Soil management practices in the Alps

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Content

Background

Soil is the basis of terrestrial ecosystems. It is a fundamental natural resource. In the past, soil was primarily considered and evaluated in terms of its suitability for agriculture and forestry. Nowadays, we recognise that soil performs vital soil ecosystem services that enable the life of terrestrial ecosystems.

Mountainous soils differ from the soils of lowland landscapes. They develop under harsh climatic conditions, in very dynamic relief and on extremely diverse geological material. Furthermore, they are modified (degraded and rarely improved) by various human activities.

Alpine soils are vulnerable. The relief and climatic conditions, as well as human activities, lead to accelerated erosion, landslides, compaction, and loss of organic matter, contamination, and acidification. The ultimate threat to soil and soil ecosystem services is soil sealing – building and paving soils with concrete, asphalt, and other impermeable materials. Sealed soil virtually provides no ecosystem services.

Alpine soils, although in general shallow, sandy, and stony, can be found in diverse forms and types. They can be deep and clayey or shallow and sandy, mineral or organic, moist, wet, or dry, etc. The diversity of Alpine soils is the reason for the different land-use suitability of a given soil, its production potentials, and the capacity to provide individual ecosystem services. Furthermore, soil fundamentally shapes Alpine landscapes, many of which we find very attractive and identify them as our natural or cultural heritage.

Sustainable management and the protection of Alpine soil enhance the quality of the Alpine environment and considerably contribute to the provision of soil ecosystem services and the resilience of ecosystems; this in turn helps to preserve biodiversity and ensure the well-being of humans. The Soil Conservation Protocol of the Alpine Convention, an international treaty, aims “[to] safeguard the multifunctional role of soil based on the concept of sustainable development.”

In a modest way, this booklet presents seventeen soil management practices in Alpine countries: i.e. Austria, Italy, France, Germany, Switzerland, and Slovenia. It reflects the diversity of soil and environmental management approaches used in the area, and the existing sustainable soil and nature protection management in different sectors and industries; mainly in agriculture, forestry, sports, and tourism.

We, the Links4Soils project partners, believe that a greater number of better, diverse, holistic and inspiring soil management and protection case studies are practised or developed in diversity of Alpine countries.

We hope that this booklet will contribute/induce further presentation of sustainable soil management and protection practices and cross-border knowledge exchange and help the Alpine Soil Partnership (AlpSP) and the Soil Protection Working Group of the Alpine Convention to continue their activities towards better implementation of the Soil Conservation Protocol of the Alpine Convention.

Dr. Borut Vrščaj
Links4Soils project leader

SOIL MANAGEMENT IN THE ALPS
AN OVERVIEW OF DIFFERENT CASE STUDIES

Sectors and Countries

One of the important Links4Soils Project objectives was to test, implement and demonstrate sustainable soil and ecosystem service management practices in mountain forestry, spatial planning, agriculture and water management through a cross-sectoral perspective. To reach the objective, several examples of best practices for the successful management of Alpine soils were collected among four categories:

1. Agriculture
2. Forestry
3. Land planning and land management
4. Sports and tourism

https://www.alpine-space.eu/projects/links4soils/en/case-studies

Seventeen case studies have been collected in the Alpine Space area countries: France, Italy, Germany, Austria, Switzerland, and Slovenia. The project partners developed widely applicable and transferable solutions for sustainable soil management and conservation by applying the concept of preservation of the ecosystem services. We compiled them in this book that is targeting practitioners, policy makers, and residents of the Alps.

Agriculture

Out of 17 case studies, three focus on agriculture, in particular the *CS1. Soil research towards a sustainable mountain vineyard management – limiting soil erosion on steep slopes and preserving cultural heritage,* explores the issue of steep slope viticulture demonstrating the importance of permanent grassing and limited machinery use in mountain vineyards, and quantifying their effect in reducing sediment yield by water erosion. The *CS10. Healthy soil for healthy food* shows the experience of a group of farmers from Austria, who successfully applied conservation agriculture measures providing high quality food for the local market. The *CS12. CO_2-Recycling; Climate Change Mitigation by Soil, Humus and Habitat Management - a demonstration project report* presents measures undertaken in the Carpathian region to counteract carbon emissions from soils through sustainable waste management, composting, preservation of organic soils, and conservation agriculture. Awareness-raising activities in schools contribute to multigenerational knowledge transfer and constitute a strong pillar of the project.

Forestry

Three case studies investigate forest management. In particular the produced thematic maps on soil compaction risk and biomass removal for protection forests, with an eye on other forest functions such as biomass production, water filtration and runoff reduction. The *CS11. Integrating soil protection in forest management planning on Pokljuka, Slovenia,* uses the available soil information with the aim of preventing soil compaction and degradation. In two case studies *CS3. Forest soil protection and management in Prägraten, Austria* and *CS11.* harvesting techniques are suggested for different soil types depending on soil development stage, chemical and physical properties and climatic conditions. The *CS4. Regional adaptation for maintaining high-quality ecosystem services during climate change (Germany),* focuses on the ability of forest soils to adapt to climate change and introduces the concept of the “living soil”, i.e. a soil performing a wide set of ecosystem services through the living components.

Planning and Land Management

A wide group of case studies deals with land planning, land management and policies, in particular the *CS2. Preventing hydrogeological risk in Aosta Valley Region, Italy,* shows a protocol for hydrogeological risk prevention developed in Aosta Valley (Italy), which also produced a soil map at the 1:100,000 scale for the regional territory. The *CS5. Evaluation of Soil Functions in Austria* provides a guideline for the evaluation of soil functions which will be gradually incorporated into state laws, thus providing a sound, standardised tool for land planners. The method presented will help reduce the consumption of valuable and fertile soils threatened by urbanisation and sealing. The *CS7. Soil protection on construction sites in Switzerland* describes the soil protection measures that are currently applied at Swiss construction sites, aiming at soil conservation using soil restoration techniques. Both, the *CS9. Management of vacant spaces in South Tyrol, Italy,* and the *CS13. Database on Land Use Management in Lower Austria* deal with different aspects of soil consumption and soil sealing. The *CS9. Management of vacant spaces in South Tyrol, Italy,* describes the strategies developed in South Tyrol in order to re-use and convert vacant buildings, thereby limiting urban sprawl and soil consumption. The *CS13.* presents the measures adopted in Austria to reduce soil sealing, promoting “internal development before external development”. All these examples are adopted at the local (town, province, etc.) level but could be implemented at a greater scale and transferred to other territories.

Sports and tourism

Sports and tourism, such as climbing, mountaineering, hiking and especially skiing are important industries in Alps. While the first three have none or little impact on the soil and ecosystems, the skiing disproportionately affects the fragile Alpine soils and ecosystems in terms of area/space as well as the impact itself. That is why the sustainable management of ski runs, often with multiple functions (pasture, tourism) was explored in a set of case studies in different countries and under different perspectives*. The CS14. Research for a sustainable ski-run soil management* and the *CS15. Environmental management of the Skilifte Lech,* both developed in Austria, explored the environmental management of ski-resorts, and in particular: the effects of climate change on soil and vegetation; the conservation of wildlife and vulnerable areas; the issue of artificial snow making and its impacts on the environment. The *CS8. Revegetation of degraded areas in the French Alps,* the *CS14. Research for a sustainable ski-run soil management; Aosta Valley, Italy* and the *CS16. Improving soil management practices on ski-slopes of Vogel and Kranjska gora, Slovenia,* focused on the management of vegetation cover during and after the construction of ski runs. *The CS8. Revegetation of degraded areas in the French Alps* proposed the “fresh hay” method for ecological restoration on ski slopes, while the *CS15.* monitored the evolution of soil and vegetation in the middle and long run on a set of ski slopes at different altitudes, representing a good example of putting the theory into practice in the field of soil management.

Finally, the *CS6. Soil education trails in Austria* presents the “soil trails” of Austria, a network of paths developed to raise soil awareness in children and non-experts with a playful engagement and a hands-on learning approach.

Transferability of approaches and methods

Nearly all the case studies indicate good transferability to other Alpine regions, as well as in a wider area. Most of them involved participatory planning and strongly engaged stakeholders. In addition, awareness-raising activities were organised in most cases.

The wide set of experiences provides an overview of threats and management issues which widely affect the soils of the Alps. The results highlight the importance of the involvement of the stakeholders and of a cross-sectoral approach taking into account multiple ecosystem services that are performed by soils; the relevance of awareness raising in order to actively engage the residents in soil management and participatory development as well as the transferability of most of the underlying principles that were applied locally for the sustainable soil management.

A SELECTION OF
GOOD SOIL MANAGEMENT
PRACTICES IN THE ALPS

CS1.
Soil research towards a sustainable mountain vineyard management – limiting soil erosion on steep slopes and preserving cultural heritage; Valle d'Aosta, Italy

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Country, Region:	*Italy – Aosta Valley*
Organisation:	*University of Turin (UniTO-DISAFA) and Institut Agricole Régional (IAR)*
Sector:	*agriculture, erosion control*
Land uses:	*agriculture*
Main soil threat:	*soil erosion*
Key soil ecosystem services:	*agricultural biomass production, surface run-off regulation, nutrient cycle regulation, recreational and spiritual services*
Summary:	*Vineyards on steep slopes are very common in the Alpine region. In this case study we investigated the effect of permanent grassing on erosion rates with respect to weed killing practices, and we assessed rainfall erosivity thresholds for an experimental site located in Aosta Valley (NW Italy).*
Keywords:	*soil erosion, prevention, vineyard, permanent grass cover, herbicide, Aosta Valley*

Background and description of the problem

Soil erosion is affecting large areas worldwide, especially on steep slopes and where the soil formation rate is particularly low. In such conditions, when the vegetation cover is scarce or discontinuous, it has been suggested that even relatively limited erosion rates (e.g. < 5 t ha^{-1} y^{-1}) can lead to irreversible soil loss, and through this to severe landscape degradation and a significant decline of soil ecosystem services.

In NW Italy, severe storms are frequent, and soil loss in the range 20–50 t ha^{-1} y^{-1} has often been predicted in mountain areas. To mitigate accelerated erosion, the sustainable agricultural management practices are crucial for soil conservation and natural hazard mitigation.

Steep-slope Alpine vineyards are often characterised by high-quality wine production but are prone to severe erosion when the soil is left bare, i.e. grass-cover is removed and herbicides are applied regularly. By maintaining permanent grass cover, proper management can significantly limit run-off and soil erosion in the area of steep-slope Alpine vineyards. This approach was studied and demonstrated at an experimental site that was designed to assess the effect of permanent grassing on erosion rates with respect to weed killing practices.

Expected improvements / contribution to better soil management

The demonstration area aims at disseminating knowledge on mitigation/better management of soil erosion in steep-slope Alpine vineyards. In addition, being a typical landscape component of the Alpine regions, the mountain vineyards in Aosta Valley have a considerable economic and aesthetic value. Namely, vineyards have been present in Aosta Valley since the Roman age, thus they represent a true cultural heritage that is important to local people and interesting to tourists.

The ancient practice of terraced vineyard slopes helped prevent various forms of land degradation such as severe erosion (Figure 1), soil creeping, landslides and floods. Where terraces are not present, or where slopes are too steep, erosion can lead to permanent soil and nutrient loss, compromising the main ecosystem functions, triggering hydrogeological hazard and loss of cultural heritage. The critical goal of the sustainable mountain viticulture is to find a compromise between economically viable production, erosion control and prevention of natural disasters, and loss of heritage.

Stakeholders and knowledge transfer

Farmers are interested in sustainable vineyard management and environmentally sound wine production. Local communities and the tourist sector support the preservation of vineyards that represent cultural heritage.

At the moment, the site is managed by the Institut Agricole Régional and the University of Torino who are jointly carrying out the experimental activities to collect knowledge for sustainable and economically viable management of vineyards and erosion decrease. Research activities are focused on planning, site maintenance, run-off and sediment collection, sediment analysis, interpretation of results.

Data and methods

The IAR experimental site located in Aosta Valley (NW Italy, Figure 2) is a mountain vineyard characterised by up and down the slope tillage, with an average 40% slope. Eighteen tanks for run-off and sediment collection were installed in the vineyard (one per vine-row, Figure 3). Three treatments (i.e. weed killing, permanent grassing, and buffer zone) were taken into consideration. For three years, sediments and surface runoff were collected during the vine-growing season. Sediments were weighted and analysed for texture, organic C and N contents in order to assess the effect of management on sediment delivery and depletion of nutrients. The climatic data (precipitation, temperature) were continuously measured at a nearby weather station and evaluated against the run-off data.

At the beginning of the experiment, representative soil profiles were described and characterised at the experimental site. Soils were predominantly skeletal, moderately deep and moderately developed (Inceptisols according to the USDA Soil Taxonomy). Chemical and physical analyses were carried out (pH, cation exchange capacity, C and N contents, carbonates, texture, aggregate stability and Atterberg limits). Geological maps and land management history were evaluated.

Prior to the start of the Links4Soils project, a 3-year soil erosion experiment was conducted (between the years 2014 to 2016). The experiment data will be merged in order to obtain more statistically sound results.

Results and conclusions

Since 2014, ten erosive events have occurred. In general, major events occurred in July and October. In 2017, there was a severe summer draught.

Considering the entire experiment, soil loss for single events ranged from almost negligible for low rainfall intensities to ~4 t ha^{-1} (bare soil with tractor passage, recorded for a maximum rainfall rate of 95 mm h^{-1}). Although the erosion rates in most cases were below 1 t ha^{-1} for single events, differences among weed-killing and permanent grassing were sometimes ten-fold. The effect of tractor passage was very relevant as well, and favoured the generation of channelled surface run-off. With respect to the original soil, the collected sediments were enriched in fine fraction and nutrients.

We draw the following conclusions:

1) in order to mitigate soil erosion loss and nutrients depletion, permanent grassing and reduced tillage (i.e. minimum machinery and tractor passage) are strongly recommended in sloping vineyards, in particular in old vineyards where the vines were planted up and down the slope.

2) buffer strips (i.e. 10 m permanent grassing in the bottom 5 m part) are still quite effective in erosion mitigation and should be preserved in order to find a compromise between erosion control and habitat and biodiversity functions.

Transferability and applicability

The good practices resulting from the case study can be transferred to similar contexts (i.e. mountain vineyards on steep slopes) in Aosta Valley. The results will provide a basis for best practices and guidelines for erosion prevention at similar sites, and by this contribute to sustainable management of important economic resources, preservation of tourist appeal, and protection of the cultural heritage.

Photos / illustrations / maps

Figure 1: Intense erosion after a summer storm in 2012 *(Photo: O. Zecca).*

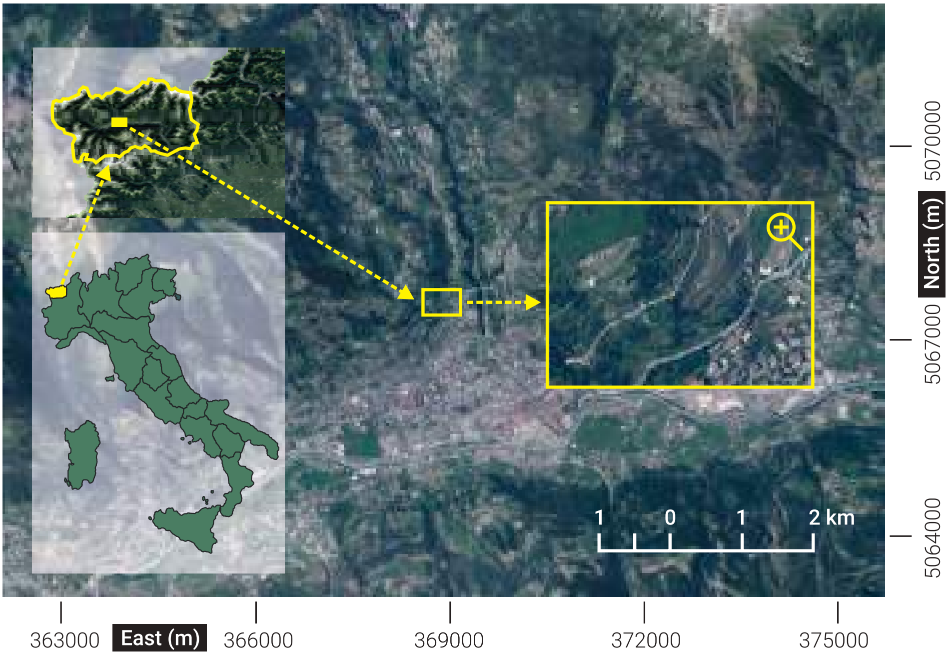

Figure 2: Study site location with indication of the Aosta Valley Region and the experimental site of Moncenis (WGS 84/UTM Zone 32N).

Figure 3: Experimental setting. View of the 18 vineyard rows from the opposite side of the valley. Rows with continuous grass cover are clearly identifiable, as well as the buffer-rows with ½ grassed surface, and the white tanks for the collection of sediments *(Photo: O. Zecca)*.

CS2.
Preventing hydrogeological risk in Aosta Valley Region, Italy

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Country, Region: *Italy – Aosta Valley*

Organisation: *Regional administration of Aosta Valley*

Sector: *hydrogeological risk prevention*

Land uses: *agriculture, forest, pasture, urban centres, ski resorts*

Main soil threat: *erosion, loss of soil habitat and biodiversity, loss of fertility*

Key soil ecosystem services: *surface runoff regulation, water filtration and purification*

Summary: *Soils in mountainous regions, such as Aosta Valley, are intrinsically vulnerable and sensitive to degradation processes such as water erosion, shallow landslides and loss of chemical and physical quality. Thus, the integration of knowledge concerning soil that is based on soil maps and soil vulnerability, specific for every environmental condition and type of soil, is necessary for land planning and hydrogeological risk prevention. The main results of the work package (maps showing soil erosion and vulnerability of soil regarding shallow landslides) are shown and explained.*

Keywords: *land planning, RUSLE, shallow landslides, soil erosion*

Background and description of the problem

Following the floods of October 2000, the Region has proved to be vulnerable to different types of natural disasters including shallow landslides affecting the topsoil horizons. Alpine soils are particularly vulnerable to water erosion processes, where the significant amounts of fertile soils are lost. In order to find out more about these issues, several studies have been conducted in the last decade that helped increase the knowledge of the soil properties in the Region, in particular with respect to hydrogeological risk. The purpose of previous studies was to assess the vulnerability of soils to pedo-environmental hazards at the regional level, and the main goal was to provide practical tools to prevent these phenomena from occurring. The obtained information provides an indispensable in-depth analysis to support the preventive action and prevention of disasters, as well as to promote a balanced territorial development. The study aimed at identifying the areas within the regional territory that are most prone to this type of phenomena. The study involved the entire regional territory in order to produce soil vulnerability and soil erosion maps at 1:100,000 scale.

