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Avalanches keep habitats open and species-rich in the montane and subalpine belt

Andreas Bohner, Heinz Habeler, Franz Starlinger & Michael Suanjak

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Abstract

From a conservation point of view, avalanches are a natural ecological process. However, they can also endanger people and cause serious damage to buildings and infrastructure. From an anthropocentric point of view, protective measures in the form of avalanche barriers are necessary. Avalanche barriers in the starting zone of avalanches can prevent avalanche events. Hence there is a conflict between nature conservation and protection against natural hazards. This study aimed primarily at assessing the conservation value of active avalanche tracks. To this end we examined 16 plant stands on three different avalanche tracks in the Gesäuse National Park (Styria, Austria) and recorded butterfly species at the same time.

On the investigated avalanche tracks, the soils are very shallow, stony, periodically dry, nutrient-poor, base-rich rendzinas developed over limestone debris. The sites are scree-covered, steep and mainly east-facing slopes located in the montane belt. The plant stands investigated belong mainly to the *Origano-Calamagrostietum variae* community.

This study of biodiversity concludes that under these conditions the vegetation in active avalanche tracks is characterized by a high richness of vascular plant species. On average, a plot size of 20 m² contains 71 vascular plant species and 5 bryophyte species. The species-rich plant stands, colourful when in bloom, are dominated by herbs, resulting in a high aesthetic value and an increased diversity of butterflies. The avalanche tracks investigated have a high conservation value because natural ecological processes continue to happen, leading to near-natural and species-rich disclimax communities.

Profile

Protected area

Gesäuse National Park

Mountain range

Alps

Country

Austria

Introduction

Nature conservation has four important aims (Knapp 1998): the protection of individual species, the protection of specific biotopes, the conservation of abiotic resources and the protection of natural processes. The latter aims at preserving or creating the greatest possible naturalness of the ecosystems and letting ecological processes happen as naturally as possible (letting nature be nature). The protection of natural ecological processes is the basis for a long-term conservation of natural and near-natural ecosystems. Highest priority for conservation in a national park is therefore protection of natural processes (Scherzinger 1990).

Avalanches are a natural environmental factor and a natural ecological process in all high mountains across the world. As they occur outside the vegetation period, avalanches destroy mainly the shrub and even more the tree layer (Egger 2001). Active avalanche tracks are thus periodically or episodically disturbed ecosystems. They are part of the rare naturally open areas below the climatic tree line (Ellenberg 1996).

Avalanches are not only a natural factor of disturbance, they can also endanger people and cause serious damage to buildings and infrastructure. From an anthropocentric point of view, protective measures in

Avalanches can endanger people and cause serious damage to buildings and infrastructure, but they also keep habitats open and species-rich in the montane and subalpine belt. © M. Mayerl

the form of avalanche barriers in the starting zone of avalanches are necessary. Avalanche barriers can prevent avalanches, leading to a permanent suppression of the natural dynamics, to a sustainable change of the vegetation and to a decline in biodiversity as well

