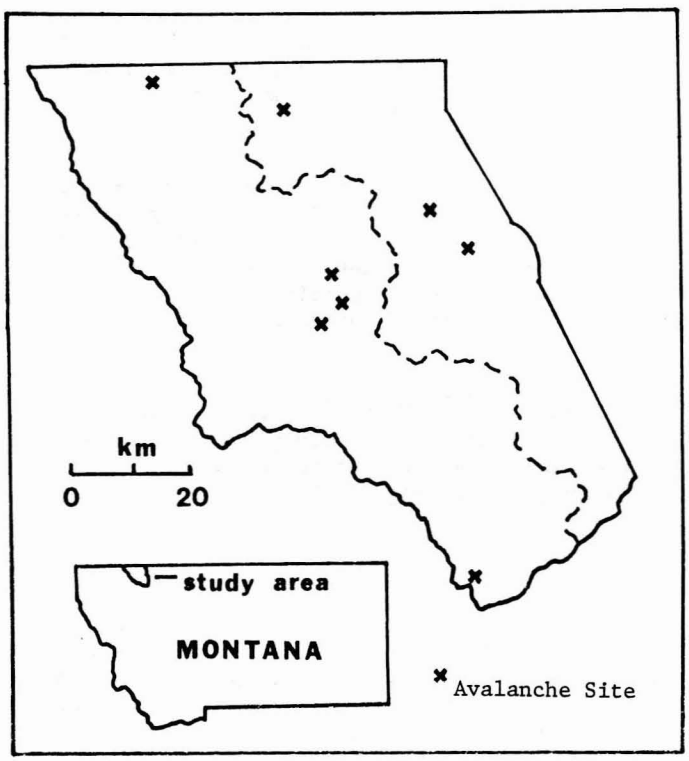

Figure 3.--Distribution of high-magnitude snow avalanches, winter of 1938-1939.

Table 1.--Activity categories of avalanche victims in Glacier National Park, 1910-1985.

Activity	#Killed	#Injured/Transported
Mountaineering	5	--
Snowshoeing	-	1
Cross-country Skiing	-	1
Railroad Employee	5	12
Highway Driving	-	7
Highway Snow Clearance	2	6
Unknown	-	1

Table 2.--Month of occurrence of avalanches causing human death, injury, or transport in Glacier National Park, 1910-1985.

Month	#Killed	#Injured/Transported
December	5	--
January	2	14
February	-	4
March	3	4
April	-	--
May	2	3
June	-	--
July	-	5

Property Damage

The geographic distribution of property damage by avalanches is clearly Park-wide (fig. 2). Two primary high-hazard areas stand out; along either side of the Continental Divide, and the southern Park boundary. The widespread damage throughout the central Continental Divide region has not been explicitly recognized. The damage in the US2 region has been more accurately documented (Beals 1910, Panebaker 1982, Martinelli 1984, Atkinson and Atkinson 1985, Butler and Malanson 1985a, 1985b), but has not been presented in summary map form.

Categories of property damage by avalanches are diverse, but fall into five major categories: 14 buildings (7 cottages/cabins, 6 chalets, and 1 boat storage shed); 7 transport-related facilities (4 bridges, 2 snowsheds, 1 highway); 10 trails and campsites (8 trails and 2 campsites); 23 transport conveyances (8 trucks, 7 cars, 4 trains, 3 snowplows, and 1 boat); and 6 communication lines (5 telephone lines and 1 telephone microwave tower). Damage occurs throughout the winter and spring seasons: for those with known months of occurrence, January, 14 cases; February, 9; March, 10; April, 5; May, 3; and July, 3. A sharp drop-off obviously occurs coinciding with the onset of spring. Property damage has been much more widespread than is commonly realized (Table 4), and several historic structures in the Park have been damaged or destroyed.