Expected improvements / contribution to better soil management

The main expected impact of the project is raising of awareness on the importance of Alpine soils, not only in the forestry and agricultural sectors, but also in terms of global heritage that is threatened by urban pressures around the inhabited centres. The land conformation, i.e. the narrow central valley with steep lateral slopes, strongly affected the distribution of productive soils.

The management of sludge drainage from hydrogeological reservoirs and the continuous extension of agricultural land is reshaping naturally endangered soil surfaces, which are often covered by materials with poor geotechnical, physical and fertility properties. The development of appropriate soil management techniques should also take into consideration the specific climatic characteristics of the region, which significantly differ between the border areas or the central area (dryer precipitation regimes). Erosion risk should be taken into account.

The report and the map were designed to get better understanding of soil functions, threats and soil ecosystem services and thereby improve land management in the region.

Workshops concerning soil characteristics and vulnerability have been organised, as well as workshops regarding the use of the new maps. The map results that were obtained from scientific data are broadly applicable, understandable and therefore useful for field operatives.

Stakeholders and knowledge transfer

Our main stakeholders are regional administrators in the following sectors:

- Agriculture
- Regional rural development policies
- Agricultural territorial planning and business structures
- Crop productions, quality systems and plant protection products
- Forests and natural resources
- Protected areas
- Forestry and forest roads

- Environment
- Land planning
- Transportation
- Cableways infrastructure
- Civil protection and fire department
- Education, training and research (Institut Agricole Régional)

The following professional members were also identified:

- Architects
- Engineers
- Forest engineers, agronomist
- Geologists

The following Public Administrators of natural parks and protected areas in the regional territory have been identified as stakeholders:

- Gran Paradiso National Park
- Mont Avic Natural Park
- C.E.L.V.A. ("Consorzio degli Enti Locali della Valle d'Aosta") Association of Municipalities of Aosta Valley.

Considering the heterogeneity of stakeholders, in order to overcome differences in attitude, find shared and appropriate solutions and spread the awareness of soils, meetings have been organised during the Links4Soils project. Based on existing environmental data and the recent soil maps (created within the project), soil erosion maps were created, and their use was presented to the stakeholders. In addition, the participants' opinions and suggestions were further used to improve the usability of the new maps and related datasets.

Data and methods

After the collection of all the available soil data and new soil sampling, 712 soil profiles were used to create the soil map (1:100,000), and the subsequent erosion and shallow landslide vulnerability maps.

Six cartographic layers were used for the creation of the soil map (which is the obvious base for erosion risk maps s.l.), and they were provided by the regional administration. In particular, we used the vegetation map ("Carta della Natura"), geological map (1:100,000, modified to better characterise soil parent material lithology), slope steepness, aspect and altitude (derived from the DTM, 10 m) and the spatialisation of measured rainfall data. These data were statistically assembled using a maximum likelihood algorithm to produce the soil type map, where each soil type is characterised by specific chemical, physical and fertility properties, and by specific erodibility and shallow erosion vulnerability. The characterised soil properties included soil morphology, chemical (pH, organic carbon, total nitrogen, carbonates, CSC, Fe and Al), and physical data (texture, index of vulnerability of structure, WAS (Wet Aggregate Stability), Atterberg limits.

The RUSLE equation was then applied (Renard et al. 1997), in which soil erosion (A, t ha^{-1} $year^{-1}$) is the product of rainfall erosivity (R), soil erodibility factor (K), land cover protective action factor (C), slope steepness and length (LS) factor and protective infrastructures factor (P, normally not considered at 1:100,000 or larger scales):

$$A = R * K * C * LS * P$$

Soil erodibility, in particular, is related to soil structure, organic matter content and soil texture, and it is thus easily derived from the soil type map. In this case, we considered A as potential erosion, since humus types on the surface are not considered in the RUSLE equation and are only partially included in the C factor. Therefore, we added an expert-based classification of the H factor, differentially reducing the actual erosion under natural vegetation according to the humus form, considering that the presence of OH organic horizons requires many decades to form and they have a highly protective effect on the underlying mineral soil.

All soil profile properties have also been correlated with WAS and Atterberg limits that are available for a more limited number of sites; moreover, the frequency of shallow landslides of 16 soil types has been calculated in order to improve the existing shallow landslide susceptibility map.

Results

The soil type map of the entire Aosta Valley region has been created (1:100,000, Fig. 4).

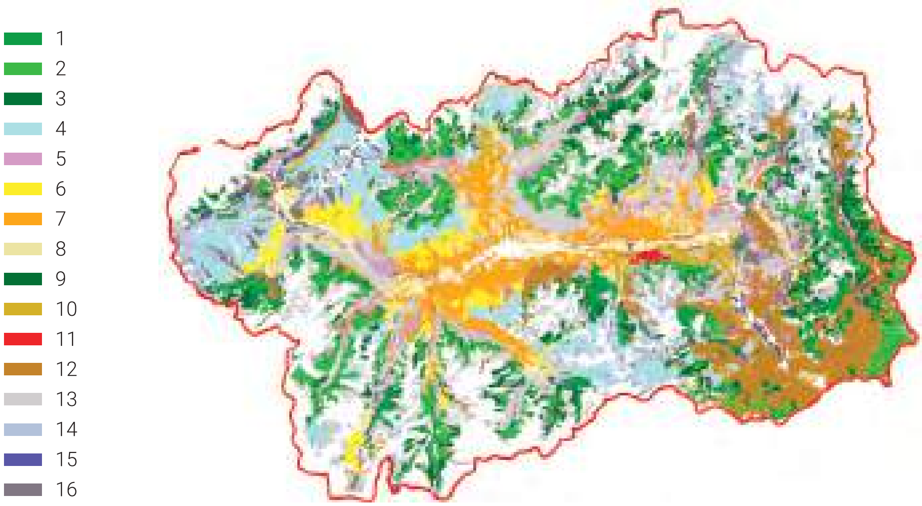

Figure 4: The soil map of the Aosta Valley Region; the 16 soil types are explained in Table 1.

As a first derivation, the soil erodibility map (K value in the RUSLE model, 1:100,000, Fig. 5) and the soil erosion map (t/ha/year, 1:100,000, Fig. 6) were created.

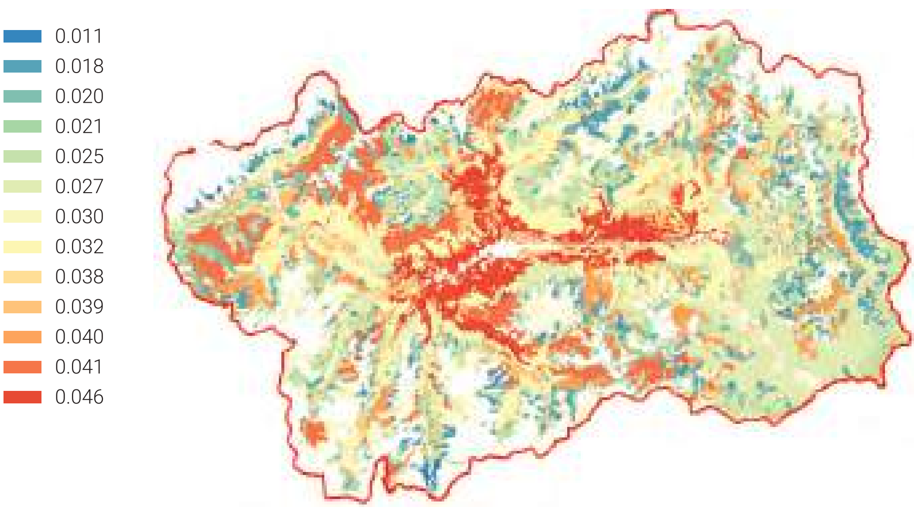

Figure 5: K (erodibility) factor calculated for the 16 soil types (t ha $MJ^{-1}mm^{-1}$); the soils developed in the most xeric area are most susceptible to erosion, followed by high altitude soils on calcschists.

Figure 6: Soil erosion values in the Aosta Valley Region (t ha^{-1} y^{-1}).

The density of shallow landslides (Fig. 7) basically follows the K factor map evidencing an intrinsic weakness of the soils developed in the inner Alpine area that is related to a less developed surface structure and degree of weathering in the subsoil, which also have a quite good correlation with the Atterberg Liquid Limit (not shown).

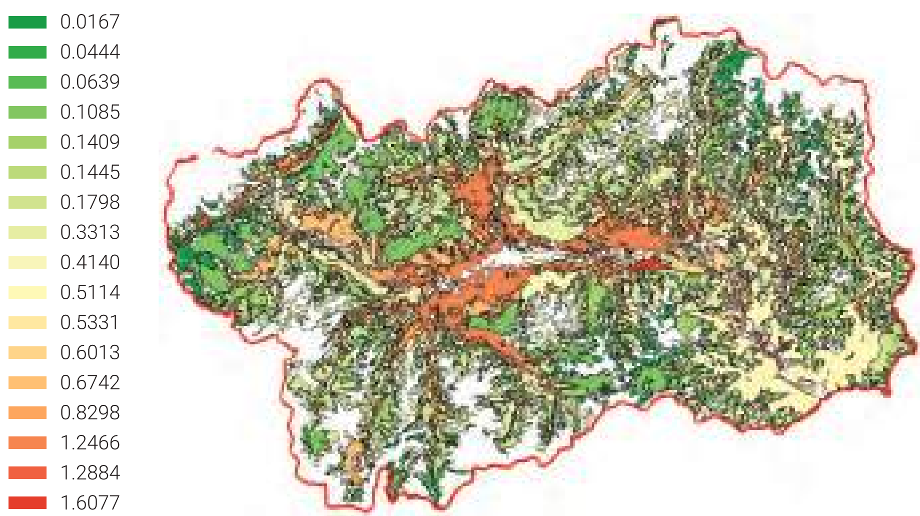

Figure 7: The density of shallow landslides in the different soil types (N km^{-2}).

Table 1: Soil type classification, erodibility and main erodibility factors in topsoil mineral horizon

SOIL TYPE	WRB2015	K	MAIN SOIL ERODIBILITY FACTORS
1	Albic Podzol	0.040	Lack of structure, texture
2	Skeletic Entic Podzol	0.025	Weak structure
3	Umbric Entic Podzol	0.011	Texture
4	Dystric Cambisol (Protospodic, Arenic; Alpine grassland on calcschists)	0.041	Lack of structure, texture
5	Haplic/Cambic/Gleyic Phaeozem	0.027	Texture, occasional loose consistence
6	Haplic Kastanozem	0.032	Loose consistence
7	Petric/Haplic Calcisol	0.046	Lack of structure, little TOC, loose consistence
8	Calcaric Regosol	0.039	Lack of structure, little TOC, loose consistence
9	Haplic Umbrisol	0.018	Texture
10	Eutric Cambisol	0.030	Texture, thin A horizon
11	Hypocalcic Rhodic Cambisol	0.046	Texture, lack of structure, thin organic horizons
12	Dystric Cambisol	0.027	Texture, thin A horizon
13	Hyperskeletic/Skeletic Regosol	0.032	Weak structure, little TOC, loose consistence
14	Skeletic Eutric Regosol (Turbic)	0.021	Little TOC, cryoturbation
15	Fluvisol	0.038	Weak structure, little TOC, loose consistence
16	Skeletic Dystric Leptosol	0.020	Shallowness

In the central part of the region, change of land use from natural vegetation to cultivation that implies the removal of the organic layer and topsoil reworking should be considered carefully, particularly on soil types 6 (Fig.8), 7, 16. The removal of natural vegetation, particularly of the protective shrub layer and of the litter layer should also be avoided on soil type 3 (Fig. 9), during forestry operations or, above treeline, because of intense grazing.

Overgrazing should be avoided, particularly on Alpine grasslands on calcschists, on the soil type 1, which has a surface mineral horizon characterised by an extremely weak structure and high erodibility when exposed to rainfall and runoff without the protective effect of the thin organic horizons. One peculiarity of soil types 4, 13 and 14 is the large carbon stock included in the mineral horizons, caused by grassland vegetation characterising the soil cover. Therefore, preservation of pastures and grasslands is important to preserve the large C content and limit CO_2 emissions.

In the stakeholder meetings, specific types of management to be considered when working on soils have been shown.

Transferability and applicability to best soil management practice

The soil map approach, with derived maps regarding erosion, soil functions etc., is applicable to any context in mountainous environments and can be calibrated in relation to the environmental specificity.

However, the method is widely applicable only for the areas where soil maps exist and the basic data for soil types are available. Such maps are an important basis for better decision-making at local level and can thereby improve land planning and agro-forestry heritage management, allowing a better soil protection which is especially important in mountainous areas.

Environmental and climate change impact

In general, mountain soils evolve slowly because low temperatures and erosion-related processes limit their formation and evolution. They are also highly diverse and vary significantly within limited areas due to different exposure and steepness. With increased elevation, they usually become less productive and developed. Mountain soils are frequently less productive than plain soils and agricultural activities are more difficult, as well as less productive. To better exploit the surfaces on steep slopes, farmers build terraces and other structures to limit erosion and land degradation. Their evolution is a product of unstable and delicate equilibrium between formation and erosion processes and time. On steep slopes, soil can be eroded and transported away very easily, particularly under increased rainfall erodibility which is likely one of the effects of climate change in Alpine regions. A correct soil management is therefore required.

Photos / illustrations / maps

Figure 8: A common soil in the inner Alpine area of the Region: soil type 6, characterised by $CaCO_3$ accumulation in the deep subsoil but with a very weakly developed structure and loose consistence, extremely vulnerable to all kinds of erosive processes. Pont d'Aël, Cogne Valley *(Photo: M. D'Amico).*

Figure 9: A common soil under subalpine forest or heathland, soil type 3 (Albic Podzol). The light E horizon below the dark organic layers is loose, structureless and sandy and, thus, sensitive to erosion. In Valsavaranche, past grazing activities probably caused the disruption of the heath vege-tation and the removal of organic horizons, causing the widespread soil slips and erosion of the E horizon.

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CS3.
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Country, Region:	*Austria, East Tyrol, Lienz, Prägraten*
Organisation:	*Forest Group – Office of the Tyrolean Government*
Sector:	*forestry*
Land uses:	*forest*
Main soil threat:	*compaction, nutrient depletion, erosion, water logging*
Key soil ecosystem services:	*wood production, biodiversity*
Summary:	*Forests in the Prägraten and Großvenediger regions primarily act as protection forests, where the water logging ability of soils, their vulnerability to compaction, and nutrient depletion play a key role in the safeguarding of the populated areas from avalanches and rockfalls. Unsustainable harvesting practices, lack of data and general knowledge about soils further exacerbate the situation. Thus, thematic maps on soil compaction risk and biomass removal were generated within the context of this project and used to improve forest management decision making and support stakeholders' dialogue within the forest management planning process.*
Keywords:	*biomass, harvesting, compaction, Tyrol, soil management*

Background and description of the problem

In past centuries, intensive forest exploitation in Austria, to support glass, salt and iron industry, as well as livestock activities, has caused problems to forests and forest soils. Huge amounts of forest biomass including stems, branches, roots, leaves and needles were extracted. Thus, an important source of nutrients was taken from the soils and extended forest areas were converted to other land uses. In the last decade, an increased demand for forest biomass as a renewable energy resource is especially significant. Thus, the 2020 Forest Strategy was developed by the Tyrolean Forest Service promoting measures to support sustainable forest biomass use, ensure long term soil productivity and minimise soil degradation by adapting harvesting machinery and its use. Available soil data and knowledge on stand dynamics and forest site productivity were collected within the framework of the strategy. Soil thematic maps on sustainable biomass use and compaction risk for the forest area (1936 ha, approx. 7% of the municipality's surface) of the municipality of Prägraten were elaborated within the Interreg project "Links4Soils". The information and knowledge gained from this were integrated into the forest management plans.

Expected improvements / contribution to better soil management

The thematic maps and best practice guidelines are an important baseline for decision making on future forest management within the forest management planning process, as well as its implementation. Description of the forest type including site characteristics (exposition, inclination etc.), stand description (e.g. tree species composition, site index) and management guidelines were improved with information on forest soils characteristic. Information on physical and chemical soil characteristics are used to improve biomass harvesting practices and prevent soil compaction. That is particularly important for the areas where forest plays an important protective role. The sustainable harvesting practices and limitation of soil degradation is therefore fundamental for prevention of water logging and regulation of water flow that might cause substantial damages to the downstream infrastructure. The traffic light system maps inform forest management planners and practitioners on soil compaction and biomass use risks. Furthermore, guidelines for the implementation of specific measures according to different risk category (green, orange and red) have been elaborated. The tool enables forestry experts and land owners to improve forest management, ensure long term site productivity and minimise soil compaction.

Stakeholders and knowledge transfer

Within the process of case study elaboration, a participatory approach was used to include relevant stakeholders and the public. In the area of Prägraten, soil protection issues in forest management were presented to the public in the first phase of the project (July 2017). Local residents, the Mayor, the Tyrolean Forest Service experts and primary school pupils of Prägraten were involved. Presentations on Links4Soils project, Alpine soils and soil threats contributed in raising awareness and explained the necessity of the actions taken. In addition, educational activities for children were organised. A six-station nature trail and soil profiles were prepared to increase knowledge on soil characteristics and processes. Besides that, other workshops and field excursions for experts and forest practitioners were organised at different sites in Tyrol including the soil profile plot prepared for the Austrian Soil Forum excursion (July, October 2019). Within Links4Soils final conference in Innsbruck (October 2019), the forest management plans of Tyrol including developed soil management guidelines for Prägraten were presented to members of Austrian and German Municipalities, representatives of regional governments of project partner countries, scientists, students and other experts and practitioners. During all activities, soil sustainability in forest and appropriate use of elaborated maps and guidelines were the main topics.

Data and methods

The primary source of soil data is the Soil Condition Inventory (Bodenzustand-sinventur) established in 1988. The inventory includes 263 forest soil-sampling plots throughout the Tyrol region. A resampling activity was performed in 1996 on 14 locations only. Additional 66 sampling plots in Tyrol were derived from the forest soil condition inventory (Waldbodenzustandsinventur) performed in 1992. More recently, in 2006, the Public Research Centre for Forest (Bundesfoschungszentrum für Wald) in the framework of a European forest soil monitoring project (BioSoil), collected and analysed 139 forest soils in Austria; of which 13 were from the Tyrol region (BFW Report 145I/2013). In 2014, the forest group of the Tyrolean Government sampled soils on 36 locations, for which chemical characteristics were analysed as well. Soil characteristics for a total number of 392 locations were used. The dataset includes: pH, C (%), N (%), cation exchange capacity (mmol/kg), base saturation (%), C/N, Ca, Mg, K, P (kg/ha) and (Mg + Ca)/CEC. These characteristics were used to set up thresholds for the biomass use while the combination of coarse fraction values and the texture were used to define compaction risk categories. The threshold levels were based on literature and expert knowledge.

