AVALANCHE TERRAIN AND CONDITIONS IN THE PRESIDENTIAL RANGE, NEW HAMPSHIRE, USA

Kai-Uwe Allen, Snow Ranger*

US Forest Service, White Mountain National Forest, New Hampshire

ABSTRACT: The Presidential Range in the White Mountains of New Hampshire has the greatest concentration of avalanche terrain east of the Rocky Mountains in the United States. Mount Washington, the highest summit in the range (1917 m) and the highest peak in the northeastern United States, is a small mountain with a fierce reputation. Harsh winter weather and a high accident rate have earned Mount Washington the distinction of having "the worst weather in the world" and as "the most dangerous small mountain in the world". The highest wind speed ever recorded over land was measured on Mount Washington at 371 km/h. Hurricane force winds (>121 km/h) are measured on average of 110 days per year. While the notoriously severe winter weather of the Presidential Range is commonly acknowledged, much less is known about the avalanche terrain, snowpack and weather conditions which characterize this small mountain range. The consistently high winds and their influence upon avalanche conditions are unique to avalanche prone areas in the United States. Winter recreation use of the Presidential Range, including Mount Washington is intense. Since 1954 there have been 10 avalanche fatalities and many other avalanche accidents in the Presidential Range. Historical data indicate that avalanche accidents have increased in the past decade, mirroring the national trend in recreation related avalanche accidents in the United States.

KEYWORDS: New Hampshire, Presidential Range, Mount Washington

1. INTRODUCTION

Located in northern New Hampshire, the Presidential Range is the highest mountain range in the White Mountains. Mount Washington (1917 m), the apex of the Presidential Range, is the highest peak east of the Mississippi River and north of the Carolinas. Because of its elevation, the range is biologically and ecologically similar to the subarctic and arctic regions of the world. It hosts 12.1 km² of true arctic/alpine vegetation, the most extensive area of alpine tundra in the eastern United States and south of Labrador. (Bliss, 1963).

While this small mountain range is of relatively low stature in comparison to the great mountain ranges of the world, Mount Washington has earned the reputation as having "the worst weather in the world" and has the distinction as "the most dangerous small mountain in the world". The highest wind speed ever recorded over land was measured from the summit of Mount Washington at 371 km/h. Hurricane force winds (> 121 km/h) are measured on average of 110 days per year. The harsh weather conditions are well known and often acknowledged, yet much less is known about avalanche conditions in the range. The Presidential Range hosts the greatest concentration of avalanche terrain east of the Rocky Mountains in the United States.

The Presidential Range is located within a day's drive (24 hours) of 80 million people, roughly 1/3 of the population of the United States. The area, with its rich cultural history, provides great attraction to seekers of winter alpine challenge. It offers some of the best, most accessible and most challenging alpine mountaineering and backcountry skiing in the northeastern United States. Recreation opportunities of this variety are not common in the region.

Of little surprise, winter recreation use is at a high level. Recreation activity in avalanche prone areas is highly concentrated in Tuckerman and Huntington Ravines on the eastern side of Mount Washington. It is within this area that the US Forest Service operates the only avalanche forecasting and education program in the eastern United States.

^{*}Correspondence address: Kai-Uwe Allen, USDA Forest Service 300 Glen Road, Gorham NH, USA 03581 Tel: (603) 466-2713 email: <u>kallen01@fs.fed.us</u>

Roughly 35 to 40,000 people will visit the avalanche forecast area on Mount Washington each winter (B.Ray pers. com.). Our experience as avalanche forecasters indicate that a very small percentage of persons climbing and skiing within the forecast area have the knowledge, skills or rescue equipment to safely evaluate and mitigate avalanche hazards, presenting no small challenge to mountain safety personnel.

Several avalanche accidents occur in the Presidential Range each winter. Ten lives have been lost in avalanches since 1954. Four fatal avalanche accidents have occurred in the past 4 years. These fatal accidents have all occurred on the eastern, lee slope of Mount Washington. This small area is the most popular recreation destination in the range (Figure 5.) An examination of historical accident data indicate that avalanche accidents have increased in this area within the past 10 years, mirroring a national trend in recreation related avalanche fatalities in the United States.



