INTRODUCTION

A snow avalanche is a fascinating natural phenomenon. Experts on the subject aren't able to predict, nor do they completely understand each and every avalanche occurrence. Regional avalanche centers across the country do have the technology to forecast avalanche danger. These forecasts are valuable tools in reducing danger to people. However, no matter what forecasts indicate even the smallest avalanche can be injurious or life threatening! In the United States avalanches kill about 30 people each year.

The general guidelines in this brochure will help you recognize the presence and the degree of avalanche danger.

- ***Awareness*** can help you and others avoid becoming an avalanche victim. Apply red-yellow-green light methodology to help determine whether terrain, weather, snow pack and human factors produce a go or no-go situation (see *Snow Sense* in the "For Further Information" section).
- ***Frequency.*** The more you participate in winter activities such as skiing, snowshoeing, and snowmobiling, the greater your risk of being caught in an avalanche —prepare for and learn about dangerous situations.
- ***Play it safe.*** Check the avalanche danger forecast for the area in which you plan to travel. Think about the changing weather, type of terrain and snow pack conditions around you, and constantly update your assessment of the avalanche danger. You can help minimize avalanche exposure to you and those around you by being cautious and alert. In the event of a burial, your preparedness may be the key to survival.

SNOW AVALANCHES

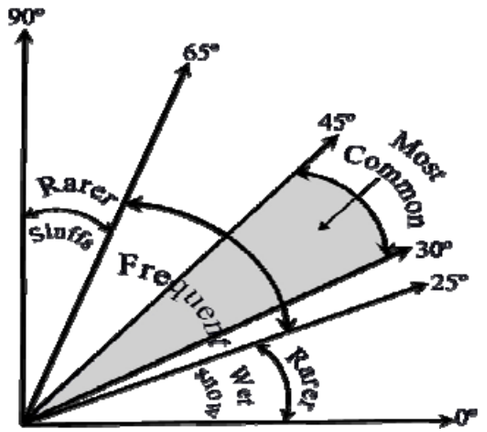
- ***Avalanches*** are caused by unstable snow conditions. Snow that is not well bonded to a slope, with underlying snow layers or other snow crystals, is categorized as "unstable snow". Weather, terrain, snow pack, and human factors also influence avalanche potential in unstable snow conditions
- **Loose-Snow Avalanches** start when unattached snow crystals slide down a slope. As it descends, this type of avalanche widens, forming an inverted V-shape and may become quite large as it gathers more surface snow. Depending on the size and conditions, it may also trigger the even more dangerous "slab avalanche".
- **Slab Avalanches** start when a solid area of the snow cover ruptures or breaks away all at once, leaving behind a well-defined fracture line.
- **Avalanche Safety Basics**—Remember that avalanches don't happen by accident and most human involvement is a matter of choice, not chance. Most avalanche accidents are caused by slab avalanches that are triggered by the victim or a member of the victim's party. However, any avalanche may cause injury or death and even small slides may be dangerous. Hence, always practice safe route finding skills, be aware of changing conditions, and carry avalanche rescue gear (a minimum of shovel, probe, beacon). Learn and apply avalanche terrain analysis and snow stability evaluation techniques to help minimize your risk. Remember that the avalanche danger rating levels issued by regional avalanche centers are only general guidelines. Distinctions between geographic areas, elevations, slope aspect and slope angle are approximate and transition zones between dangers exist. No matter what the current avalanche danger, there are avalanche safe areas in the mountains.