Results

The main results of the best practice are:

- Thematic maps of Prägraten based on substrate unit and forest type;
- A database including all collected soil properties;
- A short report on forest types which will be included in the management plan;
- A substrate unit report, where chemical and physical properties of soils are averaged over depth steps of specific soil profile and grouped for the same geological unit.

Table 2: Definition, criteria and measures for biomass use

CLASS	SOIL TYPE (WRB)	SOIL PROPERTIES	GEOLOGY*	MEASURES
1	Chernozems, Phaeozems, Fluvisols, Eutric Cambisols, Gleysols, Stagnosols	Base Saturation 70%, CEC > 200 mmol/kg, pH > 6.2, C/N < 12	Calcite, rich in clay minerals (K+); siliceous-carbonate rocks, intermediate (C0); siliceous-carbonate rocks, rich in clay minerals (C+); carbonate-siliceous rocks, intermediate (M0); carbonate-siliceous rocks, rich in clay minerals (M+)	Maintainable whole-tree harvesting
2	Dystric Cambisol, skeletic Cambisols, Luvisols	25% < BS < 70%, 60 < CEC < 200 mmol/kg, 4.2 < pH < 6.2, 12 < C/N < 25	Calcite, intermediate (K0), carbonate-siliceous rocks, poor in clay minerals (M-), mafic rocks, intermediate (B0), intermediate siliceous rocks, intermediate (I0)	Maintainable modified tree harvesting with on-site topping and partial delimbing
3	Podzols, Histosols, Leptosols	BS < 25%, CEC < 60 mmol/kg, pH < 4.2, C/N > 25	Calcite, poor in clay minerals (K-), Dolomite, poor in clay minerals (D-)siliceous- carbonate rocks, poor in clay minerals (C-), not clayey base intermediate siliceous rocks (I-), acid quartz rich rocks (S)	Maintainable log harvesting only

Table 3: Definition, criteria and measures for compaction risk

CLASS	SOIL TYPE (WRB)	SOIL PROPERTIES	GEOLOGY*	MEASURES
1	Rendzic Leptosol Cambisols, albic and entic	Coarse fraction > 50%, sand > 45%, clay < 15%	Dolomite & dolomitic lime (D-); Calcite, poor in clay minerals (K-), felsic siliceous rocks (S); mafic rocks (B0)	Transit when there is no wet soil/limit at logging trails
2	Gleyic Cambisols, stagnic cambic Leptosols	Coarse fraction 25–50%, sand 25–45%, clay 15–30%	Carbonate-siliceous rocks/poor in clay minerals (M0/M-), mafic rocks/poor in clay minerals (B0/B-), intermediate siliceous rocks/poor in clay minerals (I/I-), calcite/rich in clay minerals (K0/K+)	Transit when there is dry/ frozen soil or with technical adjustment (low pressure tires)
3	Gleysols, Stagnosols, stagnic Podzols, histic Gleysols, Fluvisols	Coarse fraction < 25%, sand < 25%, clay > 30%	Carbonate-siliceous rocks, rich in clay minerals (M+); siliceous-carbonate rocks, rich in clay minerals (C+); dolomite, rich in clay minerals (D+), intermediate siliceous rocks, rich in clay minerals (I+)	Transit should be avoided

* substrate groups from Tyrolean classification system

Transferability and applicability to best soil management practice

Biomass use and compaction risk maps with supporting guidelines based on soil data can be implemented to all Tyrolean forests. The proposed methodology could be, with some adaptions, extended to all Alpine regions with similar soil data and forest type classification. For example, the region of South Tyrol (Italy), the region of Bavaria (Germany) and a small part of the county of Salzburg (Austria) have the same forest stand type characterisation and therefore the proposed methodology is directly applicable. In addition. the Regional Government of Styria is planning to conclude the complete characterisation of the forest area of the region in a timely manner. In other Alpine regions, the proposed methodology could be modified according to local soil and forest vegetation data availability. Furthermore, the georeferenced soil data allows elaboration of multiple thematic maps, which could be easily adapted with new information. That is particularly important to address climate change risks in sensitive soil types and ensure healthy soils for multiple ecosystem services.

Environmental and climate change impact

The mountain forests in the Alps are increasingly threatened by climate change. According to the climate scenarios, (Klimaszenarien für das Bundesland Tirol bis 2100, ZAMG/UNI Salzburg/UNI Graz/BMNT/Land Tirol 2016) an up to 4-degree increase in temperature is expected by the year 2100 in Tyrol. The changes in climatic conditions will be reflected in higher damages to forest stands due to drought stress and changes in site conditions, as well as forest stand structure and composition. In the last decades, especially at altitudes below 1000 m, the increased damages caused by bark beetles and diseases were recorded. Norway spruce, Scot pines, ash and elm have been the most affected tree species. Increased soil degradation risks are expected at compacted soils, which have reduced water infiltration capacity due to longer drought periods alternating with extreme precipitation events. The management plans, including the soil management guidelines, as developed for Prägraten, are an important tool for managing climate change risks. Implementing measures to minimise soil compaction contributes to surface runoff regulation, water filtration and water purification. Controlling and limiting the biomass use in forest has a direct impact on forest productivity and soil nutrients' cycle. Within forest management, it is therefore important to balance the accumulation and losses of nutrients in soils, in order to promote climate regulation and carbon sink. These activities are an important part of long-term initiative of the Forest Group of the Office of the Tyrolean Government.

Photos / illustrations / maps

Figure 10: Typical soil profiles to be found in areas classified with classes 1, 2 and 3

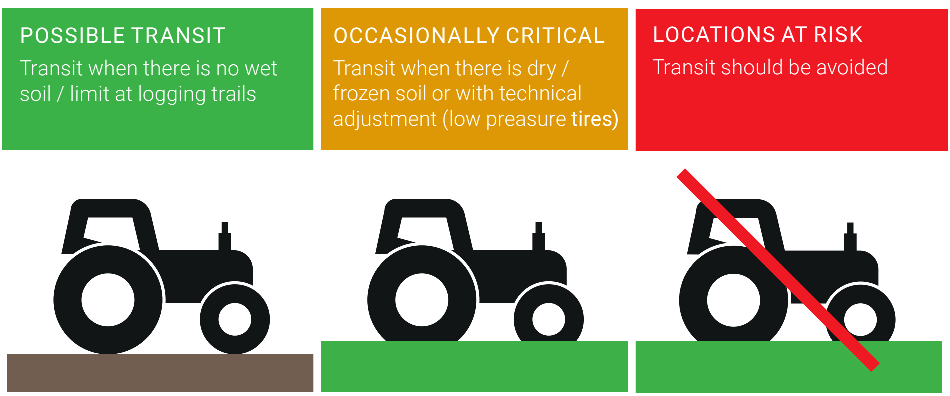


Figure 11: Technical measures for transit in areas with classes 1, 2 and 3

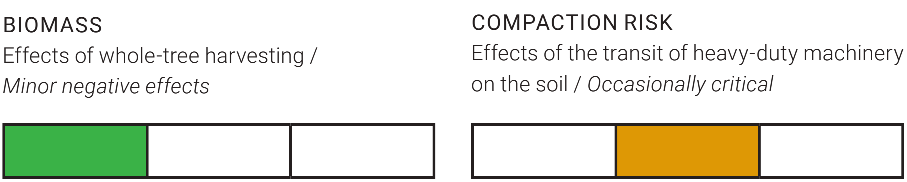
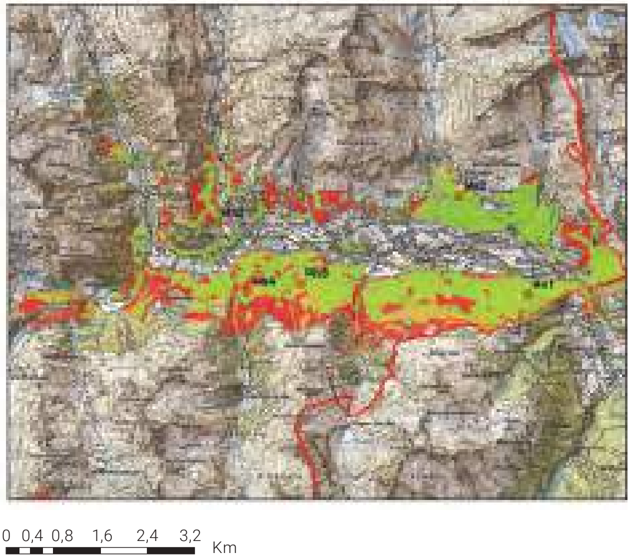


Figure 12: Examples of traffic light indicator of biomass use and compaction risk included in the forest management report.

Figure 13: Landscape of Prägraten at the Großvenediger, with protection forest *(Peter Hajek)*.

Figure 14: Technical measure for protection of debris flow above the village of Prägraten *(Peter Hajek)*.



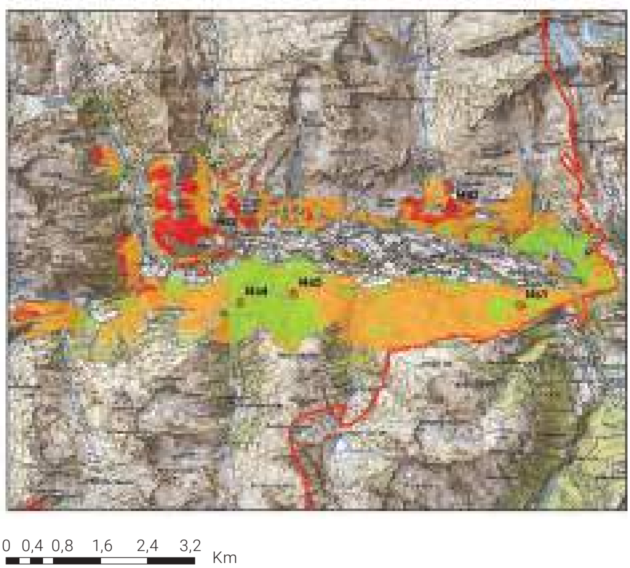
Forest based thematic map

pts_L4S

Compaction risk

Not Classified
Transitable
Occasionally critical
Location at risk

Figure 15:
Thematic map of compaction risk of Prägraten, based on forest types



Substrate group based thematic map

pts_L4S

Biomass removal

Not cassified
Minor negative effects
Intermediate negative effects
Strong negative effects

Figure 16:
Thematic map of biomass use of Prägraten, based on substrate unit

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CS4.
Regional adaptation for maintaining high-quality ecosystem services during climate change (Germany)

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Country, Region:	*Germany, Landsberg District*
Organisation:	*Municipalities Kaufering, Scheuring, Obermeitingen, Igling, and Fuchstal*
Sector:	*forestry and agriculture*
Land uses:	*forest and short rotation forest*
Main soil threat:	*low soil quality and rising risks*
Key soil ecosystem services:	*biomass production, health and water*
Summary:	*Soil improvement is essential for adaptation to rapidly rising temperatures due to climate change. Large water reservoirs for plants are supported by living soil with good humus form, numerous earthworms, and a high proportion of fine roots. Future extreme conditions could therefore be buffered more effectively with such soils. Furthermore, maintaining good soil conditions keeps the entire ecosystem functioning. This is important for maintaining the ecosystem services the forests provide.*
Keywords:	*living soil, sustainable regional adaptation*

Background and description of the problem

Conifer-based forestry has far-reaching effects on forest soils including poor humus forms, soil acidification, and low biological activity. Furthermore, the high usage of fertiliser in agriculture has led to nitrogen excess in forest soils. With the changes brought about by climate change, i.e. higher temperatures and intensified weather extremes, problems like bark beetle infestation and drought have exacerbated. All of this leads to decrease in biomass production and ecosystem services like temperature regulation through transpiration. In some cases, parts of the forest have been completely destroyed. Until they can be re-established, the interior forest climate is lost and the water filtration process is impaired.

The CO_2 emission in the Landsberg district at 11.9 metric tons per year and inhabitant is far too high. Since more than 90% of the heat is generated by fossil fuels, a transition to heating using a wood fuelled cogeneration plant could contribute significantly to reduction in CO_2 emissions. With the construction of the cogeneration plant in Kaufering in 2006, a sustainability concept was developed to counteract the negative effects of climate change. This can be achieved not only by reducing CO_2 emissions, but also by planting trees that are more resilient in the climate of the future decades and will not contribute to soil acidification. One of the problems is that these tree compositions are not necessarily the most profitable, because they are mostly deciduous trees, which only sell at high prices if they are thick and of very good quality. The wood from thinning at a young age is predominantly used for energy production (e.g. wood chips) and the market price for this type of wood is quite low. The cogeneration plant in Kaufering is fuelled by wood chips and produces heat as well as electricity. It uses wood from the forests of the municipality and regional forest owners. In the Kaufering region, there are a lot of forest owners who only possess a small forest area. For them the cogeneration plant is a potential regional customer.

The municipality Kaufering aims to achieve the following goals with their forest management:

- to cover the supply of the cogeneration plant from a radius of 15km
- to provide better drinking water and natural flood protection
- to ensure a high level of biodiversity and high-quality ecosystem services through “living soils”

The following three criteria have been established for “living soil”:

1. a humus form which is mull or mull-like mould
2. an amount of earthworms of more than 1 ton per ha of soil
3. maximised amount and depth of fine root mass

Contribution to better soil management

Concepts for economically and environmentally friendly forest management are developed together with the participating municipalities. It is crucial to these concepts to cultivate the soil with the appropriate tree species composition and to develop local uses for wood with low market demand, such as a heating plant. Those concepts should also serve as examples for the regional private forest owners, so that forestry in the region can adapt to the changing climate and is able to maintain and improve soil fertility.

Stakeholders and knowledge transfer

Five communities are involved in the project (Markt Kaufering, Scheuring community, Obermeitingen community, Igling community, Fuchstal community). The communities provide test areas, help to inform the residents about sustainable soil protection and apply forest and soil protection concepts.

Since 2009, a project week with the Weihenstephan University of Applied Sciences and the Technical University of Munich has been held annually in the last week of June. By carrying out the same measurements each year, some interesting timelines could be created. Also, some measurements for different kinds of soils have been done during this time. In addition, many student projects, like Bachelor's and Master's theses have been carried out. This research is a basis for developing concepts for sustainable forest management.

The University of Innsbruck has helped with classifying soils and conducted a project regarding heat distribution in the forest.

The results of the local research are presented to groups of interest annually.

Data and methods

In the last three years, a soil type typical for the region has been investigated. The focus of the investigations was on spruce and maple (sycamore and Norway maple), but other tree species have been examined as well. The focus was on differences between coniferous and deciduous trees. Most of the trees do not belong to the natural forest ecosystem of the region or only in a small proportion. But they have been planted and grown here for decades. Especially spruce is native to the more mountainous regions in Germany. Some of the studies were carried out by students during the annual project week of the University of Applied Sciences Weihenstephan-Triesdorf and the Technical University of Munich. Over the years, several students from both Universities have contributed to the project with their research.

The following data were collected:

- growth rates of wood, bark, branches, and leaves or needles
- amounts of coarse and fine roots
- the earthworm population
- temperature and humidity

In 2017, the first year of the project, the subject of the investigations were the gravel soils that have been washed up from the Alps by Lech river. These were carried out on areas of the municipality of Fuchstal where a soil nature trail was already established in 2014. The tree species of spruce, beech, and sycamore maple were compared.

In 2018, the focus of our research were the floodplain soils in the municipality of Scheuring. With the support of the University of Innsbruck, especially Prof. Geitner, the soil profiles were determined. The amount of earthworms for spruce and sycamore maple on deep alluvial loam (spruce 1, maple 1), as well as spruce, Norway maple, hornbeam, and lime on shallow alluvial loam with subsequent gravel layer (spruce 2, maple 2) were investigated. The fine root amount was only measured for spruce and Norway maple on shallow alluvial loam. For the latter, growth during the vegetation period was also recorded. The results of the investigations were used to create a soil nature trail in Scheuring, which informs visitors to the floodplain forest about the importance of soil in climate change.

In 2019, loess loam soil was sampled in the Kaufering community forest. Fine roots and earthworms were sampled for spruce, sycamore maple, and silver fir. In addition, the amount of earthworms for sycamore maple (maple 2) was recorded in another forest planted on a former agricultural site. The main site where the measurements were taken was previously utilised as a pure spruce forest.

Results

The aim of the projects is to demonstrate and confirm that a change in the tree species composition will lead to improved soils and increased biomass production. Therefore, improved ecosystem services can be expected. Table 1 shows the distribution of biomass in maple and spruce, at the age of approximately 20 years, as well as of the biomass produced over 17 years. The maple has an overall higher biomass production and since the leaves are newly grown each year, their share of the produced biomass over 17 years is high. Table 2 shows the amount of fine roots in different soils and for different tree species. Interestingly, maple has a high fine root mass in all soils, while spruce has a low fine root mass. This may contribute to the reduced growth of spruce in hot and dry periods compared to maple (Figure 1). The amount of earthworms found under the studied tree species is shown in Table 3. The observed variation between tree species indicates that earthworms are sensitive to the soil characteristics and are rarely found under conifers. Earthworms contribute significantly to the decomposition of organic matter, especially leaves and grass. In this region this implies that forests with a high amount of earthworms will also have a high decomposition rate. This is important, because it means that nutrients will be available to the plants sooner. On soils with a low nutrient content, the tree growth is dependent on these nutrients. However, the more frequent limiting factor for tree growth is likely water. By digging through the soil, earthworms counteract soil compaction and increase the pore volume, resulting in a higher water capacity of the soil. This leads to the conclusion that in the region forests with a high amount of earthworms will be more productive. The estimated biomass production for coniferous and hardwood (deciduous) trees until 2050 in Figure 18 shows that hardwood trees are already more productive than coniferous trees and that the disparity will further increase. It should be kept in mind that tree growth is always dependent on the soil properties and not all tree species are suited for all soils.