Figure 1. Satellite image of the Presidential Range.

2. PHYSICAL GEOGRAPHY

Located in northern New Hampshire within the White Mountain National Forest, the Presidential Range is the highest mountain range in the White Mountains. The range consists of 11 major peaks, beginning in the north with Pine Mountain near Gorham, NH and running in a S-SW direction to Mount Webster in Crawford Notch (Bliss, 1963). New England's highest mountains are mere foothills by most standards (Table 1).

SUMMIT	ELEVATION
	(m)
Pine Mountain	733
Madison	1635
Adams	1767
Jefferson	1742
Clay	1686
Washington	1917
Monroe	1641
Franklin	1524
Eisenhower	1451
Pierce	1314
Jackson	1235
Webster	1192

Table 1. Major summits of Presidential Range (N to S)

One of the most dramatic features of the range is the presence of large glacial cirgues and U-shaped basins, which flank the range. These locally termed "gulfs" and "ravines" serve as the catchment basins for large quantities of wind blown snow and are the location of the majority of avalanche prone terrain (Table 2). Mountain glaciation was generally responsible for the glacial basins on the south, east and northern sides of the range. The impressive ravines such as Tuckerman, Huntington, King Jefferson and the Great Gulf were formed in this way. These formations contrast with the more Vshaped ravines on the western side of the range, where mountain glaciers did not develop. The deep snow accumulations responsible for forming such glaciers in advance of the Wisconsin Ice Sheet, were less on the west side due to the prevailing winds in the region (Billings, 1979).

The Wisconsin glacial period, beginning some 50,000 years ago had a dramatic effect on the mountain landscape. The massive ice sheet, many thousands of feet thick, spread out over the New England area as far south as Long Island, New York. In New England, the ice sheet was of such great depth that even the summit of Mount Washington was buried beneath the ice. There is clear evidence that the last ice sheet began retreating from the region about 12,000 years ago, leaving the topography of the Presidential range closely resembling that which we observe today (Billings, 1979).

LOCATION

Webster Cliffs Monroe Gulf Oakes Gulf Gulf of Slides Tuckerman Ravine area Lion Head Raymond Cataract Huntington Ravine Eastern Snowfields of Mount Washington Great Gulf Headwall Jefferson's Knee Jefferson Ravine King Ravine **Castle Ravine Burt Ravine** Ammonusuc Ravine Monroe Brook

 Table 2.
 Major large avalanche areas in

 the Presidential Range.
 Many other smaller, more

 isolated avalanche prone areas are present.
 Many other smaller, more

3. MOUNTAIN WEATHER

The climate of Mount Washington and the Presidential Range is one of the most severe in the world (Figure 2). The severity of winter storms is unequaled by any other reporting weather station in the continental United States (Gordon, 1980). Arctic temperatures, fog, icing, frequent cloud cover and super-hurricane force winds are so common in this small mountain range that it has earned the reputation as "Home of the World's Worst Weather" (Mt. Washington Obs.). Hurricane force winds and sub-freezing temperatures have been recorded for every month of the year. The climate is similar to that found in northern Canada and Alaska. True arctic vegetation exists above 1525 m. The closest incidence of this vegetation type in eastern North America would be found by traveling 645 km north into Canada.

Treeline in the White Mountains is around 1360 m above sea level, one of the lowest anywhere in the world at this latitude. Treeline in the Rocky Mountains is seldom below 3050 m (Gordon, 1980).



Figure 2 "<u>STOP</u> The area ahead has the worst weather in America. Many have died there from exposure even in the summer. Turn back <u>now</u> if the weather is bad." This sign is posted on all the hiking trails leading to the alpine zone of the Presidential Range.

The regional climate of New England is unusual. It is said that no other location in the northern hemisphere at the same latitude is as cold as in the northeastern United States, except in northeastern China and Hokkaido, Japan. The average lowland temperatures in the northern New England region approach those recorded at Anchorage, AK and Helinski, located 15 degrees latitude or 650 km to the north. This effect is compounded by the local climate of the mountains (Marchand, 1987).

