The importance of avalanches and avalanche tracks from an ecological point of view

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Abstract

Primary aim for this study was to gain knowledge on the importance of avalanche tracks for plant species richness. Therefore, plant stands in three different avalanche tracks in the national park „Gesäuse“ (Styria, Austria) were examined.

This study of biodiversity concludes that the vegetation in avalanche tracks on very shallow, nutrient-poor, base-rich Rendzinas developed over limestone debris on locally thermal favoured steep slopes in the montane belt is characterized by a high vascular plant species richness. The average number of vascular plant species within a homogenous investigation area of 20 m² is 70. The colourful blooming, species-rich plant stands are dominated by tall-growing herbs and grasses, resulting in a high aesthetic value. The avalanche tracks investigated are valuable retreat areas for many attractive, rare and protected plant species. These ecosystems show not only a high naturalness, they are also the original habitat for some plant species of today's grassland. Disturbances by regular avalanche events are the precondition for the existence of these near-natural ecosystems. Hence, avalanche barriers and reforestation should be avoided if security for humans, existing buildings and infrastructure permits. Ecological most valuable avalanche tracks should be identified as priority areas for species, biotope and process protection and sustained as natural as possible.

Keywords

Avalanches, avalanche tracks, process-oriented nature conservation strategies, soil properties, species richness

Introduction

Avalanche tracks are a landscape-shaping type of ecosystem in the Austrian Alps.

They are, because of periodical or episodical avalanche events, part of the rare naturally open areas below the climatic tree line (Ellenberg 1996).

Avalanches are a natural environmental factor. They influence thermal, water, air and nutrient properties of soils and they are able to disturb the natural process of soil formation. Because of their high energy and their appearance outside the vegetation period, avalanches destroy mainly the shrub and even more the tree layer (Egger 2001). Therefore, avalanche tracks are periodically disturbed, more or less shrub and tree free ecosystems. For the development of vegetation and soil, most important are kind, intensity and frequency of avalanche disturbances.

Avalanches are not only a natural factor of disturbance, which creates unique vegetation types, but they can also cause heavy damage to people, buildings and infrastructure. From an anthropocentric point of view, protective measures in the form of avalanche barriers are necessary. Avalanche barriers are able to suppress avalanche disturbances, leading to a permanent change of the ecosystems characterized by natural disturbances (Egger 2001; Kulakowski 2006; Rixen et al. 2007). Hence, there is a conflict between nature conservation on the one hand and the protection against natural hazards on the other hand.

Nature conservation has four important aims (Knapp 1998). These are: The protection of certain species, the protection of certain biotopes, the conservation of abiotic resources and the protection of natural processes. The

latter aims at conservation or creation of a as high as possible naturalness of the ecosystems and therefore letting ecological processes as undisturbed and as natural as possible happen (letting nature be nature). Especially national parks offer, because of legal and ecological conditions, the possibility of protection of natural processes (Knapp 1998; Egger 2001). The protection of natural ecological processes is the basis for a long-term conservation of natural and near-natural ecosystems. Highest priority for nature conservation in a national park is therefore protection of natural processes (Scherzinger 1990).

For the land management in a national park, there is a conflict of interests concerning avalanches (E.C.O. 2005). With suitable measures two controversial targets have to be fulfilled:

1. maximum degree of naturalness of the ecosystems, therefore permit natural ecological processes
2. maximum degree of security, therefore control and prevent natural ecological processes.

To reach these targets together, the ecological value of the avalanche tracks concerned and the risk potential for people, buildings and infrastructure has to be assessed.