Table 3.--Survivors of Avalanche Transport and/or Burial

Date	Locality	Number Involved	Injuries	Activity
22 Jan 1910	Snowslip, US2	"Several"	Unspecified	Railway workers.
Winter 1912	Unspecified	One	Unspecified	Ranger on patrol, buried for 24 hours, dug his way out unaided.
4Mar 1929	Snowshed 5, US2 Region	Four	3 or 4 injured, injuries not specified	Mail clerks on train, buried by avalanche which killed three.
Feb 1933	Scalplock Mountain	One	Minor sprains & frostbite	Ranger on snowshoe patrol; carried 200 feet, buried 25 hours, dug way out unaided.
Feb 1949	US2, near Coal Creek	One	Not injured	Driving auto; avalanche came off hillside, flowed under car and lifted it completely off the ground.
Jan 1950	Unspecified snowshed, US2 area	Three	Bruises and sprained knee for non-buried man; 1 buried man unconscious	Snowplow operation on US2; 2 men buried under 12 feet of snow and ice, one rolled but not buried; one buried man reached "quickly", one after 1 hour and 20 minutes.
26 May 1953	GS Road, 5 miles W of Logan Pass	Two	1 man seriously injured, retired on disability; 1 man not injured but unconscious	Road snow clearance; injured man buried for for 1½ hours; uninjured man unconscious and buried under 7½ feet of snow for 7½ hours, returned to work in June.
Jan 1954	Windy Point, US2	One	"Shaken up"	Railway signal man, carried 100 feet but not buried.
July 1954	GS Road	"Several"	None reported	Automobile motorists, avalanche hit and damaged private cars.
29 Feb 1956	West end, snowshed #11, US2 area	One	None	Railway engineer, snowslide broke into engine cab, pinning engineer with snow against wall. Dug out by cab fireman.
May 1964	"Big Drift", GS Road E of Logan Pass	One	Broken ribs & many bruises	Snow clearance on GS Road. Snocat with operator inside carried 500 feet, rolled over six times, coming to rest upside down.
7 Feb 1979	Apgar Mountain	One	None	Cross-country skier, carried 100 feet when slab avalanche occurred beneath him; remained on surface throughout transport.

Wildlife Destruction by Avalanches

Wildlife fatalities have not been considered in typical avalanche-hazard studies; nevertheless, compilation of statistics on the number and date of carcass deposition in avalanche run-out zones provides significant additional data on locations and occurrences of large-scale avalanches. Over forty reported wild-animal deaths by avalanche have been recorded in the Park, certainly a minimum figure because of a general paucity of on-site observations except in the US2 region. A few additional statistics were compiled from reports of Park Rangers on winter backcountry patrols (HHN 1 Feb 1952, 9 Mar 1956, 15 Feb 1957, 19 Mar 1981, 28 Jan 1982; Unpublished Park Ranger monthly reports, Lake McDonald Mar 1935, Walton Jan 1939, Polebridge Jan 1939, Nyack Jan & Mar 1945, Marias District Mar 1950).

Wildlife killed include elk (Cervus canadensis), mule deer (Odocoileus hemionus), whitetail deer (O. virginianus), mountain goat (Oreamnos americanus), and bighorn sheep (Ovis canadensis). The majority of animal destruction occurs during the same January-March avalanche period described above. This temporal pattern of wildlife destruction must be interpreted cautiously, because of the limited number and areal coverage of observations. Nevertheless, the coincidence of the timing of wildlife fatalities and maximum property damage reinforces the primary hazard period of January through March.

Periods of Highway and Rail Blockage by Avalanches

Butler and Malanson (1985a) have listed winters in the US2 region in which major periods of highway and/or rail blockage occurred. On average, clearance of the rail lines is accomplished more rapidly than highway clearance, at least partially assisted by the presence of snowsheds which keep portions of the railroad tracks snow-free. Unfortunately, snow avalanches seem in some cases to be deflected toward and onto the highway by the sheds (Butler and Malanson 1985a, HHN 21 Mar 1985).

