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printed, published and © 2007

The project SURE is part-financed by the European Union within the INTERREG IIIB/CADSES programme





Successful Restoration
SURE Net
www.surenet.info

A manual for practitioners

Site-specific high-zone restoration in Austria

raumberg gumpenstein
agricultural research & education centre
www.raumberg-gumpenstein.at

Introduction

As before, in Austria's high zones thousands of hectares of ground are levelled annually for the purposes of tourism and infrastructural adaptation and thus require restoration. The necessary measures for the protection of people, buildings and technical facilities also take up large areas. Due to this intervention, all of the described measures lead to intensive building each year, which subsequently results in the need for restoration.

But rapidly worsening climatic conditions make restoration more and more difficult at increasing altitudes. For reasons of cost, cheap restoration methods are still used today. The resulting ecological and often economic damage is extensive: soil erosion, increased surface drainage, insufficient vegetation cover, high costs for ecologically questionable fertilising measures, disproportionate maintenance expenditure and flora adulteration are only a few of the related consequences.

Efforts to improve the prospects for restoration success in high zones through the use of high-quality techniques and site-specific seed mixtures were started more than 15 years ago. For the first time a scientifically exact comparison between the current state of technology, high quality application techniques was carried out in several international projects (www.surenet.info), whereby it could be proved that a combination of high-quality restoration techniques and site-specific seed led to a stable, enduring and ecologically adapted plant stocks with a high nature-protection value. Fertilising- and cultivation measures can be significantly reduced, which also makes site-specific restoration economically viable in the medium term. The following guidelines should give practitioners a brief overview of the possibilities and necessities of site-specific restoration measures.

Source of supply for site-specific restoration mixtures for differing areas of use in landscape construction:

Kärntner Saatbau
Kraßnigstraße 45
A-9020 Klagenfurt
Tel: +43 (0) 4635 12208
Fax: +43 (0) 4635 1220 885
office@saatbau.at

In-house production of site-specific ecological species
Site-specific restoration species for middle and higher zones

RWA, Raiffeisen Ware Austria AG
Wienerbergstraße 3
A-1100 Wien
Tel.: +43 (0) 1 60515-0
e-marketing@rwa.at

In-house production of native grasses and leguminosae
ÖAG quality mixtures for agricultural use in lower- and middle zones

Unser Lagerhaus Warenhandels GesmbH
Südring 240
A-9020 Klagenfurt
Tel.: +43 (0) 463 3865-519
Fax: +43 (0) 463 3865-500
office@unser-lagerhaus.at

ÖAG quality mixtures for agricultural use in lower- and middle zones

The following firm offers alpine sod rolls for restoration in high zones:

Kärntner Saatbau
Kraßnigstraße 45
A-9020 Klagenfurt
Tel: +43 (0) 4635 12208
Fax: +43 (0) 4635 1220 885
office@saatbau.at

Cultivation

With the use of site-specific seed mixtures, constant maintenance is not absolutely necessary, which in connection with the restoration of erosion areas, avalanche- and torrent barriers, etc. is often wished for.

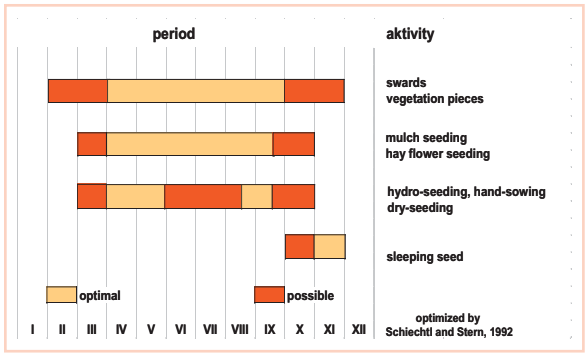
Maintenance cultivation on ski runs is also not necessary in most cases on areas that are not predominantly used for agriculture. Cultivation takes place in the form of extensive grazing or annual cutting, with or without the removal of organic material (only with a slight occurrence of biomass).

Above all during the first years of seeding with accompanying fertilising, development and completion cultivation of the run areas must take place. No grazing may take place on the areas before the achievement of sufficient grass density, at least over the first two vegetation periods. Annual mowing is necessary from the achievement of an appropriately luxuriant stock. This mowing removes biomass and thus hinders smothering of the stock in winter. Additionally, stocking up of the grasses is stimulated and grass density promoted. On impact-sensitive- and steep areas, grazing is to be hindered by fencing, if necessary in favour of mowing.

With a slighter degree of cover (< 50%) in the year following restoration, reseeding with a site-specific seed mixture (30 to 50kg/ha) is necessary. When necessary, appropriate correction must also be carried out on small areas.