Faunistic species diversity is an important part of biodiversity. Faunistic studies in the Austrian Alps conclude that avalanche tracks are of great importance for butterflies (Habeler 1981, 2005), arachnids and insects (Ökoteam 2007). In avalanche tracks there are more species and individuals of butterflies than in the adjacent forests (Habeler 2005). In the Central Pyrenees chamois prefer avalanche tracks for food intake (Garcia-Gonzalez & Cuartas 1996). Also in the Austrian Alps the herbaceous vegetation in avalanche tracks seems to be an important food source for chamois. There are relatively few studies published on the vegetation and floristic species diversity in avalanche tracks (Brücker 1981; Malanson & Butler 1984, 1986; Erschbamer 1989; Ewald 1996; Egger 2001). Detailed studies of biodiversity have been done in the Swiss Alps (Rixen & Brugger 2004; Rixen et al. 2007). The results of these investigations show a comparatively higher plant species richness in avalanche tracks than in adjacent undisturbed forests. Furthermore, plant species diversity is highest in tracks with the highest avalanche frequency. For an ecological and nature conservation evaluation solid scientific basic data from the Austrian Alps are still missing. So, there is a high need for further research on this topic, with high relevance for spatial planning and nature conservation. The national park "Gesäuse" (Styria, Austria) is well suited as a study area because of numerous avalanche tracks and frequent avalanche events due to suitable topographical and climatic conditions.

Primary aims of this study are:

- Installation of permanent plots in avalanche tracks for monitoring vegetation and soil and documentation of the initial state of species composition, plant species richness and soil properties
- Phytosociological characterization of the vegetation in avalanche tracks
- Recording, documentation, analysis and evaluation of the species composition and plant species richness of plant stands in avalanche tracks
- Description of soil and soil properties to characterize environmental conditions at the monitoring sites
- Analysis of the importance of natural disturbances by avalanches for plant species richness, soil and vegetation development
- Creation of basic recommendations for land management concerning conservation, promotion or restoration of a high species and biotope diversity in avalanche tracks, with a highest possible protection of infrastructure and settlement areas against natural hazards.

The plant sociological and vegetation ecological results with a vegetation table and comprehensive soil analysis data will be published elsewhere (Bohner et al. 2008).

In this paper the most important results and conclusions for land management in the national park "Gesäuse" will be presented.

Materials and methods

Since the year 2005, in the national park "Gesäuse" a network of permanent plots on sites devoid of large trees and tall shrubs (open-land habitats) for monitoring is set up. It is primarily designed for studies in the field of biodiversity. These permanent plots (up to now 173 in different plant communities) should also be used for recording, documentation, analysis and evaluation of long-term changes in the vegetation and soil development. The plots were surveyed with GPS and some were marked permanently with pegs. All monitoring sites have the same plot size of 20 m² and are homogeneous from a vegetation and soil science point of view. Only in this way a comparison of species richness of different vegetation types is possible (Kiehl 2000). At each plot relevés will be done according to the method of BRAUN-BLANQUET (Braun-Blanquet 1964). The total number of vascular plant species within a homogenous investigation area of 20 m² serves as a measure for plant species richness (α-diversity).

Studies on vegetation and soil in the avalanche tracks were carried out during the vegetation period of 2006. Two avalanche tracks on the SE flank of the mountain Tamischbachturm near Hieflau were investigated. These tracks were selected as study sites because they belong to the largest and most remarkable avalanche tracks in the national park "Gesäuse". The permanent plots were established within the avalanche tracks along an altitudinal gradient ranging from 523 to 960 m. The tracks are surrounded by a mixed spruce-fir-beech (*Picea abies-Abies alba-Fagus sylvatica*) forest. An additional permanent plot in a third avalanche track, located on the SE flank of the mountain Zinödl, was installed at an altitude of 1451 m a.s.l. This track is surrounded by a shrub vegetation (*Pinus mugo* community). A total of 16 permanent plots in three avalanche tracks were examined. The avalanche tracks investigated are devoid of large trees and tall shrubs; however tree seedlings, saplings, trees with shrub physiognomy and small shrubs can be found. These investigations were restricted to grassland vegetation and tall herb communities; calcareous scree vegetation was not examined up to now.

To assess the nutrient supply on the sites investigated also soil analyses have been done. Soil samples for chemical analyses were collected in autumn 2006 from the A-horizon as representative composite samples. Because of partly very shallow soils, not on all sites samples could be taken. Soil samples were air-dried, homogenized and sieved with a 2 mm mesh. Soil analyses were carried out according to the Austrian Standards (ÖNORM).

The avalanche tracks studied are generally not influenced by humans. There are no avalanche barriers, reforestation or conservation management and there is no agricultural land use such as mowing or grazing with cattles or sheep. The avalanche tracks investigated are grazed specially by chamois, therefore grazing by wild animals happens regularly.

