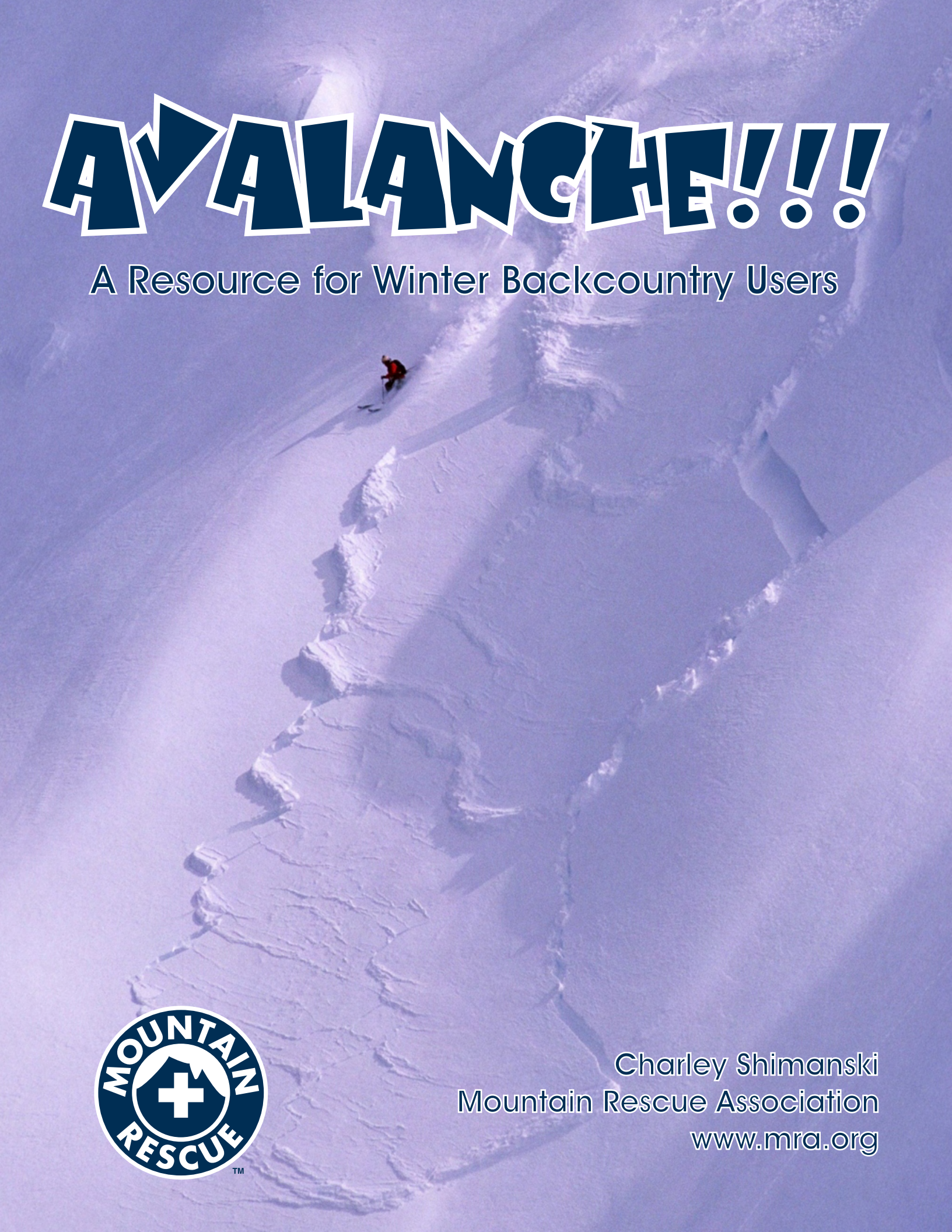
AVALANCHE!!!

A Resource for Winter Backcountry Users



Charley Shimanski
Mountain Rescue Association
www.mra.org

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COVER PHOTO: Jamey Parks in Haines Alaska by Will Wissman *(www.WillWissman.com)*

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Objective

The Mountain Rescue Association (MRA), a volunteer organization dedicated to saving lives through rescue and mountain safety education, has developed this basic level "Avalanche!!!" program. It is designed to be a resource to backcountry users who may spend time in avalanche terrain.