The more extreme the site conditions, and the larger the area for restoration, all the more important is the inclusion of a specialist who can define the restoration method as well as the seed mixture according to the respective conditions.

Time table for revegetation projects



Conservation of the topsoil

Removal of the topsoil, as is common in technical intervention, means the destruction of the specific topsoil of a site. Without the topsoil, ecologically adapted grassland can no longer grow. At best only pioneer communities can develop on stony, raw soil that is poor in fine earth, as is often created through recultivation with terrain-changing measures.

The species of grassland communities naturally occurring in high zones are adapted to an optimum to the soil- and weather conditions of their habitat (short vegetation period, poor nutrition supply). With a lack of appropriate procedure, these species are mostly lost during building activity. The natural seed supply, the vegetative renewal organs and the microorganisms in the topsoil that are important for plant growth are thus destroyed. The use of site-specific seed mixtures may help to build up vegetation suitable for the site, but it is no substitute for the humus soil layer and the valuable natural site vegetation it contains.

Use of existing vegetation

Above all in alpine zones, existing, natural vegetation is the best material for enduring restoration. One should thus proceed with care with such vegetation and destruction or non-reuse must definitely be avoided.

Grass turfs (also known as grass sods), or larger pieces of vegetation won during levelling work, are stacked and re-laid in groups after the area is completed, and are very suitable for rapid and site-specific restoration of damaged areas. The grass turfs must be affixed with wooden pegs on steep embankments.

Whenever possible, the laying of grass turfs should take place before shooting or the start of the vegetative rest period in autumn, which means just after the snow has melted or immediately before the start of the snowfalls of winter. At these times, the success of planting even in extreme high zones is exceptionally good.

Before the start of levelling, the available grass- or vegetation pieces, together with the soil and roots, are lifted and again laid after levelling. According to whether the turfs are cut manually or by machine, they are from 0.15 to 0.50 m² in size. As required, the grass turfs are to be stored in pits (maximum of 1 m wide, 0.6 m high), or on pallets to hinder drying out, smothering or rotting. Stacked turfs must be laid soil side to soil side, and plant side to plant side. The storage period should not exceed two to three weeks in summer. After levelling is completed, the grass turfs or vegetation pieces are again laid and lightly pressed into position.

Direct use of the vegetation turfs, without intermediate storage, is possible with appropriate planning within the building procedure. Success with the method is generally the best.

Alpine sod rolls

In high zones above the tree line, successful and permanent restoration following building measures is currently only possible with the use of site-specific alpine-seed mixtures. Due to the extreme climatic conditions two to three vegetation periods are generally required to achieve the minimum ground cover of at least 70%.

During this long period, however, there is often a lack of soil protection against erosion. Especially endangered are areas following building measures on steep terrain or those with problematic soil conditions.

The attendance of small areas can be repeatedly necessary into the autumn. The possibility of rapid, site-specific and enduring restoration with immediate, 100% erosion protection, would be the highest priority. But this is only achieved with the use of vegetation pieces that contain climatically adapted grasses and herbs. A solution to this problem, that is now developed and ready for marketing, is seen in the use of alpine sod rolls. They comprise alpine grasses, which are also able to survive under extreme high-alpine site conditions to an altitude of up to 2,500 metres, but can be produced in valley areas. A large production area for alpine sod rolls has already been started.

The characteristics and positive effects of alpine sod rolls were scientifically observed in several tests and their suitability already successfully proved under extreme climatic- and soil conditions. The sod rolls are harvested as pieces of grass in sod rolls measuring 2.5 x 0.4 m and are about 1 cm thick when lifted, and are delivered on pallets. The strips are generally laid horizontally to the slope direction. Grass mats must be affixed to the ground with wooden pegs. Following intervention on smaller areas, a 100% erosion protection can be achieved in this way immediately after construction has been completed.

Previous results show that the use of alpine sod rolls on highly frequented, steep and erosion-endangered restoration areas is an especially good method for immediate and permanent recultivation.

Fertilising

Restoration in the area of ski runs is only successful with the use of a suitable fertiliser. Levelled areas generally provide a very slight amount of minerals that are then available to plants. For rapid erosion protection, quick development from seeding to grass density is also necessary with site-specific restoration. A single procedure with a suitable fertiliser on such areas is generally sufficient. If sufficient vegetation cover has not been achieved by the second vegetation year, further fertilising measures are necessary until a sufficient grass density has been achieved. These measures can also be combined with overseeding with a site-specific seed mixture. Fertilising measures can be limited to unsatisfactory patches showing only partial grass density.