Several climatic and geographic factors are responsible for the harsh weather conditions of this truly arctic mountain range. Low-pressure systems in the Northern Hemisphere converge in the New England area. Major storm tracks from the South Atlantic, the Gulf region, and the Pacific Northwest merge along the east coast of the United States (Figure 3). These active lowpressure systems track up the northeast coastline and up the St. Lawrence River valley. In winter, the eastern part of North America is relatively cold and the offshore waters of the Atlantic Ocean are relatively warm, creating a natural area for storm development along the eastern seaboard. Such storms frequently experience their strongest development along the Northeast coast (Abrams, 1978). This constant progression of low-pressure systems causes sudden and often dramatic weather changes in the region.



Figure 3. An analysis of 1160 storm tracks across the US in a 10 year period. The width of the arrows on the map indicate the frequency of storms along a given path. This convergence of low pressure systems explains in large part the weather patterns so characteristic of the Northeastern United States. (Van Cleef, 1908)



Figure 4. The complementary relationship of high and low pressure systems in the Northeastern United States (Marchand, 1987)

Following this constant progression of low-pressure systems are the high-pressure cells that develop over the Hudson Bay region of the Canadian Arctic. On the backside of every low pressure system is this cold arctic air flow from the north, subjecting the region to frequent outbreaks of polar air masses year-round (Figure. 4) (Marchand, 1987). The vertical relief of the Presidential range and the White Mountain region is considerable in comparison to the surrounding landscape. The Presidential Range rises over 1220 m from the surrounding lowlands. The generally north-south orientation of the mountain range acts as a natural barrier to the prevailing westerly winds. The combination of large-scale atmospheric disturbances and the orographic effect of the mountains have dramatic effects on wind speed, temperature, and precipitation.

3.1 The winds

The Presidential Range is probably most well known for its winds. Wind velocity on Mount Washington averages 57 km/h year-round. At nearby lowland stations, the average wind velocity generally ranges from 6.5-13 km/h. Hurricane force winds (> 121 km/h) are observed from the summit of the mountain on average of 110 days per year. From November to April, hurricane force winds occur on average of 2 out of every 3 days. Winds of 161 km/h or greater occur about every 3rd day from November through March. In January, the windiest month, the winds reach or exceed hurricane force on 3 out of every 4 days (Gordon, 1989). On January 2nd, 1969, the winds averaged 161 km/h for 24 hours, with a peak gust of 241 km/h. In winter, conditions of this type are fairly common on Mount Washington. In addition, Mount Washington holds the world's record wind speed ever recorded from a surface weather station. In April 1934, observers measured a 371 km/h wind gust before the anemometer was destroyed (Gordon, 1980).

3.2 The rain and snow

Snow falls on Mount Washington every month of the year. As one would expect, frequency and amount of precipitation increase with elevation. Yearly snowfall on the summit of Mount Washington averages 645 cm. Average annual snowfall at lowland stations in the area is about 287 cm. On average, at least 2.5 cm of snow falls 68 days a year. The snowiest winter on record was 1968-69, when 1438 cm fell on Mount Washington. Snow depth measurements from the Mount Washington Observatory on the summit are somewhat uncertain, as snow often blows away as soon as it begins to accumulate, and snowfall is blown over the summit of Mount Washington from other areas of the mountain.

The pervasive high winds move large quantities of snow off the upper elevations, resulting in incredible wind loading events for the avalanche starting zones along the flanks and ravines of the range. Wind-blown snow is a major contributor to large avalanche cycles in the range. Snow depths on the floor of Tuckerman Ravine on the lee side of Mount Washington average 12 to 16 m.

The Presidential Range is located within 160 km of the Atlantic Ocean. Rain events are not uncommon during the winter months. Total average precipitation on Mount Washington is 252 cm. Precipitation levels in the lowlands around the range (610 m. elevation) average 117 cm in a year.

On average, Mount Washington is shrouded in dense fog and clouds 315 days each year (Gordon, 1980).

3.3 The cold

The commonly low temperatures recorded in the Presidential Range often catch the unwary visitor by surprise. Exposure is the second highest cause of fatalities in the range, overshadowed only by falls in steep terrain.

