AVALANCHE HAZARD AND CLIMATE IN BAXTER STATE PARK, MAINE[1]

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Abstract. On February 8, 1984, two mountaineers were killed in an avalanche on Mount Katahdin. An analysis of terrain and climatic variables associated with the avalanche hazard in Baxter State Park indicates that, while the hazard is limited in its aerial extent it is compounded by a lack of preparedness and weather system patterns.

INTRODUCTION AND BACKGROUND

On February 8, 1984, an expedition of five mountaineers were attempting a climb up Mount Katahdin[3] when they were caught in a slab avalanche, approximately 200 ft (60 m) wide. One of the mountaineers was able to free himself and go for help and, as a consequence, two additional men were recovered alive. However, the remaining two members of the five-man expedition were not so fortunate. And, even though all members of the team were well-qualified mountaineers, had a great deal of experience in climbing, and had taken six months to prepare for this expedition, none of these factors prevented the accident from occurring.

What factors then would have prevented the accident from occurring? What additional experience or knowledge might have resulted in a different outcome? The objective of this paper is to evaluate the avalanche hazard and climate in Baxter State Park, particularly the time period surrounding the accident, in order to answer the preceding questions.

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[3]Mount Katahdin is the highest point of land in Maine, rising to a height of 5,268 ft (1,606 m) and is situated in Baxter State Park.

KATAHDIN'S LURE

Mount Katahdin was given its name by the Abenaki Indians, meaning simply "main mountain." The Abenaki Indians feared the Mountain, believing that a malevolent spirit called "Pamola" lived above tree line (Hakola, 1981, p.3). This fear kept the Abenaki Indians away from the summit of Mount Katahdin and thus it remained an isolated and uninhabited topographic pinnacle for many years.

However, in 1605, Champlain sighted the peak of Mount Katahdin (Julyan, 1984, p.124). He was the first European to note the way in which Katahdin majestically rose above the surrounding terrain. Not until approximately two hundred years later (in 1804) was the first ascent by Charles Turner, a surveyor for the State of Massachusetts (Hakola, 1981, p.8), recorded.

The reknown of Katahdin became even more widespread with its ascent in 1846 by Henry D. Thoreau and his subsequent writings,

> "The mountain seemed a vast aggregation of loose rocks, as if sometime it had rained rocks, and they lay as they fell on the mountain sides, nowhere fairly at rest, but leaning on each other, all rocking-stones, with cavities between, but scarcely any soil or smoother shelf. They were the raw materials of a planet dropped from an unseen quarry, which the vast chemistry of nature would anon work up, or work down, into the smiling and verdant plains and valleys of the earth."
>
> (Thoreau, 1864, reprinted in Moldenhauer, ed., 1983, p.63)

Thoreau's writings did much to publicize the grandeur, the ruggedness and the beauty of Katahdin, inspiring many others in the late 1800s and early 1900s to climb to the peak. To this day, the lure of Katahdin continues to draw climbers from many parts of the U.S. and Canada and this appeal compounds the avalanche hazard potential in Baxter State Park.

PHYSICAL ENVIRONMENT

Baxter State Park is situated in north-central Maine (Figure 1: see following page) and encompasses a wilderness area of 200,000 acres (80,875 ha). The area has been subjected to volcanic, erosional, and glacial processes, resulting in a diverse and often rugged terrain.

An analysis of climatic variables reveals that average total snowfall is greatest during the months of December and January. Furthermore, the east-west isolines for average total snowfall show a gradual movement southward as the winter progresses, particularly in December and January. During these two months of winter, 25 inch (63.5 cm) isolines dominate central and northern Maine (see for example, Figure 2), decreasing in February and March to 15 inch - 20 inch (38 cm - 51 cm) isolines through the central portions of Maine.

