BLONS IN VORARLBERG, AUSTRIA- 60 YEARS SUSTAINABLE AVALANCHE PROTECTION: EXPERIENCE, SETBACKS AND LESSONS LEARNED

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ABSTRACT:
In 1954, the largest avalanche accident in the history of the second Austrian Republic occurred in the small Walser community of Blons in Vorarlberg. The avalanche disasters of 1951 and 1954 heralded modern avalanche protection in the Alps.
In addition to the development of various support structures in the avalanche starting zone, some of which are still in operation today, special attention was paid to the "green protective wall" - the protective forest above the residential areas in the municipality of Blons.
Sustainable avalanche protection is a permanent task for an exposed alpine valley. Competence, consistent action and the factor time are the way to success, especially in the conversion of over-grown protection forests and their refoundations. 100 years are often not enough to build protective stocks near the upper timberline.
This article provides an overview of the natural conditions of the Great Walser Valley (Vorarlberg / Austria) and explains the events of the year 1954. Subsequently it reports about the forest and technical protection measures taken over time and the associated risk assessments.
KEYWORDS: Sustainable Avalanche Protection, Protection Forest, Avalanche Hazard in Blons / Vorarlberg.

1. INTRODUCTION

In the avalanche winter of 1954 in Vorarlberg 125 people were killed, 57 of them in Blons in the Great Walser Valley. In total, 13 avalanches occurred there. The avalanche paths are shown in the event picture of 1954 (Figure 1).
Just over 60 years after this catastrophe, technical, forestry and spatial planning measures, which are explained below, were taken to protect the local community of Blons.

Figure 1: The avalanche disaster of Blons in Vorarlberg on 11.01.1954 [Source WLV Vorarlberg].

2. WALSER AND THE GREAT WALSER VALLEY

In the 13th century, the Walser, an Alemannic ethnic group from the Valais, moved to the now named after them "Great Walser Valley". The wandering movement fell into the medieval warm period. The Walser cleared the steep slopes and built their classic scattered settlements and alpine pastures. Due to the subsequent climate deterioration in the small ice age, first avalanche accidents of the year 1497 are registered in the chronicle.

The Great Walser Valley is aligned to the wet weather conditions from the west (Atlantic Ocean) and thus often affected by large amounts of snow. Although the individual farms were set up at favored locations, the remaining, non-cleared protective forest was pushed back further and further over time due to overpopulation and overuse. The highest elevation of the avalanche catchment areas of the municipality of Blons is the Falvkopf with 1849 m above sea level. The potential natural timberline is in the Great Walser Valley in the range of about 1900 m above sea level. The avalanche starting zones are thus potentially forestable. The natural forest communities are formed in the montane stage by spruce - fir - beech forest and spruce - fir forest. In the subalpine stage, in the range of 1500 m above sea level and above, the sub-alpine spruce forest prevails, often with tall bushes in the undergrowth. These stocks, which were largely outdated during the 1970s and 1980s, are very difficult to rejuvenate due to strong competition (Figure 2). The municipality area of Blons is built on rocks of the Vorarlberg Flysch. The rocks are easily weatherable and prone to erosion. Almost the entire forest area must therefore be considered in addition to the avalanche protection as a soil and erosion protection forest. A profound and interlinked rooting horizon of the faltering stocks is therefore especially in steeper locations of high conservation importance. In other words, in the long term local sustainability with respect to the local susceptibility to soil erosion can only be ensured by sufficiently stabilizing tillering. The silver fir [*Abies alba*] with its deep-reaching tap root system (up to 2 m) is the only tree species at this altitude capable of ensuring sufficiently deep-reaching stabilization of the soil structure of such cohesive soil types. The root system of the spruce [Picea abies] extends at these locations, especially on marl or marl slate, rarely deeper than 50 cm. However, it forms a dense topsoil rooting.

Figure 2: Outmoded protection forests in the high montane / subalpine altitude are in the decay phase and very difficult to rejuvenate [Source: WLV Vorarlberg].

3. HAZARD SITUATION

Figure 3 shows the forest cover situation of the Walser scattered settlement around 1958. Figure 4 gives an overview of the relevant main avalanche catchment areas in Blons and shows the forestation situation of the year 2006.