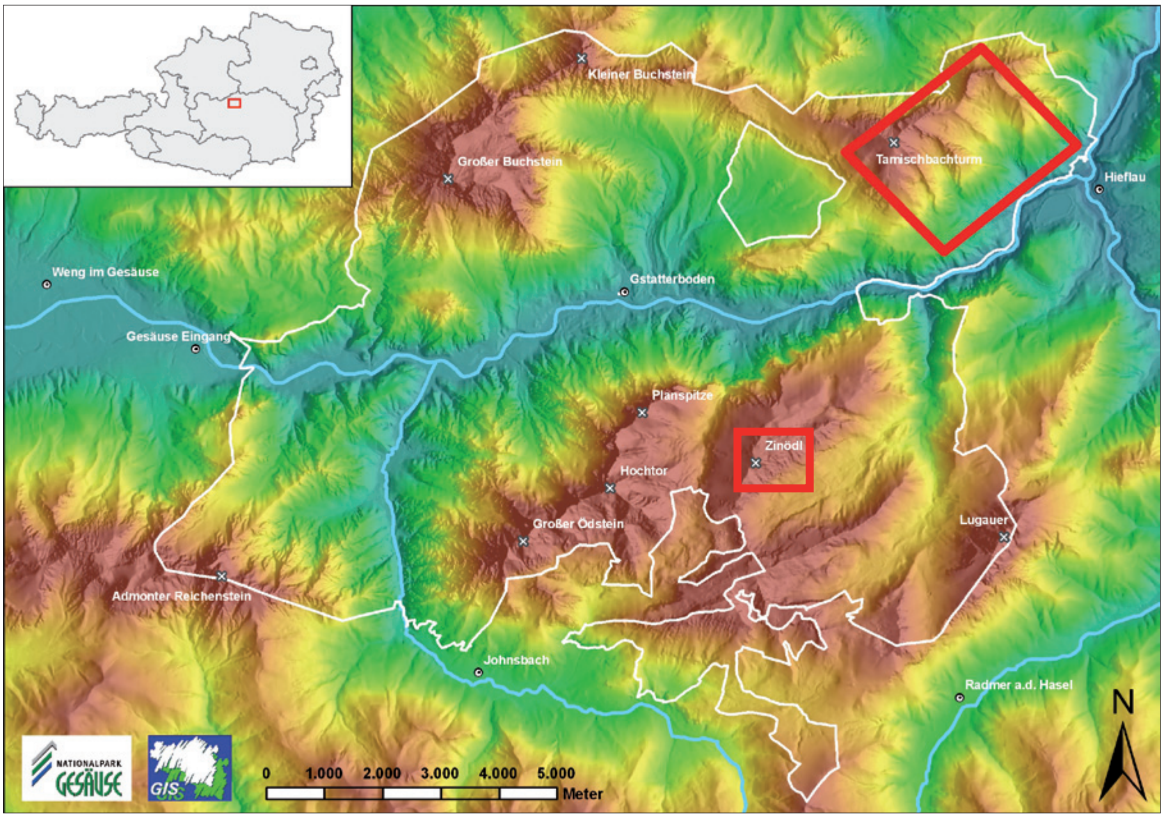

Figure 1 – Location of study area (Gesäuse National Park, Northern Limestone Alps, Styria, Austria). Red Boxes = Study areas. © Gesäuse National Park

as habitat diversity (Kulakowski et al. 2006; Cerny et al. 2006; Rixen et al. 2007). Hence, there is a conflict between nature conservation and protection against natural hazards.

For the management in a national park, there is a conflict of interests concerning avalanches (E.C.O. 2005). Suitable measures are needed to fulfil two conflicting targets:

- permitting natural ecological processes to achieve a maximum degree of naturalness of the ecosystems
- control and prevention of natural hazards to achieve a maximum degree of security for infrastructure and buildings situated outside the natural zone of the park.

To balance these targets, the conservation value of active avalanche tracks and the risk potential for people, buildings and infrastructure has to be assessed.

For a conservation evaluation, profound scientific basic data from the Austrian Alps are still missing (Bohner et al. 2009). There is a great need for research on this topic, with high relevance for spatial planning and nature conservation. The Gesäuse National Park (Northern Limestone Alps, Styria, Austria; Figure 1) is an appropriate study area because of suitable topographical and climatic conditions resulting in numerous avalanche tracks and frequent avalanche events.

This study aimed at:

- recording, documenting, analysing and evaluating the species composition and species richness of plant stands on active avalanche tracks
- analysing the importance of natural disturbances by avalanches for biodiversity and
- assessing the conservation value of active avalanche tracks.

