SKI AREA RATING FOR AVALANCHE POTENTIAL

A FORECASTING TOOL & TRAINING AID USING THE UNITED STATES AVALANCHE DANGER RATING SCALE FOR SKI AREA APPLICATION

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In avalanche forecasting there are so many weather variables that effect the snow, it is often hard to decide whether to do avalanche control or not. Do you need to do avalanche control every time you receive new snow? Is there a set amount of snow that constitutes avalanche control? Many times I have gone over these questions in my mind and many times I have gone out on avalanche control and realized it was not necessary. As far as avalanche control is concerned at Stevens Pass, we are not necessarily concerned with how much new snow we receive, but how did and how are the weather conditions effecting the snow.

Taking the US avalanche hazard rating scale developed by the US Forest Service, I decided to give each of the rating categories- LOW - MODERATE - CONSIDERABLE - HIGH - EXTREME- a corresponding set of parameters. Although I still have a hard time with the term, 'considerable', is it considerable-moderate or is it considerable-high or should it be considerable or should it be moderate-high? No big deal, I have learned to adjust considerably.

Over the years I have been observing the weather conditions that seem to correlate with the US avalanche hazard scale. Although the US avalanche scale is for back country users, it seems reasonable to give the rating levels the following nine weather parameters for avalanche control purposes in the ski area boundary: Settlement, (in percent) 24 Hour Totals, 12 Hour Totals, Temperature-Trends, Winds, Snowfall Intensity, Density, Layering, Structure, and Natural Activity. After three years of gathering data it seems this system works well, with several of the categories adjustable for human input. This is a tool developed specifically for Stevens Pass ski area. Other ski areas may focus on different factors that they use for avalanche forecasting.

All the weather and avalanche information is gathered and numbers crunched in about a half hour. Totals are taken every twelve hours from two study plots at 4000' and 5600' elevations and remote telemetry sites on the mountain. This information is presented to twenty-four avalanche control personnel at a six-thirty a.m. weather, avalanche and safety meeting prior to avalanche control. An avalanche potential level is given along with all other data found. Then looking at the US avalanche hazard scale category for that morning, control people can get an idea of what to expect on their route. For example: if the avalanche potential rating given is moderate you can expect that natural activity is unlikely, but human triggered avalanches are possible on steeper terrain.

This program does several things for us. One, it helps me and the staff keep things in perspective. Two, it helps us understand how these nine variables correlate with each other. Third, it gives us a good indication of what kind of conditions we might expect to find on our routes.

This is only a tool to assist in forecasting avalanche potential. The following table shows the nine parameters given to the US avalanche hazard scale.

	LOW	MOD	CONSIDERABLE	HIGH	EXTREME
SETTLEMENT	20%	10%	5%	0%	
24 HOUR	7 - 10"	11 - 15"	16 - 25"	26 - 30"	30+
12 HOUR	0 - 6"	7 - 10"	11 - 15"	16 - 25"	25+
TEMP-TREND	26 °	26 - 30°	30 - 31°	32 - 36°	Rain on Snow
WINDS	0 -10	12 - 18	20 - 30	30 - 50	Steady 50+
INTENSITY	.08	.10th	.11 - 18	.20 up	
DENSITY	5%	6 - 10%	11 - 18%	20% up	
LAYERING	LOW	MOD	CONSIDERABLE	HIGH	EXTREME
NATURAL ACTIVITY	LOW	MOD	CONSIDERABLE	HIGH	EXTREME

In the following example, the Avalanche hazard category most consistently represented is moderate. Therefore, moderate is the Avalanche Potential Forecast for the morning of 1-6-98.

Example: (1-6-98)
AVALANCHE POTENTIAL FORECAST
MODERATE

PARAMETERS	AVALANCHE POTENTIAL
1) SETTLEMENT	LOW
2) 24 HOUR	CONSIDERABLE
3) 12 HOUR	MODERATE
4) TEMP-TREND	MODERATE
5) WINDS	LOW
6) INTENSITY	MODERATE
7) DENSITY	CONSIDERABLE
8) LAYERING	MODERATE
9) NATURAL ACTIVITY	LOW

This is not a tool to tell you if you should do avalanche control or not, but a tool to describe what kind of conditions you might find on your avalanche control route.

These are the nine variables that we look at and assess for every twelve hour period.

