# Trends in Mountain Forest Management in Switzerland

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## Multifunctional mountain forests – protective forests

From 1850 to about 1970 an important general objective of traditional forest management was to increase the area of forest and the standing volume as well as to enhance the protective effect of forests. The objectives of silviculture in the mountains have changed considerably during the last 30 years. The multiple use of forests for recreation, conservation, biodiversity, $CO_2$-sink, etc. has been given priority, whereas income from the forest has lost importance in the mountainous regions of Europe (GLÜCK and WEBER, 1998). Furthermore, increasing labour costs and falling timber prices gradually forced forest managers to reduce interventions. However, in the long run and on a global scale, the forest as a source of timber will retain its significance. Last but not least, the understanding of the mechanisms and processes in mountain forests has grown. In order to ensure that mountain forests can meet these multiple demands, silvicultural techniques and policies must be adapted to new objectives and conditions (BISCHOFF, 1987; BRANG *et al.,* 1998; BRANG *et al.,* 2001; OTT *et al.,* 1997; GLÜCK and WEBER, 1998).

Among European ecosystems the mountain forests belong to the largest coherent areas in relatively natural condition. Therefore, they are very important for biodiversity, natural habitats, genetic resources and the conservation of the natural environment. In Switzerland, 7.5% of the forests, mostly in the mountains, are inaccessible or shrub-forest, and 23% have not been utilised for the past 30 years (BRASSEL and BRÄNDLI, 1999). The beauty of the mountain forests and the pleasant mosaic of forest and agricultural land are of high importance for the positive perception of the landscape by tourists.

In mountain regions, the protection of human settlements against natural hazards such as avalanches, landslides, rock fall, erosion and floods is often considered by the public to be the most important forest function. Many steep valleys in the Alps would be largely uninhabitable without mountain forests to protect people, buildings, traffic and power lines. Experts have estimated that the complete deforestation of Switzerland would lead to damage from avalanches that would amount to about 62 billion Euro over the next 50 years (ALTWEGG, 1991).

It is a specific property of many protective forests in the mountains that they are expected to protect continuously at a certain locality, e.g., above a village or a traffic line (SCHÖNENBERGER, 1998). In Switzerland, these mountain forests are referred to as «forests with a particular (direct) protective function». To meet this criterion, a stand must be able to reduce the potential danger of avalanches, landslides, erosion, debris flows, rock fall or torrents at places, where the potential damage for the population or objects is considerable. Direct protection is tied to the stand level. This is in contrast with many other forest functions including a general protective function, e.g., water protection, carbon sink, etc., which may be important on a regional scale but not for the stand itself.

The direct protective effect cannot be maintained continuously unless silvicultural measures are taken, because the natural development of a stand cycle includes phases during which the protective effect is temporarily reduced or missing (KORPEL, 1995). In forests which have a direct protective function, stands in a phase of disintegration, which do not regenerate sufficiently fast to ensure protection, are unacceptable. Silvicultural measures must be taken to ensure an uninterrupted and sustainable protective effect. Swiss forest experts generally agree that the diversification of stand structures is a good strategy for improving and maintaining the protective effect (OTT *et al.,* 1997; BRANG *et al.,* 1998; BRANG *et al.,* 2001). This is best achieved with a small-scale mosaic of stands at different developmental stages. If the costs of measures aimed at maintaining and improving the direct protection of the public can not be met, then state subsidies must be forthcoming. In stands where the protective functions are of secondary importance or missing altogether, minimal or no intervention may be appropriate.

According to the Swiss National Forest Inventory (BRASSEL and BRÄNDLI, 1999), forests with a direct protective function are found on 8.2% of the total forest area; 1.2% of Switzerland's forests provides protection against avalanches, 4.1% against rock fall and 2.9% against both hazards. In mountainous areas of Switzerland, an estimated 30 to 45% of forests have a direct protective effect. Currently 64% of the forest which offers protection from avalanches and 19% of the forest which offers protection from rock fall are considered to be effective. The protective function of the remainder of the forest was found to be insufficient.

## Modern silvicultural principles as applied to mountain forests

### Profiting from natural forest regeneration

Forest managers are increasingly challenged to make better use of natural processes, or at least to let them occur. During the last decades, the role of natural regeneration compared to that of artificial afforestation has gradually become more important. Afforestation is generally restricted to problematic sites, e.g., on steep slopes at high elevations where forest regeneration occurs slowly but is urgently needed to provide protection (ANGST *et al.,* 2000). Alternatives to plantation may be sufficient for the majority of the forest and of disturbed forest areas. Ensuring favourable micro-site conditions, e.g., by scarifying the surface (PELLISSIER and TROSSET, 1992) or opening the canopy, enhances natural regeneration. Transplanting wild seedlings seems to be a valuable alternative to nursery-grown seedlings. Direct sowing under degradable plastic cones at carefully selected micro-sites met with amazing success and was much cheaper than traditional plantation (SCHÖNENBERGER *et al.,* 1990b). Leaving more dead timber in the stands is a long-term, promising practice which favours natural regeneration on decaying wood (STÖCKLI, 1995).