The temperature on the summit of Mount Washington is significantly colder than the surrounding lowlands. The record high for the summit is 23 degrees C. The lowest temperature ever recorded was -45 C. July is the warmest month of the year with an average of only 9 C. February is the coldest, averaging only -15 C. Freezing temperatures are recorded 243 days during an average year. Temperatures drop to below -18 C on an average of 66 days, and reach or exceed 15 degrees C on only 19 days a year. One of the results of such cold temperatures is permafrost at 6 m deep year-round.

The high winds and brutally cold temperatures frequently arrive together. The coldest periods on Mount Washington arrive on northwest winds. Temperatures of –35 C and winds in excess of 160 km/h are not uncommon in winter (Gordon, 1989).

4. AVALANCHE CONDITIONS IN THE PRESIDENTIAL RANGE

The presence of consistently extreme winds and arctic temperatures in a maritime snow climate is an unusual feature of the Presidential Range. Avalanche conditions found in the Presidential Range of New Hampshire are unique to avalanche forecast areas in the United States.

The effect of the strong winds on avalanche conditions can be observed in Figure 6. Large areas of windswept ground are visible on the easterly, lee side of the summit cone of Mount Washington, as well as above Tuckerman Ravine. Large snow collection grounds above a glacial cirque like Tuckerman Ravine are scoured free of snow during strong wind events. The effect of such wind scour on avalanche conditions are impressive. Huge loads of wind-deposited snow and the concurrent avalanche cycles are responsible for the great depths of snow which fill the floors of the Presidential gulfs and ravines

Given optimal wind velocities and direction, snowfall totals of 5-10 cm on Mount Washington can have an incredible effect on avalanche conditions. It is not unusual for the avalanche danger in Tuckerman Ravine to be CONSIDERABLE after a snowfall of 5-10 cm and westerly winds of 95-130 km/h.

The effects of wind deposition tend to be highly variable across avalanche prone slopes. The eddy effect of localized terrain features are generally considered to be responsible for this variability. On slopes of similar aspect and elevation, it is not uncommon to encounter 0.6 m of unstable windslab within 3 m of a hard rain crust, requiring the use of crampons and ice axe. Even the smallest pocket of unstable snow can have serious consequences for a climber or skier on the steep and committing terrain found in the ravines of the Presidential Range.

On a larger geographic scale, wind effects on slab deposition within the avalanche forecasting areas can also be extremely variable. This is generally attributed to the differences in local geographic features, and the varying effects on wind loading as a result of those features. The Bigelow Lawn, a large flat plateau situated above Tuckerman Ravine, serves as a collection ground for new snow (Figure 5). Snow deposited here will later be blown down into Tuckerman Ravine with the onset of strong winds. Huntington Ravine has no similar large snow collecting grounds, and is somewhat protected from westerly winds by the summit cone of Mount Washington. Sustained high winds tend to fill the bowl of



Figure 5 East side (lee side) of Mount Washington, NH with the Gulf of Slides (L), Tuckerman Ravine, Mount Washington summit (center), and Huntington Ravine (R)



Figure 6. Tuckerman Ravine, Mount Washington, NH Avalanche forecast area, USFS



Figure 7. Huntington Ravine, Mount Washington, NH Avalanche forecast area, USFS

Tuckerman Ravine with snow and windslab, and blow snow out of the narrow climbing gullies of Huntington Ravine.

4.1 <u>A "typical" Presidential</u> avalanche cycle

Because of the great variability and complexity of avalanches and avalanche weather, a "typical" avalanche cycle is something of a misnomer. Mount Washington winds add another important level of complexity to avalanche forecasting in this area. Through observation, experience, and historical data some common trends can be observed, providing insight into larger patterns. There are as many variations and exceptions as there are rules in the following scenario.

