AVALANCHE STARTING ZONES BELOW THE TIMBER LINE – STRUCTURE OF FOREST

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ABSTRACT

Avalanches starting in small clearings of forests are not uncommon in Switzerland. Forests covering steep slopes are the main means to shelter roads and buildings from the adverse effects of avalanches. It is therefore of great interest which density of trees and maximal size of clearings are permissible. During the winters 1986 to 1991 most of the avalanches starting below the timber line in the Swiss alps have been surveyed. The survey is looking at the topographic features of the starting zone using high resolution topographic maps, the snow profile at the crown of the avalanche, the weather conditions from the moment of the release five days backward, and a detailed measurement of the forest structure within the starting zone and a the same measurements in the immediate vicinity of the starting zone. In total more than 50 parameters are measured. The statistical evaluation shows the importance of tree density and size of clearings for avalanche release. The different tree communities are not equally efficient in preventing avalanches. This difference is difficult to influence, because it is caused by the local climate and soil type. In the zone with mixed stands of the evergreen spruce (Picea abies) and the deciduous larch (Larix larix) as well as in pure larch stands the density of the trees seems to be of greater importance than the species. Unfortunately, most pure larch stands are dispersed, which may lead to the impression that they are worse than evergreen trees.

INTRODUCTION

Avalanches starting below the timber line are a common phenomenon in Switzerland. The name "forest avalanches" defines an avalanche starting within a forest. Gubler and Rychetnik (1991) were looking at forest from the viewpoint of the physical formation of an avalanche, while this work tries to look statistically at the forest structures which prevents an avalanche.

METHODS

Forests are defined as areas where the distance between the trees is less than 25 m, the crowns cover more than 20% of the ground and the trees have a minimal height of 3 m (Zingg, 1988). The starting zone of all avalanches described in this paper occurred in an area which follows this definition.

The structure of a forest can be described with many parameters. We discuss in the following the geographic parameters height of the starting zone above sea level and the slope of the starting zone together with the structural parameters of the forest. The structural parameters are number of

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trees per area, coverage of ground by the crowns, and width of gap. The composition of the forest varies within the discussed range of height considerably. We decided to split in advance the dataset in 5 classes, which are described by the composition. The five classes are deciduous trees (mainly beech), mixed deciduous and evergreen trees (mainly beech, spruce and fir), pure evergreen trees (spruce and some fir), mixed deciduous needle trees (larch) and evergreen needle trees (spruce), pure deciduous needle trees (larch). These classes follow loosely their occurrence above the height above sea level.

The data were sampled from winter 1986 (years 1985/86) till winter 1990. If a forest avalanche was recorded, the starting zone was observed as short as possible after the event, and again in summer to record the topographical and structural parameters. Around every starting zone 2 to 4 areas of about the same size as the starting zone are selected as comparison areas. These comparison areas lay above and sideways of the starting zone. The dataset is based on 118 starting zones and 131 comparison areas (some of the comparison areas have on both sides a starting zone).

RESULTS AND DISCUSSION

Figure 1 shows the distribution in altitude of the starting zones in the different forest types. Two main groups are visible. Between 800 to 1200 m asl there are starting zones in deciduous forest. The starting zones of this forest type is mainly on steep slopes exposed southward. The second group is above 1600 m asl. There the forest consists of needle trees, the growing of the trees is already slower. On steep north exposed slopes the solar radiation may be too low in this altitude to aloud the growth of young trees, when they are shaded by older ones (Imbeck and Ott, 1987).