## Establishing favourable micro-site conditions for forest regeneration

Regeneration of high-altitude forests is notoriously limited under the prevailing «man-made» stand conditions. The preconditions of forest regeneration, such as a minimum amount of water, temperature and light as well as nutrients, humus, competition, allelopathy and mycorrhiza, are much better understood today than in the past, and much more is known about the limits of regeneration (PONGE *et al.,* 1998). A number of factors can impede germination, growth and survival of the regeneration: rodents feed on seeds, humus inhibits germination and mycorhization (PELLISSIER and TROSSET, 1992). It may be too dark and cold under the canopy (BRANG, 1998; OTT *et al.,* 1997). A significant part of mountain forests is too dense and of a similar age (BRASSEL and BRÄNDLI, 1999). Thus, at high altitudes, the deep snow cover, as a result of moving snow and disease (snow fungi) often cause considerable damage (SCHÖNENBERGER *et al.,* 1990a). There is also abundant browsing by ungulates. Many stands in the mountains are considered to have insufficient amounts of decaying wood, a substrate for tree germination (STÖCKLI, 1995).

At high altitudes, favourable and unfavourable sites for tree seedlings are usually distributed in a fine spatial mosaic. On elevated micro-sites, often around tree stumps, the conditions are usually better, because the snow cover disappears more quickly and there is no movement of snow (SCHÖNENBERGER *et al.,* 1995; SENN, 1999).

The regeneration of Norway spruce on cold northerly slopes can be activated by cutting rather large openings in the stand to ensure that more precipitation, light and warmth reach the ground (BRANG, 1998). At higher temperatures, raw humus and moder are converted into mull, which is more favourable for the establishment of seedlings (PONGE *et al.,* 1998). By making slit-shaped openings, diagonal to the slope, the risk of avalanches or other natural hazards can be minimised. Such slit-shaped openings must be large enough and be appropriately placed to ensure the penetration of at least 1.5 to 2 hours of direct sunlight, during the summer, to the site where the regeneration of spruce is desired (OTT *et al.,* 1997). This means that the characteristics of the slits will depend on the aspect and slope.

## Cluster afforestation

Until the 1970s, plantations were usually evenly distributed over a large area, without gaps, resulting in uniform thickets and pole stands. Today plantations tend to be more structured and are expected to prevent the formation of uniform structures in future stands. In Switzerland, cluster afforestation has become an increasingly common practice at high altitudes (SCHÖNENBERGER, 2001). New afforestations are usually grouped irregularly over the terrain. Favourable locations are preferred for planting, while unfavourable locations, such as gullies or patches with well-established tall forbs, are not planted. This planting strategy minimises the loss of planted trees and prevents the formation of uniform thickets.

Gaps between individual trees should be relatively small, so that the saplings grow in ‹small collectives›, separated from each other by gaps. Such small collectives not only reflect the micro-site mosaic, but also influence it by changing the micro-site conditions. After two to four decades, several small collectives may grow together to form permanent tree clusters (in German: «Rotten»). If the spacing between the clusters is correct initially, then the stand will retain its group-like structure throughout its lifetime. If the collectives are too large or the gaps too small, the cluster structure will not be retained (FILLBRANDT, 1998).

## Allowing natural dynamics after disturbance

The vast windthrows in Europe caused by Vivian in 1990 and Lothar in 1999, i.e., in one decade, put the role of natural disturbance into a new light. New approaches of dealing with such events have been developed (FISCHER, 1998; FISCHER and MOESSMER, 1999; BUWAL, 2000). Mountain forest dynamics are characterised by slow, delicate, ongoing processes on the one hand and sudden, violent, destructive events on the other. Such disturbances may be snow movement (avalanches, creeping and gliding), storms, heavy snow loads or attacks of bark beetles. Forest regeneration and growth become slower with increasing elevation; over decades, the regeneration is endangered or impaired by rare seed years, snow movements, pathogenic fungi, browsing ungulates or competitive vegetation (SCHÖNENBERGER and WASEM, 1999). Therefore, forest managers have, traditionally, felt obliged to intervene and support forest restoration after disturbances.