There is a requisite snow event with the arrival of a low pressure system. Winds can be generally light to moderate by Mount Washington standards during the storm. Wind direction may be variable as well, but often has a southerly component. As the lowpressure system which brought the precipitation begins to move north and out to sea, there is a characteristic wind shift, and an increase in wind speed. This can occur within several hours. Winds shift into the W and NW and may increase to hurricane force or greater. This change in wind conditions initiates wind loading on to slopes with an easterly aspect, which in turn initiates an avalanche cvcle. Generally during this time, avalanche danger will be HIGH and possibly EXTREME. Strong winds, often reaching or exceeding 160 km/h continue for many hours. Generally there will be natural avalanche release. The persistent strong winds finally "pound the snowpack into submission". producing a dense, stiff windpack on avalanche prone slopes. The cycle is completed. Without additional precipitation, the avalanche hazard rating generally drops to MODERATE or LOW within 48 hours of the storm, and remain at this level until the next snow event.

The rapid rate at which dangerous avalanche conditions develop during the common high wind events can be imagined. In February 1999, a fatal backcountry skiing accident occurred in the Gulf of Slides, the southern-most of the easterly facing ravines of Mount Washington. Prior to the accident, 18 cm of light density snow fell over a 48 hour

period, accompanied by very light winds. As the low-pressure cell moved away from the area, the characteristic direction shift and increase in winds occurred. Within several hours, winds increased from near calm to 100 km/h. An incredible amount of snow began to load the lee slopes. Just prior to the fatal accident, the author observed natural avalanching and extremely sensitive windslab deposits up to 3 feet in depth on test slopes within several hours of the onset of drifting snow. Within the next 24 hours, winds increased to over 160 km/h. When the storm passed, 120-150 cm of snow had been deposited in avalanche areas on the east side of Mount Washington.

4.2 <u>Common weak layers in the</u> <u>Presidential snowpack</u>

The Presidential Range is characterized by a maritime snow climate and direct action avalanches. It is not unreasonable to consider the Presidential Range an "arctic variant" within the commonly accepted maritime snow climate model. This variant would account for the super-high winds and cold temperatures which characterize the Presidential Range.

Typical of a maritime snowpack, rain can and does fall at any time during the winter. An area forecasting "guideline" for Mount Washington would be that 2.5 cm of rain (rate dependant) on a mid-winter snowpack will almost always necessitate a HIGH avalanche hazard rating. Large avalanche events have occurred with heavy rains during winter.

Once buried, the rain crusts which commonly exist become ideal bed surfaces for future avalanche cycles. They also serve to "bridge" the existing snowpack, negating other deeper weak layers which may be present. These persistent crusts often become buried under the accumulation of several storm and wind events before becoming active. Faceting associated with crusts is observed on a fairly regular basis.

Weak layers are often found within the new snow of a given storm. Discontinuities can include graupel, rimed crystal forms, or cold, light density stellars. These may be subsequently buried by a dense, wind deposited hard slab, soft slab, or relatively warm, wet snow. Storms often start cold and may finish warm with rain or drizzle, a storm scenario often resulting in widespread avalanche activity.

Early in the season, considerable amounts of water ice freeze on the headwalls and gullies of Mount Washington. Weak bonds at the interface of snow and water ice have been observed to cause avalanches with the addition of new snow or human triggers. This is an especially important consideration in the early season when many ice climbers descend on the area.

The deposition of surface and depth hoar are not often encountered at the upper elevations. Due to the persistent winds, it is rarely calm enough for the deposition of surface hoar. In situations where it has been produced, one can imagine that it is quickly damaged or blown away before becoming buried as a weak layer.

Depth hoar is observed in the area, but rarely becomes a factor in avalanche events. The distinct lack of problems associated with depth hoar is related to the high density of the wind-packed snow, terrain roughness, and the incredible strength and density of the overlying snowpack. Depth hoar was the likely weak layer implicated in a fatal avalanche accident in 1996 (C. Joosen pers. com.). The avalanche occurred within a recently exposed landslide with no anchors, and is protected from the full effect of the strong winds of Mount Washington.

5. AVALANCHE ACCIDENTS IN THE PRESIDENTIAL RANGE

5.1 The crowds

The Presidential Range is located within a 24 hour drive of some 80 million people, nearly 1/3 of the population of the United States. Public lands are relatively scarce in the northeastern United States, and recreational use of the White Mountain National Forest is intense. Within the avalanche forecast area on Mount Washington, some 35-40,0000 people will visit during the avalanche season alone (B. Ray pers. com.).