Table 4: Biomass Maple and Spruce

	Maple [t/ha]	Maple [%]	Spruce [t/ha]	Spruce [%]
Trunk mass	194	37	108	43
Leaves/ branches with needles	17.56		41.88	
Leaves over 17 years	175.6	34	41.88	17
Bark	10.04	2	9.10	4
Branches	30.11	6	23.67	9
Roots	35.16	7	25.50	10
Fine roots (measurement)	18.20		6.20	
Fine roots over 17 years	73.68	14	41.33	17
Sum over 17 years	518.59		249.48	

Table 5: Fine-root mass in g/m³

	2017 gravel soil	2018 alluvial loam	2019 loess loam
Depth of measurement	0 to 30cm	0 to 40cm	0 to 40 cm
Maple	6083.67	6848.13	4332.5
Beech	1466.67		
Spruce	2066.67	3359.86	3097.5
Silver fir			4970

Table 6: Earthworm mass in kg/ha

	2017 gravel soil	2018 alluvial soil	2019 loess loam
Maple 1	154.4	375.08	547
Maple 2		574.85	141
Spruce 1	117.8	125.68	2
Spruce 2		320.62	
Beech	2.2		
Lime		177.22	
Hornbeam		801.11	
Silver fir			0

Transferability and applicability to the best soil management practices

The most challenging problem in adapting forestry to a high ecological standard is economic viability. The cogeneration plant has yet to turn a profit and wood chips are currently priced very low. The wood market is impaired by the increasing weather extremes and sales volume of wood harvested during thinning in young forests is not satisfactory. Thus, there is no incentive for the landowners to make the necessary changes in the cultivation of their forests, since it often leads to financial loss. As the ecosystem services are neither recognised nor evaluated and paid for, only owners with a personal conviction adapt to the new concepts. Fair framework conditions such as a CO_2 tax and other similar measures are therefore the necessary basis for implementing adaptation concepts. Likewise, a market must be created for the wood harvested during care measures, which can also ensure reasonable prices. Since the necessary adaptation requires decades, immediate action is essential. Further measurements are also necessary to provide the professional basis that is needed for local and regional concepts.

Environmental and climate change impact

The CO_2 balance in the market Kaufering with 5.0 metric tons of CO_2 per year and inhabitant is much better than in the district Landsberg Lech with 11.9 metric tons of CO_2 per year and inhabitant.

If the concept is implemented, the ecosystem services can be maintained and the consequences of global warming can be buffered thanks to the adaptation measures.

Photos / illustrations / maps

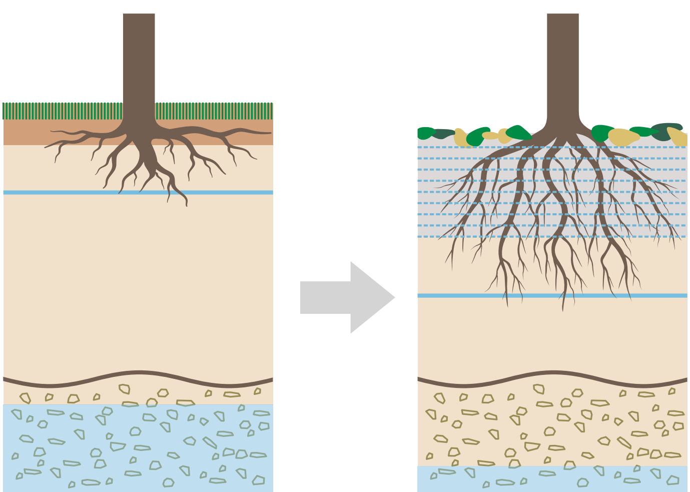

Figure 17: The same preconditions; on the left: coniferous tree with a shallow root system and thus low water uptake; on the right: broadleaf tree with a deep root system enabling a "living soil" with higher organic matter content and a lot of fine roots leading to higher water capacity and uptake.

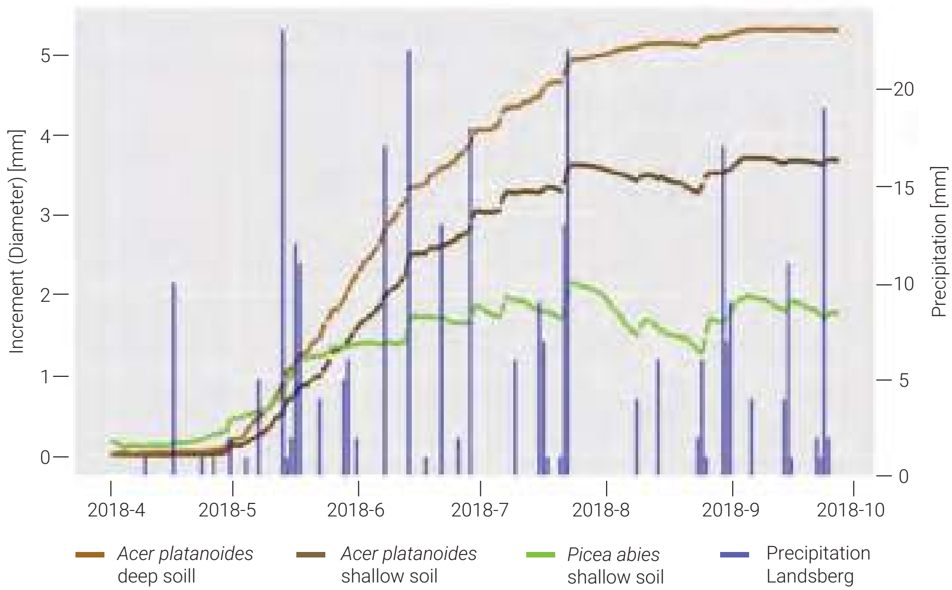

Figure 18: Growth of spruce (green) and maple (brown) at the same precipitation in the community forest of Scheuring 04.-10.2019 *(source: measurements by D. Behrendt, Graphic by L. Hänchen)*

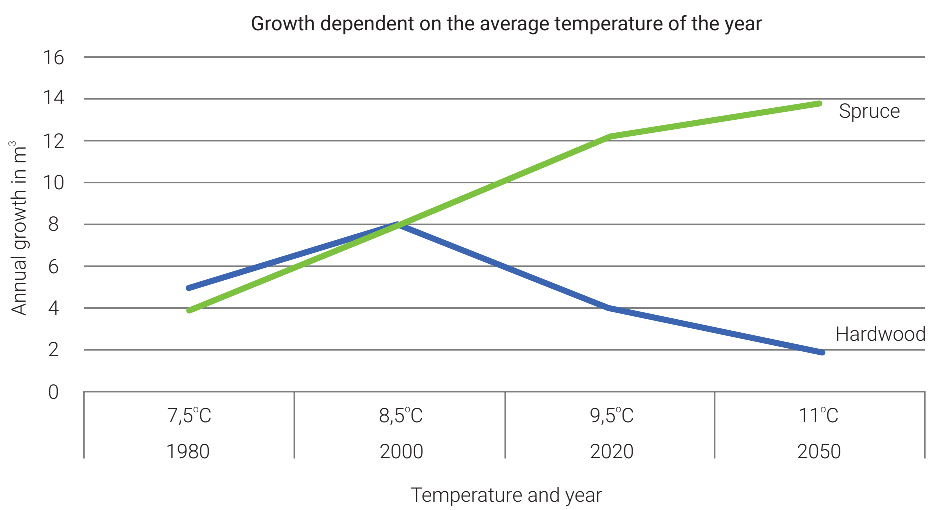

Figure 19: Growth development *(source: measured till 2020, then estimated by L. Pertl)*

CS5.
Evaluation of Soil Functions in Austria – a way towards better protection and sustainable management of Austrian soils

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Country, Region:	*Austria, several regions*
Organisation:	*Austrian Standards International, Federal Ministry for Sustainability and Tourism, Austrian Regional Governments, Austrian Soil Science Society, etc.*
Sector:	*land use planning and environmental assessments, water management, agriculture, infrastructure;*
Land uses:	*applicable to all areas since it is an evaluation system, due to soil data availability it is established for agricultural soils*
Main soil threat:	*loss of valuable soils due to land usage without prior evaluation of the degree of performance regarding partial functions of soil*
Key soil ecosystem services:	*basis for life, part of the ecosystem; habitat function, gene reservoir; water and nutrient cycle, energy and carbon household, buffer and filter function; production, utilisation and carrier function (e.g. primary production of food); archive function (natural and cultural history);*
Summary:	*Across Austria a variety of legal regulations and procedures for data collection are in place in regards to the evaluation of soil functions. In order to rectify these disparities, a new guideline "ÖNORM L 1076", which considers soil function performance in various soils and locations, is gradually*

Summary: *being incorporated into state laws. The intention is to enable a uniform and transparent approach to spatial planning. This project enables this transition through the determination of the planning scale and via data consolidation. The guideline should inform stakeholders involved in soil protection as they implement projects across all levels, ideally excluding high performance-soils from planning.*

Keywords: *land use, soil performance evaluation, ÖNORM L 1076, Austria*

Background and description of the problem

The soil is one of the essential means of providing livelihood to humans. While actions for the protection of air and water have long since been established, the importance of soil protection is only recently gaining greater attention. In the past, soil was often falsely perceived as a “commodity”. However, now it is becoming increasingly recognised as an extremely valuable and non-renewable environmental resource and not only in the context of climate discussions. In Austria alone, twenty hectares of valuable land are lost daily by sealing, building or shipping.

For agriculture and forestry, the production function certainly plays the most important role regarding soil functions. But soil is also used as land in building and supplies us with raw materials. Usually the latter two functions are ranked in the first place in spatial planning in Austria. One reason for that is the lack of an overview of existing soil management methods, which allow an evaluation of extensive soil functions in terms of spatial planning and can be integrated in planning decisions.

Austria’s agricultural soils mapping has started in the 1950s mainly for taxation reasons almost nationwide. With the soil assessment, the potential yield was evaluated. However, an assessment of other important soil functions was not carried out. Although the evaluation of soil functions nowadays is intensively pursued in Austria through research and by individual federal states (e.g. Upper Austria and Salzburg), a common nation-wide procedure has not yet been adopted. Namely, due to the federal structure of Austria each federal state has its own legal regulations.

Hence a panel of members of the Advisory Council for Soil Fertility and Soil Conservation of the Federal Ministry (Fachbeirat für Bodenfruchtbarkeit und

Bodenschutz des vormals BMLFUW, nun BMNT) and the Austrian Standards International Institute were commissioned to develop and establish an appropriate guideline. This new guideline "ÖNORM L 1076" is planned to be gradually incorporated into the laws of federal states with the future amendments. It deals with the manifold importance of the soil and should enable a uniform and transparent approach for evaluating the different soil functions.

Expected improvements / contribution to better soil management

The outcomes of the soil performance evaluation should be reconsidered in the decision-making processes of spatial planning and thus contribute to a careful management and protection of the soil resource. In addition, the environmental value of the soil evaluation outcomes can contribute to preservation of the best/ environmentally most valuable soils from destruction by sealing and construction developments.

Thus, the evaluation of soil functions is especially important in areas where arable land is a rare resource or where high-performance areas collide with economic / structural interests. In addition, soils' role in climate protection has long beenunderestimated. Soil organic carbon preservation and CO_2 sequestration practices can contribute to a lowering of the CO_2 (a green-house gas) concentrations in the atmosphere.

Stakeholders and knowledge transfer

There are numerous stakeholders:

- At the first-place decision-makers (local and regional authorities), politician sand experts (scientists, employees of engineering offices, etc.) that are involved in spatial planning on various levels (e.g. state programmes, regional programmes, local planning, project level).

- Persons involved in construction planning and who are taking soil protection measures beyond the spatial planning level.

- Persons involved in applied soil protection.

Data and methods

Soil data situation in Austria:

There are numerous soil data sets available in Austria, but as these were collected for different purposes, they are not all equally suitable for soil function evaluation. Additionally, the individual federal states work with different data sets for evaluating the soil functions as they do not have unlimited access to all data. Nevertheless, the essential data basis for the soil function evaluation is the data which were generated in the course of soil mapping by the Austrian Tax Authority. The existing data are generally available for agricultural areas, but are partially available for forest areas as well.

Some of the data suitable for evaluating the soil functions are available free of charge, others are only available for a fee.

Good examples of Austrian soil data sources are primarily:

- Computerised geo-information systems, e.g. the digital soil map eBOD
  https://bodenkarte.at/
  www.bfw.ac.at/ebod

- Analog soil maps
  https://www.umweltbundesamt.at/umweltthemen/boden/boris
  (Soil Information System BORIS)

Based on the data, an evaluation of the soil function performance of certain soils/areas is made using the ÖNORM L 1076. This soil evaluation guideline is available for a fee at the Austrian Standards International Institute under https://www.austrian-standards.at/

Preferred steps of soil evaluation procedure:

- presentation of the planning area, determination of the planning scale, determination of the soil functions relevant for the specific planning case;

- identification and consolidation of available data; if necessary, additional on-site soil investigations;

- if necessary, derivation of the parameters necessary for the soil function evaluation;

- evaluation of soil functions to a performance level in five stages: ordinal scale: 0 – without allocation, 1 – very low, 2 – low, 3 – moderate, 4 – high, and 5 – very high performance soil.

Soil management/soil conservation goal

At the individual planning levels (e.g. state programmes, regional programmes, local planning, project level), high performance-soils should be largely preserved from sealing.

Duration and costs of the project

After the panel was commissioned to develop the guideline, the first version of the ÖNORM L 1076 was issued in 2012. It was later replaced by an updated version in 2013.

The establishment and implementation (evaluation of soil functions, implementation of outcomes in digital databases, incorporation and development of soil protection laws, etc.) of the guideline is ongoing and primarily lies within the responsibilities of the federal governments.

Costs: There is no official cost statement covering all aspects of the soil function evaluation as it strongly varies with the availability of soil data.

Activities

Soils differ in their performance. Protecting soils requires, in addition to minimising the land usage, the consideration of the different capacities of the soils concerning their soil functions. In 2013, the guideline "ÖNORM L 1076" was issued. It is a manual for both the classification and evaluation of soil functions. First of all it specifies those soil functions for which an evaluation is required, e.g. habitat function, site function (potential for native plant communities etc.), natural soil fertility, water flow regulation and buffer and filter function. For this purpose, the relevant terms, a classification of soil functions, the general procedure of the soil function assessment and the minimum requirements for assessment methods are defined. Also, the evaluation can be carried out with a few parameters which can be derived from the existing databases specific to Austria.

Based on this guideline several individual projects on different levels (e.g. state programmes, regional programmes, local planning, project level) have been realised or are going to be realised.

Results

Best practice examples:

- Integration of the soil function evaluation in the local spatial planning of the town of Thalheim bei Wels (Upper Austria). Initiated by the Federal Government of Upper Austria, the possibilities of integrating soil function evaluation into local spatial planning were examined as part of a pilot project. The evaluation results were incorporated into the ongoing process of recreating the Local Development Concept and aligned with the planning intentions of the municipality.

- Soil function evaluation as part of the environmental assessment for the "partial modification Senningerfeld" of the municipality of Bramberg (Salzburg). The municipality of Bramberg intended to modify its land use plan in order to enable the construction of a tourist infrastructure in the area of a cable car system (hotel grounds, parking spaces, etc.). An environmental assessment was carried out, and the effects of the project on the soil and soil functions were evaluated.

- Soil function evaluation in the context of the environmental assessment for building a wind park in Bad Deutsch-Altenburg Carnuntum (Lower Austria).

- Soil function evaluation in Tyrol – methodological studies and possible basics for future planning decisions: within the framework of several research projects, the University of Innsbruck conducted evaluations of ecological soil functions in selected areas of Tyrol. The main objective was to apply existing assessment procedures with the databases specific to Austria, to estimate uncertainties and to identify methodological optimisation needs.

Examples of results available to the public:

ÖNORM L 1076:
https://shop.austrian-standards.at/action/en/public/details/470252/OENORM_L_1076_2013_03_15

Several documents for methodical implementation of the ÖNORM L 1076:
https://www.bmlrt.gv.at/land/produktion-maerkte/pflanzliche-produktion/boden-duengung/Bodenschutz.html
https://www.ages.at/themen/umwelt/boden/boden-und-duengerbroschueren/

Manuals for soil function evaluation:
https://www.land-oberoesterreich.gv.at/106895.htm

Soil function evaluation in Salzburg:
https://www.data.gv.at/katalog/dataset/bodenfunktionsbewertung-land-salzburg

Manual for soil function evaluation, Salzburg:
https://www.salzburg.gv.at/agrarwald_/Documents/20140203_lesehilfe_bodenschutz_salzburg_endversion_fuer_internet.pdf

Guideline for soil protection in spatial planning projects, Salzburg:
https://www.salzburg.gv.at/themen/aw/landwirtschaft/boden/bodenschutz-in-der-planung

Transferability and applicability to best soil management practice

Basically, the ÖNORM L 1067 guideline provides transparent information how to evaluate several soil functions relevant in spatial planning. The guideline is accessible to everyone; the only condition for the evaluation is the existence and access to suitable data.

The implementation is not limited to the Alpine region, but due to the data requirements, the ÖNORM will only be conditionally suitable for use outside of Austria.

Environmental and climate change impact

The protection of valuable soils serves to maintain the balance of ecological processes. Since soils play an important role in climatic processes, this effort can be counted as a contribution to climate change mitigation.