To be used is fertiliser that is slow in effect and lasting, and which promotes the accumulation of humus and has good plant tolerance. A balanced nutritional relationship is to be observed. Such organic fertiliser as well-rotted manure, composted manure or certified bio-compost (conform to the existing legal regulations) should be used if possible.

The use of liquid manure is to be avoided. The use of organic-mineral- and mineral fertiliser with appropriate characteristics (slow, permanent release of nutrition) is possible, but should be limited to the necessary degree.

A selection of recommended and tested, economic- and organic fertiliser for use from the montane zone to the alpine zone:

Fertiliser	Volume for use t/ha**	Spreading
Stable manure	16 - 20	Manure compost spreader, Compost spreader
Organic Bin compost	10 - 16	Compost spreader
Biofert	0,7 - 1	Manual fertiliser spreader
Biovin	1,5 - 2	Manual fertiliser spreader
Bioren	0,5 - 0,8	Manual fertiliser spreader
Biosol	0,6 - 0,8	Manual fertiliser spreader
Dolosol	1,5 - 2	Manual fertiliser spreader
Renatura provide Verde	0,6 - 1	Manual fertiliser spreader

* related to 40-60 kg N/ha

Choice of the correct restoration technique hinders erosion

Slopes of an average of 30% to 45% in the area of ski runs, and far higher in the area of natural erosion zones and avalanche barriers, make the use of measures with sufficient erosion protection a prerequisite for successful restoration. Only a sufficient vegetation cover stabilises the topsoil and reduces soil erosion to an acceptable degree. But such natural, sufficient protection against erosion is achieved at the earliest in high zones in the second vegetation period. For this reason a good restoration technique must be used.

Erosion can only be avoided on freshly restored areas with the use of mulch covers. The clearly better erosion protection by covering the topsoil through such differing materials as hay, straw, nets or mats can be explained by the protective effect of the organic material. At the same time, the pressure of rain is decreased and the water seeps slowly into the ground and the soil aggregates are thus protected against destruction. The capillary openings in the soil do not become muddy and clearly higher amounts of water can seep into the ground.

Comparison of different restoration methods

Method	Site conditions	advantages	erosion protection*
simple dry seeding	small areas, not steep	low costs	3
hydro-seeding	raw soils, steep road embankements	fully mechanized, relatively low costs, quick	2
mulch seeding (seed + mulch)	all sites, specially above forest line	optimal erosion protection	1
vegetation pieces, grass turfs combined with seeding	all sites, specially embankements	original vegetation preserved	2
alpine sod rolls	all sites, specially embankements	site-specific vegetation immedeate erosion protection	1

* 1 = very well suited 2 = well suited 3 = badly suited

Recommended seeding methods for restoration in high zones

Simple dry seeding

This method should only be used in high zones when combined with a topsoil cover with a layer of mulch, a net or seed mat. Simple dry seeding is understood to be the (generally manually) sowing of seed, alone or combined with fertiliser or other soil aids in a dry state. It is perfectly suitable for level areas, but can also be used on embankments with a rough soil surface. Application can take place either with diverse machines (seeding- and scattering devices) or manually. On difficult terrain, a blowing device carried on the worker's back can be helpful. On large, unopened areas, even dry seeding by helicopter can offer an economic alternative.

Cover-crop seeding

The use of cover crop in high zones brings no appreciable advantages. The prevailing poor soil- and climatic conditions also hinder rapid development of these species even with heavy fertilising. A cover crop therefore cannot be a substitute for the use of mulch material, and in high zones should only be used in combination with a topsoil cover by means of a mulch layer, net or seed mat.

Hydro-seeding

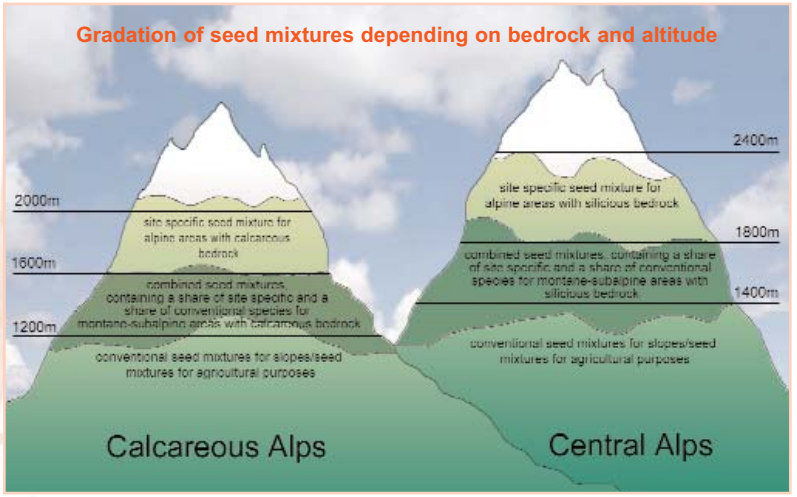
This method should only be used in high zones in combination with a topsoil cover by means of a mulch layer, net or seed mat. With this seeding method, seed, fertiliser, mulch material and adhesive is mixed with water in a special spray container and sprayed over the areas to be restored. On steep slopes, the seed-fertiliser mixture can also be sprayed onto previously pegged jute- or coconut netting. In extreme cases, this method can also be implemented by helicopter at an acceptable cost.

