AVALANCHE INFORMATION SYSTEMS IN KANANASKIS COUNTRY, ALBERTA, CANADA[1]

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Abstract --A computer oriented approach to collate avalanche and geographic information was developed to provide hazard evaluations for a variety of purposes. The major applications are modelling and mapping. A secondary use is storing information related to avalanche path activity. A zone/slope class model was used for recreation planning and will form the basis of an avalanche brochure.

INTRODUCTION

In 1977 a major recreation area (4,166 km^2), called Kananaskis Country, was announced for a region of mountains and foothills southwest of Calgary, Alberta (fig. 1). The northwest portion contains a major provincial park and winter trail systems. The northeast and southern portions contain snowmobile and winter ski trails. The development of major highways, crowding of ski trails, as well as the attractiveness of side valleys and glaciers for ski touring, heli-skiing and mountaineering has resulted in major increased use of avalanche areas by recreationists. One heli-skiing death has occurred and several parties have been caught in avalanches. The prediction of increased problems led to efforts to collect avalanche information for roads (Stetham 1982 and 1983, McPherson et al. 1983) and backcountry areas (Niemann 1982, McPherson et al. 1983).

A large amount of data, which vary in detail and scale, has been collected. It was necessary to integrate these data with geographic information into a common but flexible data base which could be updated and expanded through time. Because the information systems approach has to: serve a variety of purposes and users; handle and analyse complex data; and produce high quality cartographic products, a computerized Geographic Information System (G.I.S.) approach, supplemented by conventional products, was adopted.

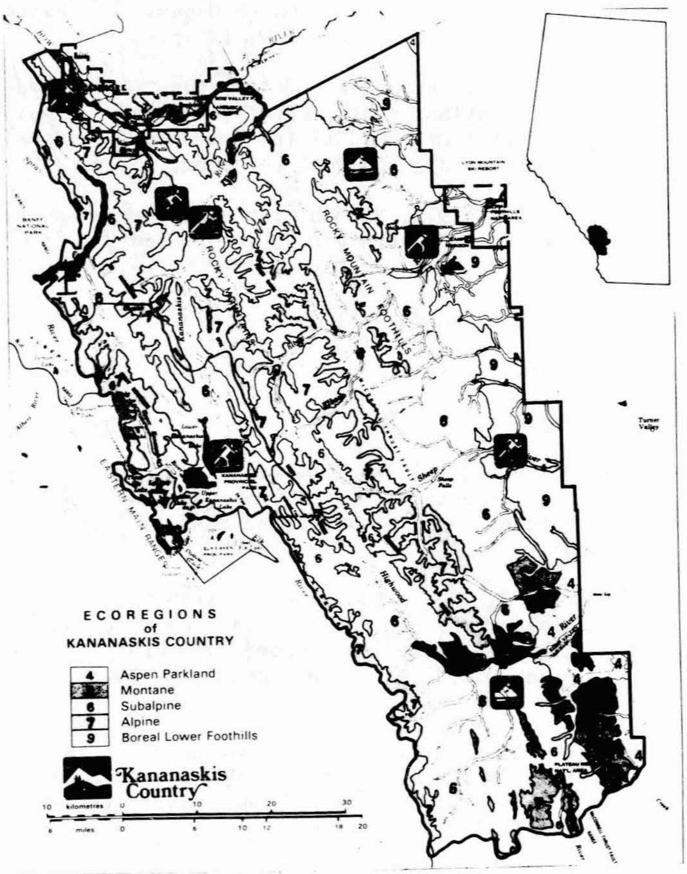

Figure 1.--Ecoregions of Kananaskis Country (after McGregor 1984). The McConnell Thrust Fault delineates the mountains from the foothills. Climatic and elevational influences are reflected in the distribution of Montane and Subalpine.