Photos / illustrations / maps

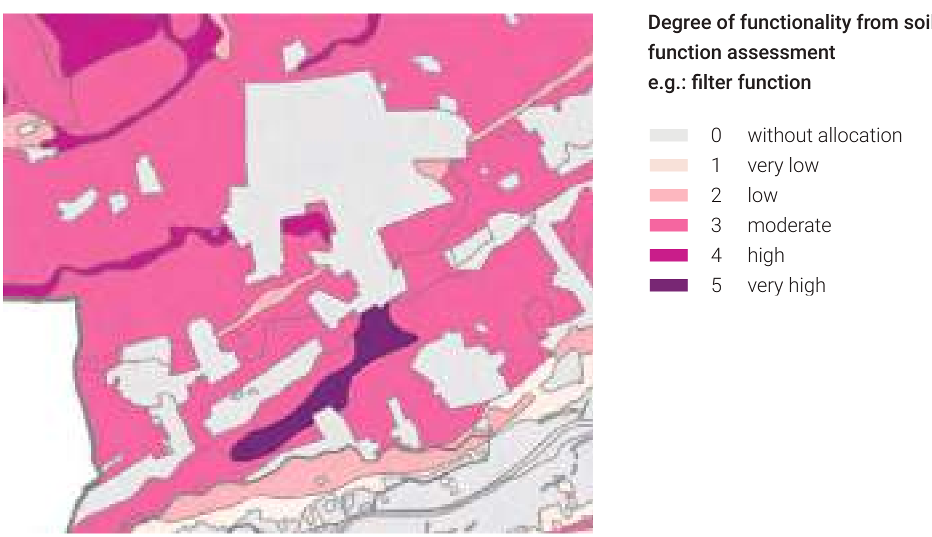

Figure 20: An example of the result of an evaluation concerning the filter function performance of soils in an area [0-without allocation, 1-very low, 2-low, 3-moderate, 4-high, 5-very high]
(Source: https://www.oebg.org/index.php?rex_media_type=download&rex_media_file=bodenbewertung_jahrestagung__bg_2011.pdf)

	Habitat function	Site function	Natural productivity	Waterflow regulation	Buffer function	Archive function
Primary parameters (soil-based)						
Aggregation					●	
Base saturation					●	
Soil humidity	●					
Soil type		●				
Carbon content		●			●	
Electrical conductivity		●				
Fine soil volume					●	
Coarse soil ratio		●		●	●	
Indications of soil changes		●				
Horizon thickness		●		●	●	
Humus form	●				●	
Humus content	●	●		●	●	
Hydromorphic characteristics		●		●	●	
pH value	●				●	
Disturbances in mass balance						●
Disturbances in water balance						●
Structures that indicate contamination	●					
Substrate and horizon sequences						●
Texture	●	●		●		
Clay content					●	
Dry bulk density		●		●	●	
Compaction						●
Primary parameters (location-based)						
Age						●
Features						●
Surface sealing						●
Ground water depth		●		●		
Gradient				●		
Exploitation	●					
Utilisation-related nutrient supply						●
Emission limits	●					
Seltenheit						●
Inundation dynamics		●				
Secondary parameters						
CECpot					●	
kf value				●		
Air capacity				●		
Usable field capacity	●	●		●		

Figure 21: List of parameters (left column) which can be assigned to six partial functions of soil (first row) *(source: Federal Ministry for Sustainability and Tourism, 2013. Bodenfunktionsbewertung: Methodische Umsetzung der ÖNORM L 1076. BMNT Wien)*

Figure 22: Graphic presentation of the results of a soil function evaluation of the market town of Thalheim bei Wels (Upper Austria). The results were integrated in the local spatial planning. *(Source: Federal Ministry for Sustainability and Tourism, 2013. Bodenfunktionsbewertung: Methodische Umsetzung der ÖNORM L 1076. BMNT Wien)*

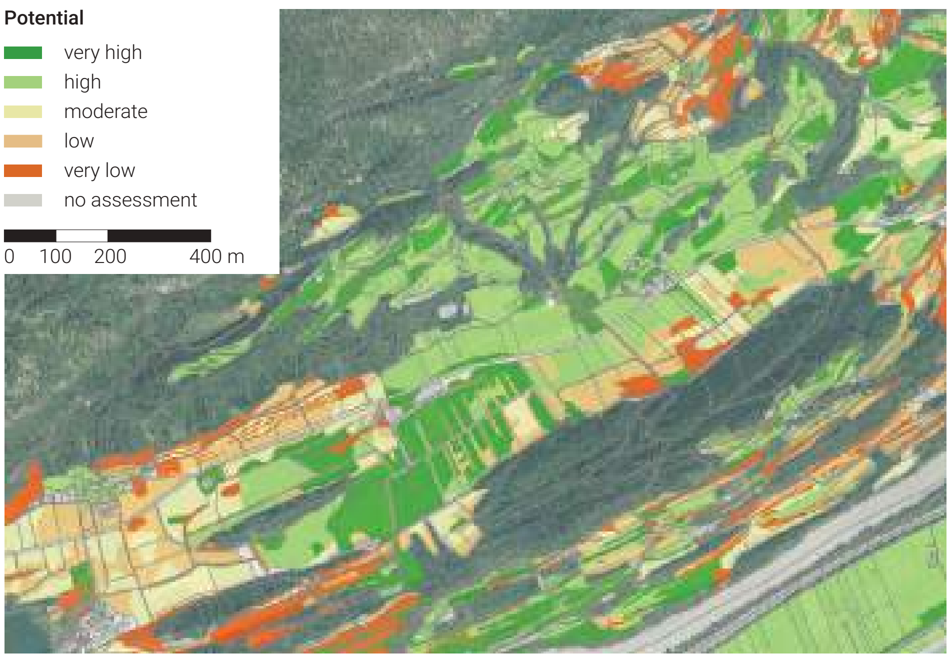

Figure 23: Evaluation of the potential of soils for the retention of precipitation northeast of Kramsach - Tyrol *(Data source: Austrian finance soil valuation system (BMF, BEV 2007) own assessments)*

CS6.
Soil education trails in Austria

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Country, Region: *Austria, Federal states of Vorarlberg, Vienna, Salzburg and Upper Austria*

Organisation: *e.g. Vorarlberg Environmental Institute, "Landreichs" Agrarium, Community Krenglbach- Zoo Schmieding, Tiergarten Schönbrunn (Vienna Hietzing), Botanical Garden (Linz), Thalheim (Wels)*

Sector: *all sectors*

Land uses: *not known; various*

Main soil threat: *erosion, organic matter decline, compaction, sealing, contamination, nutrient depletion, loss of soil biodiversity*

Key soil ecosystem services: *Multiple functions and services of soils shall be demonstrated without focusing on one specific service.*

Summary: *Through playful engagement and hands-on learning, these soil trails are intended to inform both children and adults about the relationship between landscape development, soil, and society. It is reasonable to conclude that individuals with greater understanding will be more likely to make environmentally-positive decisions; ideally discouraging actions such as sealing, contamination, loss of soil biodiversity, etc. Once soil trails are established, they will be permanently present and have a permanent impact.*

Keywords: *soil trails, education, information about soils*


Photo: Alois Simon

Background and description of the problem

Society at large is mainly unaware of soils and their functions, services and importance for the ecosystem. One reason for this is that the subject of soils is rarely covered in Austrian school curricula.

With the help of soil education trails, this subject shall be brought to the attention of all people in a playful way and contribute to the education of school children, teachers and adults.

Expected improvements / contribution to better soil management

The main objective of the soil trails is to present the importance of soils for humans and ecosystems and to show the consequences of soil disturbances.

Arranged along hiking trails, soil trails provide information on soils and their relationship to landscape development. A soil trail can inform about soil properties, the history of the landscape of a particular region and the development and evolution of soils, as well as about soil functions and ecosystem services.

Through presenting different soil profiles and by supplementing them with individual explanations, soil awareness and knowledge among visitors can be promoted.

Stakeholders and knowledge transfer

Target groups include school-age children (1st – 13th grade), hikers, travel groups, families and everyone who is interested in the environment.

Stakeholders mainly include municipalities.

Data and methods

To create a soil trail, it is helpful to have at least some information about land use, soil types and soil management practices. With this knowledge, it is possible to select sites that represent the diversity of soils and soil-forming factors within a certain area.

New data can be created by describing and analysing the soils at specific sites.

The projects are ongoing. Costs between individual trails vary and are allocated between creation of a trail concept, development of information boards, maintenance of hiking paths and soil profiles.

Results

The results are informative initiatives that bring the attention to the subject of soil.

All Austrian soil trails are listed on the homepage: www.bodeninfo.net including links that provide more detailed information.

Transferability and applicability to best soil management practice

The soil trails are easily transferable across many regions. However, Alpine regions are often characterised by greater soil diversity than non-mountainous areas. Thus, soil trails in the Alps are especially interesting as many different soils can be explored.

Soil trails are suitable for excursions since the trails are usually marked and the prepared information is understandable for non-experts. The main issue is finding an area that is suitable for a soil trail – with different soil types to be presented – and maintaining the soil profiles.

Environmental and climate change impact

A better knowledge of soils and understanding of their functions can raise awareness in the society. In the future, this awareness can lead to a change in behaviour and decisions that prevent further soil degradation.

Photos / illustrations / maps

Figure 24: Soil education trails and its information panels and soil profiles *(Photo: Alois Simon).*

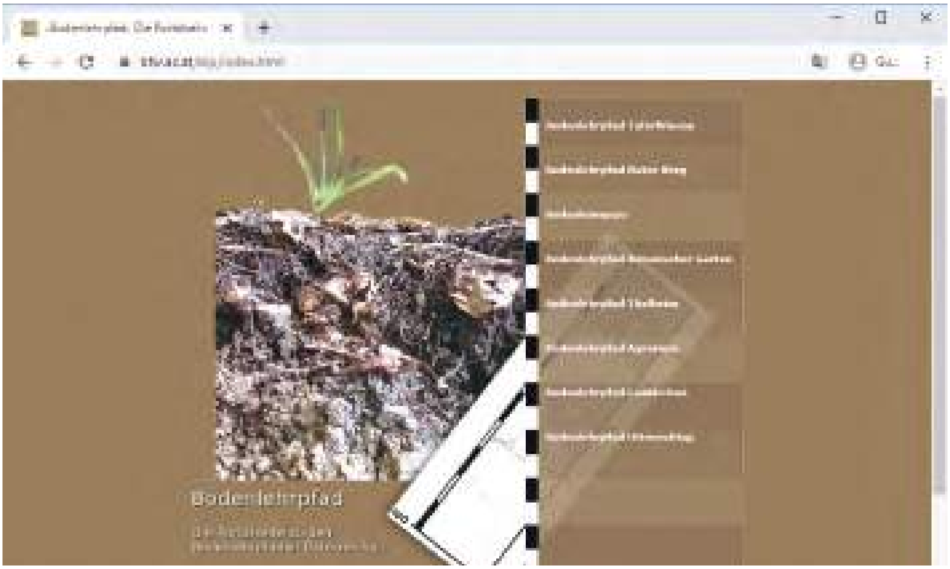

Figure 25: Homepage www.bodenlehrpfad.at with an overview of all soil education trails.

Figure 26: Example of an information board for the soil education trail.

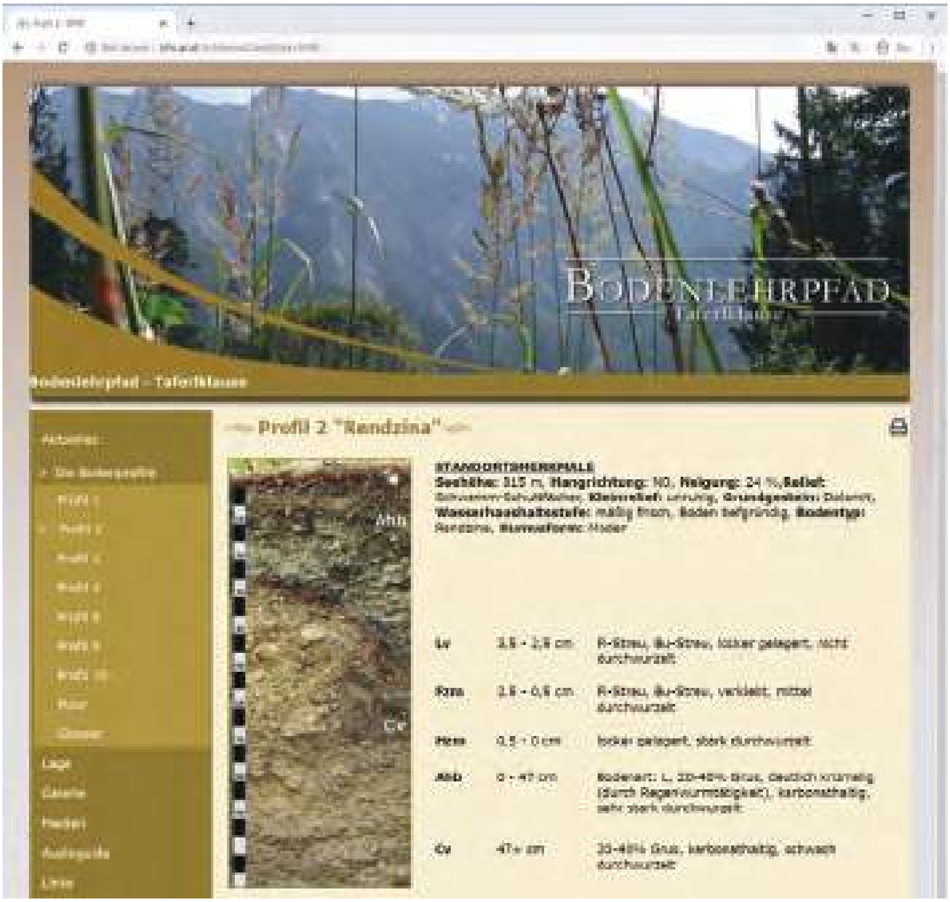

Figure 27: Example of the Taferklause soil education trail with a soil profile

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References and further reading

A map and a list containing all Austrian soil trails

Bodenbildungsnavigator – Lehrpfade (Soil Formation Navigator – Trail):
https://www.bodeninfo.net/produkte-und-informationsmedien/bodenbildungsnavigator/lehrpfade/

Bregenz (Vorarlberg)

Faszination Boden (Fascination soil):
https://vorarlberg.at/documents/21336/153654/Faszination+Boden+Flyer/0dd16827-a6ef-4c39-9032-837f581a8926
Montfortstraße 4, 6900 Bregenz
+43 (0) 5574 511 42099

Mariapfarr (Salzburg)
Bodenkulturweg (Soil culture path)
http://www.bodenkulturweg.at/
Am Weiher 175, 5571 Mariapfarr
+43 (0) 64 738 766

Steinbach am Attersee / Gmunden on Traunsee / Höllengebirge (Upper Austria)
Waldbodenlehrpfad Taferklause (Taferklause forest soil trail):
http://www.bodenlehrpfad.at/

Laakirchen (Upper Austria)
Bodenlehrpfad Laarkirchen (Laarkirchen soil trail):
https://www.land-oberoesterreich.gv.at/70252.htm

Steinerkirchen a.d. Traun (Upper Austria)
Bodenlehrpfad Agrarium (Agrarium soil trail):
http://www.bodenlehrpfad.at/
Agrarium Almegg 11, 4652 Steinerkirchen a. Traun

Ottenschlag (Upper Austria)
Bodenlehrpfad Ottenschlag (Ottenschlag soil trail):
http://www.ottenschlag.at/system/web/sonderseite.aspx?menuonr=221516850&detailonr=221516850

Thalheim bei Wels (Upper Austria)
Bodenlehrpfad Thalheim (Thalheim soil trail):
http://www.land-oberoesterreich.gv.at/70252.htm

Linz (Upper Austria)
Botanischer Garten Linz (Linz Botanical Garden):
http://www.land-oberoesterreich.gv.at/70252.htm

Krengelbach (Upper Austria)
Krengelbacher Bodenroas (Krenglbache soil trail):
http://www.land-oberoesterreich.gv.at/70252.htm

Vienna
Boden lebt! Bei den Artenschutztagen im Zoo Schönbrunn (Soil is alive, species protection day´s of the Schönbrunn Zoo):
https://bodeninfo.net/produkte-und-informationsmedien/bodenbildungsnavigator/lehrpfade/boden-lebt-artenschutztage-schoenbrunn/
Tiergarten Schönbrunn, Vienna Hietzing

Vienna
Bodenlehrpfad Roter Berg ("Red Mountain") soil trail:
https://bodeninfo.net/produkte-und-informationsmedien/bodenbildungsnavigator/lehrpfade/bodenlehrpfad-roter-berg/
Veitingergasse / corner Heinz-Nittel-Weg, 1130 Vienna

CS7.
Soil protection on construction sites in Switzerland

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Country, Region:	*Switzerland*
Organisation:	*Soil Science Society of Switzerland*
Sector:	*construction*
Land uses:	*various (e.g. agriculture, urban)*
Main soil threat:	*erosion, organic matter decline, compaction, sealing, contamination, nutrient depletion, loss of soil biodiversity*
Key soil ecosystem services:	*No focus on single services. All potential services will be considered.*
Summary:	*Since construction works negatively impact the soils directly within the construction zone, as well as the soils in its surroundings, e.g. through compaction, it is essential to consult a pedologist for all major construction projects. The soil expert is involved during the planning, execution and restoration phases and consults the builder with a comprehensive soil protection concept. In this way, the negative impacts on soils can be minimised in order to secure vital soil-based ecosystem services. The practice is standard in Switzerland, but can easily be transferred to other areas within or outside the Alps.*
Keywords:	*pedological consulting in construction projects, Switzerland, soil protection in construction*

Background and description of the problem

Heavy machinery is used wherever construction works take place and, consequently, soil is disturbed. Sustainable management during construction requires well-prepared professionals in order to avoid damage to soils and to maintain soil fertility. For several years, it has been obligatory to consult a soil expert at large construction sites. Qualified experts are responsible for advising and assisting with soil protection measures. In smaller construction projects, soil protection consulting and measures are often the responsibility of project planning and management professionals, who are not always aware of the importance of soil.

Expected improvements / contribution to better soil management

The Alpine environment is under increasing pressure due to the enhanced construction activities. Different sites illustrate that destructive construction methods lead to long-term reduction of soil quality. Therefore, preventive and protective methods are extremely important. The Soil Science Society of Switzerland found that a pedological consultation during construction projects has become a successful and effective instrument for chemical and physical soil protection since its introduction in 2001

Stakeholders and target groups

Target groups include the building companies operating in all bigger constructions. Stakeholders are the architects, planners, construction workers and experts for environmental and soil protection on construction projects.

Data and methods

In Switzerland, the data availability for the work of Soil Protection Experts for Construction Projects (SPECPs) is rather limited. While large-scale maps of geological and hydrogeological information are usually available, spatial information on vegetation or protected areas is quite scarce. Since detailed soil maps are normally not available, SPECPs have to excavate soil profiles and or mini pits or have to take soil core samples in order to obtain information about soils.

An example for a construction site with pedological consulting includes the enlargement and construction of a partly new route of the Julier pass, which was carried out between the years 2008 and 2013. It included new embankments, road dismantling, protection dams against avalanches and renaturations of river banks and resulted in the relocation of 230,000 m^3 of material and affected an area of over 18 ha. Based on point-based soil samples and vegetation maps, the SPECP and the Environmental Protection Expert for Construction Projects (EPECP) elaborated a soil protection concept – covering planning, construction and restoration phases – taking into account the available and newly gathered information. At Julier Pass, the soil depth varied from very shallow to up to 1 m. The heterogeneity of the soils and developed ecosystems required an interdisciplinary approach and specific measures in order to protect the complex environmental conditions. Direct displacement, where the soil is moved together with turf grass, was carried out to restore the original landscape.

Results

The practice is ongoing and is carried out under the management of the Federal Office for the Environment of Switzerland (FOEN).

The Swiss Soil Science Society found that pedological consultation in construction projects has become a successful and effective instrument for chemical and physical soil protection since its introduction in 2001. In Switzerland, the urge for protection of soil is widely recognised. However, the SPECP would often need more detailed spatial soil information requiring further soil surveys, in particular in mountainous areas.

Transferability and applicability to best soil management practice

This approach to protection of soil at construction sites is easily transferable to other regions and countries, and it is also highly sensible to transfer it. For example, in Germany, the organisation "Bundesverband Boden e.V." now also recommends involving soil experts at construction sites similarly to Switzerland. See: www.bodenwelten.de/content/bodenkundliche-baubegleitung (only available in German).

Environmental and climate change impact

For adaptation and mitigation of climate change, soils are a key factor as they store and can potentially act as sinks for huge amounts of carbon. Soils can be damaged (compaction/mineralisation) by unsuitable management practices and their soil-based ecosystem services can be lost. Therefore, soil protection at construction sites is a great asset to maintain healthy soils.