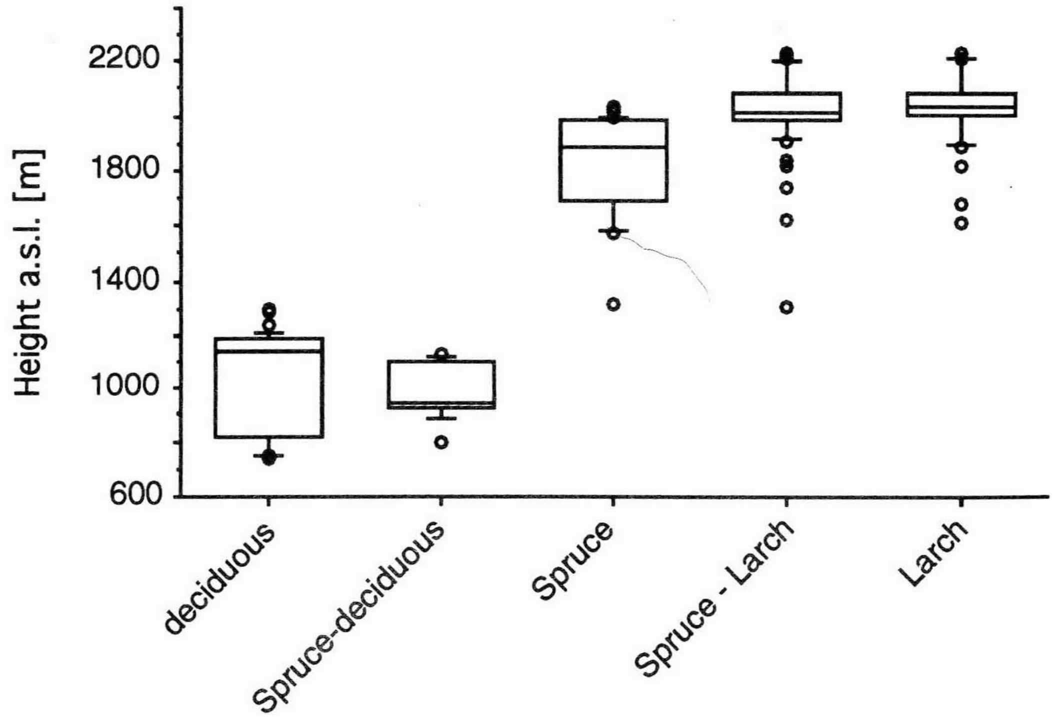

Figure 1 - Altitude above sea level of the starting zones, differentiated between the forest types. The gap around 1500 m asl is caused by naturally dense spruce forests.

Between these two groups a gap between 1300 and 1400 m asl is obvious. This gap shows the area of optimal growth of spruce and fir, which effectively prevents any avalanches.

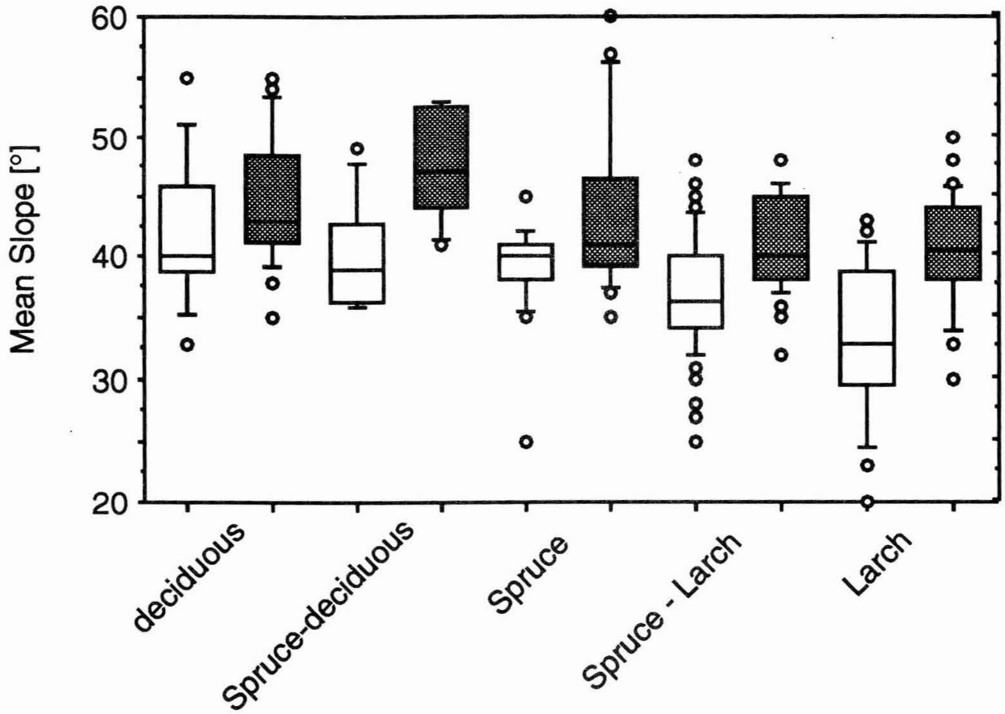

Figure 2 - Mean slope of areas of comparision (white) and starting zones (gray)

The slopes of the starting zones (Figure 2) are in the mean 43°. The steepest slopes are found in the mixed spruce-decidous forest. This is significantly steeper than starting zones in open areas with 38° (deQuervain and Meister, 1987). The comparision areas are usually less steep. This is no chance, because it is at the steepest slopes where its most difficult for trees to grow up.

The number of trees per area shows a clear differentiation between starting zones and comparison zones (Figure 3). The number of trees declines with increasing altitude. The number of trees is highly variable and the overlap between starting zones and comparison areas is considerable especially in the deciduous and mixed forest type.