The Presidential Range offers some of the most dramatic and accessible alpine terrain in the northeastern United States. The eastern slopes of Mount Washington are the most popular alpine recreation area in the East. Tuckerman Ravine, birthplace of American alpine skiing, is renowned for its deep snowpack, rich cultural history, and extreme skiing and mountaineering challenge. Huntington Ravine provides some of the best, most accessible alpine climbing and technical mountaineering routes in the east. Other areas in the range provide similar recreation opportunities with even greater chances for solitude. The area is *the* destination for mountaineers and winter climbers in the Northeast. Seekers of winter mountaineering challenge in the region will find their way to Mount Washington and the Presidential Range.

There have been 127 fatalities in the Presidential Range since 1849. It can indeed be a dangerous place, and Mount Washington has earned itself the title "the most dangerous small mountain in the world" within the mountaineering community. The late Paul Petzoldt referred to Mount Washington as "the great booby trap of the East". On a bad day in the winter, some of the most dangerous mountain terrain in the country is just 3.5 km from the nearest highway, about an hours' walk.

The area receives heavy use from visitors residing in eastern Canada, which presents particular and peculiar cultural and language barriers to effective avalanche education. It seems like the Canadian visitors are always the first ones to push the terrain during periods of unstable snow.

Avalanche awareness is very low in the New England (and eastern Canada) area. Avalanches are not a part of the daily life and culture in this part of the world, presenting no small challenge to Snow Rangers, avalanche educators, and search and rescue personnel. Personal observation and experience among avalanche forecasters reveal a very small percentage of winter visitors recreating in avalanche terrain have the appropriate avalanche awareness skills and/or rescue equipment.

5.2 Avalanche accidents

Table 3 shows accident data from all known historical accident reports on record at the US Forest Service in Gorham, New Hampshire. Since 1954, there have been 34 avalanche accidents in the Presidential Range for which records have been located. For all accidents (34), one half occurred within the period 1954-1990 (36 years). Half of all

YEAR	# OF	# PERSONS	NO	MINOR	MAJOR	FATAL
	ACCIDENTS	INVOLVED	INJURY			
1954	1	1	3			1
1956	1	1				1
1964	1	2				2
1967	1	2		1	1	
1968	1	3	1	1	1	. *
1972	1	2	1		1	
1973	1.	2		1	1	
1980	2	4		2	2	
1981	2	3		1	2	
1982	2	7	5	1		1
1985	2	3		1	2	
1989	2	3		2	1	
1991	5	15	11	1	2	1
1992	2	2		1	1	
1993	1	7	7			
1996	2	6	2	1		3
1997	2	5	4	1		
1998	1	3	3			
1999	2	6	.1	2	3	
2000	2	4	2		1	1
TOTALS	34	81	37	16	18	10
1954-90	17	33	7	10	11	5
1990-2000	17	48	30	6	7	5

 Table 3.
 Avalanche accidents in the Presidential Range, 1954-2000

accidents occurred between the 10 year period from 1990-2000. Total number of persons involved during the time period was 81, with 33 persons involved in accidents from 1954-1990 and 48 persons involved in 1990-2000. Of the 37 victims involved in accidents with no injury, 7 were within the years 1954-1990 and 30 in 1990-2000.

Table 3 and 4 show the accident fatalities in the Presidential Range from 1954-2000. There have been 10 avalanche fatalities in the Presidential Range. One half of those fatal avalanche accidents have occurred within the past 10 years. Avalanches may have been involved in several other climbing related fatalities in Huntington Ravine.

Most recently, the Gulf of Slides, a popular backcountry skiing destination outside the avalanche forecast area, has been the location of 3 avalanche related fatalities within the past 4 years. This area has great backcounty skiing and tends to be less traveled that the busier Tuckerman and Huntington Ravines. The fact that the area is less traveled has probably contributed to its increased popularity

The trend in the average number of accidents follows that of the number of fatalities, suggesting that there is an increasing incidence of avalanche accidents in the Presidential Range. This would not be unexpected, as the number of winter recreational visits have increased over the years. The increase in popularity in winter mountaineering, ice climbing, backcountry skiing and winter hiking is a likely contributor to the higher incidence of winter backcountry visitation. It is interesting to note the significant difference in the number of victims with no injury appears to have increased within the past 10 years. One might conclude from the data that although the number of avalanche accidents has increased within the past 10 years, more people are walking away without injury. It may also be a reflection on the level of accident reporting over the years.