Methods

Studies on vegetation and soil in the avalanche tracks of the Gesäuse National Park were carried out during the vegetation period of 2006. Two avalanche tracks on the SE side of the Tamischbachturm mountain near Hieflau were investigated (Figure1). These tracks were selected as study sites because they are two of the largest and most remarkable avalanche tracks in the Gesäuse National Park. In total, 15 permanent plots were established within the tracks along two altitudinal gradients ranging from 520 to 960 m. These tracks are surrounded by mixed forests of spruce, silver fir and beech (*Picea abies, Abies alba, Fagus sylvatica*). An additional permanent plot in a third avalanche track, located on the SE side of the Zinödl mountain, was installed at an altitude of 1 450 m (Figure1). This track is surrounded by shrub vegetation (*Pinus mugo* community). The avalanche tracks investigated are devoid of large trees and tall shrubs. However, tree seedlings, saplings, small trees and shrubs as well as dead wood occur. The avalanche tracks studied are generally free from human influence. There are no avalanche barriers and there is no agricultural land use such as mowing or grazing. The avalanche tracks investigated are grazed especially by chamois, grazing by wild animals is a regular occurrence. All permanent plots have the same plot size of 20 m² and are largely homogenous from a soil science point of view. At each plot, relevès have been done using the method of Braun-Blanquet. All permanent plots are representative for the avalanche tracks investigated. Areas with sparse vegetation cover or a large percentage of scree were not examined. To assess the nutrient supply for the vegetation, soil analyses were also done on the individual plots. The plots were installed immediately after snow-melt, therefore species richness did not influence the selection. At the two avalanche tracks on the SE side of the Tamischbachturm butterfly species and numbers were also recorded. Frequency and magnitude of avalanche events are unknown. The total number of vascular plant species within a homogenous investigation area of 20 m² serves as a measure for plant species richness (alpha-diversity).

Results

This study of biodiversity has already been published (Bohner et al. 2009). In this report we will summarize the major results.

Avalanches can cause soil erosion and thus disturb natural soil formation. As a consequence, the soils within the avalanche tracks investigated are very shallow, stony, nutrient-poor, base-rich rendzinas developed over limestone debris. They have a low water-holding capacity. Soil pH (in a $CaCl_2$-solution) ranges from 6.2 to 7.3. The minimal accumulation of plant residues deposited on the soil surface indicates relatively favourable environmental conditions for their rapid decomposition, mineralization and incorporation into the soil. The sites are scree-covered, steep and mainly east-facing slopes located in the montane belt (520 to 1 450 m). The soil water regime is periodically dry.

The plant stands investigated belong mainly to the *Origano-Calamagrostietum variae* community; one stand is classified as *Seslerio-Caricetum sempervirentis*. Both phytocenoses represent near-natural disclimax communities. Range of vegetation cover is between 40 % and 90 %. Because of the small amount of plant available nitrogen in the soil and the very shallow soil depth, the basiphilous plant communities are dominated by herbs. Tall herbs such as *Aconitum variegatum ssp. variegatum* are very abundant in the *Origano-Calamagrostietum variae* community. In contrast, *Calamagrostis varia* and other tall grasses achieve relatively low cover. In the *Origano-Calamagrostietum variae* community, hemicryptophytes are prevalent, with therophytes achieving the second-highest cover value.

The weighted life strategy analysis reveals that the plant stands investigated are dominated by CSR strategists, stress-tolerant competitors and competitors; all other life strategy types are insignificant. The plant strategy types according to Grime (1979) were derived from the BIOLFLOR Database (Klotz et al. 2002). Moderate stress due to periodically dry, nutrient-poor soils with an excess of calcium and low intensity of disturbance by avalanches determine species composition. The vegetation is characterized by a high species richness and evenness value (Figure 2 & 3), indicating a high conservation value and the absence of dominant species. The average number of vascular plant species within a plot size of 20 m² is 71 (minimum 58, maximum 77), and the number of bryophyte species is 5. The plant stands investigated harbour species from different vegetation types and elevation zones, contributing to the observed great species richness. They have, on average, a similar species density to semi-natural grasslands dominated by *Narcissus radiiflorus* or *Bromus erectus* in Upper Styria (70 and 68 vascular plant species respectively within a plot size of 50 m²). Only plant stands from sustainably managed alpine pastures can achieve even higher species densities (Figure 2). In contrast, plant species richness is comparatively lower in deciduous and coniferous forests (Figure 2). In Europe, according to Hobohm (2005), plant communities can be viewed as very species-rich, if more than 50

