Problems of recultivation in the subalpine and alpine belt

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Problems of recultivation

The underlying difficulty with recultivations in sufficiently moist subalpine and alpine belts is the decreasing temperature with altitude. This not only shortens the vegetation period, but also slows down all biological processes within this period. This leads to an elevated accumulation of organic material in the topsoil. The result is increased soil acidification and demineralization in the upper soil layers. These cool soils rich in humic acid and poor in nutrients have given rise to specific vegetation types according to altitude, type of terrain, and the underlying rock substratum. A common feature to all is a shallow root system (Kutschera & Lichtenegger, 1982). Their below-ground habitat is therefore restricted to the uppermost soil layers that are warmed most intensely. Removing these soil layers through erosion or earth-moving equipment not only destroys the natural vegetation, but also removes the very foundation for its existence. After loss of the topsoil and the indigenous species, recultivation typically takes place on subsoils.

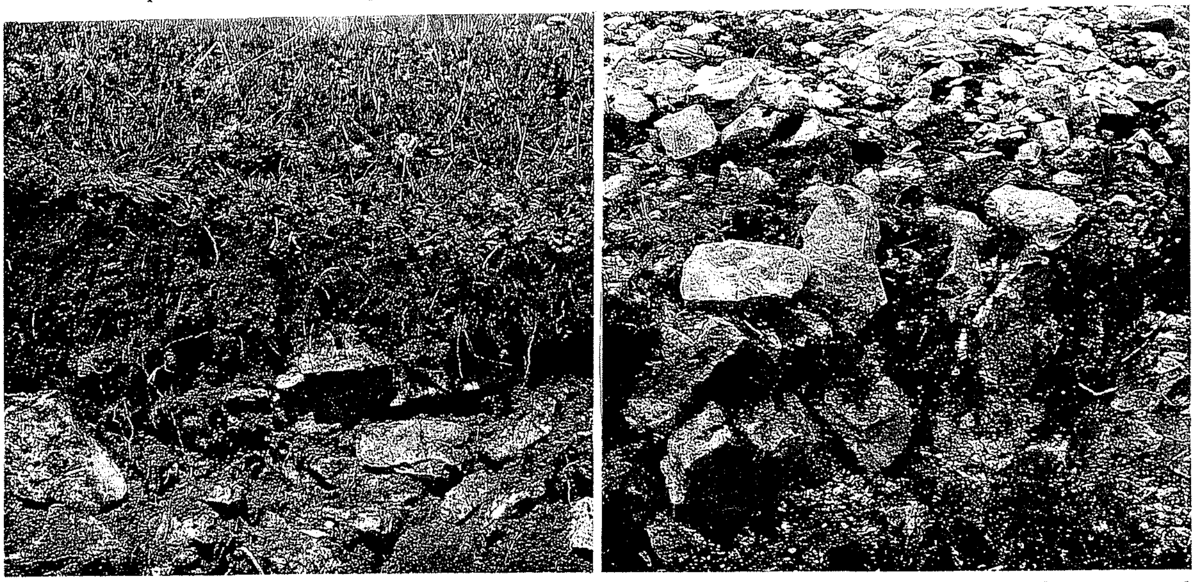


Fig. 1. Left: dense blue grass turf (Seslerion) on Rendsina with flatland, but humus-and fine-material-rich A-horizon in subalpine belt. Right: following removal of blue grass turf along with topsoil, a subsoil with sparse pioneer vegetation came about. Lichtenegger (1994, Fig. 1).

Natural revegetation

Natural revegetation can only proceed via a renewed succession. The slow nature of this process means that it is frequently interrupted by erosion, and often ruined altogether. The success of natural vegetation succession depends mainly on altitude, exposure, geological material and the nature of the terrain. In the high-alpine and subnival level, natural revegetation is often only partial and usually takes place over a long period of time. Grabherr et al. (1988) found that *Carex curvula*, the main species in acidic natural alpine meadows, spread by only 1 mm per year. Much faster natural revegetation is possible in concave areas where snowsoil vegetation is located. This is as a result of fine material deposits and shelter from wind (Ammann, 1975, Lichtenegger, 1994).

Natural revegetation is far easier and quicker in the lower alpine belt, and above all in the subalpine belt. Only in the case of material which has been disturbed a lot is vegetation succession reduced, if not impossible. This applies in all belts to fine material which can easily be eroded, and to stoney subsoils in steep areas. Steep slopes which have been eroded or graded are consequently often difficult to revegetate.

