Standardized detection of forest with protective function

European Territorial Cooperation South East European Project MONITOR II

The importance of forests with protective function has increased in the last decades due to settlement pressure and high vulnerability of society in Alpine regions and so in Austria. In this context, information on the spatial distribution of protective forest and monitoring its effect to prevent natural hazards becomes essential. However, indicators for forests with protective function that describe their protective effect e.g. against avalanches and rockfall do not exist. Furthermore there is no clear definition for forest with protective function in Austria. Some federal states determine forest with protective function with reference to infrastructure and buildings that are protected by this forest. On the other hand the Austrian NFI only detects forest with protective function while disregarding potential objects that are protected. Furthermore a useful interface between the two official maps that include information about forest with protective function in Austria, the WEP (Waldentwicklungsplan) and the GZP (Gefahrenzonenplan) is still missing.

Traditionally, the Austrian NFI delivers ground data on a national grid which serve the data and information needs on a regional basis. These needs are reflected by the plot density and the statistical design that correspond to the smallest possible information unit. However, concerning natural hazard processes, a statistical plot-based approach is not sufficient. Therefore, remote sensing techniques are an indispensable supplement of information and the applicability of remote sensing and geospatial interpolation techniques must be investigated.

This prestudy within the project MONITOR II aims to develop science-based indicators and estimation procedures for forests with protective functions using Airborne Laserscanning data (ALS). Impartial algorithms can be developed in order to get consistent results for estimated forest with protective function with the help of this rather new kind of remote sensing data. The information content of existing maps like WEP and GZP should be extended and the results should support the Austrian NFI when making clear statements about forest with protective function.

The test area included three regions in Northern Tyrol in Austria:

- Stanzer Tal (273 km²)
- Wipptal including Stubaital (817 km²)
- Östliches Mittelgebirge (219 km²)

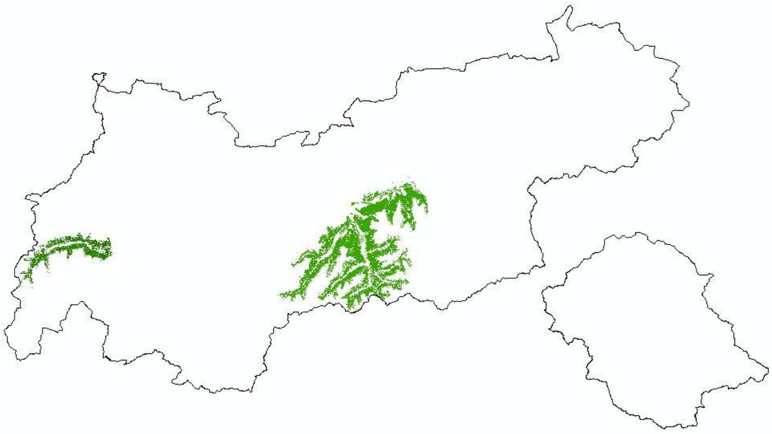

Figure 1: Forest within the test area

The forest within these regions is dominated by spruce with larch as additional tree species. Tourism plays a decisive role in this area and the infrastructure is threatened by avalanche and rockfall.

Within these regions the area of forest with protective function against avalanche and rockfall was determined.

The method used to determine forest with protective function was developed and adapted consecutively at the Department of Natural Hazards and the Department of Forest Inventory of the BFW (Federal Research and Training Centre for Forest, Natural hazards and Landscape). Because of the lack of useful data (e.g. snow maps, rock maps) the development of the method has not been completed yet.

The first step within this project was to create the basic data. A representative raster layer of objects that have to be protected includes buildings, roads, railroads, power lines, ski lifts, ski trails and forest roads. The potential damage zone was created by buffering the infrastructure with 15m.
A digital forest layer from the federal state of Tyrol was used. The terrain was represented by a Digital Terrain Model (DTM) with a resolution of 1 meter that was derived from ALS. Furthermore a digital snow height model was derived from measurements at climatological stations and a digital rock layer was exported from the official Austrian map (OEK50).

After that the area of forest with protective function concerning avalanche and rockfall could be detected. The potential starting zones for rockfall and avalanche had to be determined. Two models were applied concerning potential starting rockfall zones:
Model A: rock layer outside of forest with a slope > 43 ° and forest with a slope > 43° (due to rockfall experts from Cemagref)
Model B: rock layer outside forest with a slope > 43° and terrain with slope > 45° and forest with slope > 41° (due to the experience of Austrian NFI field surveys in Vorarlberg, Tirol, Upper Austria)