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In 1982 Kananaskis Country of Alberta Recreation and Parks initiated a G.I.S. for natural resource management using a system called TRANSMAP (Langford 1984). Avalanche information handling is only one use of this system. The avalanche related data bases have been developed as part of a comphrehensive plan to: monitor snow stability; provide the public with Kananaskis Country specific information for trip planning and safety awareness; prepare natural resource hazard evaluations for land use planning; and conduct long term avalanche frequency studies.

STUDY AREA

Kananaskis Country is composed of Rocky Mountain Front Ranges and Rocky Mountain Foothills demarcated by the McConnell Thrust Fault (fig. 1). A small portion of Eastern Main Ranges occurs west of the Kananaskis Lakes. Although the major ridges trend northwest to southeast resulting in steep northeast scarp slopes and less steep southwest dip slopes, the major valleys do not. Transverse faulting and glaciation result in long, relatively steep concave valley profiles; extensive cirque formation along ridge crests; and tributary valleys and gorges.

Lower Alpine areas (fig. 1) are dominated by shrub communities of willow and dwarf birch with islands of stunted subalpine fir, Engelmann's spruce and alpine larch. Middle to upper areas are characterized by heather or lichen/stonefields. Subalpine areas are represented by climax Engelmann's spruce and subalpine fir with extensive stands of fire maintained lodgepole pine at lower elevations and in the foothills. Natural grasslands are scattered throughout but predominate on southerly slopes. Montane areas resulting from chinook winds occur in the Bow and Highwood Valleys and have woodlands of Douglas fir or mixed stands of Douglas fir, lodgepole pine, white spruce and trembling aspen.

Climatically the area is transitional between the cordilleran and prairie regions. Polar continental air dominates from November to February with periodic intrusions of moist Pacific maritime air. These result in light snowfall (highest in the west along the Continental Divide) and periods of short lived chinooks (dominant in the west-east and southwest-northeast valleys). The major periods of snow or heavy rain occur from March to June with the increased interaction of strengthening Pacific air and Polar continental air. Cote (in press) provides a detailed climatic analysis for the area.

Within Kananaskis Country, snow distribution is highly variable both seasonally and spatially. In general, depth hoar instability predominates until early March. Consolidation and strengthening occurs under warmer spring temperatures. Isothermal conditions and heavy precipitation on melt-freeze surfaces combine to form a major period of avalanche activity until early June.

INFORMATION SYSTEMS

The cornerstone of the information systems being developed for Kananaskis Country is the TRANSMAP G.I.S. software. It is capable of handling both grid mode and polygon mode data as well as digital data from other sources such as Landsat. As a digital data base structured on spatial (geographical) distribution of information, a range of sources of different scales and projections can be accomodated. Some information is not incorporated but is handled as separate computer files, or as non-computer data bases (e.g. snow profiles, avalanche atlases).

At present, the main function of the G.I.S. is to store resource related information. This includes all relevant information regarding avalanche zones, paths, selected contours, facilities (e.g. roads, campgrounds, winter trails, summer trails), hydrology and surficial geology. These can be mapped (fig. 2) in any combination of coverages (themes), attributes, windows or scales (keeping in mind that the resolution of the original data in our case is 1:50 000). Four colours can be used in the plotting process and the products can be on paper or mylar.