Geological material, too, has a great deal of influence on natural revegetation. In the case of chalk-rich material, a pioneer vegetation containing many species appears on stoney subsoils, even in the subalpine belt (Fig. 2, left). This is caused by the fact that the many pioneer plants contained in turf with a low chalk content, recolonize subsoils quickly once vegetation has been removed (Stolz, 1984, Lichtenegger, 1994). Pioneer plants are scarcely to be found, however, in turf with a low silicate content, which generally occurs in humic acid soils, rich in fine material, overlying stone with a low chalk content. Once this turf has been removed, patchy pioneer vegetation containing few species develops very slowly. The fine material still contained in the soils removed is then very susceptible to erosion (Fig. 2, right).

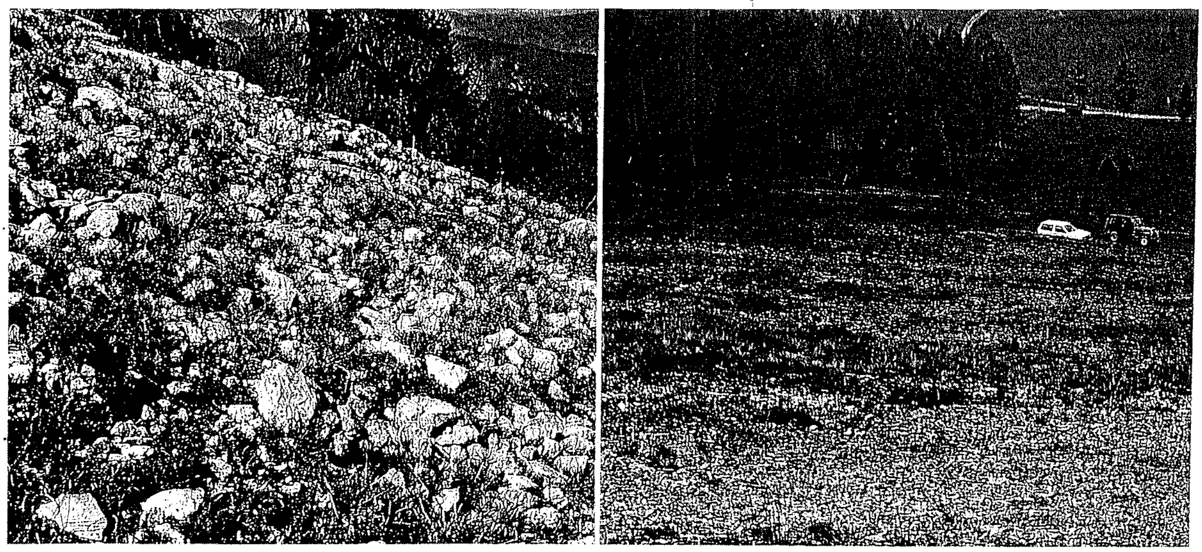


Fig. 2. Left: Many-specied pioneer vegetation on chalk subsoil following grading of a ski-slope in the subalpine belt. Right: pioneer vegetation with few species on silicate subsoil following unsuccessful revegetation of a graded ski-slope in the high-alpine-belt.

The nature of the terrain also influences vegetation succession considerably. Heavy run-off carries fine material and nutrients down from knolls and convex slopes and deposits them in

Fig. 3. Patchy pioneer vegetation and high moss growth on knoll; dense, closed pioneer vegetation in basin (snow valley) following grading of a ski-slope in the subalpine belt.

the concave areas below. Revegetation in eroded or graded areas on knolls and convex slopes which are drier, contain fewer nutrients and are more exposed to wind, is considerably slower and less complete than in the wetter, nutrient-rich concave slopes and troughs. Convex areas have, as a result of this poor vegetation, a higher moss growth than concave areas (Fig. 3).

Artificial revegetation using sods

Artificial revegetation is severely hampered by the lack of humus and the absence of indige--nous plant material and seed material.

When grading, humic topsoil and indigenous vegetation are best preserved by removing the turf in sods and replacing these sods once the grading process has been completed. This is the most natural method of revegetation and has proven successful, particularly in higher alpine areas which are difficult to revegetate using seed. This method is also suitable for lowlying areas, in particular for the revegetation of steep slopes such as scarps. In Switzerland, Mannhart (1993) achieved the quickest and most positive results using this method, even in the montane belt.

