DO STABILITY TESTS INFLUENCE FORECASTERS' SLOPE STABILITY RATINGS?

A case study supporting the application of snowpack stability tests.

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INTRODUCTION

Snow stability tests provide information about the likelihood of avalanching on slopes with a similar snow structure. They are especially important during times of conditional stability, when avalanches or obvious signs of instability may be rare (LaChapelle, 1980). Avalanche forecasters use these tests to assess stability across a region, ski area, or transportation corridor, while recreational backcountry users typically use them for assessing slopes they want to ski or ride. Regardless of these differences, stability tests are invaluable for informing decisions for traveling in, or opening or closing, avalanche terrain. This study focuses on professional avalanche forecasters, showing that stability tests influence their slope stability ratings in nearly 30% of the tests. Our results show the importance of stability tests in professional decisions regarding avalanche conditions.

METHODS

We used stability test data collected by professional avalanche forecasters in the western US over four winters (2016-17, '17-18, '18-19, '19-20). Forecasters entered snowpit profiles and stability test data into SnowPilot (snowpilot.org) so we could easily collect and analyze the data. We asked forecasters to utilize all the information they had available to assess the stability of similar slopes **prior to performing any stability tests**. After conducting a CT, ECT and/or PST, we then asked them to record an "after tests" stability rating for similar slopes.

Slope stability was rated *very good, good, fair stable, fair unstable, poor,* or *very poor* (*Figure 1*). This rating scale is adapted from table G.1 in Snow Weather and Avalanche Guidelines (American Avalanche Association, 2016). Table G.1 uses a scale of five rather than six ratings with "fair" between "good" and "poor".

Layers in the springtime snowpack in the Bridger Range, Montana. *Photo Alex Marienthal*

We asked forecasters to specify *fair stable* or *fair unstable* instead of *fair* in order to binarily classify pits as *stable* or *unstable*.

Our research question is: **Do stability tests influence slope stability ratings?**

We originally requested these data to answer questions regarding stability test accuracy and skill, so forecasters were not aware of the question presented in this article; this should reduce any potential bias of participants.

RESULTS

After four seasons of data collection we had 562 snowpit profiles that included "before test" and "after test" stability ratings and at least one stability test (CT, ECT or PST). We received profiles from Montana (235), California (127), Utah (91), Nevada (58), Colorado (49), and Idaho (2).

Out of 562 profiles:

- 437 were rated *stable* before stability tests were performed (78%).
- 125 were rated *unstable* before stability tests were performed (22%).
- After doing stability tests forecasters changed the stability rating at least one step on the six-level scale in 29.4% of profiles (165/562 profiles) (*Figure 2*).

In 11.0% of profiles (62/562), forecasters changed the slope stability from either stable to unstable or unstable to stable. Forecasters changed a total of 8.9% of profiles rated stable (39/437) to unstable, and they changed 18.4% of profiles rated unstable (23/125) to stable.

DISCUSSION

We chose professional avalanche forecasters for this study because they have all the latest information about the snowpack stability in their region, and are therefore best positioned to assess the snow stability prior to conducting a stability test. They track weak layers and snowpack structure starting with the first snowfall, document every reported avalanche, regularly check all available weather stations, and dig repeatedly to track weak layer development and stability. Forecasters assess and verify snowpack stability, and they utilize stability tests as part of this process.

There have been debates in the avalanche community whether tests are valuable since spatial variability can give conflicting results. We argue that our results are one more piece of evidence showing the value of digging and stability tests. Professional avalanche forecasters, likely the most knowledgeable of anyone traveling in their region, adjusted their assessment 29% of the time based solely on stability tests. This does not discount the dozens of other observations a forecaster makes, but rather it highlights the power of digging in the snow and performing a stability test.

TABLE G.1 Snow Stability Rating System

STABILITY		EXPECTED AVALANCHE ACTIVITY		
STABILITY RATING	COMMENT ON SNOW STABILITY	NATURAL AVALANCHES (excluding avalanches triggered by icefall, cornice fall, or rock fall)	TRIGGERED AVALANCHES (including avalanches triggered by human action, icefall, cornice fall, rock fall or wildlife)	EXPECTED RESULTS OF STABILITY TESTS
Very Good (VG)	Snowpack is stable	No natural avalanches expected	Avalanches may be triggered by very heavy loads such as large cornice falls or loads in isolated terrain features	Generally little or no result
Good (G)	Snowpack is mostly stable	No natural avalanches expected	Avalanches may be triggered by heavy loads in isolated terrain features	Generally moderate to hard results
Fair (F)	Snowpack stability varies considerably with terrain, often resulting in locally unstable areas	Isolated natural avalanches on specific terrain features	Avalanches may be triggered by light loads in areas with specific terrain features or certain snowpack characteristics	Generally easy to moderate results
Poor (P)	Snowpack is mostly unstable	Natural avalanches in areas with specific terrain features or certain snowpack characteristics	Avalanches may be triggered by light loads in many areas with sufficiently steep slopes	Generally easy results
Very Poor (VP)	Snowpack is very unstable	Widespread natural avalanches	Widespread triggering of avalanches by light loads	Generally very easy to easy results