Today salvage logging and plantation are not always considered to be compulsory after extensive breakdowns. Without a doubt, a bigger portion of timber will be left in the stand after extensive windthrows in the future. Salvage logging that does not cover labour costs and other costly interventions such as area clearing, plantation or the prevention of bark beetle must be subsidised if they are considered to be in the public interest. They may be necessary if protection against natural hazards must be restored quickly or if follow-up damage by bark beetles must be prevented. A decision-making tool for such interventions on the stand level, based on several criteria such as natural hazards, the risk of further damage, nature conservation as well as social, economic and management aspects, was recently developed in Switzerland (BUWAL, 2000). Logging for prevention against an outbreak of bark beetle after the storm Vivian in 1990 was not always sufficiently effective, depending on the extent of the damage, the weather, the tree species composition, etc. (WERMELINGER *et al.,* 1999). Thrown or broken timber left on the ground can be very important as protection against avalanches, rock fall and erosion on mountain sites up to a slope of 100%. Moreover, the stems that are left behind can improve structural diversity by differentiating the micro-sites and snow cover conditions, increasing biodiversity and creating rare habitats (DUELLI and OBRIST, 1999). Decaying timber is also very important as a substrate for forest regeneration at high altitudes (STÖCKLI, 1995). However, some risks must be taken into account: Timber left behind after a windthrow can be an excellent substrate for bark beetles and may be the main cause of an outbreak. Moreover, it hinders access to the area for forest management and may not prevent but aggravate the effects of natural hazards on very steep slopes, because decaying wood loses its protective effects over the years.

## Enhancing structural diversity

The structure of subalpine forests that are dominated by Norway spruce was an important subject of recent research (CHAUVIN *et al.,* 1994; KORPEL, 1995; BEBI *et al.,* 2001; SCHÖNENBERGER and BRANG, 2001). High-altitude forests near the timberline are generally an open patchwork of several distinct structural types, single trees or tree clusters and gaps of different sizes. They display a group-like structure and have extensive internal margins with green crowns almost reaching the ground (STROBEL, 1997). Such forests are referred to as «mountain selection forests» (OTT *et al.,* 1997). The patchwork of small structural units may correspond to the very distinct micro-site variation found at this altitude, i.e., an irregular distribution of snow and pathogenic fungi, to the distribution of avalanche tracks, different age of trees, former gaps, etc.

Such a diverse structure enhances the structural and biotic diversity. More light, warmth and rain can penetrate the stand, resulting in more varied ground vegetation and diverse habitats for insects, birds and mammals. It facilitates a sufficient number of favourable micro-sites for patchy forest regeneration. A typical mountain selection forest, which is mixed, of varying age and clustered on a small scale is more resilient and resistant to disastrous impacts such as snow load, storms and insects and less prone to extensive and total breakdown (Rottmann, 1986). On a larger scale, structural diversity is greater if stands at several developmental stages of the dynamic cycle exist side by side. Therefore, this is often the target structure in mountain silviculture.

In uniform afforestations, common in the past, artificially established stands tended to be single-storeyed, of a similar age, uniform, monospecific and short-crowned. Such dense stands offer effective protection only as long as they persist. However, they are dark, species-poor, virtually without ground vegetation and regeneration and vulnerable to pests, snow pressure and wind. Such stands, often the result of afforestation, are widespread in the Alps, and their protective effect is not sustainable (Brassel and Brändli, 1999).

In order to prevent the formation of such risky structures, uniform thickets should be managed with the aim of creating a grouped stand structure at an early stage (Ott *et al.,* 1997; Zeller, 1993). This means cutting gaps to form tree clusters. This kind of group-selection tending aims at increasing structural diversity. The gaps must be wide enough to enable the marginal trees in a cluster to permanently maintain long crowns that almost reach the ground (Fillbrandt, 1998). The diameter of the cluster is in the order of 1 to 1.5 times the height of an adult tree. If this is achieved too late, i.e., not until the pole stage, the conversion of uniform stands into a more clustered structure is risky.

### Reducing costs with minimal interventions

In forest stands with a protective function, interventions may not be profitable but are nevertheless necessary. Special guidelines have been established in Switzerland for minimal intervention to maintain a long-term protective effect (Wasser and Frehner, 1996). The guidelines describe step-by-step a standardised and transparent decision-making procedures for silvicultural intervention. They distinguish among 31 stand types and list the important criteria, indicators and minimal requirements for the protective effect of each stand type. Furthermore, the guidelines include indicators for the occurrence of natural hazards in forests such as avalanches, rock fall, landslides, debris flows, erosion, torrents and floods. The appropriate intervention in the stand in question is determined from the difference between the present condition of the stand and the minimal requirements for that stand type and hazard type. To judge the present condition of a stand, it must be analysed in terms of stand parameters such as species composition, tree age, diameter distribution, stand height, vertical and horizontal stand structure and factors that hinder regeneration.