Prior to 1979, the Montana Department of Highways did not keep records of periods of closure caused by avalanches. A reconstruction of road closures and railroad track blockages per winter (Table 5) reveals the ongoing nature of the avalanche damage in the area (data on railway blockages

Table 4.--Historical Highlights, Property Damage by Avalanche

Winter	Details	References
1912-1913	Chalet C, Many Glacier area, demolished	Ober 1973, Glacier Park Foundation 1985
1915-1916	Gunsight Chalets (1 dormitory, 1 dining room) destroyed	Historic Research Association 1980
1925-1926	All Park telephone lines torn down	Kraebel 1925
1928-1929	Phone and telegraph lines down, train derailed	Atkinson and Atkinson 1985
1932-1933	Bear Creek bridge on US2, and "several" others, destroyed	Yenne 1983
1938-1939	Chalet G, Many Glacier area, damaged; phone lines along Lake Janet, and along Rose Creek area down	Unpublished Monthly Ranger Station Reports; Jan, Many Glacier and Waterton, Feb, St. Mary.
1945-1946	Kintla Lake snowshoe cabin damaged	Unpublished Monthly Ranger Station Report, Mar, Logging Station
1949-1950	Train engine derailed; bulldozer buried and pick-up truck destroyed on US2	HHN 20 Jan 1950, 27 Jan 1950
1951-1952	125 feet of railroad snowshed crushed; tanker truck crashed into slide on US2	HHN 18 Jan 1952, 7 Mar 1952
1952-1953	Rotary snowplow destroyed in fatal accident on GS Road	Walter 1983
1953-1954	Campsite destroyed, Two Medicine area; cottages destroyed, Waterton townsite; trans-Park phone lines down	Brooks 1983, HHN 19 Feb 1954, 9 Apr 1954, 7 May 1954
1955-1956	Train engine damaged, 60% of snowshed #11 destroyed	HHN 2 Mar 1956, 9 Mar 1956
1959-1960	Sperry Chalet damaged	Unpublished letter, from Ms. K. Luding to Park officials, 1972
1963-1964	Bulldozer tractor rolled 500 feet, landing on its roof at "Big Drift" on GS Road	Unpublished Monthly Report, West Lakes District Ranger, May 1964
1970-1971	Two trucks collide after one is stuck in a snowslide	HHN 15 Jan 1971
1974-1975	Avalanche smashes boat house, damages boat at Josephine Lake	HHN 28 Feb 1975
1978-1979	Goat Lick bridge on US2 destroyed; phone lines down in US2 area	HHN 15 Feb 1979, Panebaker 1982, Martinelli 1984
1981-1982	Jersey barrier for new Goat Lick bridge cracked and pushed out of alignment; US2 guardrails destroyed; microwave phone tower damaged, equipment hut destroyed	HHN 28 Jan 1982, Martinelli 1984

were sparse, and should be regarded as minimum figures). The winters of 1932-33 (many days blockage, a highway bridge destroyed), 1949-50 (highway closed over one month), 1955-56 (US2 blocked eleven straight days), 1956-57 (US2 blocked ten days), 1971-72 (US2 closed almost one month), and 1978-79 (destruction of Goat Lick bridge closes US2 for one month with attendant 300 km detour) were especially noteworthy. Prior to the completion of US2 in 1930, roads on the periphery of the Park were also periodically closed by avalanches (Kraebel 1925).

Economic losses suffered because of highway and rail closures have been serious, although no dollar values have been assigned. During the US2 blockage of February 1950, the West Glacier Lion's Club complained to the Governor of Montana that the closure was "seriously interfering" with the business and travel economy of the area (HHN 17 Feb 1950). The Governor promised action, and plows started re-opening the road almost immediately. At other times, the economic frustrations caused by the highway closures resulted in editorials in the local press (HHN 9 Mar 1956, 15 Feb 1957, 1 Mar 1957) in favor of increased expenditures for highway relocation, bridging, and showshed construction on US2. At one point, the HHN actively campaigned for an alternative route to connect the western side of the Park with an existing route in Canada, stating "something to keep in mind is that the proposed Akamina road into Canada offers a route that has less avalanche prospect. It is a lower crossing of the continental divide than offered by U.S. No. 2, and the valley has more U than V characteristics" (HHN 16 Mar 1956, p. 2). It is clear from these examples that economic losses from avalanches, though unspecified as to amount, are of considerable local significance.