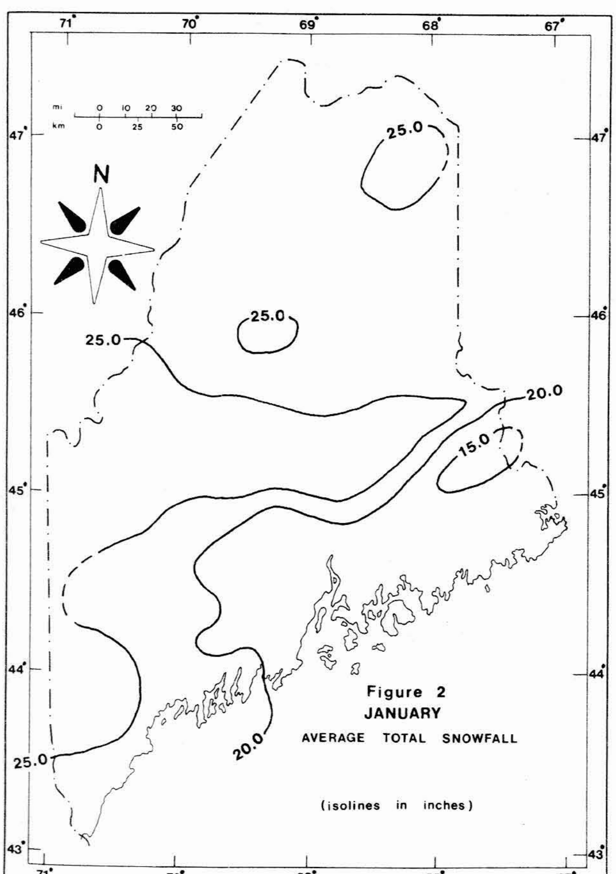

Figure 2
JANUARY
AVERAGE TOTAL SNOWFALL

(isolines in inches)

Although February and March experience low average total snowfalls, it is often during these months that "freak" snowstorms occur. Such snowstorms can be significant in causing the build-up of snow in the Katahdin mountain area.

Temperature during the winter months also forms east-west isolines. These isocheims show a gradual intrusion southward of cold, northerly air as winter progresses. The trend reverses itself beginning in February with more moderate temperatures pushing in from a southerly direction.

The coldest month is January (Figure 3), followed by February (Figure 4), and then, December. In contrast, March and November have warmer average monthly temperatures. However, the moderating influence of the Gulf of Maine can raise temperatures periodically above freezing throughout any of the winter months.

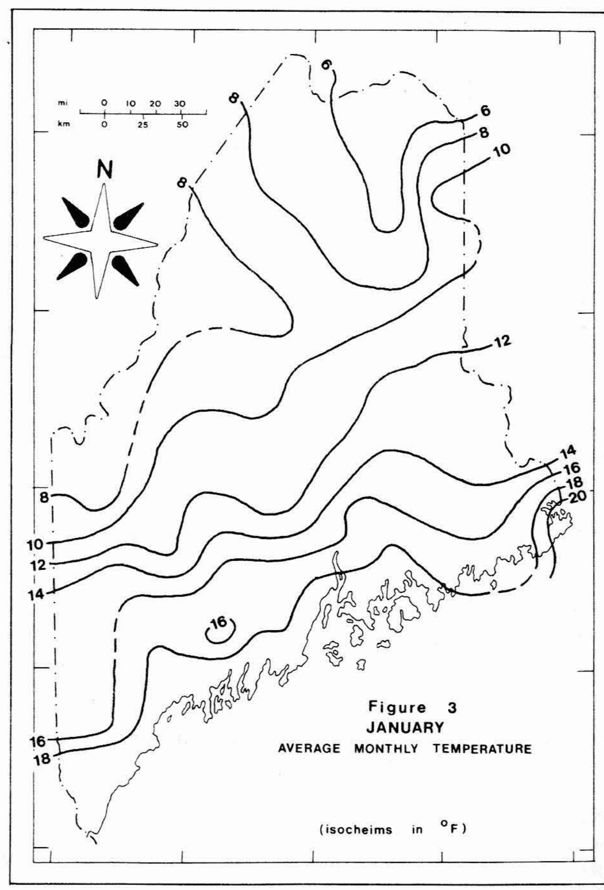

Figure 3
JANUARY
AVERAGE MONTHLY TEMPERATURE

(isocheims in °F)

Based on climatic data and the knowledge of how climate influences snow metamorphism, several general observations can be made. Firstly, January is the month in Maine in which snowfall is greatest and temperatures are coldest and such heavy snowfall can be a critical causal agent of avalanches.