## Gaps in knowledge

The abiotic and biotic conditions necessary for forest regeneration to occur are still not fully understood (Kräuchi *et al.,* 2000). The effect of ungulate browsing on forest regeneration has been discussed for a long time in many countries and is still very controversial. The impact and interaction of forest structure and dynamics with hazards, biodiversity, habitat, etc., is not yet fully understood. Many criteria and indicators of forest effects, e.g., the required stand structures for different forest sites or forest effects, are still questionable, although they are included in the guidelines (Wasser and Frehner, 1996; Buwal, 2000). Little is known about the minimal intervention necessary to achieve certain forest effects or stand structures. The effect of interventions on stands is often unpredictable. Forest managers in Europe lack experience with the natural dynamics of stands without intervention, e.g., with decomposition of dead wood or with natural reforestation after breakdowns caused by windthrow. More research must be conducted on assessing, modelling and simulating forest structures and dynamics.

## Conclusions

Silvicultural techniques for multifunctional forest management can vary from no or minimal intervention to technical constructions. However, when one function of a forest predominates, specific treatments may be necessary to maintain it. It is a delicate, laborious and expensive undertaking to permanently maintain the direct protective function of a forest. This is due not only to difficulties in the decision-making process and difficult working conditions on steep terrain, but also to the high expectations we have concerning the level of protection that forests should provide. Doing the right thing at the right place at the right time is, therefore, much more important in mountain forests than in other types of forests. If the protective function of mountain forests is to be maintained, special treatments, policies, support and research must be forthcoming.

## Summary

This paper describes principles of modern forest management in mountain areas, which have been gaining recognition in Switzerland in the last decades. Mountain forests differ remarkably from lowland forests with respect to structure, dynamics, functions and management. The economic situation has worsened, knowledge of ecology has grown and the demands placed on forests have changed. In order to meet the demand for multiple use, mountain forests must be given specially adapted silvicultural treatment. The following methods are proposed: to profit from natural processes in forest regeneration, to establish micro-site conditions for forest regeneration, to implement cluster plantation, to enable natural dynamics to occur after a disturbance, to enhance structural diversity, to reduce costs by minimising interventions.

## Zusammenfassung

### Trends im Gebirgswaldbau in der Schweiz

Der Artikel beschreibt einige moderne waldbauliche Grundsätze, die für Gebirgswälder spezifisch sind und in den letzten Jahrzehnten in der Schweiz zunehmend Anerkennung gefunden haben. Gebirgswälder unterscheiden sich in Struktur, Dynamik, Funktion und Bewirtschaftung beträchtlich von Wäldern in tiefen Lagen. Die wirtschaftliche Situation hat sich verschlechtert, die ökologischen Kenntnisse haben sich verbessert und die öffentlichen Ansprüche an vielfältige Waldfunktionen verändert. Damit der Gebirgswald die gewünschten Funktionen erfüllen kann, braucht und verdient er eine angepasste waldbauliche Behandlung. Die folgenden Grundsätze werden erläutert: Ausnützen natürlicher Prozesse bei der Waldverjüngung, Schaffen günstiger Standortsbedingungen für die Ver-

jüngung, Rottenpflanzung, Zulassen natürlicher Entwicklung nach Störungen, Fördern der strukturellen Vielfalt und Kostenreduktion durch minimale Eingriffe.


# Résumé

## Tendances dans la sylviculture de montagne en Suisse

Cet article décrit quelques principes de gestion moderne, des principes spécifiques aux forêts de montagne et de plus en plus approuvés en Suisse ces dernières décennies. Les forêts de montagne sont très différentes des forêts de plaine en termes de structure, de dynamique, de fonctions et de gestion. La situation économique s'est dégradée, le savoir écologique s'est amélioré et les exigences du public en ce qui concerne les multiples rôles de la forêt ont changé. Afin que la forêt de montagne puisse remplir les fonctions désirées, elle nécessite et mérite un traitement sylvicole approprié. Cet article propose les principes suivants: utiliser au mieux les processus naturels de régénération, créer des conditions stationnelles favorables à la régénération, privilégier une plantation en collectifs, permettre un développement naturel après des perturbations, favoriser la diversité des structures et réduire les coûts en se limitant aux soins minimaux.

*Traduction:* MONIQUE DOUSSE


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