CONCLUSIONS

This paper has shown that major hazards exist from avalanches for winter and spring users of Glacier National Park, Montana. The categories of damage described are only part of the economic damage produced by avalanching, because road and

rail closures which do not always result in human injury or property damage cause additional hardships and loss of income for the area. The chronology of major avalanche winters reveals that these hazards are not new, but as winter utilization of the Park increases, so does the likelihood of human impact. Major geographic hazard zones exist in the US2 region, especially in January through March; along GS Road and some backcountry trails in the spring and summer; and throughout high-mountain backcountry areas on both sides of the Continental Divide throughout the winter. The avalanche hazard is more geographically and temporally widespread than is usually perceived by Park personnel. A perception study of residents and Park employees is currently underway to more specifically examine human perception of, and response to, the avalanche hazard in Glacier National Park. Information should be disseminated to highway and railroad personnel, Park rangers, and the general user public, so that current and potential Park visitors will be more aware of the dangers of avalanches in this mountainous area.

Table 5.--Days with Road Closure and Rail Blockage in the US2 Region, Caused by Snow Avalanches

Winter	Highway[1, 2]	Railroad[2]
1909-1910		5
1928-1929		4
1935-1936	1	
1941-1942	1	
1947-1948	1	
1948-1949	10	
1949-1950	38	1
1950-1951	2	
1951-1952	5	
1953-1954	5	2
1955-1956	13	4
1956-1957	10	3
1959-1960	2	1
1962-1963	4	
1964-1965	5	
1965-1966	1	
1970-1971	1	
1971-1972	21	
1974-1975	3	
1978-1979	31	"Several days"
1981-1982	4	1
1984-1985	1	

[1]US2 opened over Continental Divide in 1930.

[2]Data sources: Beals 1910; Atkinson and Atkinson 1985; Monthly Ranger Reports, Walton Station Jan 1936, Walton Station Feb 1942, Chief Ranger's Office (West Glacier) Feb 1963, Two Medicine Station Mar 1963; HHN, various issues; Montana Department of Highways daily diaries, East Glacier, 1979-1984.

ACKNOWLEDGEMENTS

This study was partially funded by sources at Oklahoma State University, and the University of Georgia. Jack G. Oelfke assisted in the collection of field data during the summer of 1985. Collecting permits and general assistance were provided by personnel of Glacier National Park. A special thank-you is extended to Ms. Beth Ladeau, Park librarian and archivist, for her encouraging assistance and suggestions during perusal of many dusty tomes.

LITERATURE CITED

Anonymous. 1953. Report on avalanche tragedy, Going-to-the-Sun Highway, Glacier National Park. Unpublished Report, Glacier National Park Library, West Glacier.

Atkinson, G.S., and J.C. Atkinson. 1985. Izaak Walton Inn: a history of the Izaak Walton Inn and Essex, Montana. 39p. Hungry Horse News, Columbia Falls, Montana.

Beals, E.A. 1910. Avalanches in the Cascades and northern Rocky Mountains during winter of 1909-10. Monthly Weather Review 38(6): 951-957.

Brooks, A. 1983. Following Napi. 196p. Mountain States Lithographing Co., Casper.

Butler, D.R. 1979. Snow avalanche path terrain and vegetation, Glacier National Park, Montana. Arctic and Alpine Research 11(1): 17-32.

Butler, D.R. 1980. Terminal elevations of snow avalanche paths, Glacier National Park, Montana. Northwest Geology 9: 59-64.

Butler, D.R. 1985. Vegetational and geomorphic change on snow avalanche paths, Glacier National Park, Montana, U.S.A. Great Basin Naturalist 45(2): 313-317.

Butler, D.R. 1986. Snow-avalanche hazards in Glacier National Park, Montana: meteorologic and climatologic aspects. Physical Geography 7(1): 72-87.

Butler, D.R., and G.P. Malanson. 1985a. A history of high-magnitude snow avalanches, southern Glacier National Park, Montana, U.S.A. Mountain Research and Development 5(2): 175-182.

Butler, D.R., and G.P. Malanson. 1985b. A reconstruction of snow-avalanche characteristics in Montana, U.S.A., using vegetative indicators. Journal of Glaciology 31(108): 185-187.

Dightman, R.A. 1967. Climate of Glacier National Park, Montana. 11 p. Glacier Natural History Association, West Glacier, Montana.

Glacier Park Foundation. 1985. A history of Many Glacier Hotel. 36 p. Glacier Park Foundation, Minneapolis, Minnesota.

Great Falls Tribune. 1979. Major Montana route severed. p. 1. Issue of 14 February 1979. Great Falls Tribune, Great Falls, Montana.