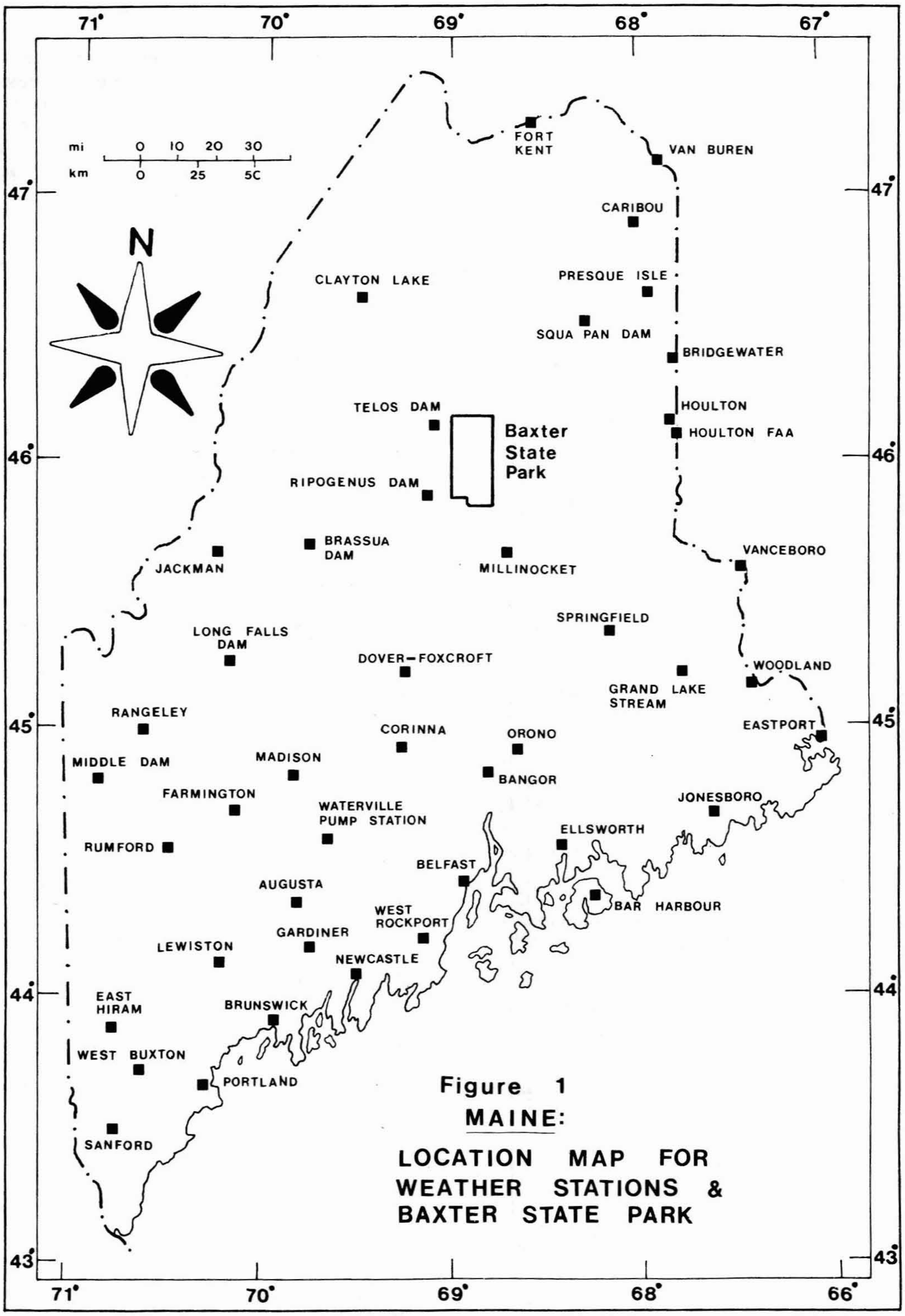

Figure 1

MAINE:

LOCATION MAP FOR WEATHER STATIONS & BAXTER STATE PARK

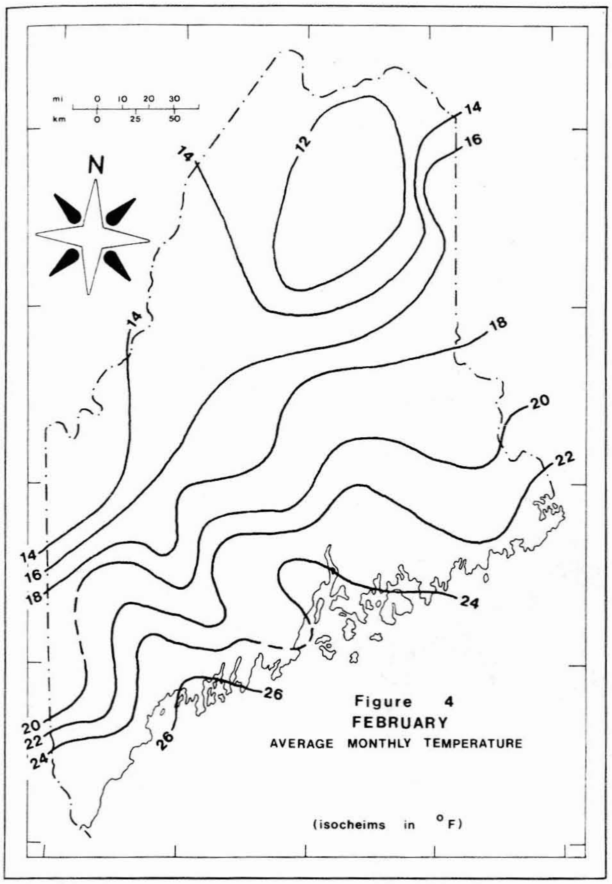

Figure 4
FEBRUARY
AVERAGE MONTHLY TEMPERATURE
(isocheims in °F)

Therefore, in general, it is during the month of January that avalanches in Maine would be most likely to occur solely from accumulation, keeping in consideration that cold temperatures will tend to stabilize the snowpack.

In addition to snow accumulation, warming temperatures can cause wet avalanches to occur. Therefore, according to snowfall and temperature data, these avalanches can be expected to occur more often during early December and late February/early March.

With weather systems replacing each other throughout the winter in Maine (Polar highs in December moving further south and Tropic of Cancer lows moving further north in March), erratic snowfall and temperature patterns may result. Furthermore, climatic effects within the snowpack will be compounded by variations in terrain. Generalizations therefore, of weather and avalanche correlations, must be assessed in a geomorphic context and in smaller regional units.

In addition, as weather systems compete with each other over Maine, moisture will be brought eastward from the Great Lakes and northward from the Gulf of Mexico and Atlantic Ocean. Strong winds often will accompany these weather systems and those slopes with a northeasterly, easterly, and southeasterly exposure will be more prone to windslab avalanches throughout the winter.

WEATHER CONDITIONS PRIOR TO FEBRUARY 8, 1984

The week prior to the 1984 avalanche accident, weather for Mount Katahdin was as follows (Slater, 1984). On February 3, 1984 temperatures were above freezing at 35°F and a light rain was falling. On February 4, the temperatures were still above freezing in the morning (38°F-40°F) and rain continued. A cooling trend in the afternoon turned freezing rain into snow. Early on the morning of February 5, snowfall had ceased and approximately 10 inches of new snow had accumulated.

