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CREDIBILITY OF AVALANCHE WARNINGS

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ABSTRACT. Avalanche warnings can provide a valuable public service. To be effective, the warning program must inspire public confidence. Experience gained from the Colorado Avalanche Warning Program is used to develop guidelines for establishing and maintaining credibility. The topics discussed are the requirements for a good forecaster, the working relationship between forecaster and field observers, relations with the news media and the public, and forecast accuracy.

RÉSUMÉ. *Crédibilité des prévisions d'avalanches.* La prévision d'avalanche peut rendre au public un réel service. Pour être efficace, la prévision doit inspirer confiance au public. L'expérience du programme de prévision d'avalanche du Colorado permet d'émettre des directives pour conquérir et garder la crédibilité. On discute les qualités d'un bon prévisionniste, les relations de travail entre le prévisionniste et les observateurs sur le terrain, les relations entre les media d'information et le public, et la précision des prévisions.

ZUSAMMENFASSUNG. *Glaubwürdigkeit von Lawinenwarnungen.* Lawinenwarnungen können von grossem Wert für die Öffentlichkeit sein. Um beachtet zu werden, muss ein Warnprogramm öffentliches Vertrauen geniessen. Erfahrungen aus dem Lawinen-Warnprogramm von Colorado werden zur Aufstellung von Richtlinien für die Begründung und Aufrechterhaltung von Glaubwürdigkeit herangezogen. Zur Diskussion stehen die Anforderungen an einen guten Vorhersager, die Arbeitsbeziehungen zwischen Vorhersager und Feldbeobachtern, die Verbindung zu den Nachrichtenmedien und die Öffentlichkeit sowie die Genauigkeit der Vorhersage.

INTRODUCTION

An effective avalanche warning program can be of benefit to a wide audience, including ski-area operators, backcountry recreationists, motorists, highway maintenance crews, construction crews, and mining companies. The obvious benefit is to minimize injury, loss of life, and property losses. The Colorado Avalanche Warning Program (CAWP) has operated formally for five years and informally for twice that time (Judson, 1976; Williams, 1978). CAWP consists of a central forecast office in Fort Collins and approximately 30 manned observation sites (and several unmanned sites) spread over roughly 100 000 km² of the Colorado Rockies. It employs the concept of central forecasting also adopted in Switzerland and in the Cascade Range of Washington and Oregon (LaChapelle and Fox, 1974). In these programs, field observers telephone daily reports to the headquarters forecast office where the forecaster analyzes the data and issues warnings when conditions warrant. The other option, that of having each observation site do its own forecasting for its immediate local area (on the order of 100–1 000 km²), has merit but lacks the coordination of central forecasting, a valuable asset. However, there is an upper areal limit of roughly 200 000 km² that can be adequately handled from one office.

The key to successful avalanche forecasting lies in the collection of accurate and timely data from the field coupled with good decision-making by experienced forecasters. A well-coordinated network and decision-making process is a necessary foundation for the establishment of a credible warning program. The emphasis in this paper is on those factors that produce credibility (and therefore success) in avalanche warnings.

SKILLS OF THE FORECASTER

A good forecaster must understand avalanches. A background in glaciology, physics, or geology is helpful, but actual experience is essential. Specifically, he should be able to recognize developing stability patterns before significant events occur. Experience in synoptic meteorology is also required, whether it is used to make weather forecasts or to obtain them from professional weather forecasters.

An avalanche forecaster must be articulate, for he speaks regularly with field observers and weather forecasters and frequently to the press, who require telephone-taped interviews for broadcast. The ability to write well is needed for him to compile clear, precisely worded avalanche-warning messages. The job also requires an organized individual who logs and analyzes data faithfully, and who is then firm in his decision-making.

Several field skills also are needed. The forecaster must know his mountains. This enables him to talk more knowledgeably with his field observers and allows him better to define hazard areas. He should also be able to ski reasonably well in all terrain.

Forecast accuracy

A warning program can have all the proper ingredients that would normally ensure success but if weather and avalanche forecasts are not accurate and reliable, credibility will erode. Therefore, the first priority in budgeting should go to equipment and training which will improve forecast ability.

Forecast weather conditions account for about half of the avalanche forecast; the remainder are the snow-pack factors. Heavy precipitation and wind are the weather factors that contribute most to avalanche formation in Colorado. In addition to conventional forecast skills, CAWP has the additional benefit of an objective aid for quantitative precipitation forecasts. This numerical model, which was developed specifically for use in the Colorado mountains, predicts amounts of orographic precipitation at specific sites (Rhea, 1978). When applied with good prognostic weather data, this model is exceptionally accurate in its quantitative precipitation forecasts. As a result, the forecaster can more confidently provide a service to his field observers that the National Weather Service cannot provide.

Now, let us consider the avalanche forecast. There are three types of avalanches which are forecast: *direction-action* avalanches, *delayed-action* avalanches, and *wet* avalanches. Direct-action* avalanches occur during or just after a storm and result from loading by falling or blowing snow; they account for roughly 80% of all avalanches. Delayed-action avalanches occur during non-storm periods and result from stress build-ups within the snow-pack; they account for roughly 5% of all avalanches. Wet avalanches occur during rapid warm-ups especially in the spring and result from stress due to thaw and free-water percolation; they account for roughly 15% of the avalanche total. Fortunately for the forecaster, direct-action avalanches are the easiest to forecast, mainly because they involve a prediction of estimable meteorological factors. Delayed-action and wet avalanches are more difficult to forecast mainly because of the inability to calculate snow-pack stresses.