Heywood, D.I., and L. Tufnell. 1985. Snow avalanche hazards in the Glen Nevis and Glen Coe areas of Scotland. Disasters 9(1): 51-56.

Historical Research Associates. 1980. Historic Resources Study, Glacier National Park, and historic structures survey. 429 p. Historic Research Associates, Missoula, Montana.

Hungry Horse News (HHN). 20 January 1950. Give account of King Winter. p.6. Columbia Falls, Montana.
HHN. 27 January 1950. Report about snow slides from Essex. p. 5.
HHN. 1 February 1950. Thaws continue U.S. No. 2 block. p. 1.
HHN. 18 January 1952. Weather, roads topics at Essex. p. 7.
HHN. 1 February 1952. Snowslides threaten Glacier Park elk. p. 4.
HHN. 7 March 1952. Essex has months of less snowfall. p. 6.
HHN. 19 February 1954. Slide damages Waterton cottage. p. 7.
HHN. 9 April 1954. Snowslides cause cottage damage. p. 10.
HHN. 7 May 1954. Avalanche knocks out telephone circuits. p. 1.
HHN. 2 March 1956. Avalanche blocks G.N. and No. 2. p. 1.
HHN. 9 March 1956. U.S. No. 2 re-opening Saturday. p. 1.
HHN. 16 March 1956. Bystander. p. 2.
HHN. 15 February 1957. Blocked U.S. No. 2. p. 2.
HHN. 1 March 1957. Late winter of 1956-57 brought usual snowslides. p. 7.
HHN. 26 April 1957. Gun may help Park snow clearing. p. 1.
HHN. 3 May 1957. Bombard snow cornice in Glacier National Park. p. 1.
HHN. 22 January 1960. Jets to sonic boom Park avalanches. p. 9.
HHN. 5 February 1960. Hungry Horse News editor watches sonic bombardment. p. 1.
HHN. 15 January 1971. Collision in U.S. 2 snowslide area. p. 9.
HHN. 28 February 1975. Avalanche smashes boat house on Josephine Lake. p. 1.
HHN. 15 February 1979. Avalanches block U.S. 2, train tracks. p. 1.
HHN. 19 March 1981. Two ski over pass. p. 6.
HHN. 28 January 1982. Slides close Hwy. 2, cut off BN main line. p. 1.
HHN. 21 March 1985. Avalanche buries highway. p. 5.
HHN. 18 September 1985. Three trails closed in Park. p. 5.
Kraebel, C.J. 1925. Glacier National Park, annual report of the Superintendent. In Report of the Director of the National Park Service to the Secretary of the Interior. p. 112-116. Washington, D.C., U.S. Government Printing Office.
Laut, A.C. 1926. Enchanted trails of Glacier Park. 251 p. Robert M. McBride and Co., New York.
Martinelli, M., Jr. 1984. The Goat Lick bridge avalanches of 1979 and 1982. p. 198-207. In Proceedings of the International Snow Science Workshop. (Aspen, Colorado, October, 1984). International Snow Science Workshop Committee, Aspen, Colorado.
Ober, M.J. 1973. Enmity and alliance: Park Service - Concessioner Relations in Glacier National Park, 1892-1961. Unpublished Master's Thesis, University of Montana: 211 p.
Panebaker, D. 1982. Avalanche! Glacier's Goat Lick slide. In Montana Weather (ed. by C. Cunningham), 156 p. Montana Magazine, Inc., Helena, Montana.
Panebaker, J. 1985. Ski trails of Glacier National Park. 15 p. Glacier Natural History Association, West Glacier, Montana.
Payne, W.W. 1918. Annual report of the Superintendent, Glacier National Park, Montana. In Report of the Director of the National Park Service to the Secretary of the Interior. p. 974-979. Washington, D.C., U.S. Government Printing Office.
Walter, D. 1983. Avalanche on Going-to-the-Sun Road. Montana Magazine 60(July-August): 47-50.
Williams, K. 1975. The snowy torrents: avalanche accidents in the United State 1967-71. U.S.D.A. Forest Service General Technical Report RM-8, 190 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
Yenne, W.J. 1983. Switchback. 170 p. WY Books, Kalispell, Montana.