At the conclusion of this program, students should be able to:

- Understand the basic essentials of snow science;
- Understand how weather, terrain, and snowpack effect avalanche hazard;
- Understand safe route selection in avalanche terrain; and,
- Understand precautions, and how to perform an avalanche rescue.

This program would not have been possible without the guidance, mentorship, and teaching of Dale Atkins, a long-time snow scientist, patroller, rescuer, and friend.

We also thank the American Avalanche Association, the National Ski Patrol, the National Forest Service, and the Colorado Avalanche Information Center (CAIC). We are grateful to each of the snow science and avalanche professional who kindly offered their assistance.

About the Author

Charley Shimanski is President and Education Director for the Mountain Rescue Association, a national organization of rescue mountaineers. A 20-year veteran of Colorado's *Alpine Rescue Team*, Charley has participated as a field member and Incident Commander for hundreds of rescues among Colorado's highest peaks.

The author of the Mountain Rescue Association's *Helicopters in Mountain Rescue Operations* manuals and co-author of the *Avalanche Rescue Operations* manual, Charley has consulted rescue mountaineers, mountain guides, and climbers throughout the world, from Israel to China, from Kilimanjaro to Aconcogua. Charley is a frequent speaker at meetings of the International Technical Rescue Symposium, The National Association of Search and Rescue, the Wilderness Medical Society, and the Mountain Rescue Association.

Introduction

Avalanches are a natural phenomenon. They have been recorded as far back as 192 BC, when Hannibal crossed the Alps. At one time, it was thought that avalanches were caused by evil witches living in the villages below. These witches were often burned at the stake after a destructive avalanche.

The whole key to avalanches is gravity. Without gravity, there would be no avalanches. Every flake of snow and every piece of rock has but one wish... to succumb to gravity and fall to a lower point.

It has been estimated that 1 million avalanches occur worldwide each year. Most of these occur in the Alps in Austria, Switzerland, France and Italy. In the United States, 100,000 occur annually.

100,000 avalanches occur each year in the United States

The worst recorded avalanche in the U.S. occurred in 1910 in Wellington, Washington and left 96 dead with 22 survivors. The worst known in the world occurred in Yungay, Peru and left 20,000 dead. This avalanche was measured to be 10 miles long, 1 mile wide, and displaced 3 million cubic yards of snow. 3 million cubic yards of snow... That's enough snow to fill a 200 story building the size of a football field.

More than 180 people are caught in avalanches each year in the United States. Of these, 90 are partly or completely buried, 29 are injured and an average of 28 are killed. Over 200 people die worldwide each year. These statistics are based on reported burials... it is safe to assume that many more burials occur than are actually reported.

From 1950 to 2001, avalanches in the United States killed 491 people.

Recreationalists accounted for the vast majority of avalanche fatalities, with climbers, ski tourers, lift skiers, and snowmachiners comprising most of the recreational deaths. The majority of the lift skiers were killed while skiing out of bounds or in closed sections of the ski area.

When looking at avalanche fatalities, one cannot overstate the importance of the human element. In fact, 90% of the time, avalanche victims are killed in avalanches that they themselves trigger. In other words, the avalanche would not have occurred if they had not been on the slope at that moment.

Finally, statistics say that 61% of all avalanche deaths occur during the months of January, February and March.

What follows is an evaluation of the science behind what has been appropriately called "White Death."

Part 1 – Snow Science

The "Average" Avalanche

Avalanches come in all shapes and sizes. The average snow avalanche is 2 to 3 feet

deep at the fracture line, about 150 feet wide and will fall about 400 feet in elevation. That's a slide area bigger than a football field! What's more impressive is that the average avalanche travels at speeds around 50 M.P.H., a little faster than most of us like to ski! The average time duration of a slide of this size is less than 30 seconds. This is the size of avalanche that catches and kills most backcountry travelers.