Which seed mixtures should be used for high-zone restoration?

Common commercially available (cheap) restoration mixtures comprise mainly high-growth, non-site-adapted lowland plants that were originally cultivated for grassland agriculture or sport grasses. These varieties are adapted to lower, warmer zones and are not suitable for restoration in high zones. The high need for nutrition of the species requires long-term, expensive fertilising measures to maintain the necessary grass density. Moreover, the plants in conventional mixtures show no reproduction, which means that after the dying off of the first restoration a total failure of the seeded vegetation takes place.

Site-specific subalpine and alpine plants are adapted to an optimum to the high-zone climate and extreme site conditions. They produce little biomass, but high-quality forage among certain species. Seeding with site-specific seed requires only slight, nutritional amounts and short-term maintenance measures, and lead in the shortest time to natural grasses that are to a great extent self-maintaining.

Recommended, site-specific high-zone restoration mixtures from specialised firms are now commercially available (e.g. www.saatbau.at). Differing mixtures according to the basic rock should be used according to altitude.



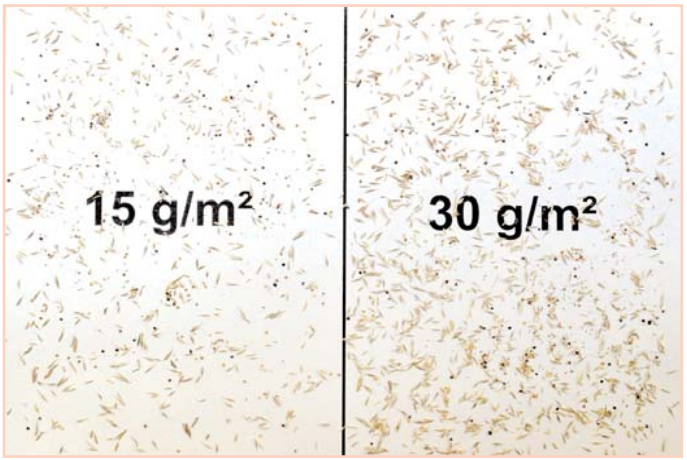
Seeding volumes

Which criteria must restoration fulfil? A rapid, good vegetation density as protection against erosion, lasting and easily maintained stocks, ecologically and optically successful integration in the surrounding area are the most important factors. Moreover, forage yield- and quality in areas used for agriculture play a significant role. One must often turn to a suitable seed mixture. The question of the optimum seeding volume repeatedly arises.

If one works according to conventional wisdom, the necessary volumes for restoration is about 300-500 kg/ha in high zones. With average seed weights and even distribution, between 30,000 and 50,000 seeds are sown per square metre. According to investigations by the Office of the Provincial Government of Tyrol, and the HBLFA Raumberg-Gumpenstein, this is clearly too much and gives only profit to the seed manufacturers.

With the use of site-specific seed mixtures, the actual necessary amounts can be clearly reduced. Important influence factors for seed amounts are the mixtures used, site factors, the seeding technique, the time of seeding or the possible use of a cover crop. The lower the site, the better the soil conditions and the more even the distribution of the seed (e.g. use of hydro-seeding) and the more the seed amounts can be reduced. In practice, with the use of site-specific seed mixtures, amounts from 80 to 150 kg/ha, and under extreme conditions up to 180 kg/ha, can be recommended.

For manual seeding, even when experienced personnel are involved, seeding volumes of at least 150 kg/ha must be calculated for.



Mulch seeding

Mulch seeding means the protection of seeds with a covering of various organic materials. For optimum growth, the depth of the mulch layer should never exceed 3-4 cm and must be translucent. The most common mulch materials are hay and straw. Mulch layers that are too deep, however, can lead to the smothering of the seedlings, layers that are too shallow increase the risk of erosion. A 3-4 cm hay- or straw cover is laid over the seeding. The prerequisite for this restoration method are zones that are wind protected and not too steep. The material expenditure amounts to 300-600 g/m² in a dry state.