Special Thanks

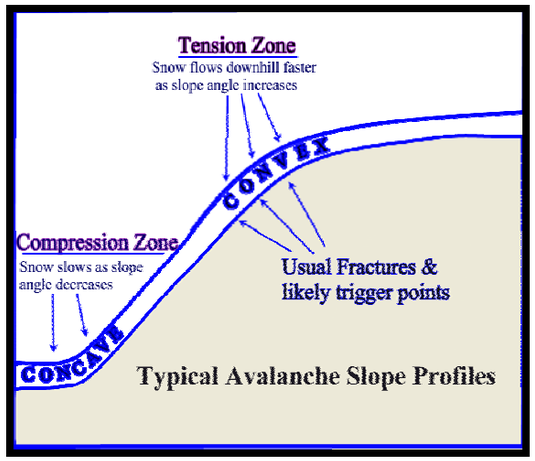
Produced in cooperation with the Friends of the Northwest Weather and Avalanche Center (www.avalanchenw.org).

TERRAIN FACTORS

Slope Steepness—Avalanches most frequently occur on slopes of 30 to 45 degrees, but they may occasionally release from either gentler or steeper terrain. The diagram below illustrates the slope angles where avalanches most commonly start.



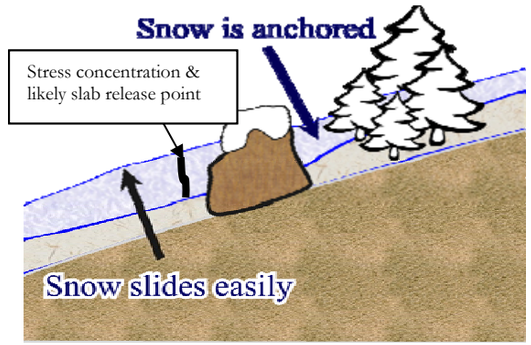
Slope Profile—Dangerous slab avalanches are more likely to begin on convex (raised or curving outward) slopes but may also begin on concave (sunken, or curving inward) slopes. Short slopes may be as dangerous as long slopes, especially if an avalanche carries its victims into or over terrain traps like cliffs, trees, rocks, creeks or crevasses. Almost half of all avalanche fatalities result from slides running less than 300 feet (about 90 m) slope distance.



Slope Aspect—North-facing slopes may be slower to stabilize than slopes facing in other directions. South facing slopes are especially dangerous in the spring when heated by the sun. *Leeward slopes*, slopes facing away from the wind, are dangerous because this is where the snow collects and may form an unstable slab. *Windward* slopes that face the wind generally have less snow and are usually more stable.

SNOW COVER FACTORS

Snow Depth—Large rocks, trees, and heavy brush help anchor the snow. Smooth, open slopes without these natural anchors are more dangerous. However, avalanches can start even among trees. When the snow depth covers natural anchors, additional snow layers will slide more readily. Snow depth also determines the rates of internal snowpack changes, like the development of weak sugar-like snow. Snow depth over an upper-level rain crust can also affect how rapidly snow layers weaken or facet above the crust when air temperatures are low—shallower depths mean more weakening.



Snow Layering—Make a habit of testing the layering and bonding of the snow structure by using ski or probe poles. Feel how the strength of the various snow layers changes as you push your probe through the snowpack. Test snow layering often as you move from area to area and use increasing caution if the resistance to a probe or pole decreases with increased depth. Snow structure and its stability can change significantly from slope to slope. Pay particular attention to very weak or very strong layers buried beneath the snow surface. The strong layers may act as a sliding surface for avalanches, especially if overlain by a weak layer.

If you are uncomfortable about what you feel (such as heavy snow over light snow, or the "whomping--collapse" of a snowpack around you), conduct further stability tests such as ski cutting, snowpits and shear tests, such as shovel shears, compression, stuff block or Rutshcblock tests.

Old Snow Surface—It is important to know the condition of the old snow surface when trying to assess developing snow stability. For example, cold snow falling on a hard, refrozen snow surface, such as a sun or rain crust, may form a weak bond and lead to a rapid increase in the danger.