Successful revegetation can also be achieved by removing the topsoil containing the rooting vegetation and replacing this `broken sod` once the grading process has been completed. This method also preserves a large proportion of fine material and indigenous vegetation. Combined with additional seeding, it can produce a near-natural turf in a short space of time, even in the subalpine belt. As the following table shows, a turf produced in this way after grading differs little from the original turf after a few years.

Table 1: Composition of the turf following topsoil replacement. 1 natural turf on an ungraded slope, 2,3 artificial turf on graded ski-slope.

Test area	1	2	3
Soil coverage in area percentage	100	100	100
Species coverage in area percentage	117	124	112
sowed species	8	18	4
indigenous species	109	106	108
Number of Species	33	34	32

Artificial revegetation using seed

Artifical revegetation of eroded or graded areas using seed is the cheapest method of revegetion. The success of this method depends on the use of seed mixes which are suited to the ecological conditions of the area in question. Valuable information regarding the composition of these mixes can be found in Florineth (1992), Kutschera (1961), and Lichtenegger (1985, 1994). Revegetation can be effected above the treeline using commercial seed mixes which are principally used for agricultural crops in lowlying areas. Growth declines after a few years, however, as a result of the raw climate and short growing season. Lasting revegetation in the subalpine and alpine belt is possible only if native alpine plant or seed material is used. This is illustrated by the frequent occurrance of stunted turf with heavy moss growth in areas sown with commercial lowland seed, particularly in convex areas. However, even in the concave areas in which the valley grass holds longer, it is crowded out by indigenous grasses(Fig. 4).

The generally unsatisfactory results achieved by using lowland seed in mountain areas led to the multiplication of alpine plant and seed material. Urbanska (1990), Urbanska & Schütz (1986), Grabherr & Hohengartner (1989) and Hasler (1988) in particular, discuss the idea of raising indigenous plants for the purpose of revegetation in eroded and graded areas. In spite of the good results achieved by revegetation using plants, this method proved to be too costly, even for areas with extreme conditions. The multiplication of alpine seed material is much cheaper and achieves results which are at least as successful. Weinzierl (1902), Köck et al. (1989), Krautzer (1995) and Lichtenegger (1994) all looked at this method. Their investiga-

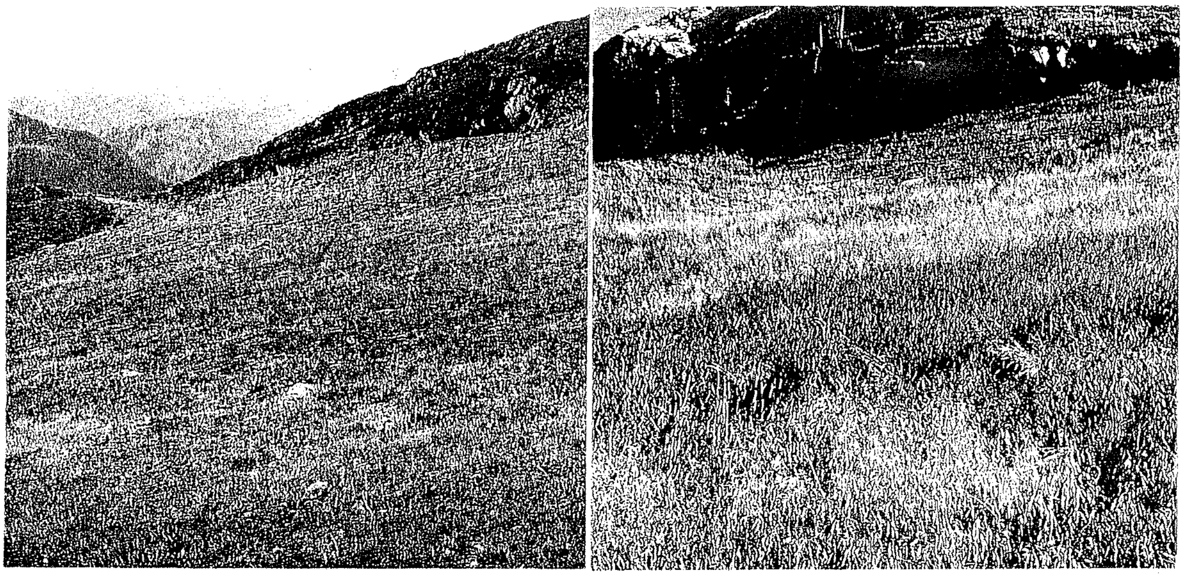


Fig. 4. Left: stunted turf with heavy moss growth on a graded ski-slope, sown with commercial lowland seed. Right: indigenous grass Deschampsia cespitosa displaces the valley meadow grass Phleum pratense (remainder in centre of picture) in concave area in the subalpine belt.