Photos / illustrations / maps

Figure 28: A negative example for soil excavation: No separation of turf, the high thickness of topsoil deposit and driving on deposit with heavy machinery *(Photo: Thomas Peham)*.

Figure 29: A positive example of soil treatment: The loosening of compacted soil followed by filling of underground and top soil in layers *(Photo: Thomas Peham)*.

References and further reading

Soil Science Society of Switzerland – List of experts: http://www.soil.ch/cms/bbb/bbb-liste/

Soil Science Society of Switzerland – Bodenkundliche Baubegleitung (pedological consulting in construction projects): http://www.soil.ch/cms/bodenkundliche-baubegleitung/

Federal Office for the Environment (FOEN): https://www.bafu.admin.ch/bafu/en/home/topics/soil/info-specialists/soil-protection-measures.html

Clemens Geitner; Jasmin Baruck; Michele Freppaz; Danilo Godone; Sven Grashey-Jansen; Fabian E Gruber; Kati Heinrich; Andreas Papritz; Alois Simon; Silvia Stanchi; Robert Traidl; Nina von Albertini; Borut Vrščaj (2017). "Soil and land use in the Alps – challenges and examples of soil survey and soil data use to support sustainable development". Soil Mapping and Process Modelling for Sustainable Land Use Management. 225-296.

CS8.
Revegetation of degraded areas in the French Alps

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Country, Region: *France, Auvergne Rhône Alpes*

Organisation: *INRAE, French National Research Institute for Agriculture, Food and Environment*

Sector: *ski resorts, tourism*

Land uses: *pasture, ski slopes*

Main soil threat: *erosion*

Key soil ecosystem services: *erosion, tourism, production (agropastoralism)*

Summary: *Following the degradation that comes with infrastructure development, ecological restoration initiatives often utilise non-native seed mixtures resulting in hybridisation, and competition with local flora. This project aimed to develop and test a more efficient reseeding method by utilising the so-called "fresh hay transfer" method, which calls for the use of species adapted to the local biotope. The method was successful estimating a 70–80% recovery within the next years.*

Keywords: *erosion, hay transfer technique, revegetation, local seeds*

Background and description of the problem

The restoration of degraded land at high altitude is strongly linked to the creation of infrastructure (tourist buildings, roads, ski slopes, pastoral and forestry use, power lines, protection against natural hazards, etc.) and requires compensatory works to mitigate the negative consequences of the construction works. In general, the purpose of ecological restoration is to block or slow down the degradation of natural environments and the loss of biodiversity. Thus, the revegetation is practically systematic when structure of the ground is modified.

In Courchevel, as part of development work for the resort, major surfaces were redesigned in 2017 in the Moriond sector (coordinates: 45°24′48″ N, 6°36′54″ E – altitude: 2000 m). Machine-graded ski run constructions had an impact on the environment and soil in particular. Thus, actions have been taken to mitigate the negative consequences of the construction. Société des 3 Vallées (S3V – the company in charge of ski resort operations) in conjunction with the MDP (landscape planner) and the farmer-operator have initiated revegetation operations in the area affected by the development. The main reason mentioned by S3V was to mitigate the erosion process. A soil that is left bare is exposed to high risk of erosion and, at such altitude, the vegetation has difficulties growing due to climate and soil characteristics, all the more because of soil compaction due to the use of construction machinery. The revegetation is also needed to minimise the project impact on landscape. Finally, the vegetation provides a protection of the snowpack that is valuable for ski slopes. From another point of view, the benefit of revegetation is also to ensure a plant cover to allow agropastoral activity during the summer season.

However, the seed mixtures that are usually used for the revegetation of high-altitude areas in the French Alps are very rarely of Alpine origin and often result in low altitude multiplication and little diversity in species. Of the plant species most frequently used for planting, three are mainly cultivated outside the European Union (Achillea millefolium in New Zealand, Bromus erectus in the United States and Trifolium subterraneum in Australia).

The use of these commercial mixtures can have several negative consequences on the vegetation growing at high altitudes:

- low durability of planted cover crops with high risk of erosion of poorly protected soils,
- need to bring large numbers of seedlings and doses of fertilisers,
- risk of hybridisation and competition with local flora inducing a modification of plant communities and landscapes.

This case study aimed to develop and test a more efficient reseeding method. The so-called "fresh hay transfer" method is based on the use of local species adapted to the local biotope. Société des 3 Vallées aimed at reseeding a pilot plot in Ariondaz at an altitude of 2000 meters.

Duration of the project: The project took place in august 2017

The cost of the project for an area of 4,000 m² was €2,350 of which the farmer received a total of: €850 and compensation for the hay totalling: €300. These costs do not include the time spent for the negotiations, organisation, and coordination of the construction works.

Contribution to better soil management

As a preamble, we remind you that this project took place in a specific ecosystem of ski resorts. This ecosystem is strongly impacted by the presence of snow and in particular artificial snow, involving the destruction of soil and the use of fertilizers.

This project was an opportunity to present the feasibility of an alternative method compared to the usual one that is used to vegetate ski slopes. Indeed, earth-moving companies use practices that are harmful to soil preservation. During the operations, the soil should be stripped, stored and reinstalled horizon by horizon.

The soil should not be smoothed with a power shovel but rather scratched perpendicular to the line of greatest slope to obtain a roughness which limits erosion phenomena and to ensure sufficient decompaction of the topsoil.

This project also highlighted the limitations of the contractual conditions under which the work is carried out. Earth-moving companies are contractually committed to ensure vegetation recovery rate a few months after seeding. For this reason, they use fertilisers. With the hay transfer technique we can demonstrate to earth-moving companies that the use of local seeds adapted to the specific conditions of high mountainous areas (climate and poor substrate) and careful soil preparation can garner comparable if not better result.

Stakeholders and target groups

This project of revegetation concerns a large public of practitioners involved in the mountain area management: ski resort managers, engineering offices, managers of natural areas, seed producers, public administrations, pastoral services, and public research centres.

The revegetation project of Courchevel was carried out by:

Société des Trois Vallées (S3V)
La Croisette
73120 Courchevel
+33 (0) 4 79 08 04 09
contact@s3v.com

MDP Consulting
5A chemin de la Dhuy
38240 Meylan
+ 33 (0)4 76 90 20 60
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INRAE, French National Research Institute for Agriculture, Food and Environment:
2 Rue de la Papeterie
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+ 33 (0)4 76 76 27 27

The case study was funded within the project of SEM'LES ALPES, S3V and the departmental board of Haute Savoie.

Data and methods

The site is located in Courchevel (France). The vegetated area corresponds to an area of 4,000 m². According to the EUNIS habitat classification, the natural habitat of the site is classified as E2.3, which corresponds to a hay meadow. The hay was harvested on an area of 17,500 m².

The procedure followed is broken down into several steps as follows:

1. Protection of the harvesting area

The area to be mowed is to be protected as soon as the snow melts on 1 to 2 hectares. A harvesting area of 2 hectares for every 1 hectare to be replanted will provide a safety margin in the implementation of the hay transfer if the mowing period or method results in a loss of seed.

2. Placement of the substrate on the plot to be restored

The successful completion of this step is critical to the success of revegetation. The topsoil must be identified with the prime contractor, stripped and stored separately. After the reconstitution of the mineral horizons, the topsoil is to be spread just before sowing in a fairly thick layer without large clods, and very slightly compacted. The objective is to have a loose substrate on the surface at the time of sowing. Otherwise, the soil must be de-compacted just before sowing with a harrow passage or the power shovel bucket.

If the topsoil is rich, there is no need to spread manure. If the choice is made to add manure, it can be spread just after the topsoil, or, when there is lack of it, it can be mixed in. The amount of manure must be reasonable so as not to have a substrate that is too fertile, which would limit the germination of certain species.

3. Hay harvesting at the sampling site

The optimal mowing date corresponds to the beginning of the maturation of the seeds of the main grasses of the prairie at the soft pasty stage, i.e. 5–6 days before maturity. Adjusting the date according to the observed phenological stages is recommanded. It is preferable to mow at low speed at about 5–7 cm cutting height in cool to wet conditions, with morning dew, to prevent seeds from falling out.

4. Transport of fresh hay

Mowed hay should be picked up soon after cutting if possible, during the day. If work is not completed on the areas to be revegetated, hay can be left on site for up to one week, even if it rains, or loaded on a tarpaulin and covered with it and stored for up to 2–3 days. Several options are available for pick-up:

– Swathing and collecting with a fork, which is labour-intensive but significantly reduces seed loss. For forklifting, you should plan a day with 5 -10 people per hectare.

– Swathing and baling the hay into bales, which results in a significant loss of seed, but limits the amount of labour required. Small rectangular bales hold more seed than round bales. Large rectangular bales are to be avoided. When pressing, be careful not to overtighten the bales.

– If a loader is available, bulk pick-up can be carried out more quickly. Bulk hay or unpacked bales can be put directly into the manure spreader, or stored in a semi-trailer with a tarpaulin spread at the bottom to recover falling seed.

5. Spreading fresh hay

On the site to be replanted, spread the hay 2 cm thick. If necessary, recover the seeds that have fallen on the tarpaulin in the semi-trailer and sow them.

6. Protection of the restored area

If livestock pass nearby, set up an area enclosed by an electric fence and put up signage for at least 2 years following the completion of works.

Activities

Before main construction activities, the topsoil has been removed with an excavator and stored next to the site. Below the same area, an ecologically similar plot of grassland has been identified and allocated as a source area for obtaining natural seeds.

Once the modifications have been done, the topsoil has been repositioned. Then, the soil has been superficially scratched in the direction perpendicular to the line of maximum gradient to mitigate potential erosion due to rain and snow melting. The soil has not been amended to avoid a perturbation of the natural species mixture, i.e. favouring of one species over another.

On the pilot site, two different plots were identified, on which to apply two different seeding methods. The first method consists of spreading the fresh hay on the ground. The second consists of seeding non local seeds mixtures to allow an accurate evaluation of the “fresh hay transfer” method.

The source plot was mown in early August when the seeds of the main species were reaching maturity. After the reconstitution of a topsoil horizon over the area to be restored, the harvested hay was spread by hand at a thickness of 2 cm providing mixed seeds, and mulching favourable to germination.

Results and success of the project

The “fresh hay” method on all the sites has been successful: it makes it possible to obtain remarkable plant cover rates over the first two years of monitoring and a specific composition that over time resembles that of the reference environment. The vegetation cover percentages that were observed in the plots that were seeded using the “fresh hay” method suggest that vegetation can be expected to recover over the next few years, and will most likely reach values of 70 to 80% for sufficient protection against mountain erosion (Krautzer et al. 2006; Dupin et al. 2014). The return of the vegetation cover on the entire surface may take time, but the results of this study show a more accurate fast and efficient recovery on plots reseeded using the fresh hay transfer method.

Detailed results in French can be found on the website of the “Sem Les Alpes” Project http://www.cbn-alpin.fr/actualites/poia/semlesalpes.html

Transferability and applicability to better soil management practice

The implementation of the “fresh hay transfer” method has the advantage of being replicable in various contexts. To be successful, it requires special attention from the landscape contractors with regards to the location of source grasslands and planning.

The first important step is to identify a source grassland where the first mowing can be delayed to build a seed stock, and then to plan the service with the farmer of the plot. The ratio between the area to be harvested and that to be restored depends on the environment. The second important step is the operation schedule that has to be adapted both to the progress of development projects and to the maturity periods of the seeds.

Environmental and climate change impact

The case study has focused on developing the use of locally sourced seeds in restoration work in Alpine mountain areas. The actions carried out have been reasonable in such a way as to positively impact biodiversity, preserving genetic, specific, and ecosystem-based heritage. The impacts in terms of greenhouse gas (GHG) emissions were not the main purpose of the project but were taken into account throughout its implementation.

Firstly, the restoration of open habitats with local seeds, which consists of restoration of sustainable and autonomous plant covers, has the effect of storing carbon in vegetation and soil. Indeed, the permanent grasslands are carbon sinks, the storage of which has been evaluated in Europe at 2.7 t eCO_2/ha/year (or 0.7 t C/ha/ year), a value comparable to that of temperate forests. The intensity of carbon storage in permanent grasslands depends on many factors, such as management practices, which cannot be reported here for a quantitative assessment of GHGs stored during the performance of restoration work.

The use of locally sourced seeds in these ecological restoration works also has direct impact on GHG. Firstly, the transport of seed stocks is minimised, whether the mixtures come from direct harvests in natural environments or from multiplication. In the case of harvests in the natural environment, the source sites must be bioclimatically similar to the areas to be restored. The geographic information system tool for identifying potential harvest areas has been designed with this in mind, which also meets the feasibility criteria. Secondly, as locally sourced seeds are adapted to the poor soils of mountainous and subalpine areas, they do not require fertilisation, unlike non local seeds generally used by landscape contractors. However, chemical or organic fertilisation of soils, directly and indirectly, generates emissions of nitrous oxide, a gas with a very high global warming potential. In addition, as exogenous seeds are unsuitable for mountain bioclimatic conditions, their recovery is weak, requiring over-seeding and over-fertilisation in the years following restoration.

Finally, sowing non local mixtures generates plant cover with some species disappearing in the mid-term, which does not allow grasslands to fulfil their role as carbon sinks. On the other hand, sowing local mixtures makes it possible to obtain autonomous herbaceous cover crops, whose carbon storage function is stabilised.

Photos / illustrations / maps

Figure 30: Soil preparation

Figure 31: Spreading of fresh hay.

References and further reading

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CS9.
Management of vacant spaces in South Tyrol, Italy

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Country, Region:	*Italy, South Tyrol*
Organisation:	*Plattform Land*
Sector:	*space management: spatial planning, communal development*
Land uses:	*agricultural land*
Main soil threat:	*soil sealing*
Key soil ecosystem services:	*No focus on single services. All potential services will be considered.*
Summary:	*The negative economic, societal and environmental impacts caused by irresponsible land use demand a more effective approach to vacancy management. This ongoing pilot project explores the idea of prioritising lower land use by redeveloping empty buildings in twelve South Tyrolean municipalities. Activities include the documentation of building vacancies, raising of public awareness, digitalisation of data, and consultations regarding future activities with residents and experts. The primary goal of this project is to decrease land consumption throughout the Alpine region.*
Keywords:	*spatial planning, reduced land use, recycling of brown fields*


Background and description of the problem

Vacancy management as a contribution to the sustainable use of space

Vacancy management is a central aspect of intelligent land use, i.e. a responsible use of limited space in harmony with society, the economy and the environment. This is all the more true in a mountain region such as South Tyrol, where space is scarce and land is valuable.

The sealing of soils, mainly agricultural land, is limiting sustainable development. Therefore, a general awareness-raising event took place in May 2018 in South Tyrol and a pilot project regarding vacancy management in five South Tyrolean municipalities has been under way since summer 2017. The aim is to further increase the appeal of the municipalities, while at the same time reducing land consumption.

Expected improvements / contribution to better soil management

The most obvious improvement regarding soil management is decreased land use, due to prioritising the reuse of empty buildings first. In other words, as mayor of one pilot municipality put it:

"We have collected data on vacant apartments and commercial real estate. In Tramin, 37 apartments and 26 buildings are empty, which corresponds to the living space of about 340 people. If new residential zones had to be designated here, about 3.5 hectares of "cultivated land" would be needed".

Especially the sector for restoration using old craft techniques and the energy renovation sector can profit from this initiative.

Stakeholders and knowledge transfer

- Public administrations
- Building or property owners
- Research institutions
- Companies or entrepreneurs
- Architects, planners
- Investors
- General public

Data and methods

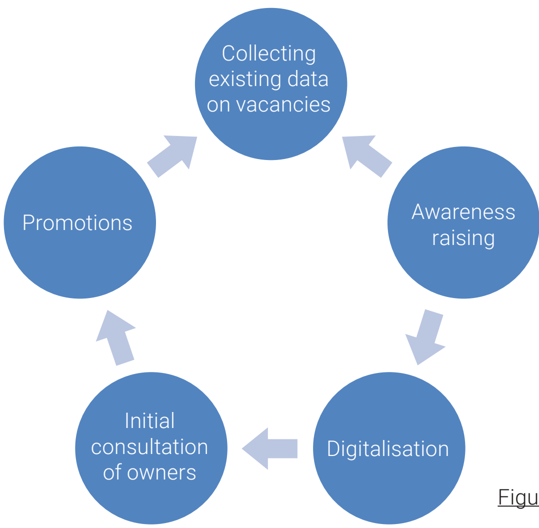

Figure 32: The 5 phases

Duration and costs of the project

The pilot project started in summer 2017 and its first phase was finished by the middle of 2018. In 2019, the project was extended to other municipalities and it also includes initial consulting of interested individuals by architects regarding renovation of old/empty houses.

Another series of local awareness raising events started at the end of 2019.

Each municipality had to cover the costs of the local contact person, the local events and coordination. It is estimated that with respect to the size of the municipality, each municipality spent a few thousand euros.

Activities

Since summer 2017, the Platform Land has been conducting a pilot project on vacancy management in five selected pilot communities in South Tyrol:

- Kaltern
- Klausen
- St. Leonhard in Passeier
- Tramin
- Truden

The focus here is on collecting information about empty buildings, raising awareness and advising target groups and communicating with owners. The approach is based on the needs of the people concerned, it incorporates the existing building fabric and the environment and concentrates on promoting action during implementation.

The work phases of the project include the following steps:

I. Recording of vacancies/building gaps in the five pilot municipalities involved according to the specifications and definition in coordination with the responsible regional authority and the South Tyrolean Association of Municipalities.

II. Raising the awareness of the population regarding the comprehensive internal development: initiation and coordination of the process with the involvement of the population and thus definition of the needs and topics for the respective internal development (active internal development). First results of the pilot project were presented at the 2018 annual conference of the Platform Land and have been presented in the form of a small exhibition.

III. Digitalisation of the data in coordination with the South Tyrol and the Association of Municipalities with regard to the uniform GIS software and its further development for vacancy management.

IV. Initial consultations of the residents concerned including experts (architects, KVW

Arche) taking place on the day of inner development, which were initially carried out in Glurns and Truden in late summer/autumn 2018.

Results

The pilot project delivered a map of the vacant buildings and spaces in each participating municipality, a poster and a short explanation for the general public, as well as a more detailed database for internal use of the vacancies in each municipality and a standardised procedure in the entire area of South Tyrol. Furthermore, about 100 local and regional decision makers took part in the awareness-raising events, while about 80 residents took part in the first local events as well.

Further information can be found on the webpage (in German):
http://www.plattformland.org/pilotprojekt-leerstandsmanagement/

Transferability and applicability to best soil management practice

The methods can be adapted and transferred to other Alpine regions –from the definitions to the use of tools for collection of information about vacant buildings and spaces, as well as templates for contacting owners or informing the public.