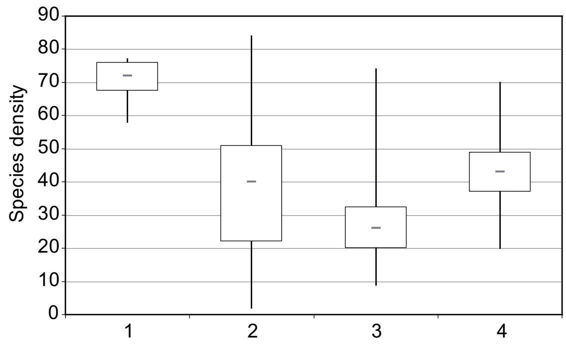

Figure 2 – Plant species density (minimum, maximum, median, upper and lower quartile)
1 = plant species density on active avalanche tracks (total number of vascular plant species within a plot size of 20 m², 16 relevés); 2 = non-forest areas in the Gesäuse National Park (plot size 20 m², 145 relevés); 3 = deciduous and coniferous forests adjacent to the Gesäuse National Park (plot size 300 to 500 m², 123 relevés); 4 = selected grassland communities (high and low intensity managed grasslands) in Upper Styria, Austria (plot size: 5 – 100 m², 14 plant communities). See Bohner et al. (2009) for further details.

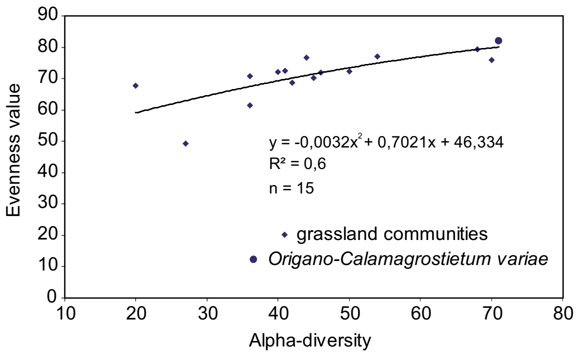

Figure 3 – Relationships between alpha-diversity and evenness values of selected grassland communities (high and low intensity managed grasslands) in Upper Styria plus Origano-Calamagrostietum variae *(plant stands on active avalanche tracks)*

different species of vascular plants, bryophyte species and lichens can be recorded within an area of 100 m². The plant stands on the avalanche tracks investigated thus belong to the most species-rich phytocenoses in Europe.

Because of a negligible human influence, the real and the potential natural vegetation on the avalanche tracks investigated are more or less identical. This is an indication of a high degree of naturalness of the vegetation. Moreover, active avalanche tracks represent the potential natural species richness that is possible in open (non-forested) areas.

The investigated plant stands are rich in species of herbs, colourful when in bloom, resulting in a high aesthetic value and an increased diversity of butterflies. Diversity and abundance of butterflies are much higher than in the surrounding forests. Since 2005, 501 butterfly species have been recorded on the two avalanche tracks studied. During one night, a maximum value of 228 different species was observed. Active avalanche tracks seem to be a preferred habitat for butterflies. Moreover, the herbaceous vegetation is an important food source for chamois.

In sum, the investigated avalanche tracks have a high conservation value because natural ecological processes continue to happen, leading to near-natural and species-rich ecosystems.

Discussion

Several factors are responsible for the observed high diversity of vascular plant species in the avalanche tracks studied. As they occur outside the vegetation period, avalanches damage or kill mainly large trees and tall shrubs. This means that in active avalanche tracks light is not limited by a dense shrub layer or a closed tree canopy, which encourages light-demanding herbaceous plant species. As a result of the very shallow, periodically dry, nutrient-poor soils (primarily nitrogen-poor soils), resulting in relatively low above-ground plant biomass production and hence better light conditions at the soil surface, many different light-demanding plant species can co-exist. Avalanches can create bare soil, fostering the incidence of plant species which benefit from the open sward (mainly therophytes). Active avalanche tracks represent natural corridors (Erschbamer 1989; Rixen & Brugger 2004). A migration of plant species between different elevation zones can occur, increasing vascular plant species diversity by the mass effect or vicinism (Shmida & Wilson 1985). Finally, the small quantity of herbaceous litter on the soil surface and the high regional species pool may also encourage the observed high species richness in the avalanche tracks studied. In sum, the results of this study of biodiversity are consistent with the "intermediate disturbance hypothesis" (Connell 1978). According to this hypothesis, moderate stress and low intensity of disturbance increase plant species diversity.