tions showed that certain alpine species display sufficient germination and yield ability to be used for the purpose of seed multiplication. Thus commercial multiplication could be developed. Alpine seed mixes should contain at least 50% alpine species. Successful revegetation in the subalpine belt can only be guaranteed if mixes containing this percentage are used. For revegetation in the alpine belt, mixes containing alpine seed only are recommended. Because of regular misuse, alpine seed material should be defined according to generally accepted criteria and be legally protected as such. Revegetation using alpine seed material suited to the prevailing ecological conditions in a given area quickly produces a lasting closed turf. This proved to be the case, among others, with the revegetation of a ski-slope overlying chalk scree after

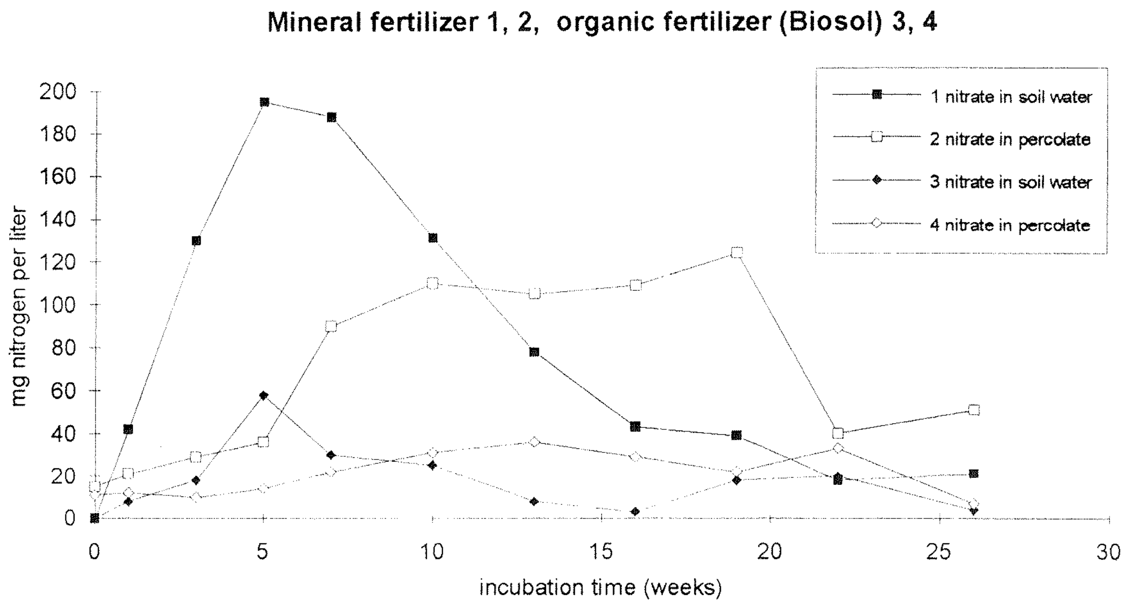
Fig. 5. Left: exposed chalk scree on ski-slope after failed revegetation using lowland seed in the subalpine belt. Right: following revegetation with alpine seed mixes and fertilization with Biosol a lasting closed turf established itself within two years. Lichtenegger (1994, Fig. 44,45).

standard revegetation using lowland seed had failed (Fig. 5).

Fertilization of artificial revegetation

Revegetation using seed requires sufficient fertilization to speed up the growth process up until the closed turf stage. Fertilization also promotes the recovery of indige- nous species. Thus many instances of lasting revegetation using lowland seed can be attributed to the recovery of these species and not to the endurance of the species sown. Only organic fertilizers which are ecologically friendly should be used in high areas.