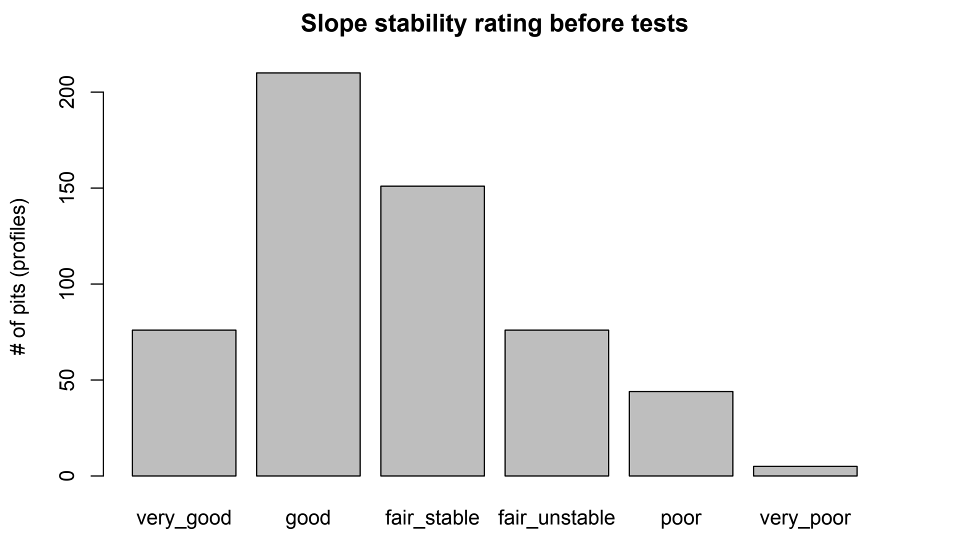

Figure 1. Distribution of stability rating for profiles before stability tests. Scale of stability ratings shown along x-axis.

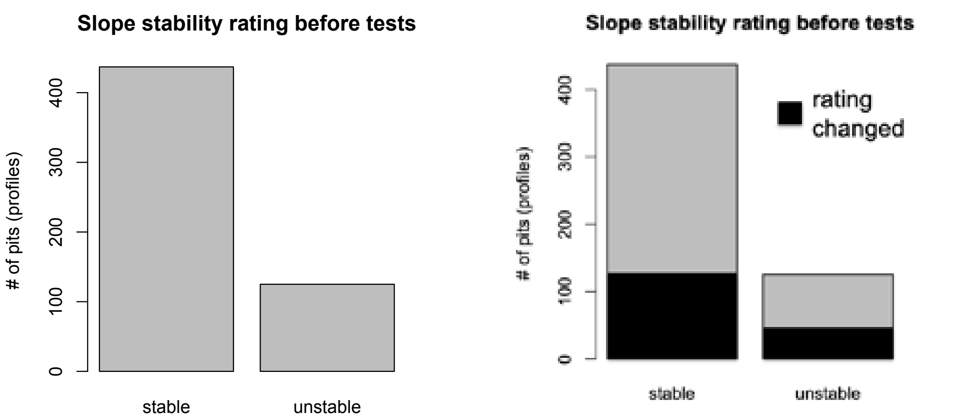

Figure 2. Distribution of profiles binarily classified as either "stable" or "unstable" (left), and the number (29.4%) of profiles that the rating changed at least one step on the scale of six after stability tests were performed (shaded on right).

Forecasters in this study rated 125 slopes unstable prior to doing a stability test, but in 23 (18.4%) of these cases doing a test changed their rating to stable. This may seem surprising since we typically teach people to never use stability tests to convince us that a potentially unstable slope is stable. Rather, tests are typically only used to search for instability. In other words, if we think a slope is unstable before doing a test for whatever reasons, we should not ski/ride it even if our tests show stable results. Despite this, forecasters in this study changed their rating to stable on almost 1 in 5 slopes they had originally rated as unstable. This reflects how forecasters are constantly tracking and assessing stability for a region versus making an assessment to ride a specific slope, and these changes might be as forecasters utilize tests to reduce their uncertainty about instabilities. Of course, false stable test results are dangerous, so forecasters often dig multiple pits/tests to confirm any significant change in stability assessment.

Alternatively, of the 437 slopes that forecasters rated as stable prior to conducting a stability test, doing a test changed their minds 39 times (8.9%). This shows that even a person with an intimate knowledge of the snowpack in their region changes their assessment from stable to unstable nearly 10% of the time. Clearly, a stability test in these situations can prevent the user from making a "go" decision in a "no go" situation.

In summary, forecasters changed their slope stability rating at least one step on 29% of slopes after performing a stability test. These findings support the usefulness of stability tests for assessing snowpack stability on similar slopes in a region. Interestingly, stability tests commonly influence slope stability assessments of avalanche forecasters, even when they already possess an extensive amount of information about the snow stability. This highlights the importance of gathering as much information as possible to justify our decision of whether or not to travel in avalanche terrain.

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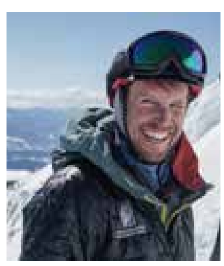

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