Avalanches can be much larger...some of the largest reported avalanches have involved complete mountainsides of snow, the area of 20 football fields, having a depth of 10 feet at the fracture line and falling over 1½ miles at speeds well over 100 miles per hour! As impressive as these avalanches are, generally the smaller ones are the killers. In fact, 50% of avalanche fatalities are killed in slides of less than 100 feet and people have been killed in slides of less than 40 feet. The bigger ones almost always release from natural causes and do not involve people unless they happen to be in the wrong place at the wrong time. Artificial triggers, such as snowmobiles or skiers are much more effective at releasing small to medium sized avalanches in shallower snowpack, where the stress caused by their weight is enough to cause the snowpack to fail.

Avalanches are a powerful phenomenon. In 1969 at a ski hill in Washington, steel chair-lift poles were bent in an avalanche. In a recent Colorado avalanche, a flashlight inside a glove compartment of a buried automobile was found completely packed with snow. Larger avalanches possess the force to uproot mature forests and even destroy structures built of concrete. The reason, forces in excess of 15,000 lbs. per square foot.

The fastest recorded avalanche occurred in Japan and was measured to be traveling at speeds in excess of 230 m.p.h.

Two Types of Avalanches

Avalanches come in two distinctly different types... **"Loose Snow"** and **"Slab"** avalanches.

Loose snow avalanches are a cohesionless mass of snow that start at a point and fan out as they run, forming an inverted "V". This type of avalanche usually involves small amounts of near-surface snow and is not considered a major threat to people. Do not lose respect for these slides as they have taken lives.

A Loose Snow Avalanche. Photo: Charley Shimanski

Slab avalanches, on the other hand, start when a large area of cohesive snow fails and slides down the slope. There is a well-defined fracture line from where the snow broke away. In addition, there may be angular blocks or chunks of snow in the slide, sometimes larger than a refrigerator. A slab avalanche can involve a range of snow thickness from just near surface layers to an event that includes the entire snow cover down to the ground.

Slab avalanches are almost always caused by additional stress on the hill, such as a snowmobiler or skier.

A Slab Avalanche. Photo: Dale Atkins

Since slab avalanches cause nearly all avalanche accidents, it is important to understand the conditions within the snowpack that lead to these slab avalanches

Snowstorms and wind-redistribution cause the snowpack to develop in layers. Once a layer has achieved sufficient cohesive strength, the first prerequisite for a slab avalanche has been established. Weather will help add the second requirement... a weak layer. If a weak layer has developed underneath a strong layer, the perfect recipe for an avalanche exists. If the weak layer fails, the cohesive strong layer above it will fracture and fall away from the stress. Both ingredients - a cohesive layer of snow and a weak layer below - are necessary for a slab avalanche.

When the strong layer fractures, the crack is estimated to shoot across the snowfield at a speed of over 1000 miles per hour.

There are three main variables that help develop a potentially unstable snowcover: weather, terrain and snowpack. By understanding these variables, backcountry users will have a better chance of predicting avalanche danger.

80 percent of avalanches occur either during or shortly after a storm. Photo: Charley Shimanski

Weather

The first significant contributing factor is weather. 80% of avalanches occur during or shortly after a storm. For this reason, the information gathering process must begin BEFORE you leave on your outing.

Before you leave home, gather as much information as possible! Utilize your local avalanche forecast center's web site and/or recorded avalanche hot line and listen to weather reports on the TV and radio. The local Ski Patrol may also have information regarding the latest avalanche forecast.

Invest in a commercially sold cross-country trail map if one exists for the area you plan to visit. Sometimes, dangerous avalanche zones are noted, giving you advance warning of problem areas.

What should you look for when on the trail? Beware of changing weather patterns, especially unusual changes in wind, snowfall and temperatures.

Storms

The first thing to look for is storms. Remember that 80% of avalanches occur during or shortly after a storm, often because of the fact that the existing snowpack cannot support the weight of the new snow, especially if stressed by the added weight of a skier or snowmobiler.

Winds

You must also be alert to the presence of winds. Winds of over 15 M.P.H. cause avalanche hazard to increase greatly. Under these conditions, the wind lifts snow from windward slopes and redeposits it onto leeward slopes. This produces greater accumulations of heavier, denser snow on these leeward slopes, which stresses the existing snowpack. Snow plumes off the tops of ridges are a good indication that wind is moving the snow. Cornices on leeward slopes indicate accumulations of wind-deposited snow.