HUMAN FACTORS

Within the basic triangle of snow pack, weather, and terrain lies the subjective **human factor**. All too often people ignore factual information, and make decisions that are neither prudent nor wise and are based on human issues. Some of these human considerations include:

Attitude—overconfidence, ego (pride or greed), stress, conflict, impatience, euphoria, hormones, *lion syndrome* (first tracks or rush to the summit).
Physical—fatigue, cold, wet, schedules, equipment, injury, "gizmo reliance"
Group—poor communication, poor planning, time management, tunnel vision, incorrect assumptions, disparate skill or physical levels, "*herding instinct*" (safety in numbers), "*lemming instinct*" (always follow), "*horse syndrome*" (head back to the barn), goals.
Skill level—do avalanche skills match travel skills?
Other factors—good weather; familiarity smugness; positive reinforcement, it-won't-happen-to-me beliefs, "*flatland vs. avalanche eyeballs*"

WEATHER FACTORS

- ***Changing Factors***—Rapid changes in weather conditions (wind, temperature, snow/rainfall) can quickly change snow pack stability; therefore you need to stay aware of the weather and the trends in the weather at all times. The snow pack is very dynamic, and weather may change what was a stable snow pack in the morning, into an unstable snow pack by afternoon.
- ***Winds***—Sustained winds of 15 mph or more, even during clear weather, may increase danger rapidly since such winds can quickly redistribute large amounts of loose surface snow. Snow plumes from ridges and peaks indicate that snow is being moved onto leeward slopes, which can accumulate ten times as much wind-blown snow as nearby sheltered valleys. . This can quickly create dangerous wind conditions on leeward slopes and large changes in slope stability as you traverse from windward to leeward slopes.
- ***Temperature***—Cold temperatures (well below freezing) tend to maintain an unstable snow pack, while warmer temperatures (near or above freezing) allow snow to "settle", bond and strengthen more quickly, thus making the snow pack more uniform and stable. Prolonged cold air temperatures result in internal weakening of the existing snow pack through strong vertical temperature differences in the snow pack and associated development of new weakly bonded crystals (faceting or depth hoar). Meanwhile prolonged warm temperatures result in introduction of liquid water into snow layers that acts to lubricate and weaken snow pack bonds.
- ***Storms***—A high percentage of all avalanches occur during or shortly after storms. Be especially aware of storms that start cold and then warm during snowfall.
- ***Rate of Snowfall***—Snow falling at the rate of 1 inch (2-3 cm) per hour or more increases avalanche danger rapidly, and allows underlying weaker layers less chance to safely accommodate the new load.
- ***New Snow***—Be alert to dangerous conditions with a foot or more of new snow. Remember that new snow depth may vary considerably with slope elevation and aspect.
- ***Wet Snow***—Rainfall can rapidly weaken surface snow and overload buried, weak layers, sometimes causing avalanches to occur almost instantaneously with the start of rain. Rain may also percolate through the snow until it reaches an ice layer or a layer of smaller grains. It can then pool or lubricate the snow near or within this layer and produce large, wet-slab avalanches. During sustained heavy rainfall, a series of avalanches may occur on the same slope as progressively deeper snow layers are weakened or stressed. Wet-slab avalanches are also produced in the spring by strong sunshine or radiation through clouds that melt and weaken the snowcover. When a warm day is followed by clouds overnight that prevent the snow surface from refreezing, dangerous avalanche conditions may develop the next day when temperatures increase, and larger deep slabs may result.
- ***Clear weather***—While clear, calm skies during winter often allows for excellent recreating opportunities and great visibility, it may also produce surface hoar, the ice equivalent of dew. Fragile ice crystals may be deposited directly on the snow surface during clear nights, and may provide very weak attachment to subsequent new or wind transported snow. In such instances, very sensitive slab slides are possible.