By February 7, the air temperatures had dropped into the teens and winds had shifted to the northwest at 10-15 mph. These winds continued through to February 8, increasing in intensity to 15-25 mph. At 9:45 a.m. on February 8 the avalanche occurred.

So strong were the winds on February 8, resulting in a wind chill factor of -40°F (Wylie, 1986, p.70), that the climbing party abandoned their initial plans of a technical climb up the face of Mount Katahdin to the more well-travelled Cathedral Trail route,

> "They came back between 7:45 a.m. and 8 a.m. because of the high winds and cold temperatures. They...decided to go to Baxter Peak up the Cathedral Trail."
>
> (Bangor Daily News, 1984, February 10, p.2)

Such weather conditions, both on February 8 and during the preceding week, are reflected in the snowpit observations made by Slater (1984). Figures 5 and 6 are snow profiles based on that data. Snow temperatures and some snow crystal data were not recorded and therefore could not be included in the analysis. Nevertheless, the data that are available are useful in reconstructing circumstances surrounding the avalanche accident.

Figure 5, Snowprofile Adjacent to the Fracture Line, shows that there were approximately 18-20 inches of snow sitting above a layer of ice crust. This ice crust was most likely formed as a result of the rainfall on February 3 and 4. Total snow depth was approximately 5 ft.

The 10 inches of snow above the ice layer is likely the accumulation that fell on the afternoon of February 4 and ended the morning of February 5. The remaining snow layer

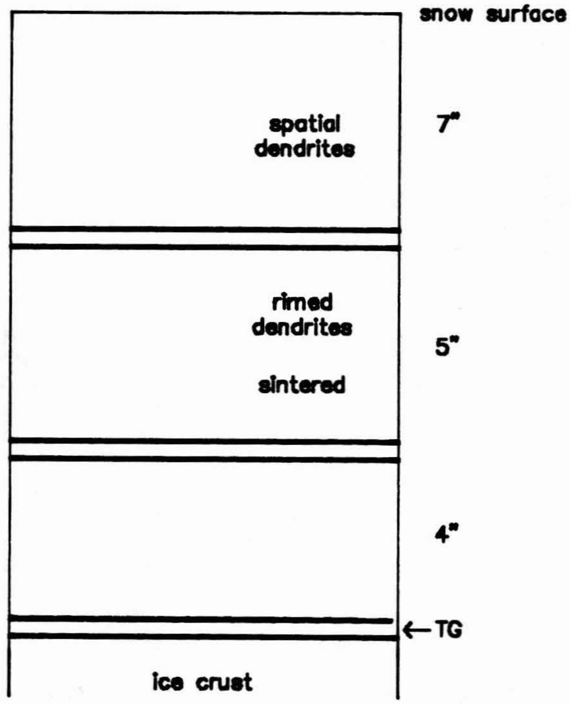

Figure 5: Snowprofile Adjacent to the Fracture Line (after: Slater, 1984)

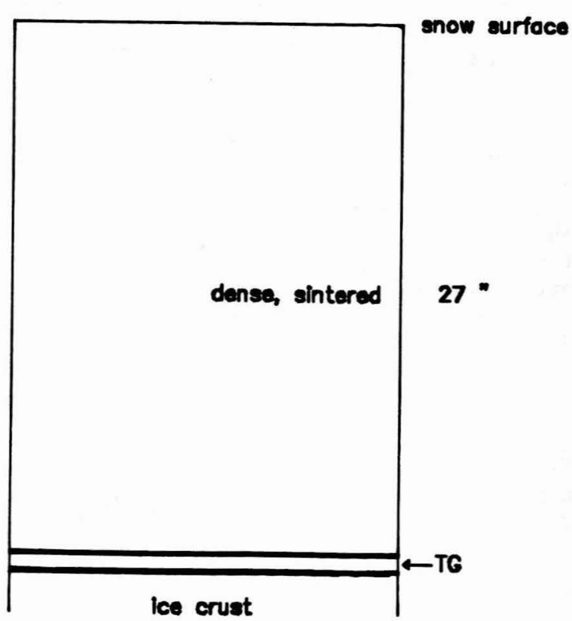

Figure 6: Snowprofile at Fracture Line (after: Slater, 1984)