The nutrients in organic fertilizers are only released by mineralisation of the organic substance. The extent to which nutrients are released is highly temperature-dependent. As a result, a correlation can be seen between the intensity of nutrient release and that of plant growth (Naschberger, 1987, Purwin et al., 1991, Köck & Naschberger, 1991). The degree of nitrate leaching in organic fertilizers is therefore much lower than in mineral fertilizers (Fig. 6). Ecologically friendly organic fertilizers have little or no mineral ballast material and have a low



6. Degree of nitrate leaching much higher in mineral fertilizers than in organic fertilizers. Insam et al., by Naschberger

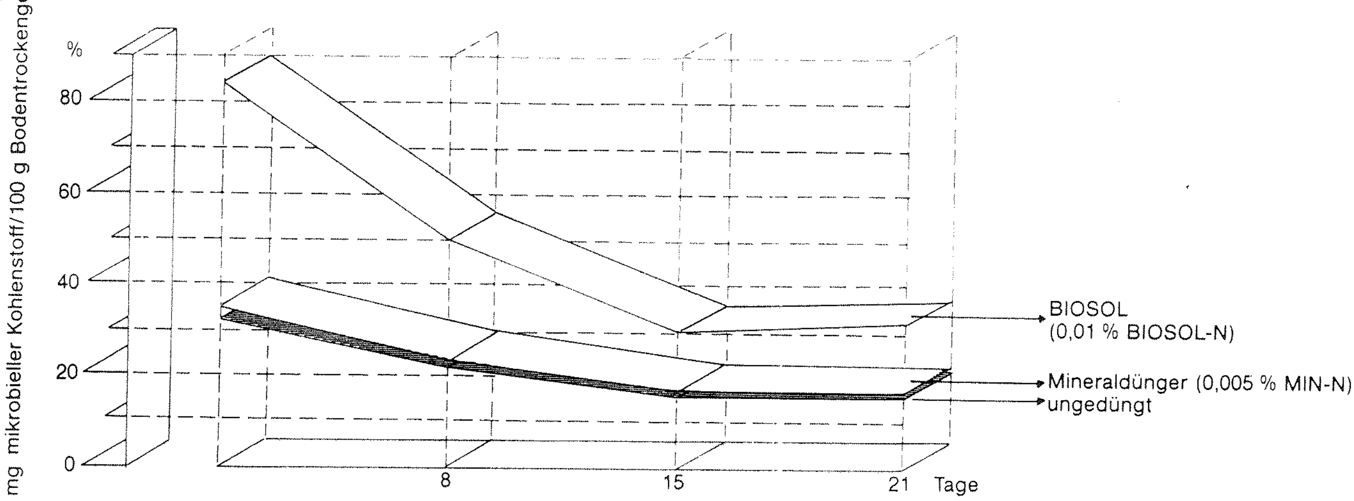


Fig. 7. Organic fertilizer (Biosol) promotes microbiotic biomass more than mineral fertilizer. Naschberger (1987).

salinity. Thus they promote soil life considerably more than mineral fertilizers (Fig. 7). The use of mineral fertilizers can, after an extended period of time, actually stunt growth in higher areas. Thus, for revegetation using seed, the lower the humus content of the eroded or graded area, the more organic fertilizer should be used. After sowing, gradually smaller amounts of fertilizer should be used every year until such time as the ground is completely covered. Using too little fertilizer or not fertilizing often enough following revegetation slows down this process of coverage, and as such, the provision of adequate protection against erosion (Fig. 8). Investigations carried out by Landesanstalt für Pflanzenzucht und Samenprüfung , Rinn/Tirol), show also that organic fertilizers promote thickening considerably more than mineral fertilizers (Fig. 9).