New Snow

Snow falling at a rate of one inch per hour or greater increases the avalanche danger as a result of the increased weight. If a foot or more of fresh snow is deposited at one time, then avalanche danger is often extreme. Even four inches of fresh snow is dangerous, in conditions of high wind.

Temperature

Snow remains unstable (or may become less stable) in cold temperatures, due to the temperature difference between the surface of the snow and the surface of the ground. Once temperatures climb into the range of 20-32 degrees, the snow cover will rapidly stabilize, due to settling. Temperatures above freezing produce very dangerous conditions, because melting snow introduces water into the snowpack. Water weakens the existing snow crystals and acts as a lubricant in the snowpack. In other words, temperatures significantly above freezing increase the danger.

Terrain

Learning to identify avalanche terrain is most important in recognizing and evaluating avalanche hazard. It's easy to recognize where avalanches are common and where they are not.

Slope Steepness

The steepness of a slope is a key factor in determining avalanche danger. It is a common misconception that avalanches occur on steep slopes. The fact is that most avalanches occur on slopes of 30 to 45 degrees. It is within this range of steepness that the balance between the strength of the layers of snow and the stress of gravity is most critical. Steeper slopes tend not to hold a significant amount of snow due to gravity. Slopes of less than 30 degrees may not be as prone to slide, but may be as dangerous in the right conditions especially in the spring when wet avalanches occur.

Unfortunately, 30 to 45 degrees also provides the most challenging ski terrain.

Remember, too, that short slopes may be as dangerous as long ones.

Slope Orientation

The orientation of a slope is also an important factor. By "orientation," we mean whether the slope is having snow blown onto it or blown off from it. We also mean whether the slope faces north or south. Leeward slopes, or those drifted by winds, are more dangerous because of the added depth and weight of the snow. North-facing and shaded slopes tend to be more dangerous during the mid-winter periods, mostly because of the colder surface

temperatures. South-facing slopes tend to be more dangerous during spring thaw, especially on a sunny day, due to solar heating and the introduction of water (melting snow on the surface) into the snowpack.

Carrying an inclinometer helps measure slope angles. Photo: Ron Bookman

Slope Profile

We must also evaluate the slope profile. That is, whether the slope is flat or curved. Convex slopes are likely to fracture at the bulge. Concave slopes provide a certain amount of support at the base, though they are still capable of avalanching.

Be especially cautious around bowl-shaped slopes or those with narrow, deep gullies. Both of these features help trap blowing snow, especially on the leeward side of the mountain.

Vegetation

Vegetation can be a key indication of avalanche hazard. The first thing to look for is "ground cover." Large rocks, trees and heavy brush help anchor the snow, at least until they become covered. Avalanches can start even in the trees, since sparse trees can actually weeken the snow cover. To be reasonably safe, the trees must be so dense as to make it difficult to maneuver.

Equally important, yet often neglected, is knowing what the slope looks like without the snowpack. If the slope is a grassy hill in the summer, it is more likely to slide due to the lack of anchors. Conversely, if the slope is known to have many large rocks, tree stumps or bushes, it may be more stable. This is true only as long as the snowpack is not so deep as to cover these natural anchors.

Elevation

What about elevation? Avalanche danger generally increases with elevation. Most large avalanche starting zones are above timberline. This is due to the fact that there is generally a greater snow cover above treeline. In addition, there are less natural anchors above treeline.

Past Avalanche Activity

Indicators of past avalanches point out dangerous terrain. Signs that indicate that an avalanche has occurred before are:

- Slide debris indicating an earlier slide.
- Swaths of open slope between forested or vegetated areas
- Bent or broken trees;"flagged" trees
- Presence of aspens or willows in swaths between pine forests

These indicators are equally visible during the summer months. Be alert of these signs year-round and make notes of the dangerous zones if you plan to ski the area and make a note on your maps. Things always look different under several feet of snow.