sitting on the surface was a very dense slab and it is probable that this snow was wind deposited by the northwest winds of February 7 and 8. Scouring of the slopes on the windward side and deposition on the leeward side appears to have been very active in this area.

Figure 6 differs from Figure 5 in that it is a snow profile taken from the remaining stauch wall of the slab avalanche. Twenty-seven inches of very dense, sintered snow sit above the ice crust. It would appear that the upper layer is all wind deposited snow. Both the location of this stauch wall, further down the lee slope than the test snowpit in Figure 5, and the larger amount of sintered snow would reaffirm the belief that this 27 inches of snow was deposited by wind. Its position atop the ice crust layer would have meant virtually no bonding in the cold weather between the sintered snow layer and the ice layer below it. Furthermore, the wind-deposited snow layer would have resulted in snow crystals with needle shapes rather than dendritic shapes and consequently, <u>within</u> the 27 inch snow layer, cohesiveness and shear strength would have been very weak.

In addition to snowpack conditions, the large fragments of granite rock brought down by the avalanche affected the outcome. Largely due to this debris, injuries were sustained by the victims, compounding the avalanche hazard potential at the Cathedral Trail Site (Figure 7).

CONCLUSIONS

Given the nature of the terrain, snowpack data and climatic variables in Maine there are a number of avalanche variables that are of importance to Baxter State Park Rangers and recreationists. These relate particularly to slope aspects, wind, snowfall and temperature patterns.

Lee slopes facing northeast, east and southeast need to be examined closely for wind slab avalanche potential. In addition, periods of approximately 24 hours immediately following a snowfall should be exempted from hiking/ climbing. Further, because of the nature of the warm lows moving into Maine from the Gulf of Mexico, temperatures are likely to vary considerably in December, February and March. This phenomenon becomes critical when freezing temperatures and snowfall ensue.

The terrain in Baxter State Park that bears attention is the Mount Katahdin area, both because of the mountain's popularity and because of its avalanche potential. Slope angles of approximately 30°-50° are more

FIGURE 7: CATHEDRAL TRAIL AVALANCHE SITE

likely to be avalanche-prone than those with slopes greater than 50° or less than 30°. Moreover, the concave slope at the base of Cathedral Trail is an important avalanche initiator.

With respect to the avalanche hazard within Baxter State Park, current Park practice in which avalanche hazard is not evaluated is perhaps the most needed change. Winter recreationists would be greatly aided by an avalanche hazard rating for the Mount Katahdin area.

Up until March of 1986, Park Rangers had little experience in snowpit analysis. These skills need further testing and application, as do search and rescue techniques. This is particularly important in light of the increasing popularity of winter sports and trends in avalanche victims. Recreationists, primarily mountaineers, are the group most frequently caught, buried or killed by avalanches in both Canada (McFarlane, 1986) and the U.S. (Armstrong, 1985).

Park Rangers also need to more closely examine the avalanche preparedness of mountaineers and alpine skiers. For example, the climbers caught in 1984 did not carry an avalanche shovel.

If the preceding factors are carefully incorporated into Park Management Policy (that of forecasting, search and rescue and avalanche preparedness), avalanche hazard potential in Baxter State Park can be substantially reduced. Furthermore, the experience of Mount Katahdin can be enjoyed in safety and meditation atop the "...unfinished part of the globe...." (Thoreau, 1864, reprinted in Moldenhauer (ed.) 1983, p.65)

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