	
Figure 3: The municipality of Blons 1958 with low afforestation [Source: WLV Vorarlberg].	Figure 4: The avalanche catchment areas of Blons in 2006. The increase in forest cover is easy to see. [Source: WLV Vorarlberg]

The main avalanche paths "Hüggenlawine", "Eschtobellawine" and "Mont Calf-Avalanche" extend over the entire, south-exposed valley flank of the municipality of Blons. The "Hüggen" and the "Mont-Calf-avalanche" are surface avalanches while the "Eschtobel avalanche" has a canalized avalanche path.

4. THE AVALANCHE WINTER OF 1954

Between the 10th and 12th of January 1954, several avalanche accidents occurred in Vorarlberg. The trigger was extreme snowfalls of more than 2 m of fresh snow within 24 hours. 280 people were spilled, 125 of them died. In the municipality of Blons, one third of the houses were destroyed and one third of the village population, a total of 57 people, lost their lives. The avalanche disaster led to an unprecedented wave of helpfulness and solidarity. The first airlift in the history of Austria was built in Blons. In addition, the two avalanche winters of 1951 and 1954 resulted through their numerous personal and material damages in the development and establishment of modern avalanche protection.

5. THE TECHNICAL PROTECTION MEASURES

The first avalanche protection measures in Blons were probably object protection measures such as roof terraces and splitting wedges. More details are not known. First organized avalanche protection measures in the avalanche starting zones of Blons were established between the years 1906 and 1908. These were Arlberg Rakes (Arlbergrechen) over a length of 1.2 km. Figure 5 shows this type of construction with an effective height of 2 - 2.5 m. The partially already ailing support structures were largely destroyed during the avalanche winter of 1954. The securing of the "Hüggen avalanche" was resumed in 1954. In the process, further types of constructions were developed. The so-called "snow-hanging bridges" (Schneehängebrücken in Figure 6) and, subsequently, the basic structure of the still common snow bridges made of steel. Significant development steps in this type of construction can be found in the foundation. Thus, the originally concreted foundations for micropile foundations and shallow foundations have developed (Figure 7).

Figure 5: Arlberg Rake in the avalanche starting zone of the Hüggenlawine in the year 1906 [source: WLV Vorarlberg].

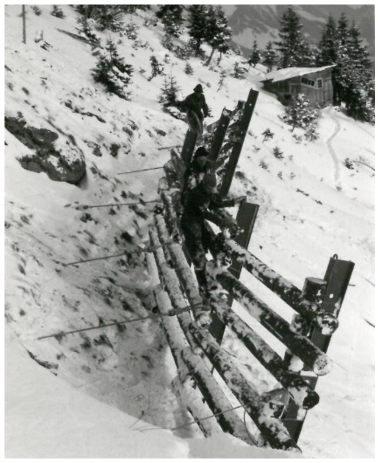

Figure 6: "Snow-hanging bridges", Dk = 3m, mounting after snowfall in the 60s of the last century in the avalanche starting zone of the Hüggen avalanche [Source: WLV Vorarlberg]

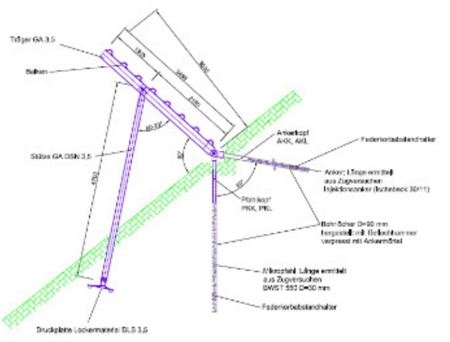

Figure 7: Construction type of modern state-of-the-art snow bridges [Source: WLV Vorarlberg].

Figure 8: The overloaded support structures in the avalanche starting zones of the Hüggenlawine and the Etschtobellawine in February 1999 [Source: WLV Vorarlberg].