Snowpack

Snowpack is the last variable that we will use for clues. By combining the clues you observe, identify and feel from the snowpack, a decision should easily be made whether or not the snow is unstable and has potential to slide. Some of the signs of

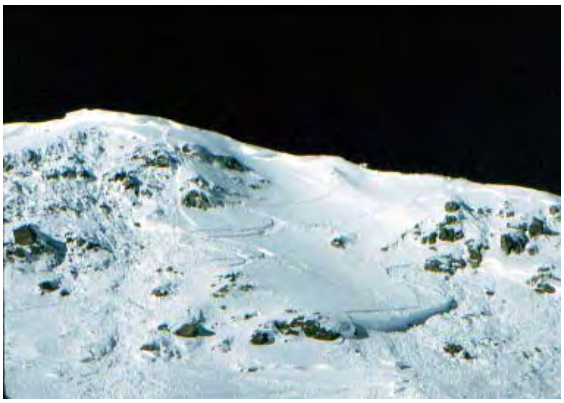
avalanche are obvious. The following clues are direct indications of instability in the snowpack:

Recent Avalanche Activity

Again, recent avalanche activity is the best indicator of dangerous slopes, especially when it is on slopes of similar aspect and steepness. In other words, if you see the debris from a recent avalanche, know that there is danger of additional avalanches on similar slopes.

Recent Wind-Loading

Recent wind-loading is another indicator of avalanche danger. Smooth "pillows" and cornices as well as snow plumes of the ridge tops are indicators of wind-transported snow. This means increased stress is being exerted on the snowpack due to the addition of the wind deposited snow. Furthermore, wind deposited crystals develop dangerous "wind slabs," since this type of crystal is subject to numerous collisions while the snow is wind-blown.



Recent avalanche activity is a key indicator of possibly dangerous terrain. Photo: Charley Shimanski

Hollow Sounds

You must use your ears as you evaluate avalanche hazard. "Drum-like" or "whumpf" sounds that occur under your feet indicate unstable slab conditions. Also, pay attention to distinctive settling sounds; feeling the snow settle or drop are clues of an unstable layer of snow...indicating a dangerous avalanche condition.

Shooting Cracks

Look closely at the terrain you wish to cross. Cracks in the snow around you are an excellent indicator of avalanche danger, especially if they are occurring around you as you move across the snowpack. You should not only avoid the slope where you see or produce cracks, but also any slopes with similar profile and/or orientation.

Snow stability evaluations can be an important tool of any hazard assessment. Photo: Ron Bookman

Snow Stability Tests

Through additional training, you can learn to recognize the weaknesses in the snowpack by evaluating a cut-away of the snow layers. For now, just remember that avalanches occur when a weak layer in the snowpack fails. Your ability to recognize these weaknesses will help you make an educated decision regarding safe backcountry travel.

Conclusion

In summary, by looking, listening and feeling you should be able to recognize,

evaluate and avoid avalanche hazards that you may encounter on your next backcountry trip. You must be **thinking avalanche** whenever you are on or near slopes, regardless of the slope size and time of year. By always **thinking avalanche** you will be much more observant, you will gather more information from clues, and you will become a better decision-maker.

Part 2 – Avoidance, Survival, and Rescue

Route Selection

In Part I, we learned about what causes an avalanche. We also learned that there are some basic ways to recognize avalanche hazard. Sometimes you may have no choice but to cross a potential slide zone.

If you MUST cross a dangerous slope, follow these guidelines:

Travel on the windward side of ridges, slightly away from the ridge top. By doing so, you are exposing yourselves to areas with lesser snowpack and are avoiding dangerous cornices.

Choose your campsites carefully. Campsites in narrow valleys are dangerous.

Use areas of dense timber, ridges or rock outcrops as islands of safety. The less time you spend exposed to hazard, the less your chances of triggering an avalanche.

Precautions

Before crossing, prepare yourself for the worst. Put on your hat, gloves, scarf and goggles. Zip up your coat and tighten the cuffs and collar. Your goal here is to make yourself padded and insulated in the event you become trapped. Next, remove ski pole straps from your wrists and unfasten your ski safety straps.

When crossing a potential slide zone, one person should cross at a time. All other party members should watch from a position of safety. This is a very important point to remember for two reasons: First, by only exposing one member of the party to the hazard at a time, the remaining party members are available to act as rescuers if necessary. Second, less stress is being put on the snowcover at a given time. In 1986, eleven people died in six Colorado avalanches -- had they all followed this one simple rule, five of those victims would have lived.

All party members should cross in the same track. Doing so allows the crossing to be accomplished more quickly, but more importantly, less snow is disturbed, reducing the chance that a slide will release.