It is very likely that many more avalanche accidents occurred than were reported to Snow Rangers in the early years of the USFS forecasting program on Mount Washington, particularly those which resulted in no injury.

Date	Victim(s)	Location	Activity	
1/31/54	Phillip Lonanecker	Tuckerman Ravine	Hikina	
4/5/54	Hugo Stadtmuller John Griffin	Huntington Ravine	Ice climbing	
2/19/56	Aaron Leve	Tuckerman Ravine	Camping	
1/25/82	Albert Dow	Lion Head	Hiking	
1/24/91	Thomas Smith	Huntington Ravine	Ice climbing	
1/5/96	Andre Cassan	Lion Head	Hiking	
3/24/96	John Wald Todd Crumbaker	Gulf of Slides	Skiing	
2/20/00	David MacPhedran	Gulf of Slides	Skiing	

Table 4. Avalanche fatalities in the Presidential Range, 1954-2000

Skiing and climbing in Tuckerman and Huntington Ravines have a rich history, dating back to the early 1900's. Many people climbed and skied the avalanche prone slopes in the Presidential Range long before any type of accident data was kept. It is no small coincidence that avalanche accidents began to be reported with the onset of an official presence of USFS Snow Rangers in the early 1950's.

Improvements in avalanche accident record keeping in the past decade may be in part responsible for the supposed increase in avalanche accidents. That the trends in avalanche fatalities mirrors that of overall accident occurrence is reassuring, but may not be actually representative of the facts. It is known that there have been avalanche accidents in Tuckerman Ravine involving over a dozen persons at one time that were never recorded (B. Ray pers. com). In addition, avalanche accidents resulting in serious injury or requiring search and rescue assistance are more likely to be reported. Also, staffing of the Snow Ranger program was reduced to 3 days a week for many years, drastically reducing the presence on the mountain. We are certain that countless avalanche accidents in the Presidential Range have gone unreported over the years.

6. THE USFS SNOW RANGER PROGRAM ON MOUNT WASHINGTON, NH.

The avalanche forecasting and education program on Mount Washington is the only US Forest Service avalanche program east of the Rocky Mountains in the United States. The first Snow Ranger was employed in Tuckerman Ravine in 1952, making it one of the oldest avalanche programs in the country. By this time, Tuckerman Ravine had already earned quite a reputation. The spectacular glacial cirque renowned for its steep "extreme" skiing and rich cultural history emerged as the most popular backcountry skiing and winter mountaineering destination in the Northeast. Not only was increasing use of the Tuckerman Ravine creating management issues, but the area was subject to frequent avalanches, requiring the presence of skilled Snow Rangers.

To the north of Tuckerman Ravine, Huntington Ravine offers some of the best, most accessible alpine mountaineering and technical climbing routes in the Northeast. Following the avalanche deaths of two worldclass mountaineers in 1964, the Forest Service expanded avalanche forecasting to include all the popular climbing gullies in Huntington Ravine.

During this time, the Snow Rangers would close the ravines during periods of perceived avalanche danger. In 1958, an avalanche control program was initiated in Tuckerman Ravine. Originally intended as a way to control the dangerous icefalls that build up on the Headwall each winter, Snow Rangers would take aim at the ice in an effort to trigger avalanches. In 1966, the Forest Service acquired one of the first prototype Avalaunchers for use in Tuckerman Ravine. After an accident in which a shell exploded in the Avalauncher barrel, injuring 2 Snow Rangers. This signaled the end of avalanche control in Tuckerman Ravine. The use of firearms to control the icefall and area closures during periods of avalanche hazard would continue for many years.

In the early 1980's, the Forest Service began to manage people and avalanches from a strictly advisory and educational perspective. This method and philosophy continues to the present day. Today, the Snow Rangers educate and warn the public about all the major hazards on the mountain that can include icefall, crevasses, fierce weather, and undermined snow, in addition to avalanches.