In the main starting zones of Blons, about 6.5 km of avalanche defense works (snow bridges made of steel, hangings, combined steel-wood works, etc.), 315 creeping snow constructions and 745 running meters of wind drift barriers fences have been erected. The support structures in the starting zones have proven them-selves in the last 60 years. In the snowy winters of 1967 and 1999, the functionality of the technical constructions of the starting zones could be proven. However, the level of impact of the construction was exceeded in the avalanche winter of 1999 (Figure 7).

Sustainable avalanche protection can only be achieved in wooded areas with adequate forest tillering.

In addition to the protective measures mentioned in the starting zones, protective measures were also taken in the transport area and in the deposit area (dams and object protection measures), which will not be discussed further here.

6. SUSTAINABLE AVALANCHE PROTECTION

In Austria, the Forest Engineering Service for Torrent and Avalanche Control has been responsible for protection against alpine natural hazards since its foundation in 1884. The maxim of the natural hazard management located there is the consideration of the problem for the whole catchment.
Permanent technical protection measures are subject to a certain limited lifetime. In order to achieve sustainable avalanche protection, a combination of different measures such as spatial planning and land-use approaches (forestry) is necessary.
In the starting zone of the Hüggenlawine in the years 1906 to 1908 20,000 pine and 15,000 spruces were planted.

High altitude reforestation was a completely new field of work at that time. There was little empirical value for such exposed reforestation sites. Today it can be seen that about 90- 99% of the plants have failed from this first reforestation.

Further afforestation efforts were made after the avalanche winter of 1954. The clearings were reforested extensively and overaged protection forests were rehabilitated with artificial afforestation. Frequently the rejuvenation was initiated in the protection of technical constructions.

In the municipality of Blons, around half a million forest plants have been planted in the last 60 years. Four fifths of them are spruce [*Picea abies*], the natural main tree species in this sub-alpine area. The forest area in Blons has been increased from about 520 ha in 1971 to 601 ha in 2009.

6.1 Experiences and setbacks

Comparing the forest stands of Figures 3 and 4, the afforestation offensive and 60 years of permanent care seem to be successful. However, the afforestation areas have hardly any protective stocks.
The following problems can be mentioned here:

- Incorrect provenance in early reforestation and the use of large, fast-growing plants (see the consequences in the creeping snow problem).
- Black snow mold [*Herpotrichia nigra, H. juniper*]: Due to the area planting at the beginning of the large afforestations with approx. 10,000 plants / hectare, the small relief was paid too little attention. This led to a widespread spread of the snow mold.
- Creeping snow: Snow creeping and gliding lead to the following damage patterns in the afforestations
    - pull the rootball out of the soil
    - trunk cracks (Figure 9):
    - snow breakage and snow pressure (Figure 10)

Trunk cracks in particular pose major problems for the further development of the stock, as this damage to the stem can provide potential break points for later snow or wind breakage. Lederle (2017) notes that around 90% (!) of the plants are affected at the construction site of the Hüggen avalanche. Although it has been tried for over 60 years to prevent sliding and creeping movements of the snow (Figures 11 and 12).

Figure 9: Strongly drawn trunk cracks, usually these are shorter than 50 cm [Source: WLV Vorarlberg].

Figure 10: Heavy snow pressure damage on ca. 25-30 cm thick trunks after the avalanche winter 1999 [Source: WLV Vorarlberg]

Figure 11: Creeping Snow Construction Dk 1.5. There must be built about 250- 350 pieces per hectare [source: WLV Vorarlberg]

Figure 12: Combined steel-wood works consist of a simple foundation, a slight rust of steel elements and a bed of robinia or chestnut wood, and are expected to last about 30 years, with a effective height (Dk) of 2 to 3 meters [source : WLV Vorarlberg]

Hoofed game (red deer, roe deer and chamois): A close-to-nature silviculture is not possible without the naturally adapted hoofed game stocks (cf. Lederle and Scheier, 2002). The hoofed game bites (special attention must be drawn to the selective biting of the fir [*Abies alba*]), beats, sweeps and peels the forest plants. Rejuvenation of montane mixed forests and the application of subalpine spruce forests can only be achieved with consistent wildlife management. The solution of the existing conflict of interest between hunting and forestry, the so-called "Wald-Wild-Problem" (forest-game-problem) poses major challenges for politics.