If you must ascend or descend a dangerous slope, go straight up or straight down. Do not traverse back and forth across the slope, as the additional stress caused by the turns may be enough to cause the snowpack to fail. Travel as close to the sides of the slope as possible, leaving you a way out if a slide occurs.

If you must ascend or descend a dangerous slope, go straight up or straight down. Do not traverse back and forth across the slope. Photo: Charley Shimanski

Do not assume that because others have crossed safely just before you, there is no danger. They may have disturbed the snow just enough for you to set off a slide. There are documented cases where an avalanche

was triggered by the tenth or eleventh skier in a group.

A slope should not be considered safe just because you crossed it earlier the same day. Serious weaknesses in the snow layers may develop overnight, or in the right circumstances, in a matter of hours.

Always obey signs closing slopes or warning of avalanche danger, especially at developed ski areas.

Carry and use an avalanche rescue beacon. Carry a collapsible probe pole or probe ski poles. Be competent in the use of these tools BEFORE going into the field.

ALWAYS carry a shovel. Your hands, skis and poles make lousy tools for digging. Avalanche debris sets up very hard...almost as hard as concrete - and it sets up fast. Several years ago, a test was conducted in Switzerland where a group of people was assembled at a mound of fresh avalanche debris and instructed to dig a one cubic yard hole. The first time, they did it using only hands, skis and poles; it took each person, on the average, 45 minutes. The second time, they used a shovel and it took an average of 8 minutes. The difference - 37 minutes - is literally a lifetime to a buried victim.

A compass is helpful in determining slope orientation. Furthermore, certain compasses can help you assess slope angle.

Sometimes, even with very careful scrutiny of the weather, terrain and snowpack, and with the ability to recognize, evaluate and avoid the avalanche hazard, you might still find yourself having to deal with an avalanche. Usually, this means either you or another team member (or if you really blew it, both of you) are caught in the slide.

Avalanche Survival Techniques

If YOU are caught in an avalanche, follow these guidelines:

1. SHOUT OUT! You want to alert the other party members of your predicament. Shout, close your mouth to avoid taking in snow and discard all cumbersome equipment, such as your backpack. If you are on skis, or on a snow mobile, try to remain upright and maneuver to the side of the slide, where the forces are less. If you get knocked down, release your ski poles or snowmobile. Don't try to outrun the avalanche, even if you are on skis. Remember the average avalanche travels at speeds around 50 m.p.h. and will eventually overtake even the fastest skiers.

2. Once you are down and are caught in the avalanche, concentrate on staying on the surface of the moving snow. While the snow is moving, it will have virtually the same characteristics as water in a river. The closer you are to the surface, the greater your chances for survival. Whatever you do, make every effort to stay on top of the surface. Fight aggressively to stay on top and ferry yourself to the side of the avalanche.

3. If possible, grab a tree, bush, or rock to try to stabilize your position. For every second that you are not moving, the snow that slides past you cannot bury you.

4. Just before you come to a stop, get your hands in front of your face with your elbows at your chest in a fetal position and try to make an air pocket in the snow by moving your head back and forth. Take a deep slow breath and hold it until the snow settles around you.

5. As you come to a stop, attempt to get one hand above the surface so that others can see it.

6. Do not waste energy trying to extricate yourself, unless you can see light. Conserve your energy.

7. DO NOT PANIC (good luck!!!) Remain calm and wait for assistance.

Avalanche Rescue Techniques

Now let's look at the other side of the coin. What do you do if you just watched a member of your party get buried in a slide?

Time is of the essence in an avalanche rescue. Photo: Charley Shimanski

First, some facts and statistics regarding avalanche burials. These numbers paint a grim picture, but that is the necessary point to be made. This is a critical situation, since time is the victim's biggest enemy. What you as rescuers do in the first few minutes after the slide can possibly mean the difference between a successful rescue and a body recovery.

As might be expected, the chance for survival decreases with the length of time buried. Only 50% of all victims will survive after being buried for 30 minutes. One-third will survive after an hour and only one in ten will survive after three hours. The message in all of this - time kills.