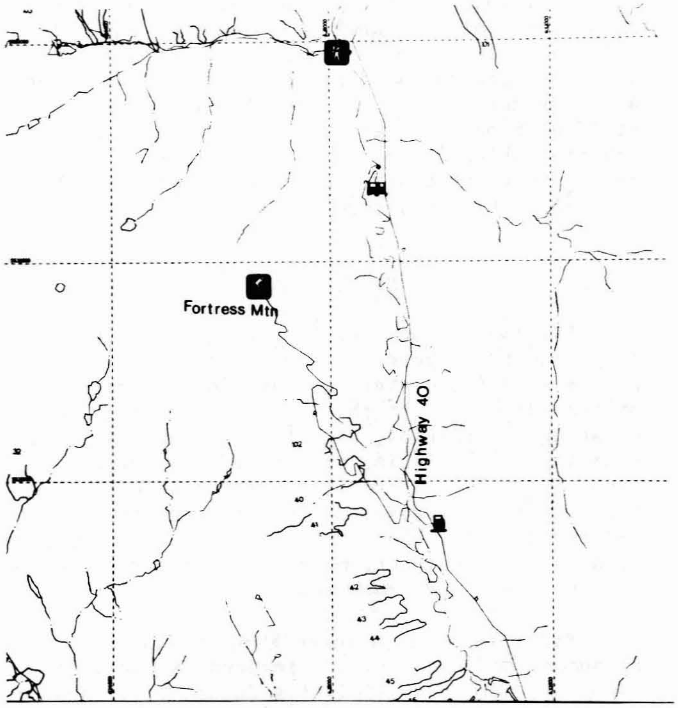

Figure 2.--An example of a computer drawn map of the Fortress Mountain area showing avalanche zones, numbered avalanche paths, roads, summer trails and hydrology. U.T.M. grid is at 4 km intervals.

Another important use is analytic and has been used to create derivative coverages from existing digital data. Two avalanche related coverages were derived. Niemann et al. (1983) describes the model inputs and assumptions. The first is a model which defines potential and active starting zones for different avalanche types. The second provides a slope breakdown within avalanche zones which experience active avalanching. Digital inputs to both of these models included Landsat derived cover types and a digital terrain model (D.T.M.) which describes the slopes, aspects and elevations in three separate coverages.

Digital tapes of the models were prepared and a colour negative produced with a DIPIX Aries II image analysis system by assigning the classes of each model a colour code. The colour negatives are then printed to whatever scale is desired.

Inventory of Individual Paths

Paths with historic avalanche information, and indicator paths monitored for avalanche forecasting were delineated from colour photography (1:20 000) onto 1:50 000 map sheets and then digitized. Certain paths not affecting facilities are shown only as a line and identifier number. Information from all sources was collated (Niemann unpubl. data, Steel 1982, McPherson et al. 1983, Kananaskis Country unpubl. data, Alberta Transportation unpubl. data). The file includes path statistics, brief physical descriptions and activity records for 237 paths.

Exact delineations of paths are not necessary except for runouts that cross valley bottoms and human use areas. Paths are dynamic and change in size, vegetation patterns and level of activity. Paths are monitored weekly, monthly or annually and the avalanche path map helps field staff to differentiate paths to be recorded. Oblique photos are considered to be superior for familiarizing staff with path characteristics. For this reason existing atlases and the computer printouts of path inventory records were combined into a comprehensive and expandable avalanche atlas.

DISCUSSION

Information scattered between and within a large number of reports is not easy for land use planners of field staff to use. The information systems developed to this point essentially took existing information, organized it and allowed for updating and analysis, or derived new outputs (products). The bottom line for our efforts is the ability to prepare useful products for the public and field staff. These products can take many forms such as risk analyses, maps, route descriptions on photos, signs and brochures.

There is much to learn about avalanche phenomena and climate. Our regional scale data bases may not be sufficiently detailed for some of our requirements. The best test is the application of the information systems to specific problems to determine the shortcomings. A public safety problem is presented as an example of how avalanche zone information can be provided to the public.

Public Safety Application

The need to provide more information on avalanche potential in Kananaskis Country was highlighted by visitors avoiding ski trails in non-avalanche areas during and after an extreme hazard period in 1983 because they associated the entire area as being hazardous. A limited survey of ski tourers in Kananaskis Provincial Park indicated 75-85% of the individuals had little to no avalanche awareness and yet were skiing in avalanche terrain. Despite the provision of snow pack stability ratings and weather forecasts at two information centres and two park offices as well as local radio and TV stations, only 60% of the groups availed themselves of the information.

In the past we provided the standard warning information and forecasts without determining its usefulness to the specific types of recreationists or taking into account the fact that our trail facilities were planned to avoid avalanche areas. At the same time we were looking into the future and trying to determine changes in recreational patterns.