There is a large subjective component in avalanche forecasting which can lead to problems of uneven forecasting over the course of a winter or unequal treatment of a given avalanche situation by two different forecasters. Consistency and credibility would be enhanced if more objectivity could be introduced into the decision-making process. A numerical predictive model would be a valuable aid and research is proceeding on such a model (Judson and others, 1980). Another step toward objectivity is to define and standardize categories of avalanche hazard. One such scheme employed by CAWP and the Cascades warning program is shown in Table I. In using this scheme, the normal day-to-day hazard is low to moderate. The avalanche forecaster issues a weekend advisory notice under these conditions. He issues an avalanche warning when the hazard moves into the high or extreme categories. Admittedly, there is still the possibility of subjective interpretation of these categories, but with further experience, their definitions should become better.

* This long-standing terminology may be due for a change to more definite terms. One suggestion is *storm-induced* (or simply *storm*) and *non-storm* for *direct-action* and *delayed-action*, respectively.

There are other considerations in forecast accuracy that contribute to credibility. Good timing is required for the initiation and termination of warnings. Warnings initiated too late or terminated either too soon or too late will damage credibility. Similarly, the "false-alarm rate", defined as the number of misses (warnings that did not verify) divided by the number of warning episodes, should be low to avoid the "cry wolf" syndrome. Ideally, the false-alarm rate should be zero for a large number of cases. In practice, however, a value slightly greater than zero is desirable, based on the premise that slight overforecasting is a better public service than underforecasting.

Table I. Avalanche hazard classifications

Hazard condition	*Snow condition*	*Avalanche likelihood on steep snow-covered open slopes and gulleys*	*Backcountry travel*
Low	Mostly stable	Unlikely except in isolated pockets	Generally safe
Moderate	Areas of instability	Possible	Caution necessary
High	Mostly unstable	Likely	Not recommended
Extreme	Widespread instability	Certain; large destructive avalanches are possible	Should be avoided

Relations with field observers

Since CAWP field sites are manned mostly by volunteers, the forecaster must maintain a good working relationship with the observers. He must be available often and respond to the observers' needs. The CAWP operates on a quasi-24 h basis seven days a week (the forecast office is manned 9 to 10 h per day and a recording telephone is used for the remaining hours) so that the observers have ample opportunity to talk directly with the forecaster. The job requires periodic travel into the field so that the forecaster may work directly with the observers. The forecaster must provide training, supplies, and instruments for making observations. The forecaster also provides each observer with a daily weather forecast and resulting snow-stability trends. Obviously, the better the forecasts, the higher the credibility in the program.

Relations with the news media

A credible warning program spreads the news of dangerous avalanche conditions to the media and the public quickly. Judson (1975) covers the content and dissemination of warning bulletins thoroughly, but a few points of advice bear repetition.

Bulletins must be accurate and timely. Warnings must be issued before serious avalanching has been reported by the press. A warning issued after news releases of several serious accidents damages credibility, since the press and public will correctly realize that the warning should have been issued earlier. Bulletins should be timed so as to receive maximum media coverage. In Colorado, 11.00 and 16.00 h are the optimum release times, just before the noon and evening television- and radio-news broadcasts.

Bulletins should be carefully worded so that there is no misunderstanding in the area or duration of coverage. Bulletins should be believable and interesting; it helps to support generalizations with examples, and this can include the citation of snow-fall amounts, excessive wind speeds, numbers of avalanches, and any avalanche accidents.

It is also helpful to establish personal contact with the media personnel. A general availability and willingness to provide telephone interviews greatly enhances credibility with the press.

Relations with the public

In Colorado, the public normally learns of dangerous avalanche conditions through news broadcasts. In a few locations, the public can telephone to receive a recorded message of current snow and avalanche conditions or can receive updated information via National Weather Service v.h.f. radio broadcasts. The avalanche forecaster has the responsibility not only for the forecast, but also of making sure that the message reaches the public and is updated as frequently as conditions change.

Educating the public in order to increase its avalanche awareness is the most important action that can be taken to reduce avalanche fatalities. This problem is compounded by many mountain users who do not live in the mountains but make occasional trips there mostly for recreational purposes. Too often the avalanche victim never realizes that a danger exists. One way to increase avalanche awareness is to present lectures and slide shows tailored to the needs of the audience. By educating the public, the avalanche forecaster builds credibility and thereby increases the effectiveness of the avalanche-warning program.

Summary

The credibility of an avalanche-warning program depends on several factors. Internally, the field observers must have confidence in the forecaster. The forecaster must supply accurate forecasts, be capable of proper decision making, make himself available often, and respond to the needs of the observers. Failure in any of these responsibilities results in an erosion of credibility within the program, with the emphasis being on forecast accuracy. To be correct often shows that the forecaster has the skills and tools necessary for the job. Thus, his judgment will be respected, his credibility high.

The forecaster needs to establish a working relationship with the press and issue accurate, timely, well-worded, and interesting warning bulletins. Avalanche warnings can provide a valuable public service. The better educated the public, the greater the effectiveness of the warning program. The forecaster can help his own program by presenting avalanche awareness lectures to groups involved in winter work or recreation.

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