Colorado Mountain Club
Youth Education Program
AVALANCHE SCIENCE
www.cmc.org/YEP

This avalanche awareness curriculum was produced in partnership between the Colorado Mountain Club's Conservation Department's Backcountry Snowsports Initiative and Youth Education Program as well as the 10th Mountain Division Hut Association.

Activity 1:	**Snow Pits**
Time frame	1 hour +
Age Group	High School
References:	http://www.nasa.gov/pdf/186123main_SnowPitProcedures.pdf
Materials needed:	1. Probe 2. Snow Shovel 3. Notebook and Writing Utensil 4. Snow Saw or other Straightedge Object 5. Ruler 6. Thermometer
Goal:	Students will: • Learn how to assess a snow pit for avalanche danger
Objectives:	Students will be able to: • Dig and assess a snow pit • Test the snow pack to failure
Introduction:	The creation and evaluation of a snow pit is the best tool anyone has in evaluating the conditions of the snowpack in their present location. It also presents a relevant means of collecting and interpreting data from the natural environment. Snow pit evaluation can range from a highly analytical science to a quick and dirty assessment tool. The means depth of analysis will depend on the needs of your group, but regardless of your goal a snow pit offers a means of learning from your surroundings which should be taken advantage of.
Outline:	*How to assess a snowpack with your group:* **Temperature** Recording the temperature of the snowpack provides a quantitative means of determining variations in the snow due to alterations in snow density. Temperature should be measured on the shaded side of the pit. 1. Choose a set interval to measure temperature with in the pit i.e. 10 or 20cms.

2. Starting near the surface, place thermometer in the snow and shade the snow above it with a shovel. Allow the thermometer to sit undisturbed within the snow for approximately 1 min. Remove and record temperature.
3. Repeat this process at the determine interval for the entire depth of the snow pit.

Layer Boundaries

1. Physically determine the layers by running a thin solid object (such as a credit card) through the snowpack while feeling for changes in hardness or pressing 1 gloved finger into the snow pack from the top to bottom noting the changes in hardness.
2. Record the depth at which all the layers occur i.e. Layer 1: 0-13cm Layer 2: 13-37cm ….
3. Visually determine layers within the snowpack by creating a 4-6 inch slice of snow on the shaded side of the pit. Removing the snow from behind this slice will allow the sun to pass though the snow and help define the layers
4. Once layers are determined, it is good practice to attempt to trace the layer through the 3 sides of the pit to ensure it is continuous within the snowpack.

Snow Hardness

Once the layers of snow have been determined, testing the hardness of each layer offers another interactive tool for gathering information from the snow pack.

1. Find a fresh surface on a snow layer and start by pressing your gloved fist into the layer with 2 – 3 pounds of force (about enough to push a full coffee mug across a flat table). If your gloved fist enters the snow layer note the layer as F. If not, continue to four gloved fingers and so forth. Please keep in mind that the test shows relative hardness of the layers so as long as you are consistent in the force you use, the test has value.
2. Repeat for each layer.
    - The table below provides the test and symbols.

Symbol	*Hand test*	*Term*
F	*Fist in glove*	*Very Low*
4F	*Four fingers in glove*	*Low*
1F	*One finger in glove*	*Medium*
P	*Sharp end of pencil*	*High*
K	*Knife blade*	*Very High*
I	*Too hard to insert knife*	*Ice*

As a note Slab layers are generally harder and more cohesive than weak layers. Hard cohesive slab layers above weak layers are areas of concern. For example: Finding a 20cm thick P layer on top of a 4cm thick 4F.

Strength and Stability Test

Once all this data collection is complete it is important to test the snow pack stability to gain a reference for what the data you collected means within this area. There are many ways to test snow pack stability safely. The one described below presents a simple and effective means of seeing alterations in the weak layers of the snowpack.

1. In an undisturbed location representative of the terrain in which you took your snow pit measurements, dig a pit leaving a 30cm square block undisturbed along the back wall.
2. Use your snow saw to cut behind the block to completely isolate the column from the walls of the snow pit.
3. Perform the tap test described below by tapping on top of the isolated column.
4. Make a quick reference to your previous notes regarding the location of weak layers so you know where to watch for changes.
5. Follow the progression of tapping illustrated in the chart below.

Term	*Description*
Very Easy	*Fractures during cutting*
Easy	*Fractures within 10 light taps using finger tips only*
Moderate	*Fractures within 10 moderate taps from the elbow using finger tips*
Hard	*Fractures within 10 firm taps from whole arm using palm or fist*
No Fracture	*Does not fracture*

7. Record the point at which fracturing (the breaking or shearing of the weak layer) occurs.
8. Be sure to continue the test through its entirety to see if any deeper factures will occur.

Conclusions

Making observations about the snow pack though a snow pit is a wonderful way to learn about the snow and alert you about the potential dangers of traveling on that specific snow pack. Keep in mind that snow is an incredibly dynamic surface that is affected by lots of very small conditions that are commonly difficult to determine. That means your observations from a snow pit may only characterize the terrain immediately surrounding the pit. Changes in slope angle, slope aspects, and vegetation will all play a role in altering the snowpack. Please travel with respect and caution whenever you are moving though winter terrain.