Conclusions

This study of biodiversity leads us to conclude that avalanches have a positive side: they keep habitats open and species-rich in the montane and subalpine belt. The avalanche tracks investigated are most valuable ecosystems in terms of conservation. They should become priority areas for species, biotope and process protection and sustained as near-natural ecosystems in the long term. Disturbances by periodic or occasional avalanche events are the precondition for the existence of these ecosystems. Hence, buildings and infrastructure should not be constructed below avalanche tracks in order to avoid a need for protective measures in the form of avalanche barriers. In the case of permanent suppression of avalanches, natural succession would result in reforestation of the sites, leading to a decline in biodiversity and a loss of habitat diversity. Avalanche galleries could be an alternative to avalanche barriers in the starting zone, because they ensure a protection against avalanches without suppressing natural ecological processes. Under certain conditions, another possibility would be the construction of deviation dams or brake barriers in the runout zone of the tracks.

In all probability, alpine pastures and grasslands in mountain regions of Austria, especially on marginal soils, will in future be gradually replaced by forests as a result of a changed land-use pattern, leading to afforestation of abandoned grasslands. Moreover, global warming might result in an upward shift of the climatic tree line. In climatically favoured areas, however, a further intensification of grassland management is to be expected. In Upper Styria in particular, and consequently also in the Gesäuse National Park, more wet avalanches in spring are to be expected as a consequence of climate change (Baumann 2008). The importance of active avalanche tracks as retreat and replacement areas for many plant and animal species will therefore increase (Habeler 1981; Rixen & Brugger 2004). Species that cannot survive in closed forests or in intensively used grasslands will benefit especially from open areas created by avalanches.

Results from this study are representative for calcareous sites on very shallow, periodically dry, nutrient-poor soils in the montane belt in the Gesäuse National Park. Further systematic studies on biodiversity in different landscape areas, at different altitudes and on different sites are necessary for a more comprehensive conservation evaluation of active avalanche tracks.

In future investigations, the above-ground plant biomass as well as frequency and magnitude of avalanche events should also be determined. For the latter, avalanche simulation models (Brugger 2002) and the expertise of the members of the local avalanche commission can be helpful. Large avalanche events can be read off scars on trees and shrubs growing in the track (Johnson 1987). In populated areas and in areas with tourist infrastructure, the Austrian Service for Torrent and Avalanche Control records avalanche events.

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Authors

Dr. Andreas Bohner
Head of the Department of Environmental Ecology at the Agricultural Research and Education Centre Raumberg-Gumpenstein; lecturer at the University of Natural Resources and Applied Life Sciences, Vienna
Fields of research: grassland ecology, soil-plant relationships, indicator values of grassland species, biodiversity, nature conservation
andreas.bohner@raumberg-gumpenstein.at
Agricultural Research and Education Centre Raumberg-Gumpenstein
Raumberg 38; 8952 Irdning, Austria

DI Heinz Habeler
Developer of the Lepidat system, a data base program for butterflies in Europe.
Fields of research: inventory of butterflies, biodiversity, nature conservation
heinz.habeler@gmx.at
Auersperggasse 19, 8010 Graz, Austria

Dr. Franz Starlinger
Fields of research: vegetation ecology of forest ecosystems, vegetation monitoring, phytosociology, forest site classification
franz.starlinger@bfw.gv.at
Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Department of Forest Ecology and Soils, Unit of Site and Vegetation Research
Seckendorff-Gudent-Weg 8, 1131 Wien, Austira

Dr. Michael Suanjak
Head of Department, "Arche Noah" gene bank; Arche Noah is an NGO for the preservation and distribution of traditional cultivated plants.
Fields of research: bryophyte diversity, bryophyte flora in Austria, nature conservation
michael_suanjak@hotmail.com
Kogelbuch 34, 8302 Nestelbach bei Graz, Austria