A bitumen-straw cover (black-green system is a suitable method for steep areas, especially above the forest line. A 3-4 cm straw layer is laid over the seed and fertiliser and an unstable bitumen emulsion sprayed over the whole (not to be used in drinking-water protection areas). Hay is not as suitable for spraying with bitumen because it is pressed together; as hay cover seeding alone, due to its thinner stalks and better cohesion it is more stable than straw. Hay and straw can also be sufficiently well adhered with light organic adhesives.

Cover with vegetation pieces and seeding

Because the area to be restored is often larger than can be covered with the available vegetation, covering with grass sods or other vegetation parts can be combined with dry- or wet seeding. On a dry site, grass sods (0.2-0.5 m²) are laid in groups (to prevent them from drying out), and in precipitation-rich areas they are arranged in a grid form on the area to be restored. Site-specific seed is introduced into the open spaces between the sods. This method has been tested in high zones of up to 2,400 metres and is in accord with the latest state of technology. In steeper areas (over 30% slope inclination), and on erosion-endangered terrain, the use of geological textile mats are to be used to protect the covered vegetation or to prevent erosion of the topsoil.

Seeding techniques with the use of nets and seed mats

A number of differing geological textiles are commercially available. These nets of jute, coconut fibre, synthetic fibres or wire can be used combined with all of the previously described restoration processes.

The use of synthetic fibres and wire netting as cultivation aids is to be relinquished if possible for site-specific restoration. Geological textiles are used predominantly in a clear case erosion danger or extreme site conditions (e.g. very steep embankment edges).

They offer the possibility of enhanced surface protection and serve the temporary assurance of seeding, the creation of a positive microclimate and storage of water. According to the material used, they are more or less stable in the face of natural force, such as rock fall, snow pressure, precipitation, etc.

According to the material, site conditions and altitude, nets rot within one to four years and leave no deposits. Galvanised-iron nets and plastic nets can remain for up to about 30 years and are not broken down biologically. The latter should therefore only be used in exceptional cases.

The following points are to be observed when laying: the net should have soil contact despite all ground irregularities, have sufficient anchoring (min. 4 per m^2) and be adapted to the wind situation. Unstable gravel and stone should be able to roll to the foot of an embankment to hinder the nets being torn down. The nets must be strongly anchored to the embankment crest.

Seed mats comprise wood-wool, coconut fibres, hemp, straw or other natural fibres as filler material, which is sown into a fine, jute net. The seed is contained in the seed mats. These seed mats require full soil contact, and can therefore only be pegged to flat and smooth surfaces. Use in high zones is therefore not recommended.

Sleeping seeding

One of the basic rules for the assured restoration of areas, which was developed in the course of alpine-meadow revitalisation measures, road- and ski-run construction, etc., is the need for undertaking restoration as early as possible in the vegetation period to make optimum use of winter dampness, especially on dry sites. In practice, the restoration period is generally moved towards high summer to early autumn when building measures are mostly completed. Especially in higher zones, the remaining few vegetation weeks are often unable to assure the growth of seed. On not too exposed, not too steep areas, sleeping seed is then recommended. Sleeping seeding is understood as restoration with seed that is sown so late in the vegetation period that germination takes place only the following spring. The seed "sleeps", so to speak, during the winter period. The seed is sown after the end of the vegetation period, according to altitude and weather from the beginning of October to the beginning of December, together with organic fertiliser. On steep and exposed areas, manual seeding, or where possible the use of hydro-seeding and an additional straw or hay cover, is recommended. Only site-specific seed mixtures combined with the sleeping seed should be used in high zones. Sleeping seeding should only be used at altitudes over 1,400 metres and in zones with sufficient snow cover.

The many years of experience of restoration with sleeping seed has generally shown very satisfactory results. Nevertheless, there is a weather-dependent risk that cannot be calculated, which in extreme conditions can make subsequent restoration necessary the following year.

Advantages of sleeping seeding:

- no time pressure in the execution of building measures
- optimum use of winter dampness the following year
- good soil-seed contact
- brief, controlled grazing of lower areas is already possible at the end of the first vegetation year

Risks of sleeping seeding:

- seed germination in extremely warm weather also in late autumn, which leads to severe winter losses
- care is required when seeding the sleeping seed especially in south-wind locations
- rainwash is to be reckoned with on exposed and steep areas, and with strong meltwater, which requires additional protective measures (use of adhesive, straw, hay)
- an early start of winter can hinder restoration measures