- **Settlement** - By adding the two twelve hour snow totals together and subtracting the 24 hour total we come up with a settlement rate. The stability factor goes up, the higher the settlement rate
- **24 Hour Snow Total** - We take a 24 hour snow total from 4:00 a.m. to 4:00 a.m. from our two study plot locations. This gives us a reading to compare to the 24 hour forecast and a reading for the overall layering structure of the new snow.
- **12 Hour Snow Total** - The twelve hour totals are taken from 4:00 a.m. to 4:00 p.m. and 4:00 p.m. to 4:00 a.m. Most of our mountain closes around 4:00 p.m. From this we have an indication of what has been skier compacted up to that point. Usually we are dealing with the last twelve hour total—4:00 p.m. to 4:00 a.m.—snow fall over night. This also gives us a way to compute a snow settlement rate.
- **Temperature-Trends** - Temperature is one of the most important factors we look at. The temperature trend over a 24 hour period gives us an indication of settlement and layering structure. Here at Stevens Pass we can see radical and rapid changes in temperature. Warmer temperatures help to settle the snow more rapidly, while cooling trends promote stability. Sometimes it can warm up 20° in two hours and sometimes it can cool down 20° just about as rapidly. Other questions we consider are: Is the temperature above or below freezing? Is the temperature near the freezing point? Is the temperature cool enough not to allow the snow to settle?
- **Winds** - Was there enough steady wind to transport snow? Was the wind from a steady direction? Was the temperature warm and were the winds strong enough to transport warm snow? Was the temperature cold enough to allow lighter winds to transport snow? With high gusty winds we tend to down grade the rating because we do not have the steady wind that typically transport large amounts of snow.
- **Intensity** - Intensity per hour over the 24 hour and 12 hour period is good for picking out the layering structure on the snow stakes. If the intensity is erratic then the layering of the new snow tends not to act as one mass.
- **Density** - Density relates to slab structure. Taking densities every twelve hours gives us an indication of whether slab is building in the new snow. It also gives us a water equivalent.
- **Layering Structure** - The layering structure category is somewhat subjective and comes with time, experience and comparing avalanche control results with what you find on the stakes. In general, if there is more than one layer on the stake, we down grade by one. If the depth of the weak layer equals or exceeds the depth of the slab we down grade by one. If ninety percent of the snow on the stake acts as one body the rating is high. These are figures observed and compared to avalanche control results over the years.
- **Natural Activity** - In the category of natural activity we have several locations that we can access quickly. These areas are slide paths that are steep and if we are at the point of natural activity it is pretty obvious. If no natural activity is observed the rating is low. If we feel and observe the beginning stages of natural activity, the rating is high. If at 4:30 a.m. when the observation is taken and the natural activity is wide spread the rating goes down to considerable. Snow conditions can change rapidly, even in a matter of moments. Usually when natural activity is wide spread at 4:30 a.m. most all paths that are going to slide naturally will by 6:30 a.m. when we go out on avalanche control.

In conclusion, giving all available information to the avalanche control people and allowing them to make assumptions as to what they might expect on their control routes seems to help our avalanche control program in several ways. As an example, people tend to learn quicker how to read the type of condition conducive to avalanche potential. More responsibility is placed on the route leaders as far as making decisions as to what needs to be done on their routes. We have seen a dramatic drop in the amount of explosives we use. In the 96/97 season we had over 700" of snow fall and used a little over half of our budgeted amount of explosives.

Stevens Pass lies in the north-central Cascades with elevations ranging from 3000' - 7000'. Average snowfalls are around 450" - 500" per season. Stevens Pass is a class A avalanche area with over two hundred recorded slide paths. Weather and snow pack conditions are influenced by the Maritime climate which can change rapidly. Stevens Pass has a large night ski operation with avalanche paths that effect main ski runs at night. Most avalanche control is done with hand control teams and three Avalaunchers.

The following information is presented to the avalanche control team on an overhead.

C-7		DUDLEY'S		C-1		BASE	
W Dir	N/A	**W Dir**	330 NW	**24 HR**	20	**24 HR**	25
W Max	N/A	**W Max**	28	**12 Hr**	10	**12 HR**	12
Average	N/A	**Average**	10 mph	**Storm**	-	**Water**	1.3
				Total	89	**Density**	11%
						Storm	-
						Intensity	0.1 hr
						Total	72
TEMP		**TEMP**				**TEMP**	
H	30	**H**	31			**H**	28
L	21	**L**	22			**L**	21
Current	23	**Current**	24			**Current**	28
						Settlement	5"

AVALANCHE FORECAST				WEATHER FORECAST
			40	
	MODERATE		38	Sidewinder Natural at 5:30 a.m.
			36	
			34	Continued Warming
			32	
			30	Decrease in winds and precip.
			28	
11%	10"	4 a.m.	26	
			24	
			22	
			20	
			18	
			16	
7%	20"	4 p.m.	14	
			12	
			10	
			8	
			6	
			4	
			2	