PROTECTION FORESTS MAPPING AND FOREST MANAGEMENT ARRANGEMENT

A FRENCH METHOD USING GEOMATICS AND FIELD SURVEYS

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INTRODUCTION

The first function of forest stands has always been the wood production. Nowadays, the society becomes aware of the necessity of these environments: tourism, outdoor activities, fauna and flora protection, biodiversity, etc. In mountain areas, forests can also have an important role: a protective function against natural hazards. In the French Alps, 33% of the area is covered by forest. Experience has shown that forest stands can have a significant role for reducing the occurrence and the impact of natural hazards on our society, in particular for snow avalanches and rock falls.
The importance of forests with protective functions has increased in the last ten years due to settlement pressure and high vulnerability of society in Alpine regions. Furthermore, forest cover is not unchanging, and a specific silviculture is needed to maintain or increase the protective role. Even if this silviculture is based on natural cycles, adopting this type of management is impossible on all mountain forests due to financial restrictions. A protection forest is not financially profitable: we don't manage it for timber production, but to protect us... In this context, the knowledge of the spatial distribution of these protective forests and of its effects to prevent natural hazards becomes essential.
A forest has a protective function only if it protects society and facilities from hazards. There are also 3 main topics for protection forest mapping: hazards, human stakes and forests. The developed method for protection forest mapping uses Geographic Information Systems (GIS). In this extended abstract, only snow avalanches and rock falls are considered. These hazards are first modelled under a GIS environment. Then, protection forests are identified, depending on their ability to control hazards, their stability and the human stakes situated below forest stands. Finally, in these protection forests, we defined priority areas for forest management.

NATURAL HAZARDS CHARACTERIZATION

Different documents already focus on natural hazards (Carte de Localisation des Phénomènes d'Avalanches CLPA, Risk Prevention Plan PPR, etc.) but they only list and map past events. They don't make a census of topographic conditions needed for a hazard release. On many hillsides, topographic conditions can be combined for a hazard release, but forest coverage plays its protective function so no hazard already occurred. It's also crucial to develop models to localize all potential release zones, according to topographic conditions.
First, all potential release points were mapped: 2D GIS models have been developed to localize them depending on topographic conditions. (1) For rock falls, a slope threshold is applied to the slope surface raster (computed from the raster Digital Elevation Model [DEM]), according to the equation: $\alpha = 55 \times RES^{-0.075}$, where RES is the DEM resolution. All cells with values higher than the threshold α are qualified as potential release zones for rock falls. (2) For snow avalanches, curvature, slope, altitudinal and area criteria are chosen, depending on regional and geoclimatic conditions. For instance, in the French northern Alps, all cells in the raster with a slope between 28 and 55 degrees, a convex form, an altitude higher than 1000m and an area higher than 500m² are considered as potential release zones for avalanches.

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Then, from each of the potential release point, GIS models simulate the probable run out envelops:
(1) RockForLINE for rockfalls is based on the Energy Line principle, which allows relating rock fall run out envelops to slope angles. (2) AvalForLine, for avalanches, is also based on energy Line. The maximal probable run out envelop is determined by intersecting the ground and an imaginary line drawn from its release point with a calibrated angle. AvalForLine angles have been calibrated with Airborne Laser scanning data (ALS or LiDAR). We made a GIS crossed analysis between release points, run out envelops and forest polygons to only keep forest stands that are concerned by hazard.

HUMAN STAKES COTATION

Good information on facilities location is required to classify forests that have a protective function and organize priority blocks for forest actions. The BD TOPO of the French National Geographic Institute (IGN) is a GIS database that maps and lists all human stakes: public facilities, dwellings, communication, electrical, gaz and water networks, industries, stores, etc. According to their importance or their extent, all items have been classified into 4 levels (0: low to 3: high level). Human stakes are crossed with forests concerned by hazard to localize all protection forests. This classification will also help to define priority levels for specific silvicultural actions, to maintain or increase the protective function of the above forest.

PROTECTION FOREST CLASSIFICATION

In all protection forests stands, an important field survey must be carried on to collect dendrometric data. The goal of this data collection is to classify the forest stands into a Hazard Mastership Index (IMA). This index is a vision at a given moment and shows the ability for the forest stand to control or reduce the hazard intensity and/or frequency. Stand density (N/ha), basal area (m²/ha), winter canopy (%), deciduous trees proportion (%) are the main characteristics for the IMA, but also, mean diameter (cm), regeneration, structure, forest condition and blank proportion are collected.
The IMA ranges from 0 (no control) to 6 (high control) and is a relative quotation to compare all stands between them. For rock falls, the forest can play a role in the release and transit zone and IMA depends on the basal area and the stand density. For snow avalanches, the protective role focuses on the release zone, and IMA depends on the basal area and the winter canopy. The other dendrometric characteristics have been compiled in a dichotomic key to know if the forest stand is considered as stable or not.

DEFINITION OF PRIORITY ZONES FOR SILVICULTURE ACTIONS

Forest stands have a final code, called Priority Zones for silviculture actions (ZIFP). This code expresses the emergency for foresters to adopt specific actions to improve the forest effect in the long term. ZIFP depends on three parameters: IMA (code from 0 to 6), the forest stability (stable / unsteady) and the human stakes (code 0, 1, 2 or 3).
A final matrix allows classifying forest stands in ZIFP code, from 1 to 6. Performed with GIS, a protection forest stand with a ZIFP code of 1 or 2 couldn't be efficient ever, and civil engineering can be helpful. On the other side, a ZIFP code of 5 or 6 means that forest stands are correctly settled, and an adapted silviculture will be enough and very efficient to maintain in the long term the protective function against rock falls and/or avalanches.

This methodology has been developed during an Interreg project on protection forests. It has been tested and validated on 2200 km² in different alpine study areas. The average proportion of protection forest is about 20% and now foresters have to use the Mountain silviculture guide to maintain their protective function.

Keywords: protection forest, GIS, natural hazards, silviculture, forest management.