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Avalanche Assessment Background Information

Field based snow assessment is a wonderful way to introduce the complexities of snow to individuals and develop the skills needed to become a safe and aware snow sport recreationalist.

Snow Types

Framing: Just like rain we all know that snow comes in many different forms. Be it the lovely airy powder of a cold winter storm or the heavy moist snow of the springtime that gives us flashbacks of winter. We get to see and feel snow as it falls, so we understand it. However, as we travel across a snow covered landscape we must be aware of not only that which is on the surface, but also that which is beneath our feet. That is because snow on the ground changes as a result of weather conditions, compaction, and time. Being able to see and assess these changes within the snowpack will better allow you to make knowledgeable decisions about traveling on the snowpack.

Snowpack

Snowpack is defined as layers of snow that have accumulated on a landscape and are able to harden via their own weight.
When assessing the snowpack for travel considerations, the two most important factors are the layers present and the boundaries between those layers.

Layers

The layers of the snowpack can generally, though not exclusively, be associated with snowfall events. However, factors such as temperature, relative humidity and sunlight quickly go to work in altering the conditions of the snow layer as it is exposed at the surface. Once buried, pressure and temperature are the primary forces in altering the snow layer. What this means is that the characteristics of the snow that lands on the surface is likely to be different from the characteristics of the snow found within the snowpack. This process of change is known as snow metamorphism and it quickly becomes a very complex topic. For our purposes it is best to know and expect change to occur with the snowpack over time. So what you saw last week may not be the same as the snowpack today.

Strong or Weak

Layers of snow within the snowpack are generally characterized as strong or weak. Strong layers are typically made up of well-bonded (cohesive) small grains. These layers tend to be well defined and generally can be thicker than their weaker counterparts. Weak layers are typically made up of poorly bonded (incohesive) grains. These layers can be as minimal as the connection of two different layers of snow. The cohesiveness of a layer should be viewed as the snow's ability to propagate a fracture rather than its ability to stick to itself. If I break off a piece of this layer do I see the crack continue though the snow?

When assessing the layers of the snow pack it is very important to define the strength or weakness of the layers relative to the other layers of the snowpack. This is because you are concerned about the interactions between the layers rather than a comparison to a textbook quality.

Boundaries

Slab avalanches typically occur when a strong cohesive slab layer is resting on top of a weak incohesive layer, because the weak layer can act as a "shear plane" that the slab can move upon. The weak layer is in a sense creating a poor boundary between the slab and the rest of the snow pack. The boundary is poor because it is not strongly connected to the slab above it. Defining the boundaries of the snow pack may be difficult to do visually, so a physical test may be more telling.

Weather

Weather is a crucial element to consider when evaluating the snowpack. For starters it is what initially brings in the snow. More importantly it is the most important factor in determining how much and what type of snow metamorphism you are likely to see. Recording the weather before and during your trip is an easy way to get a feeling for how the snowpack will be changing.

Precipitation:

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Snow and rain add weight to the snow pack that can contribute to instability.
Rain: Generally adds more weight and decreases the slope stability.
Snow: Can go either way, either fusing to the existing snowpack to increase stability or adding a large amount of mass. In general the rate and weight of the precipitation is the most important aspect to consider
>mass and >rate = high slope instability; i.e. a rainy deluge, or mashed potato snow.

Wind: Wind is an effective transporter of snow. It generally moves a lot of material and can round it, which results in a great potential for slab creation.
The most concerning aspect of wind is slope loading of a leeward (the opposite side of the slope to which the wind is blowing) slope. This process puts a mass of snow at the top of a slope called a cornice that could be enough to trigger a slide.

Temperature: Temperature changes affect snowpack in a number of complex ways. Some guidelines include:

- Warm weather results in more rapid changes and greater potential for cohesive slab formation.
- Cold weather results in little alteration of snowpack and persistence of weak layers.

Terrain

Avalanches are most likely to occur in areas where avalanches have occurred in the past
Identifying likely starting zones, paths, and areas of runoff is essential in determining the route to travel across a landscape.

Slope Angle:
Avalanches generally occur on slopes with slope angles that are greater than 25 degrees. Slope angles of 30 to 45 degrees have the highest probability of producing a slab avalanche due to their ability to hold snowpack and the snow pack's ability to slide downward.

Slope aspect:
Which direction the slope is facing affects the amount of sunlight it receives as well as the potential for wind loading. North facing faces are colder than south facing faces.

Anchors/Slope Surface:

For more avalanche education opportunities with youth, please check out the Colorado Mountain Club's Youth Education Program: http://www.cmc.org/Youth/SchoolsGroups

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The roughness or texture of the surface beneath the snowpack greatly affects a slabs ability to move downward. In general, the smoother the surface the greater potential there is for the movement of slabs. Trees and large rocks add to the resistance of a slope.

Slope shapes:
Avalanches can occur on any slope but are most likely in areas of higher strain, such as convex bulges.

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