In rethinking our approach we determined that our three levels of recreationists are: those vaguely aware of avalanche danger who recreate on and off trails and would prefer to remain in safe areas; those with a basic awareness of avalanche danger but limited experience who use avalanche areas as well as safe areas; and those with good avalanche knowledge and experience who concentrate their activities in avalanche areas. In Kananaskis Country about 75% of the recreationists are in the first group, 20% in the second and 5% in the third.

Our objectives for the first group are: to inform the individuals of the location of avalanche danger and why; to encourage them to use safe areas only; and to encourage them to undertake training to advance to group two if they desire to use avalanche areas. This will be accomplished by the availability of zone maps at our information outlets, and the publicizing of trails in safe areas, particularly during high avalanche danger periods.

Group two is the critical group to provide detailed information to. These individuals lack experience and need to develop their skills through practice. Our objectives are: to encourage the use of specific information on avalanche terrain, snow pack stability, weather forecasts and recent avalanche events by individuals while planning and carrying out their activities; and to deter these individuals from using avalanche areas during low stability periods.

The level three group is possibly the highest in risk but the level we can least help other than by providing snow profiles and weather information, and consultation on particularly tricky routes. Our objective is to provide specific information if requested.

In order to provide specific information on high use areas, we are preparing a brochure for Kananaskis Provincial Park and environs. The focus of the brochure will be a map of slope categories indicative of avalanche activity within avalanche zones. Slope is considered to be an integral factor in avalanching (Perla 1978). By coding slope classes in symbolic warning colours, it is possible to indicate slope conditions for avalanching without stipulating actual hazards or particular avalanche paths. Slope categories will be symbolically coloured as follows: brown - slopes over 100%, usually bedrock; red - slopes 50-100%, usually start zones for large slides; orange - slopes 30-50%, possible tracks and runouts; and yellow - slopes under 30%, possible runouts. This map will be produced on a topographic base to allow good map readers (not a common phenomenon) to interprete aspects, distances, terrain features, topographic reference points such as stream courses, lakes and ridges, and development reference locations such as roads and trailheads.

The slope breakdown does not show terrain roughness and particular features that might be conducive to snow accumulation or release - critical clues that are normally determined during route finding in the field anyway. However, it does show general terrain steepness and juxtaposition of steep slopes, particularly in narrow valleys. Most importantly it classifies slopes in the intermediate range - the range most critical to avalanching and yet the most difficult to determine on the ground without a clinometer. The map could be used in trip planning and general route finding; depending on the snow pack stability and weather forecast, the recreationist could select where to go and whether to go.

Descriptive text and sketches are being developed to describe the local climate, terrain and aspects in Kananaskis Country, and how this information relates to avalanche danger through the seasons. A description of information available (snow profiles and weather forecasts) and the outlets through which to obtain the information will be provided. A guide to using the map and slope categories, and the limitations will be stressed. Emphasis will be placed on party self-reliance for rescues, particularly of equipment to carry and search techniques, in order to raise the chance of quick rescue by the recreationists.

It should be emphasized that the public must learn to understand that our information by itself cannot provide direct answers to the degree of hazard each individual and/or group faces when in avalanche zones. They must determine their own ability to assess a risk and to consciously make decisions whether to take a risk or not.

CONCLUSIONS

The informations systems in use in Kananaskis Country provide suitable record keeping methods for avalanche event monitoring, and allows the production of high quality cartographic products - some of which would not be possible without computers. We can provide area specific information to the public that is individualized as to the level of understanding and specific needs. Our intent is to enhance the awareness of avalanche danger in the mind of a public that is mainly naive about avalanches, rather than encourage reliance on hazard ratings as the means of making personal risk decisions.

There are still important data to be incorporated into the system including predictive approaches that can be built upon the initial work. The most useful application of the avalanche records is in the area of helping forecasters monitor trends on specific paths. The integration of climate data and more detailed path surveys to determine snow catchments and terrain features that act as key influences on releases are essential but missing components. These will be the focus of our attention in the future.

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