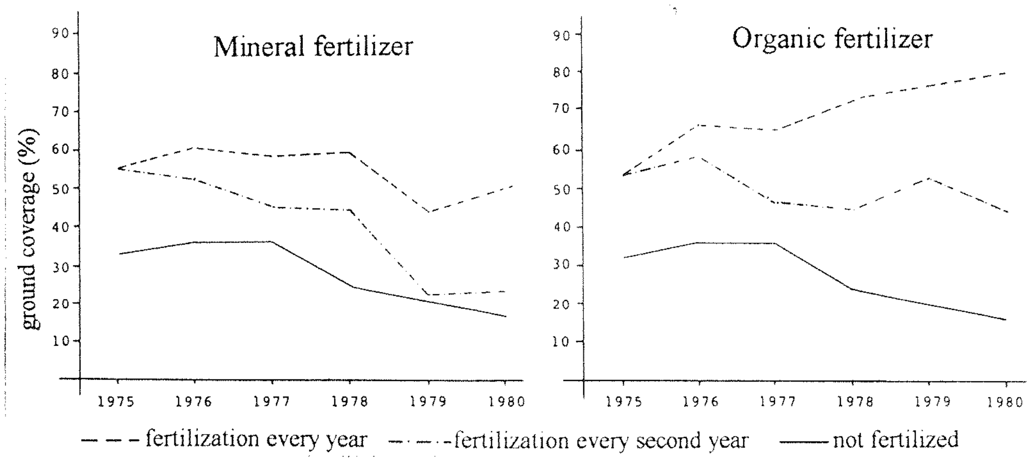


Fig. 8. Organic fertilizers promote better soil coverage (%) than min. fertil. Annual fertilization can improve this result, whereas fertilization only every other year can lower it. Holaus & Köck (1989).

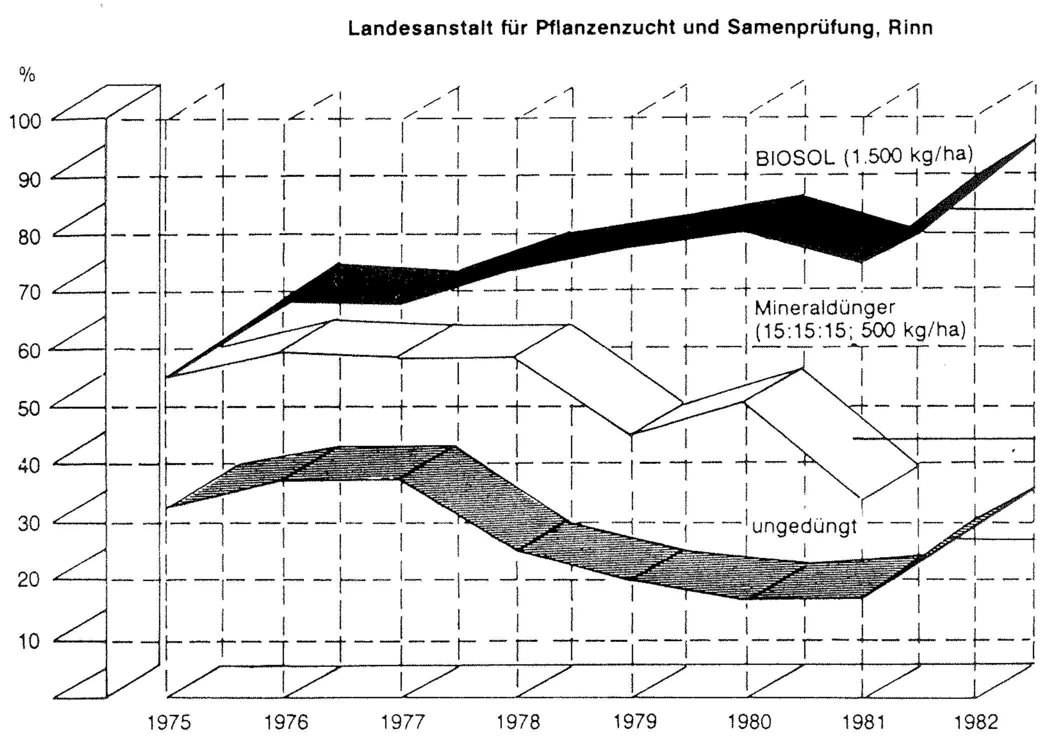


Fig. 9. Turf coverage (%) with organic fertilizer (Biosol) and with mineral fertilizer (Vollkorn gelb). Naschberger (1987)

Summary

After loss of topsoil as a result of erosion or grading, natural revegetation can only proceed via a renewed succession. The slow nature of this process means that it is frequently interrupted by erosion, and often ruined altogether. Artificial revegetation is carried out mainly by sowing seed. Traditional commercial seed from lowland species does not enable permanent revegetation above the timberline. This can only be achieved by using alpine plants and seed. Artificial revegetation using seed requires fertilization to accelerate development up until the closed turf stage, in order to avoid damage by erosion. Fertilization also promotes the recovery of indigenous species. Only environmentally friendly organic fertilizers should be used in alpine areas. Organic fertilizers alone promote the spread of humus to the subsoil and reduce the degree of nutrient leaching to a minimum.

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