There exists a broad overlap in number of trees in the deciduous and even more in the mixed deciduous forests. The number of trees is a good discriminator in the other types. The coverage of the ground by the crowns is in its distribution very similar to the number of trees (Figure 4). The overlap between starting zones and comparison zones is greater than comparing the number of trees in the starting and comparison area. The coverage of the deciduous trees is irrelevant in winter, when the trees are bald.

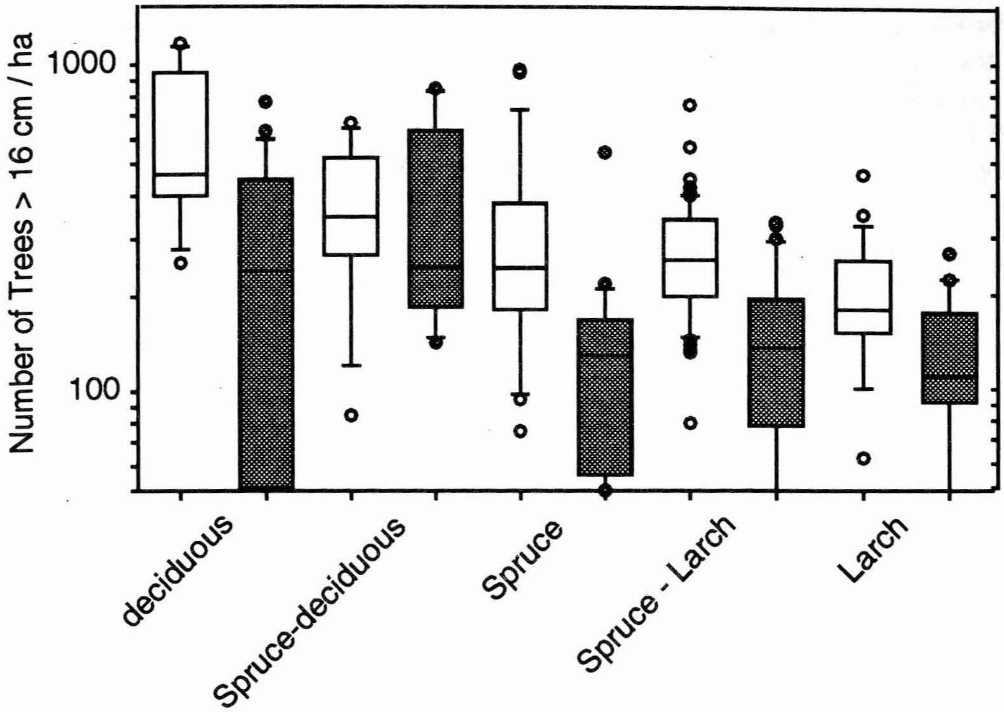

Figure 3 - Number of trees greater than 16 cm at 1.5 m above ground

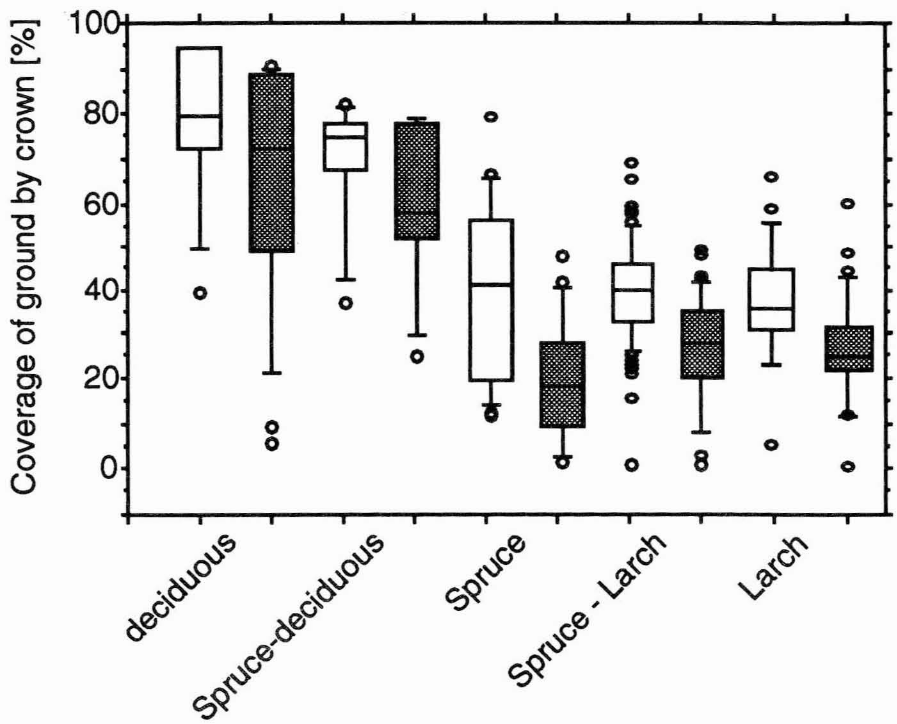

Figure 4 - Coverage of ground by crowns, differentiated between type of forest. Gray boxes are coverages with avalanches, white boxes without.