GENERAL OBSERVATIONS

- ***Old Slide Paths***—Generally, avalanches reoccur in "paths" where they have already established a track and run out area. Look for steep open slopes in the middle of otherwise forested areas, pushed over smaller trees and trees with limbs broken off, especially on the uphill side. Avoid steep gullies and steep open slopes. Even gentler open terrain may be dangerous when connected to steeper terrain above.
- ***Recent Avalanche Activity***—If you see evidence of recent avalanches (like fracture lines and debris), this is bull's eye information. Suspect dangerous conditions, especially on other slopes with similar aspects.
- ***Sounds and Cracks***—If the snow sounds hollow, particularly on a leeward slope, conditions are probably dangerous. If the snow cracks and the cracks spread, this usually indicates slab avalanche danger is high.
- ***Elevation***—Although avalanche danger generally increases with elevation, unusual weather conditions combined with local topography may occasionally reverse this relationship. Don't assume anything when your life may be on the line.
- ***Information***—Check the local weather and avalanche forecasts before you go. Generally, NOAA weather radio will carry avalanche forecasts when high or extreme danger is expected. You can also contact local agency (Forest or Park Service, etc) offices or patrollers at ski areas.

LEVELS OF AVALANCHE DANGER

Avalanche danger ratings levels have been adopted within North America (with slight changes in Canada) and are generally accepted internationally. These levels are (with appropriate color coding for visual display):

- ***Low Avalanche Danger (green)***—Natural avalanches very unlikely. Human triggered avalanches unlikely. Generally stable snow. Isolated areas of instability. Travel is generally safe. Normal caution advised.
- ***Moderate Avalanche Danger (yellow)***—Natural avalanches unlikely. Human triggered avalanches possible. Unstable slabs possible on steep terrain. Use caution in steeper terrain on certain aspects.
- ***Considerable Avalanche Danger (orange)***—Natural avalanches possible. Human triggered avalanches probable. Unstable slabs probable on steep terrain. Be increasingly cautious in steeper terrain.
- ***High Avalanche Danger (red)***—Natural and human triggered avalanches likely. Unstable slabs likely on a variety of aspects and slope angles. Travel in avalanche terrain is not recommended. Safest travel on windward ridges of lower angle slopes without steeper terrain above.
- ***Extreme Avalanche Danger (red with black border)***—Widespread natural or human triggered avalanches certain. Extremely unstable slabs certain on most aspects and slope angles. Large destructive avalanches possible. Travel in avalanche terrain should be avoided and travel confined to low angle terrain well away from avalanche path runouts.

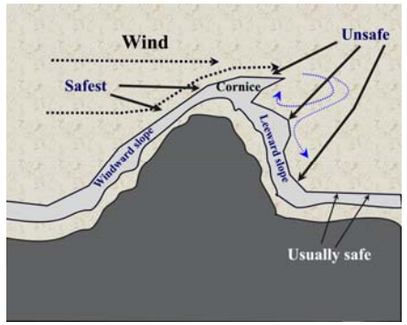
COMMON SNOW PACK TESTS

Stability and snow structure tests like the ski cut, hand shear, probe test, Rutschblock, stuff block, compression test and shovel shear are often important pieces of the puzzle when trying to assess snow pack layering and related avalanche danger. Although specifics for such tests are beyond the scope of this pamphlet, backcountry users are urged to read some of the references listed, watch a video or take avalanche education and awareness classes to learn how to best utilize the often-critical information such snow tests can provide.

ROUTE SELECTION AND PRECAUTIONS

The safest routes are on ridge tops and slightly on the windward side, away from cornices. Windward slopes are usually safer than leeward slopes. If you cannot travel on ridges the next safest route is out in the valley, far from the bottom of slopes.

Avoid cornices and steeper sections of a slope. Move toward ridge tops by detouring around cornice areas, using minor ribs or ridges on which the snow, if released, would generally move away from you.



If you must cross a potentially dangerous slope, stay high and near the top. If you see cracks in the snow, it is best to backtrack and avoid them as well as nearby similar slopes.

If you are "highmarking" on snowmobiles and a member of your party gets stuck near the high point, do **not** go to assist. Many avalanche accidents involving sleds have occurred as a result of multiple snowmobiles stressing the snow pack simultaneously. Even the normally forceful act of a sledder trying to turn a stuck sled around may trigger an avalanche. Please do not assume that your machine can outrun a slide—several sledders have tried to win this race and have lost.