Photos / illustrations / maps

Figure 33: Examples of mapping as well as before-and-after footage of formerly vacant houses

Figure 34: Mapping of vacant buildings

CS10.
Healthy soil for healthy food, WWF Austria

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Country, Region:	*Austria*
Organisation:	*NGO: WWF Austria, Retailer: SPAR Austria and 69 Farmers*
Sector:	*agriculture – vegetable production*
Land uses:	*agricultural land*
Main soil threat:	*soil compaction, soil contamination, erosion*
Key soil ecosystem services:	*carbon sequestration, food production, biodiversity*
Summary:	*Across Austria the threat of poor soil health, economic instability among farmers, and low public knowledge of the threats caused by soil degradation have motivated the collaboration of three leaders in the agricultural field. The retailer 'SPAR', the WWF, and 69 farmers have launched a 2015–2021 project aimed at combating these issues by promoting soil-conserving agricultural practices, building public awareness through media, and selling produced vegetables at grocery stores. The underlying goal is to enhance soil biodiversity and its ability to capture and store atmospheric carbon.*
Keywords:	*organic matter decline, loss of soil biodiversity, carbon sequestration, food production*

Background and description of the problem

Soil is a life supporting resource that is under heavy strain due to the increasing threats. The accelerated degradation of soil and its essential functions, which are important for human well-being, is triggered by the increasing demand for food, continuing urbanisation and high levels of environmental pollution. A quarter of all agricultural land worldwide is in poor condition. This also applies to Austria.

It is estimated that every year an average of ten tons of fertile soil per hectare is lost through erosion and humus depletion – 20 times the amount that can be recovered each year, with enormous consequences for the global community. Improving soil health is therefore essential for a safe and peaceful future.

The main objectives of the “Healthy Soil for Healthy Food” project are to improve soil health and carbon sequestration by using agricultural practices that build up organic matter in the soil. These practices also reduce biodiversity loss and the risk of erosion. Furthermore, the project aims to bring this topic to the forefront. Austrians lack awareness of the importance of healthy soil. Therefore, more information is needed to spread the knowledge about the benefits of healthy and fertile soil.

Expected improvements / contribution to better soil management

What is an example of an asset for a particular area? How has information on soil contributed to nature conservation and conflicts over land use reduction? What is the economic aspect of this example? Do you intend to use similar approaches in the future?

This project integrated the collaboration between Austrian farmers, SPAR Austria and WWF Austria. The farmers used targeted measures to build up topsoil on these fields and grow vegetables that are sold in SPAR stores throughout Austria. For sake of better recognition, the products are branded with a special “Humus” label and a WWF logo. Austrian consumers benefit from this cooperation by healthy food that was grown on that soil – conserving agricultural production to Austrian consumers.

During the “Healthy Soil for Healthy Food” project, major steps are being taken to improve soil biodiversity, such as the ability of the soil to capture and store CO_2, in order to improve economic situation of farmers and to raise the awareness on soil degradation.

Economic aspect: Contracts guarantee that project participants can purchase the products cultivated on these fields. Furthermore, SPAR rewards the implementation of "humus-friendly" measures according to the percentage of the sold product. (After verification of the increase in humus content by an independent certified engineer.)

The project will continue to promote sustainable soil management in the future by raising public awareness through various printed and digital media channels. SPAR customers and WWF friends are also provided with knowledge about the importance of soil functions for our daily lives and advice on how they can contribute to soil protection. In addition, participating farmers become role models for others in implementing soil protection measures. Besides increasing the number of fields and participants to improve soil health and sequester more carbon, the project aims to **place more emphasis on the important issues of biodiversity and flooding** in the future. The importance of soils for flood protection, as well as for biodiversity hotspots should be made generally known in civil society.

Stakeholders and target groups

The cooperation between 69 farmers, SPAR and the WWF leads to a strong alliance throughout the supply chain for sustainable development. Together, stakeholders can influence food-related patterns from production to consumption.

The role of WWF Austria in this project is to provide expertise and knowledge on soil issues. Moreover, the NGO has a strong position in civil society and uses its communication channels to raise awareness on soil degradation issues.

SPAR coordinates the project and monitors the cooperation with independent soil experts. By guaranteeing the sale of the vegetables produced and paying a bonus to the farmers, the company provides a strong incentive for soil-conserving production.

The farmers deliver healthy food from healthy soils by using soil-conserving methods such as crop rotation, fertilisation with compost and direct sowing.

Data and methods

SPAR analyses soil samples in cooperation with independent soil experts to monitor carbon storage and progress in soil health, thus ensuring the effectiveness of the project.

Soil samples:

- 1st soil sample is analysed upon entry into the project, 2nd soil sample 2–3 years later (the latest after 5 years)
- Soil measurements are carried out by an independent specially certified engineer
- Supported by GPS measurements
- Analysis by the Austrian Agency for Health and Food Safety (AGES)
- Indicators monitored:
    - pH-value: $CaCl_2$
    - Phosphorus (P): CAL
    - Potassium (K): CAL
    - Humus content
    - Total nitrogen (N)

Results and success of the project

The Project began in 2015 – the International Year of Soils. In the meantime, it has been running for 5 years and the contracts are undergoing until 2021. It is important to have a long-term project running, as the humus content cannot be affected in the short run. Furthermore, precise measures must be taken in order to ensure carbon storage in the soil.

The project started in 2015 with 800 hectares and by 2019 the project included about 1,050 hectares. The aim is to further increase the land area.

SPAR is covering the costs of the project including the support of WWF Austria and payments for the farmers.

The following soil-conserving agricultural practices are recommended to participating farmers:

- Fertilisation with compost
- Minimum tillage and direct sowing
- Permanent green cover
- Crop rotation and mixed crops

In order to build awareness among Austrians, articles have been regularly published in the SPAR customer¬ magazine MAHLZEIT (reach of 800,000 people) since the beginning of 2015, presenting the project and emphasising the importance of soil protection. The WWF PANDA magazine, with a reach of 100,000 readers, also published reports on the subject. Moreover, this NGO gives high priority to soil on its website (see www.wwf.at/boden).

SPAR website: https://www.spar.at/nachhaltigkeit/produkte/obst-und-gemuese/gesunde-humus-boeden

The vegetables produced are sold in more than 1,600 shops throughout Austria. Customers can buy them at the same price as comparable products, i.e. products that are produced with less sustainable methods. The products are marked with a special humus sticker and the WWF brand to ensure easy recognition.

Transferability and applicability

Transferability of the described best practice to other Alpine areas and beyond. Can the best practice approach be easily replicated and applied elsewhere? Important “hints” for imitators should be given. What are the main framework conditions and requirements that need to be set for the transfer of the best practice (difficult or easy to set and imitate)?

The project can easily be transferred to other regions and countries. Our aim is to extend and strengthen the dissemination of the project’s practices and to become a model for other initiatives. The project has a high social as well as economic viability, as it already has the infrastructure necessary for its realisation in place.

The farmers have traditionally been cultivating their fields for decades and have been supplying food to SPAR before the humus project started. Therefore, it required a small bureaucratic effort to implement the additional contracts. Great attention was paid to the exchange of knowledge between all three parties to ensure the improvement of soil health and carbon storage. SPAR and the WWF have a long-term partnership with close contact that makes the exchange of topics easy. Existing communication channels are being used to reach the civil population about the issues of soil health. Therefore, the project can easily be implemented in other regions and countries if there is a strong motivation for sustainable development among both, the farmers and retailers.

Environmental and climate change impact

In addition to improving soil health, the capture and storage of atmospheric carbon is a key objective of the project.

Soil has an enormous potential to bind atmospheric carbon by building up organic matter (humus), but it can only be used if soil-conserving techniques are applied. In this way, the project has already resulted in a considerable amount of stored carbon.

Public awareness of soil ability to store carbon appears to vary. Therefore, the principles of humus formation could serve as a tool for communication on climate change issues. The project 'Healthy Soil for Healthy Food' brings the topic of soil health back to the forefront and combines climate protection with daily cooperation activities.

Photos / illustrations / maps

Figure 35: Areas in Austria

Figure 36: Visible product range (2016)

Figure 37: Visible product range (2016)

Figure 38: More products available but without packaging

Figure 39: Austrian media

CS11.
Integrating soil protection in forest management planning, Pokljuka, Slovenia

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Country, Region: *Slovenia, Triglav National Park, Pokljuka*

Organisation: *Slovenia Forest Service*

Sector: *forestry – forest harvesting operations*

Land uses: *forest*

Main soil threat: *soil compaction, soil contamination, erosion*

Key soil ecosystem services: *wood production, biodiversity, water filtration, recreation and tourism, carbon sequestration*

Summary: *Unplanned use of modern forest harvesting operations (FHO) can lead to soil degradation and consequently to the reduction of forest productivity. Thus, integration of soil protection in forest management taking into account soil characteristics, climate conditions and the best available forest harvesting operations is needed. The available soil data and soil map for Pokljuka plateau were used to elaborate a derived map showing suitability of FHO use. The used approach is explained, and its applicability is discussed.*

Keywords: *forest management, harvesting technology, soil compaction, Pokljuka, Triglav National Park*

Background and description of the problem

With its 6,300 ha of forests, the Pokljuka plateau is the biggest forest complex in Triglav National Park, Slovenia. The forests provide many ecosystem services (ESS) including forest biomass production, global climate regulation (carbon cycle), recreation and spiritual services, habitat provision (biodiversity), water retention, filtration and purification, as well as local climate regulation. High-valued Norway spruce forests require qualitative sustainable forest management and provide economic benefits for forests owners while respecting other ESS.

Pokljuka forests in basic figures: average growing stock is 492 m^3/ha, annual increment totals 8.15 m^3/ha, annual felling in managed forests totals 8.4 m^3/ha.

Modern forest harvesting operations (FHO) in use have several advantages and disadvantages. Heavy machinery effects are substantial, especially on soils, but on the other hand they are very economically efficient, safer for workers and useful, particularly in cases of salvage cutting and natural disasters. Regardless of the high efficiency of FHO, unplanned use of FHO can lead to soil compaction, destruction of soil structure, loss of soil biodiversity, erosion, poor soil aeration and consequently to the reduction of soil fertility and forest productivity. The soil compaction is regarded as a major problem because it can be permanent, which means that the soil porosity and related soil ecosystem services cannot be restored. There had been conflicts and disagreements about the (non-critical) use of MHT between owners, contractors, forest service and other stakeholders (e.g. tourism and recreational activities).

To avoid the above listed problems, the SFS is integrating soil protection in forest management planning taking into account soil characteristics, climate conditions and the best available forest harvesting operations.

Expected improvements / contribution to better soil management

Sustainable use of FHO is an important subject for SFS. SFS work is based on the following guidelines: Instruction for work preparation in stands, relevant for FHO and guidance for FHO practice, where limitations, advantages, technical details and impact on forest soils are discussed. Workshops concerning FHO topic ranging from technical details to soil protection have been organised.

For the Pokljuka plateau, FHO suitability map was created taking into account soil characteristics, climate conditions and the best available harvesting techniques. The map was integrated into the forest management plan for Pokljuka as additional guidelines for FHO use. Although the map was compiled using scientific data, it is very applicable, understandable and therefore useful for field operatives (Figure 3). Therefore, it is an expert base decision tool to reduce soil degradation and minimise conflicts with contractors and other stakeholders.

Stakeholders and knowledge transfer

The attitude of different stakeholders towards FHO has been and still is diverse. To overcome differences in attitude and find appropriate solutions, a participatory process consisting of several workshops (WS) has been introduced in 2002 and has been repeated several times (2010 and 2018). Such uniform approach enabled us to get a systematic view on participants' attitude towards the use of FHO over the last two decades. The results show that soil damage caused by FHO is one of the most important issues. Thus, several activities for better integration of soil protection in forest harvesting operations were performed within the Links4Soils project. Maps showing risks of harvesting operations for soil degradation based on existing soil data were prepared and guidelines for forest operations were upgraded. Important part of the activities was WS (2018) on soil protection for forest experts and practitioners, organised as a continuation of the participatory process. Participants from different fields discussed sustainable use of FHO with special emphasis on soil degradation prevention. The participants' opinion, suggestions and disagreements were further used to improve guidelines for planning and use of FHO.

Data and methods

Expertise about forest soils including soil description, soil sample analyses and the soil map was performed in forests of Bohinj valley, Pokljuka and Mežakla (Pavšner, 1967) plateaus. The fundamental analysed soil parameters are pH, the depth of horizons, soil organic matter (humus) content, C, N, C/N ratio, K_20, CaO, P_2O_2, physiological activity of P_2O_2, K_20, soil skeleton, texture, humidity and porosity. From soil data, the soil experts estimated soil productivity, acidity, nutrients availability, soil water holding capacity, and soil parent material (geological substrate) for 42 identified different forest soil types and complexes of Pokljuka plateau area. Furthermore, the soil types and complexes were mapped at a scale 1:10,000 that is most applicable for the decision making at local level. The report and the map were designed to get better understanding of soil capacities, threats and soil ecosystem services and thus to improve forest management in the area.

Using the available soil data, the sensitivity to compaction, water retention and soil erosion was assessed for each of the 42 forest soil types and complexes. The soil types and complexes were further classified in three categories according to suitability for FHO use. The classification and soil map were than used to elaborate a derived map showing suitability of FHO use at the Pokljuka plateau.

Results

Table 7: Classification of soil types into FHO categories

SOIL TYPE	MAJOR SOIL PROPERTIES	FHO CATEGORIES	CONDITIONS
No soil, very shallow drained soil on compact parent material	Depth (shallow soil), drainage (drained soil)	1	No restrictions
All other soil types: histosols, leptosols, gleysols, cambisols, stagnosols, luvisols	Soil development stage (developed soil), organic and mineral horizons, depth, texture	2	Frozen soil or snow cover is higher than 0.5 m or suitably dry soil
Podzols, peat bogs	Rare soil types, organic soil	3	Not allowed in any condition

Transferability and applicability to best soil management practice

The approach is widely applicable in areas where soil maps exist and the basic data for soil types are available. Foresters with help of soil specialists could classify soil types in categories showing suitability for FHO. Such maps are an important basis for better decision making on FHO at local level and thus improve forest management and soil protection, which is especially important in mountainous areas.

Environmental and climate change impact

Soil acts as a storage of greenhouse gases and represents important terrestrial pool of carbon. Providing nutrient cycling and filtering services, soil regulates greenhouse gas fluxes. Soil compaction has a negative impact on virtually all physical, chemical and biological soil properties and, consequently, on the provision of soil ecosystem services. Soil compaction is causing modified soil physical properties, poor soil aeration, lower biological activity that can decrease availability of macro and micro nutrients, nitrogen fixation and carbon cycles in favour of more emissions of greenhouse gases under wet conditions (Nawaz et al. 2013) to preserve forest soil quality and retain forest productivity. Therefore, the use of FHO in forests should be carefully planned. The FHO suitability map helps in regulating the use of FHO and is a fundamental step in sustainable management of forest soil.

Figure 40: Modern harvesting technologies are used on a daily basis in Slovenia. Without them, we cannot imagine the performance of forest works, especially in forests that have been damaged by natural disasters *(Photo: Jože Primožič).*

Figure 41: Heavy machinery used in inappropriate conditions may damage soils; consequently, the provision of ecosystem services is reduced *(Photo: Andreja Nève Repe).*

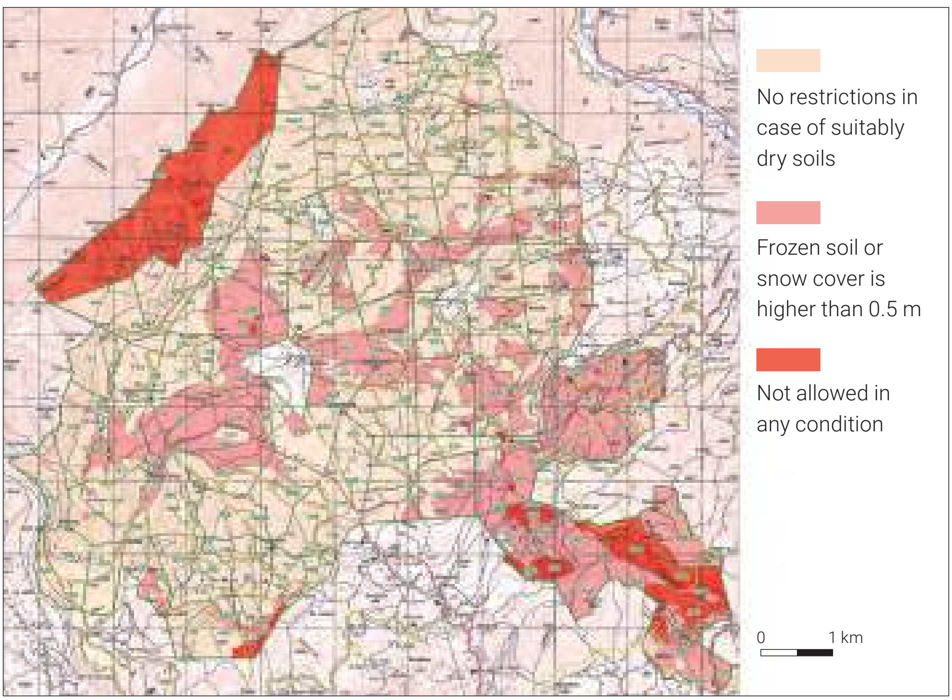

Figure 42: FHO suitability map for Pokljuka plateau *(Slovenia Forest Service).*

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CS12.
Austria CO_2- Recycling; Climate Change Mitigation by means of Soil, Humus and Habitat Management – a Demonstration Project Report

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Country, Region:	*Austria, Südkärnten*
Organisation:	*Regional Management South Carinthia (project execution organisation)*
Sector:	*agriculture and waste management*
Land uses:	*agricultural land, wetlands*
Main soil threat:	*organic matter decline, loss of soil biodiversity*
Key soil ecosystem services:	*erosion regulation, biodiversity, carbon sequestration*
Summary:	*Intensive farming leads to a permanent loss of soil organic matter (SOM), particularly in cropland and moors, where the humus' ability to stabilise the landscape water regime, improve biodiversity, and store CO_2 is of the utmost importance. To counteract SOM depletion, this pilot project was aimed at fostering the building of capacities among farmers and municipalities in the Carinthian region via activities connected with waste management, humus formation on cropland, and moor management. Awareness-raising activities in schools contributed to additional multigeneration transfer of knowledge.*
Keywords:	*carbon sequestration, regional carbon circle, Südkärnten (South Carinthia)*

Background and description of the problem

About 30–40% of worldwide greenhouse gas emissions are caused by land use and land use change. Apart from livestock farming, the moor degradation and loss of humus on cropland are the main CO_2 polluters in this sector in highly industrialised countries. For example, in Germany, drainage and intensive use of moors are responsible for about 5% of total CO_2-emissions. Intensive conventional farming leads to a permanent loss of SOM, in particular on cropland. Degraded moors and cropland soils with low humus content are not able to sufficiently stabilise landscape water regime. Negative impacts of droughts and heavy rain-induced torrents and erosion are dramatically increasing. Studies (Höper, 2007; Bundesamt für Naturschutz 2013) proved that drained and intensively used moors cause up to

40 t CO_2/y/ha. Composting organic materials, e.g. greenery from private gardens and municipalities, is not very common in South Carinthia. Unfortunately, organic waste from households is predominantly illegally deposited in landfills in the woods.