Figure 5 shows the gap width in the different forest types. Again the deciduous forest types are very different from the evergreen and Larch forest types. Small gaps are sufficient to create starting zones. Altough these avalanches are ususally not very large, they may cause some damage on buildings and on roads, because they are wet snow avalanches. The gap width in the forest types in higher altidtudes are very similar. The larch forest are rarely dense, which is caused by their use as ranges.

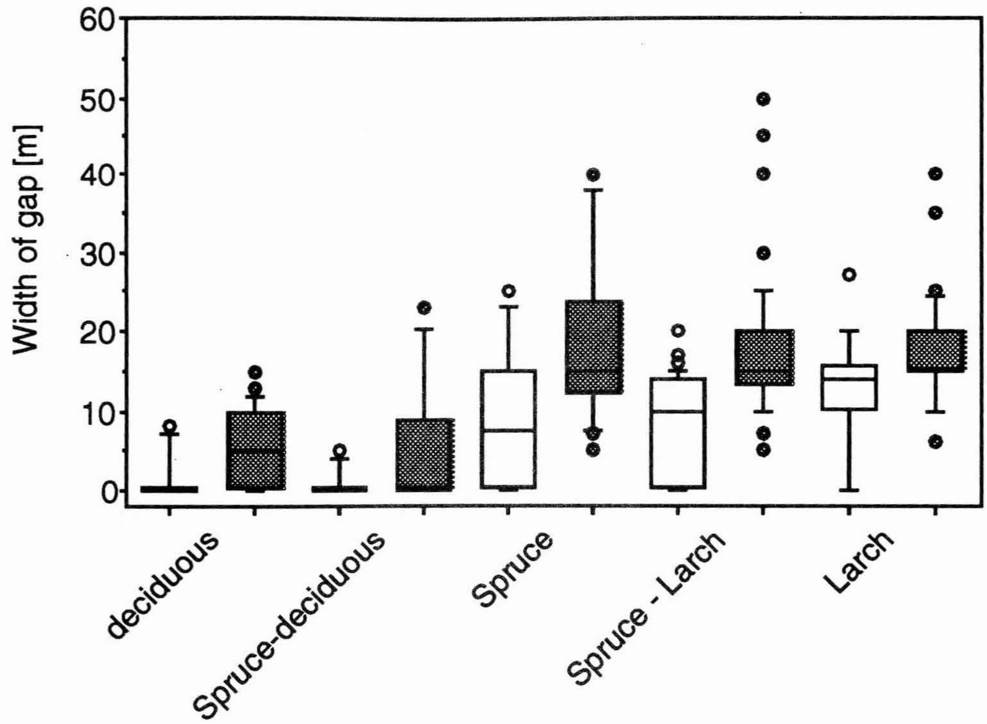

Figure 5 - Width of gap, differentiated between type of forest

CONCLUSIONS

The statistical description of the starting zones of forest avalanches helps to designate forest stands which are prone to avalanching. Table 1 shows the critical values found for the different forest types in Switzerland. This table shows very clearly, that evergreen needle trees are most effective in preventing avalanches. Larch trees are not much worse. This is astonishing compared with the results of Gubler and Rychetnik (1991) which found only a very small influence of these trees on the snowpack. Obviously there must be a process which consolidates the snowpack, but is hardly macroscopically visible. The density of the trees seem to be more important than the species, at least for forest above 1600 m asl. Unfortunately, most pure larch stands are dispersed, which may lead to the impression that they are worse than evergreen trees.

Parameter	Forest Type				
	1	2	3	4	5
Slope [•]	>38	>42	>38	>35	>32
Coverage [%]	<80	<70	<35	<30	<35
Trees/ha (Diam.>16cm)	<450	<280	<190	<200	<180
Gap Width [m]	>5	>5	>10	>10	>10

Table 1 - Critical parameters for different forest types in Switzerland (1: deciduous, 2: mixed deciduous - spruce forest, 3: spruce, 4: mixed spruce larch forest, 5: pure larch forest)

These values are valid within the observed variation of avalanche activity between 1986 to 1990. It is difficult to calibrate these winter with an "avalanche activity index", because we found no data which could be used for this purpose. A comparision with the avalanche observations of the oberserver stations showed that all oberserved winters caused at most a medium damage. It may therefore be expected that the above values may be lower for extreme events.

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