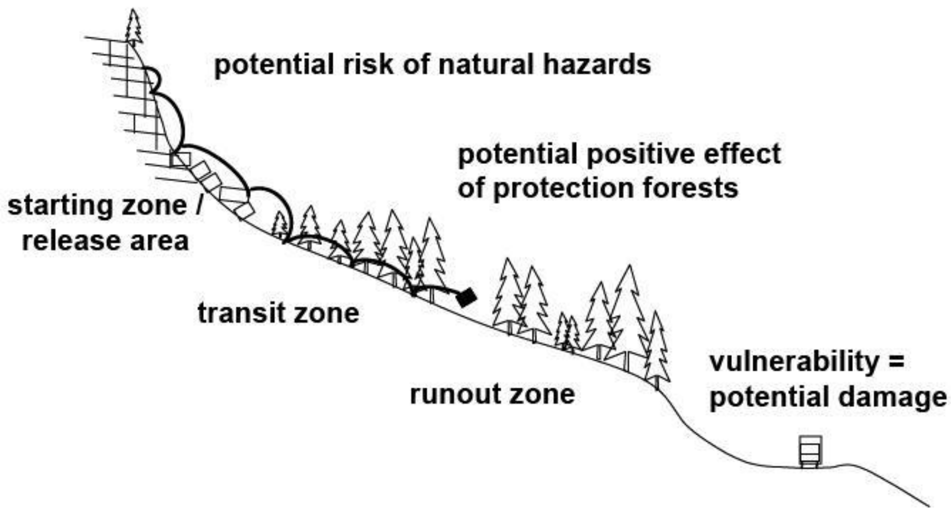

Figure 2: schematic sketch of starting, transit and runout zone of rocks

A modified model that was developed within the ISDW program of the Austrian Federal Ministry of Agriculture was used in order to determine potential starting avalanche zones.
Several indicators are used in order to determine the hazard potential: the average maximal snow height, slope and curvature of the terrain.
The hazard potential is defined as follows:

0 - starting avalanche is improbable
1 - low risk: starting avalanche is only possible with massive/extreme snow heights
2 - medium risk: starting avalanche is possible at instable snow conditions
3 - high risk: starting avalanche is possible also at stable snow conditions

In general avalanches mostly occur on rather steep slopes (29 °– 55°) in snowy regions. Below a slope angle of 28° almost no large avalanches have been observed and above 60° the terrain is so steep, that the snow is continuously avalanching without being able to form large avalanches (Gruber&Bartelt, 2007).

A one-dimensional topographic-statistical model including the energy line approach according to Heim (1932) is used in order to calculate the range of natural hazard processes. This approach primarily was applied to rockfall. It was applied to avalanches by Körner in 1976 for the first time.

The energy line is the connecting straight line between an avalanche or rockfall starting zone and its runout zone. The relative range of the process and its loss of energy along its way are described by the angle between the energy line and the horizontal. This angle is indicated as α.

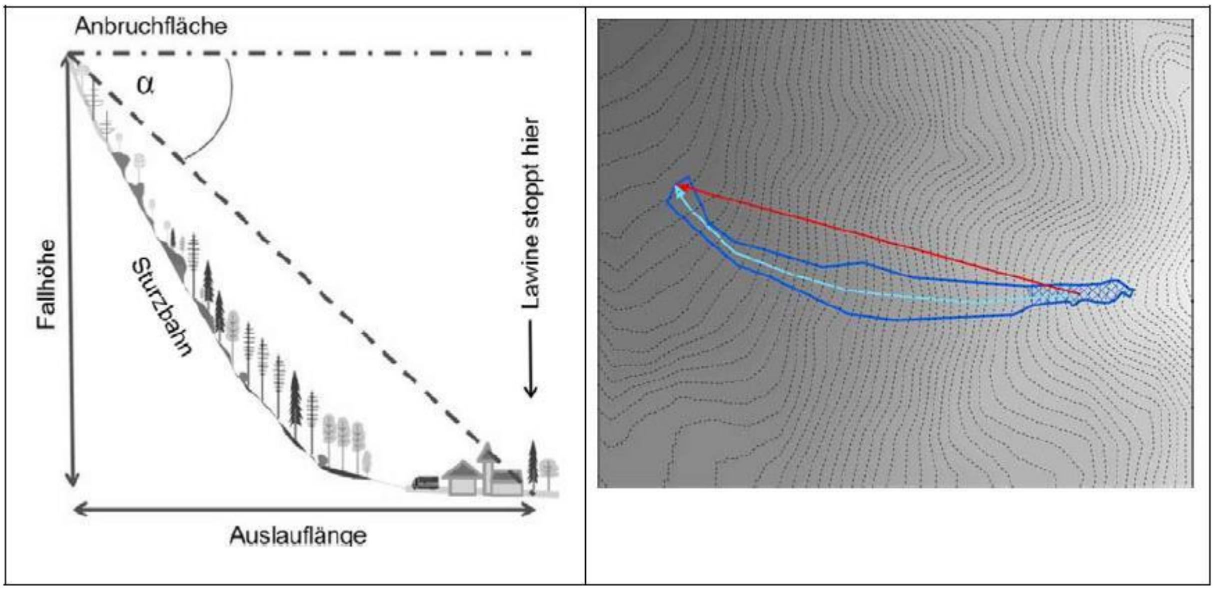

Figure 3: schematic description of the energy line approach: Fahrböschungslinie (cyan) and direction vector (red) of a documented avalanche in tyrol

If the potential starting zone of a rockfall or snow transit is known it will be possible to estimate the end point and the potential transit range of a rockfall or snow transit by intersecting the potential transit route with a virtual cone that is defined by α.

In general the range of the transit process is getting wider with a smaller α.

Within this project a program developed by Fromm (2004) is used in order to calculate the potential range of avalanches and rockfall. This program uses the angle α without a specifically adjustment of the transit route.

Each pixel that was defined as starting zone is a start pixel for the D8 method: the deepest of the eight neighboured pixels is always determined to be the next pixel of the transit route. If two pixels have the same height the pixel that is located next to the direction of the avalanche or rockfall is chosen as the next transit route pixel. The calculation will be stopped if α is outrun or if a pixel with 8 higher neighbour pixels is reached.

All trajectories that reach objects that have to be protected including their starting positions are exported as ascii files. Pre- and post processing is done with ArcGIS (ESRI).