No matter what sort of equipment you are on (skis, snowboard, snowmobile, snowshoe, etc), only one person at a time should cross a potentially dangerous slope. All others should watch. Before crossing the slope, prepare for a potential slide, and remove or loosen equipment that might restrict your ability to swim in the slide. Fasten down all clothing, put on your hat and gloves, and raise your parka hood.

Each person in the party should carry and know how to use an avalanche beacon, sectional probe poles, and a shovel.

If you must ascend or descend a dangerous slope, it is generally best to go straight up or down; do not traverse back and forth across the slope. Also take advantage of areas of dense timber, ridges, or rocky outcrops as "islands of safety".

Spend as little time as possible on open slopes. As the danger increases, proper route selection becomes more important and the number of slopes that can be safely negotiated decreases. Always think about how the weather might have affected the snow pack along your planned route of travel. Finally never travel above anyone or allow anyone to travel above you.

AVALANCHE SURVIVAL

If you are caught in an avalanche

- Try to discard all equipment and move away from a snowmobile if you're riding one. Yell and try to attract the attention of your group.
- Make swimming motions. Fight to stay on top of the snow; if possible try to work your way to the side of the avalanche.
- Before coming to a stop, get your hands in front of your face and try to make an air space in the snow. If you know you are close to the surface, try to stick a hand or foot out of the snow so you can more easily be found.
- Try to remain calm and breathe slowly.

If you see someone caught in an avalanche

- Determine that it is safe to enter into the area of the avalanche. You do not want to become another victim if adjacent slopes release. Stay aware of the changing avalanche danger if a storm is in progress.
- Mark the last seen area of the victim(s). Maintain contact with any eye witness(es) and seek out all the information possible about the event.
- Search directly down slope from the last seen area or try to establish a likely trajectory. If the victim is not immediately visible on the surface, scuff or probe likely burial areas (deposits, terrain transitions, above barriers, etc.) quickly with a ski or probe pole while using avalanche beacons if available.

You are the victim's best hope for survival

- Time is critical! Do not desert the victim(s) by going for help, unless help is only moments away. Remember, you must consider not only the time required for you to get help but also the time required for help to return.

First Aid

- Treat for suffocation, shock, impact injuries and hypothermia.

Time is the key to survival

- Only one in two victims buried survive the first half hour. Every minute counts!

FOR FURTHER INFORMATION

During the winter, daily avalanche danger analyses and forecasts, along with hourly mountain weather data, are available from a variety of sources, including the Internet, NOAA weather radio, avalanche hotlines, and local news sources. You may also want to contact Forest Service or Park Service offices or local ski patrols. In addition, many excellent references exist including: *Staying Alive in Avalanche Terrain*—B. Tremper; *The Avalanche Handbook*—D. McClung & P. Schaerer; *Snow Sense*—Fesler & Fredston; *Avalanche Safety for Skiers and Climbers*—T. Daffern; *Snowy Torrents*—Logan & Atkins; *Free Riding in Avalanche Terrain*—B. Jamieson & McDonald; *Sledding in Avalanche Terrain*—B Jamieson & Svederus; *Backcountry Avalanche Awareness*—Jamieson. Some web sites that offer avalanche education or links to education sources include: www.avalanche.org and www.nwac.us. Finally, recent videos such as *Winning the Avalanche Game* and *Riding Safely in Avalanche Country* are instructive, and more are being developed annually.

R6-REC-REG-01-03

BASIC PRINCIPLES FOR AVOIDING AND SURVIVING

SNOW AVALANCHES

A skier was lucky after triggering this relatively small slab avalanche near Whistler, BC. Note the tracks leaving the debris at the bottom of the slide.

–Photo by Mark Moore.

Northwest Weather & Avalanche Center
7600 Sandpoint Way NE
Seattle, WA 98115-6349
www.nwac.us

USDA United States Department of Agriculture

Forest Service Pacific Northwest Region