With a current staffing level of 3 full time and one part time avalanche forecaster. Snow Rangers today issue daily avalanche forecasts for Tuckerman and Huntington Ravines. This avalanche bulletin is widely available through radio, television, Internet, and local mountain equipment shops. In addition, the US Forest Service Snow Rangers are the lead agency for all winter search and rescue operations on the east side of Mount Washington. This is no small undertaking on a such a malevolent piece of mountain real estate. The Snow Rangers perform law enforcement, manage a 20 person Volunteer Ski Patrol, serve as incident commanders and rescue leaders, maintain downhill ski trails, administer special use permits, maintain snow tractors, teach avalanche courses and educate and interact with the public as part of our daily duties. While computer and Internet technology have changed the way the Snow Rangers do business, the avalanche danger is still posted in a slat board every day, the old-fashioned way. Snow Rangers on Mount Washington are "the last of the old time Snow Rangers" as opposed to the solely dedicated avalanche forecasters of today (R. Newcomb, P Lev. pers. com.)

7. CONCLUSION

The Presidential Range of New Hampshire is truly an unusual mountain environment within the United States. Mount Washington presents the most severe combinations of high winds, cold, icing and storminess available anywhere in the world where people are on location to make weather observations. The Presidential Range lies in the path of the major storm tracks and air mass routes affecting the northeastern United States, and it is, because of its elevation, biologically and ecologically similar to the subarctic and arctic regions of the world.

The Range has the greatest concentration of avalanche terrain on the eastern seaboard of the United States. On the east side of this seemingly barren pile of jumbled rocks is the only USFS avalanche center east of the Rocky mountains. Rarely considered to be avalanche country, it proves to be a busy place for avalanche professionals. Because the northeastern United States has little true alpine recreation opportunities, the Presidential Range holds great attraction and draws the crowds. A great many persons are exposed to avalanche danger on a regular basis in pursuit of their chosen sport, with little knowledge or awareness of the risks involved. The level of avalanche awareness is remarkably low among the majority of visitors. Winter recreation use is on the increase, and subsequently, increases in avalanche accidents can be expected in the future.

Located within a days drive of 80 million people and just 2 miles from the nearest highway, the Presidential Range will continue to be a dangerous place, commanding great respect among those who know it well.

8. ACKNOWLEDGEMENTS

Special thanks to Roger Damon for the means of flight by which this paper began. Thanks to Brad Ray, Christopher Joosen, Marianne Leberman, Don Muise and the entire Androscoggin Ranger District. Appreciation goes out to Sean Doucette of the Mount Washington Observatory for his assistance with the slide library. Special thanks to Kori for your patience.

9. REFERENCES

- Abrahms, E. 1978. Why Mount Washington? Mount Washington Observatory News Bulletin. V. 19 no. 2. p. 26-29.
- Billings, M.P. Fowler-Billings K, Chapman, C, Chapman, R. and Goldthwait, R. 1979. Geology of the Mount Washington Quadrangle, New Hampshire. State of New Hampshire Department of Natural Resources.

- Bliss, L. C. 1963. Alpine Zone of the Presidential Range.
- Gordon, G. 1980. The Home of Boreas: Mount Washington's Meteorological Phenomena. Mount Washington Observatory News Bulletin. V.21 No. 2. p. 26-33.
- Gordon, G. 1989. The Worst Weather in the World. Windswept. Vol 30, Fall 1989. p 66-69.
- Howe, J. 1970. Weather Observations on Mount Washington: Problems and Solutions. Windswept, June 1970 p. 82-90.
- Leich, J. 1998. Over the Headwall. New England Ski Museum Newsletter. No. 6, Summer 1998.
- Leich, J. 1999. Over the Headwall. New England Ski Museum Newsletter. No. 7, Winter 1999.
- Marchand, P. 1987. North Woods. Appalachian Mountain Club, Boston, MA.
- Mount Washington Observatory Publication. "The Only Outpost Left".
- Van Cleef, 1908. Monthly Weather Review. US Department of Agriculture 36: p. 56-58. <u>In</u> Marchand, P. 1987. North Woods. p. 8.