Results and discussion

The results of the study up to now can be summarized as follows:

- Avalanches can cause soil erosion and thus disturb natural soil formation. As a consequence, eroded soils are very shallow, nutrient-poor and have a low water-holding capacity.
- The plant stands investigated were found

in avalanche tracks on locally thermal favoured steep slopes in the montane belt. The calcareous soils are very shallow, nutrient-poor, base-rich Rendzinas and developed over limestone debris. The colourful blooming, species-rich plant stands are dominated by tall-growing herbs and grasses, resulting in a high aesthetic value. The average number of vascular plant species within a homogenous investigation area of 20 m² is 70. In Europe, following Hobohm (2005), plant communities can be viewed as very species-rich, if they contain more than 50 different species of vascular plants, mosses and lichens within an area of 100 m². Several factors are responsible for this very high species richness in the avalanche tracks studied. Because of periodical avalanche events, the natural establishment of shrubs and trees is more or less avoided, therefore no light limitation due to a dense shrub or closed tree layer is happening. In consequence of the very shallow, nutrient-poor soils (primarily nitrogen-poor soils), resulting in a relatively low above-ground plant biomass production and hence better light conditions on the soil surface, many different light-demanding plant species can co-exist. Avalanches may transport seeds or other propagules of alpine and subalpine plants to lower zones (Brücker 1981; Erschbamer 1989) and they are able to create bare ground. Therefore, avalanche tracks harbour plant species from different vegetation types and elevation zones, leading to a high plant species richness.

- The richness of flowers enhances the food sources for butterflies, therefore and because of favourable thermal conditions herb-rich avalanche tracks are a preferred habitat for many butterfly species (Habeler 1981, 2005).
- Avalanche tracks are ecological valuable retreat areas and near-natural habitats for many attractive, rare and protected plant species. Avalanches create open areas and the resulting herbaceous, colourful blooming, species-rich vegetation has a great importance both for biodiversity and landscape aesthetics.
- In the future alpine pastures and grasslands especially on marginal soils will be gradually replaced by forests due to a potential global warming and changed land use pattern, resulting in an increase of the climatic tree line and leading to reforestation or a natural recovery of shrubs and trees in the case of abandonment. On the other hand, in climatically favourable areas a further intensification of grassland management will be expected. Consequently, the importance of avalanche tracks as retreat and replacement areas for many plant and animal species will increase (Habeler 1981, 2005; Rixen & Brugger 2004). Especially, species which can not survive in closed forests or in intensively used grasslands will benefit from open areas created by avalanches.
- Some of the recorded plant species are typical grassland species, indicating that avalanche tracks are the original habitat for some plant species of today's grassland.
- Avalanche tracks shape the landscape in at least parts of the national park. They increase landscape diversity and are therefore an element of the landscape worth protecting.

Conclusions

Depending on the point of view of man or on his assessment criteria, respectively, avalanches can be seen both positive and negative. Seen from a bio-centric point of view, avalanches keep habitats open and species-rich in the montane belt. At least the avalanche tracks investigated are most valuable ecosystems from a nature conservation point of view. Therefore, species-rich avalanche tracks with a high nature conservation value have to be sustained as natural as possible. This requires to avoid the construction of

avalanche barriers and reforestation, if security for humans, existing buildings and infrastructure permits. On deeper soils with a higher plant available nitrogen supply, leading to a greater above-ground plant biomass production and a vegetation rich in grasses, an extensive grazing with cattles or sheep is necessary, if a high diversity of vascular plant species should be maintained or if species richness is to be increased. Avalanche tracks with a high ecological and nature conservation value should become priority areas for species, biotope and process protection and sustained as near-natural ecosystems in the long term.

Following the installation of permanent plots and the documentation of the initial state of species composition, plant species richness and soil properties, the possibility of a long-term monitoring of environment and biodiversity in the avalanche tracks exists. The nutritional status of the soils and soil formation can be observed over many years, vegetation development and long-term changes of plant species richness and species composition of plant stands can be examined and ecologically evaluated.

Results from this study are representative for calcareous sites on very shallow, nutrient-poor soils in the montane belt in the national park "Gesäuse". Further systematic studies on biodiversity in different landscape areas and on different sites are necessary for a more comprehensive ecological and nature conservation evaluation of avalanche tracks.

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