Another relationship worth mentioning is survival rate vs. burial depth. Almost 90% of all victims buried one foot or less survives. Usually these people are able to dig themselves out or are easily located by rescuers. For victims buried between one and two feet, only about 53% will survive. At four feet, the survival rate is 39%.

Now that you understand what you as rescuers are up against, let's talk about how to best utilize what little time you realistically have.

1. If there are several people in your party, the first thing that must be done is that someone must take charge and direct the rescue effort. He or she should tell each rescuer specifically what they are to do. This is extremely important as it helps reduce panic and confusion and ensures an efficient operation. As we have just seen, time is everything and you can't afford to spend even a few minutes debating about what to do.

2. Before moving into the slide area, look for further avalanche danger and establish an escape route in the event of a second slide. If your team is large enough, assign a member to act as a lookout from the side of the slope. It is the lookout's job to alert the rescuers if a second slide releases. If your group is small enough that you don't have a lookout, each rescuer should constantly be watching and listening on his or her own.

3. Mark the spot where the victim was last seen.

4. Search downhill of the last seen area. Perform an avalanche beacon search if you have beacons. Before the search starts, all rescuers should switch their beacons from the "transmit" to the "receive" mode. This is critical to prevent false signals from being transmitted.

5. If you do not have beacons, start with a scuff search. Kick the snow surface looking

for clues that may be just under the surface. If you find something, such as an article of clothing or a ski pole, uncover it - and then leave it for future reference. Probe the area beneath the clue to determine if the victim is attached to or beneath the clue.

6. If you do not locate the victim during the scuff search, begin probing for the victim with an inverted ski pole, an avalanche probe or ski tip. Primary probing areas are around trees, rocks, and depressions in the snow and places where the slide debris has accumulated. Also, search the "toe" of the slide (the area where the debris field begins). Many victims end up here. After thoroughly probing all likely burial spots, you will want to start a probe line working from the bottom of the debris field uphill to the last seen point.

In organizing a probe line, all rescuers stand elbow to elbow and place their probes between their feet. When the leader gives the command to probe, all rescuers should

Probing for victims should be considered only after the avalanche transceiver search is completed. Photo: Charley Shimanski

then probe. At the next command, all rescuers pull their probes out of the snow and advance uphill together - approximately one foot - and repeat the probing process. In order for the probe line to be efficient, the team must work as a unit and never deviate from the described spacing. If someone encounters a "strike," that person should drop out of the line and begin shoveling. The rest of the line should continue probing. If the group is large enough that you can preassign someone to shovel, then no one should drop out of the line when a strike is encountered. The line should keep moving while the shoveler does his or her job.

7. DO NOT GO FOR HELP unless that help can be on scene in less than five minutes. Your team members are realistically the only chance the victim has for being saved, since the victim's chance for survival falls below 50% after just 30 minutes. Rescue teams are generally hours away from you and can usually do no more than recover the body.

At what point do you quit searching and go for additional help? This is probably one of the toughest decisions you will have to make. If there is a rule of thumb, it is that you should search until you cannot or should not continue. The welfare of the survivors cannot be overlooked or forgotten. Stop when there is danger of hypothermia, when weather conditions dictate or if there is the threat of another avalanche.

8. When you do go for help, contact the local sheriff or ski patrol. They will dispatch the local rescue group, who generally can do no more than bring out the body.

9. If you DO find the victim, perform standard first aid, including treatment for shock, hypothermia and any trauma-related injuries.

Conclusion

Each year, the Colorado rescue community meets in Breckenridge for a weekend-long avalanche clinic hosted by the Colorado Search and Rescue Board. For many years, one of the lead instructors at that clinic was Knox Williams. The Founder and long-time Director of the Colorado Avalanche

Information Center, and co-author of "The Avalanche Book", Knox was widely recognized as one of the foremost scholars in the field of avalanche study. It was a sobering experience to hear Knox say, year after year, there is no such thing as an "expert" in the field of avalanche prediction. After decades of studying this phenomenon, even Knox did not claim to be able to predict avalanches with absolute certainty. "Avoiding avalanches," says Knox "is much easier than predicting them."

MOUNTAIN
RESCUE
ASSOCIATION

The Mountain Rescue Association is an organization dedicated to saving lives through rescue and mountain safety education

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