In particular, the hoofed game is a limiting factor for the silver fir, so that it has not been able to achieve a sufficient proportion of white fir 20-30% in the established forest stands.

*6.2 **Risk assessment***

In Austria the danger assessment for torrents, avalanches and possibly erosion is based on the hazard-zone map of the Austrian Service for Torrent and Avalanche Control. In 1975, this area-wide appraisal was fixed in the Forestry Act as part of forestry spatial planning. The hazard zones are distinguished here into two intensity classes. In the case of avalanche danger, only the avalanche pressure parameter is decisive. With an avalanche pressure above 10 kPa a high intensity is given and these areas are indicated as "red zone". The "yellow zone" has a low hazard and represents ranges between 1 and 10 kPa. (cf. BMLFUW, 2011)

Hazard zoning is an important planning tool. This applies both to in-house planning (setting of measures, financing, expert activity, etc.) and to external planning such as spatial planning or construction. Consideration in spatial planning ensures that no new settlements are built in hazardous areas. Here is the principle of avoiding the danger. The consequence for Blons was a partial abandonment of scattered settlements and a concentration of residential properties in the most avalanche safe places (Figure 9).

The hazard zones are only indicated for the so-called "space relevant area". A review of the threat is foreseen at least 15 annually or after changes in the catchment areas.

The hazard-zone map of Blons was revised in 2011. With the help of modern avalanche simulation programs it was possible to simulate hazard scenarios such as the partial failure of the technical constructions of the starting zone. (cf. GZP Blons, 2011).

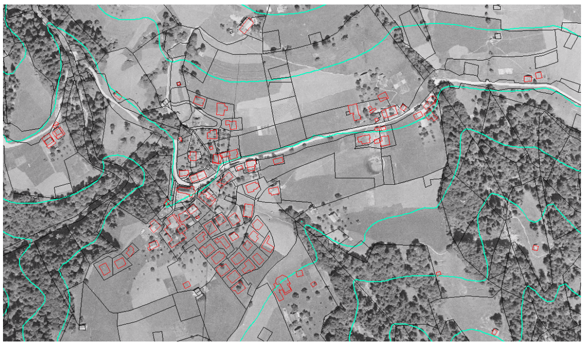

Figure 9: Settlement concentration at the avalanche technically safest place in Blons. The red framed areas are the residential buildings as of 2016. The aerial photo is from the 1950s. The turquoise lines represent contour lines. [VOGIS]]

7. RESULTS AND CONCLOUSION

The Austrian Service for Torrent and Avalanche Control, a department of the Federal Ministry of Sustainability and Tourism pursues a sustainable avalanche protection in Austria. Regardless of political will and the associated provision of financial and human resources for (costly) avalanche protection, the following three points are crucial for sustainable hazard prevention:

1. Competence

As described above, the implementation of sustainable protection measures requires a high level of technical and forestry knowledge. This requires a competent and dedicated staff and further education. However, some insights are only apparent in the practical implementation of the measures during the course of a working life. It is indispensable to pass on this wealth of experience. For example, in Blons, over the years, it has been found that a misplaced provenance of forest plants leads to scarcely protective stock.

2. Consistent action

Successes in high-altitude afforestation and protection forest regeneration require consistent and constant care. However, success can often only be measured after decades. The more important it is to have clear management objectives that look at both the individual tree and the protection forest as a whole. These goals must be consistently implemented in the next generation. Considering natural hazards in spatial planning requires a high degree of assertiveness. It is necessary to resolve conflicts that arise through the interference with the right of ownership of the population.

3. Factor time

The time factor must be seen in the context of sustainable hazard prevention. As can be seen in the example of afforestation and protection forest management in Blons, over a period of 60 years large areas of forest cover, mainly spruce, could be planted. However, these areas are not yet able to withstand the snow pressure due to the poor quality (trunk cracks, etc.). Until these areas have been planted effectively, a further, comparably long period, permanent reforestation and protection forest management, including the maintenance and repair of the technical protection infrastructure, must be expected.

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