To solve these problems, the project aimed to demonstrate the best waste management practice in terms of:

- Closing the carbon cycle by composting the organic matter and using the compost for humus formation on cropland, and
- Sustainable moor management and moor regeneration.

Expected improvements / contribution to better soil management

Environmental benefits for the area and the people:

Better moor management and regeneration of moors contribute to:

- A stabilised water regime
- Reduced carbon emission due to moor degeneration, and
- Improved biodiversity.

Composting organic materials from private gardens and public green areas by farmers that use the produced compost for humus formation on their agriculture land:

- Is considered a cornerstone of closing the regional carbon cycle,
- Sequestrates CO_2 and helps to stabilise the water balance,
- Improves and preserves natural fertility of agricultural soils and
- Creates new job opportunities for farmers.

The project was only able to foster pilot actions and disseminate knowledge to farmers regarding sustainable moor management, humus management on cropland and household organic waste composting.

The project motivated farmers and municipalities in South Carinthia and, in particular, members of climate and energy model regions to start additional composting and C-cycle related projects.

It is planned to give a new boost to this idea by establishing a regional carbon trade system like the one that was started by Ökoregion Kaindorf in Styria several years ago.

Stakeholders and knowledge transfer

Three different modules that follow specific stakeholders and target groups were identified and involved into the knowledge transfer activities:

- The Waste Management Module that focuses on composting organic materials of the municipalities: it integrates interested farmers, administration of the municipalities, and general public/citizens.
- The Humus Formation on Cropland module was well received by regional farmers, Bio Austria Kärnten, an organic farmers association, and the Climate Alliance Austria, an important Austrian non-governmental organisation.
- The Pilot Actions Moor Management module has proven valuable to the Arge NATUSCHUTZ (nature conservation organisation), as well as land owners.
- Awareness rising in schools, including presentations in two secondary schools.

Data and methods

1. Feasibility study regarding composting municipal organic waste
The estimation of the amount of organic waste was based on experience gathered across Austria and the information that was provided by the municipalities.

2. Humus formation on cropland
Several experts for careful soil cultivation were involved.

3. Pilot actions moor management
To identify suitable moor habitats for management measures, available habitat maps were evaluated. However, degraded and drained moors that are intensively used for agriculture are not included, therefore the underlying data for these sites were scarce.

The activities in 4 project modules:

1. Waste management

- Feasibility study regarding composting of organic materials by farmers in South Carinthia (8 municipalities). The study estimated the total amount of organic waste in the region, proposed suitable sites for compost plants and identified farmers that showed strong interest.

2. Humus formation on cropland

- Demonstration project regarding humus formation on one hectare of cropland carried out by Goldbrunnhof professional school for farming in Völkermarkt.
- Humus formation workshop for farmers at Goldbrunnhof was organised.

3. Pilot actions moor management

- 4 practical habitat management measures have been carried out.

4. Awareness rising in schools

- Excursions for students to the moors in the region.
- 2 workshops in schools on the topic of soil and climate change including building a compost pile.

Duration: June 2012 – January 2014

Results

The strategy of the project was to involve the relevant target groups into activities of each project module.

1. Waste management

The Feasibility study regarding composting of organic materials by farmers in South Carinthia was elaborated in close connection with the municipalities. Additionally, interested farmers were interviewed about their ideas and wishes regarding composting organic materials for the municipalities. At the end, the results of the feasibility study were presented to the mayors and heads of office of the municipalities.

2. Humus formation on cropland
Humus formation demonstration project on one hectare of cropland was carried out by Goldbrunnhof Professional School for Farming in Völkermarkt. The students were responsible for the activities of this module under supervision of their professors. The brochure "Climate Protection and Climate Adaptation in Agriculture" was published and co-financed by Bio Austria Kärnten. One of the chapters includes the results of the humus formation pilot action of Goldbrunnhof.

3. Pilot action moor management
Practical habitat management measures have been carried out. E.g. landowners were paid to remove tree and shrub cover from their moor.

4. Awareness rising regarding soil in schools

- excursions for students to the moors in the region
- compost-preparation workshops that included the topic "soil and climate change" were organised in two secondary schools.

All outcomes of the project were summarised in a project booklet. Several local newspapers reported on the entire project or about some special activities. The project won the Energy Globe Award of Carinthia in the "air" category and was nominated for the Austrian Energy Global Award.

Transferability and applicability to best soil management practice

The project has produced knowledge and know-how on humus management that is transferable virtually to any rural area apart from farmland at higher altitudes.

Humus formation is most effective on cropland. For that reason, the proportion of cropland compared to the entire agricultural land should be high. This is the most important pre-condition for a successful transfer of this activity. Generally, it is challenging to get conventional farmers interested in innovations. For that reason it brings a great advantage if some farmers in the project region already practice soil protective measures (e.g. farmers who practice less till farming or organic farmers) because normally farmers are more open to learning from other farmers who live in the neighbourhood and are often not receptive to guidance from external experts.

In many rural areas in Austria, establishing composting of municipal organic waste by farmers is difficult and requires use of state-of-the-art equipment. In some regions in Austria, organic waste composting is centralised in large technical plants that are not suitable for small scale decentralised composting by farmers as was demonstrated in the project. Such areas may exist in other Alpine countries as well.

Environmental and climate change impact

The demonstration of soil related CO_2 reduction measures was the main target of the project. The key focus of the project was to demonstrate humus formation on cropland by using the compost from municipal organic waste as a carbon source, and, in this way to utilise soil as a carbon sink.

Additionally, reducing CO_2 emission from degraded moors was another important activity aiming to combat climate change.

Photos / illustrations / maps

Figure 43: Typical intensively prepared arable land with low humus content. The soil has formed a crust.

Figure 44: Land on moor site (drained). This soil emits up to 40 t CO_2 per hectare and year.

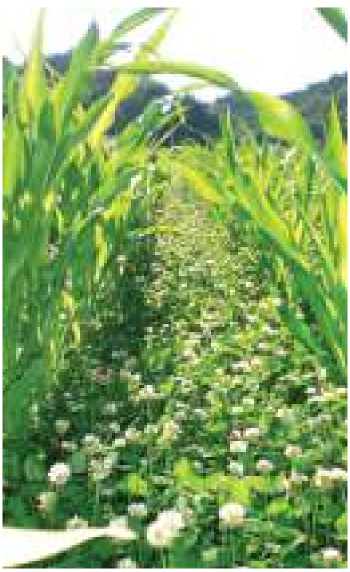

Figure 45: No till organic arable land with permanent green cover. Conservation tillage and promotion of soil life is crucial for successful humus formation.

Figure 46: Humus formation workshop for local farmers at Goldbrunnhof professional school for farming in Völkermarkt.

CS13.
Database on Land Use Management in Lower Austria

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Country, Region:	*Austria, Lower Austria*
Organisation:	*Provincial Government of Lower Austria (Department of Spatial Planning)*
Sector:	*spatial planning, land use management*
Land uses:	*building land, agricultural land*
Main soil threat:	*soil sealing*
Key soil ecosystem services:	*All services are threatened by soil sealing.*
Summary:	*Municipalities and provinces in Austria face an ongoing challenge of soil sealing — a situation that is further exacerbated due to a lack of information about the potential and availability of land and unexploited areas. In this ongoing project, an inventory of available land and associated contact persons is being developed, in order to understand the current status quo and to contribute the data needed in the creation of a database for land use management. An important outcome will be more effective and sustainable spatial planning - specifically a reduction in soil sealing.*
Keywords:	*land use management, database, stock taking*

Background and description of the problem

On one hand, soil sealing is a major problem in Austria and its limitation is a challenge for stakeholders especially in municipalities and federal provinces. On the other hand, municipalities often know far too little about the potential of land or unexploited areas. There is a lack of information on the status of availability of these sites. Structural vacancy, brown fields, vacant lots, and derelict land are just a few other relevant keywords here. To combat the problem, a first step to be undertaken is a systematic inventory-taking of the status quo. This is what the unit of spatial planning of the Provincial Government of Lower Austria has intended with the development of the "Database on Land Use Management" project.

Expected improvements / contribution to better soil management

Municipalities collect data on land use so that the potential for internal development can be utilised from the very start. By getting a bigger picture of the status quo, internal development is possible. As a next step, the municipality gets in contact with land owners to get information about their ideas for their land and buildings.

This tool is a key instrument to realise the planning principle of "internal development before external development". One major aim is to avoid soil sealing. The planning tool is free of charge and available for any municipality in Lower Austria.

Stakeholders and knowledge transfer

Target groups are mayors, heads of offices, employees in public administration and local resident groups in general. The database was tested by four pilot municipalities and there were also workshops aimed at gaining even more experience from these pilot projects.

The unit of spatial planning of the Provincial Government of Lower Austria developed the project and is in contact with the interested parties.

Data and methods

The project started in 2014 and is still ongoing. There is no information on costs.

There are three main steps:

1. Discover the potential of internal development and
2. Get in contact with the owners of land and buildings
3. Monitoring

For further information:

https://www.raumordnung-noe.at/index.php?id=520

https://www.raumordnung-noe.at/fileadmin/root_raumordnung/gemeinde/oertliche_raumordnung/planungstools/Folder_FMD.pdf
(only German version available)

Results

The outcome is a database (MS Access Database) with collected information on available land and contact persons.

The Database was tested in four pilot municipalities and users gave positive response to the database.

The “Database on Land Use Management” project is not only about land use management and prevention of soil sealing, but it also aims at enhancing the appeal of city centres, enhancing liveability in the municipalities and, last but not least, helping to reduce community charges. These are important issues for community stakeholders who can function as multipliers and reach a broad audience with these topics.

Transferability and applicability

The approach can easily be replicated and applied in other regions and states. Lower Austria also developed this database following a project on land use management in Bavaria.

- Important fact: land use management is part of the every-day planning process and will not be completed on a specific date. This also means: The database must be updated on a regular basis.
- Intensive communication with local communities and awareness-raising are key factors at all stages.
- The project leader drafted a decision about the adoption of the database as an instrument for long-term planning for the municipal council. (further information: http://www.raumordnung-noe.at/index.php?id=520)
- In case there is an external person who is in charge of spatial planning concepts for the community, the database must be explained to them and used as basic information for the next planning stages.

The database can also be an instrument for inter-municipal cooperation.

Environmental and climate change impact

Measures like brownfield development or reactivation of vacancies have a positive effect on climate change. Internal development causes shorter distances and reduces the need for motorised private transport. Other positive effects are the conservation of resources and, of course, soil conservation.

Photos / illustrations / maps

The illustration on the next page (available only in German language) shows scenarios for internal development. The number of residents, residential units and energy consumption varies widely:

1. Status Quo
17 residents/hectare
35 residential units
100 residents
energy consumption of 2 megawatts per hour

2. Internal development within existing structures
100 residents/hectare
250 residential units
600 residents
energy consumption of 12 megawatts per hour

3. Terraced houses
88 residents/hectare
220 residential units
500 residents
energy consumption of 11 megawatts per hour

4. Maximum
180 residents/hectare
450 residential units
1,000 residents
energy consumption of 22 megawatts per hour

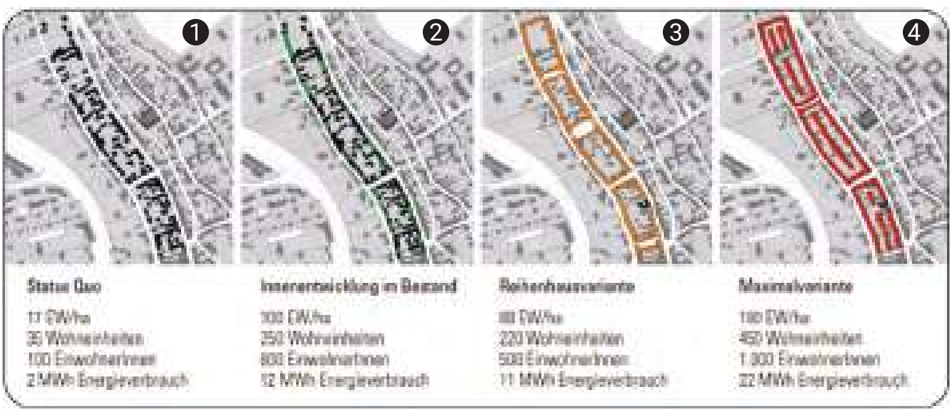

Figure 47: With information from the Database on Land Use Management, it is also possible to develop scenarios for the internal development of a municipality.
(Source: https://www.raumordnung-noe.at/fileadmin/root_raumordnung/gemeinde/oertliche_raumordnung/planungstools/Folder_FMD.pdf)

CS14.

Research for a sustainable ski-run soil management; Valle d'Aosta, Italy

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Country, Region:	*Italy – Aosta Valley*
Organisation:	*University of Turin (UniTO-DISAFA) and Monterosa Ski*
Sector:	*tourism*
Land uses:	*ski run, pasture*
Main soil threat:	*erosion, organic matter decline, compaction, nutrient depletion, loss of soil biodiversity*
Key soil ecosystem services:	*water retention (runoff control), habitat provision (biodiversity), nutrient cycling regulation, recreation*
Summary:	*With an increase in construction of new ski slopes and infrastructure throughout the Alpine region, and the associated damage to the entire soil ecosystem, this project develops a set of soil management and restoration techniques to ensure positive development of plant communities and the mitigation of ecosystem damage. Findings described relevant short, mid and long term management options and expertise, so as to support stakeholders like other ski resorts, farmers, environmental agencies, etc. in future planning and management.*
Keywords:	*soil restoration, soil*

Background and description of the problem

Tourism in ski resorts brings many benefits to a mountainous region including economic diversification and the improvement of services and infrastructure. However, as with many human activities, the development of winter sport resorts can affect the mountain landscape and environment. The growing popularity of skiing – the Alps are home to 84% of the major ski areas in the World attracting 80% of total skiers – has increased the demand for wide and levelled ski runs that enable easy slope preparation with the option of using artificial snow and snow grooming. The grading of slopes using heavy-duty machinery on ski runs and construction of related infrastructure (ski lifts, roads, buildings etc.) can have a drastic and long-term effect on the local and surrounding environment and affect many essential ecosystem services of the mountain soils. To create ski-runs, the natural landforms are often changed to level the surface, thus exposing deep soil horizons or even unweathered parent material. Thus, the original soil thickness can be reduced, often resulting in a "turbated" topsoil. As a result, the soils on ski-runs almost completely lack structure which subsequently causes problems in terms of soil compaction and reduction of water and air permeability. Erosion on ski-runs is thus enhanced. One control that is often used is artificial seeding. However, depletion of soil organic matter, reduction in soil aggregate stability, and the nutrient imbalance can affect plant development. Therefore, the chosen soil restoration and management techniques are fundamental in order to influence the level and time needed for the successful recovery of the ski courses and the rehabilitation of damaged mountain soil ecosystems.

Duration: 15 years (since 2005, before project start).

Expected improvements / contribution to better soil management

The study aims at achieving better management of soil restoration techniques that are applied during and after the machine-grading of slopes for construction of ski runs. Comprehensive information about soil is fundamental in ski run management and planning, especially when construction on a ski area is carried out at high altitudes where the environment and natural setting are much more fragile. The presence of rare soils that are fundamental for unique plant species should influence the land use planning and the choice of the most appropriate ecological restoration and soil protection techniques in order to reduce the environmental impact of ski run construction. Due to harsh environmental conditions, the recovery of degraded soils and thus ecosystems at high altitudes is slow. That is why sustainable ski slope management requires exhaustive and often long-term monitoring of soil properties in order to better understand recovery processes and successfully implement soil prevention and landscape restoration techniques.

Stakeholders and knowledge transfer

The Monterosa Ski resort has been hosting the study site for more than 20 years. Its staff provided information about the ski run construction and management, logistic support and contributed to the discussions and evaluation of the main outcomes. A specific focus was devoted to the management of the topsoil during the ski run construction and the benefits of applying local seeds during restoration of sites. Target groups would include other ski resorts, regional environmental agencies, national authorities, research organisations, seed providing companies, farmers, NGOs.

Data and methods

The data on the soil management techniques applied in ski run construction were collected through reviewing the literature and by interviewing stakeholders. The effect of soil restoration techniques on ski runs of different ages have been investigated using a paired-site approach. In the ski runs and in control sites a specific field campaign was organised in order to collect new data on plant cover and species composition with related root characteristics (rooting depth, root area ratio, root length, root diameter and root biomass), as well as on physical and chemical properties of the soil (total organic carbon, total nitrogen, available phosphorus, available magnesium, potassium and calcium, particle size distribution, soil bulk density and soil aggregate stability). Visual estimation of soil erosion was also quantified to evaluate the potential for soil erosion resistance/stabilisation of the restored sites.

Activities

The activities carried out in this case study were performed on four ski runs and paired sites under natural conditions along the ski runs in the Monterosa Ski resort, in the NW Italian Alps (Val d'Ayas, Aosta). The sites are located between 2,000 to 2,600 m a.s.l. with an inner-alpine subcontinental climate. The undisturbed soils are classified as Regosols, Cambisols and Podzols, developed from morainic parent material composed of calcic schists mixed with mafic and ultramafic rocks. The natural vegetation mainly consists of acidophilus Alpine grasslands and dwarf shrub heath.

The case study observed machine-graded slopes where construction of ski runs was underway and assessed the effectiveness of appropriate soil restoration techniques in short (~8 y) and mid-term (25 y). The study was conducted from the start of construction and used soil and vegetation surveys. The field surveys were carried out with the logistic support provided by the operators of ski areas and were focused on soil sampling and plant collection for further laboratory processing.

Results

In the mid-term, the soil restoration techniques applied on the ski runs (the removal and reuse of the topsoil, turf transplanting, and manuring after sowing) have led to a partial recovery of the soil properties. That allowed the establishment of a sufficiently dense plant cover in the lower and mid elevation, although after 25 – 30 years it did not reach the cover values (% of ground surface covered by vegetation) of the adjacent natural Alpine pasture at high altitude.

The results obtained in this case study contributed to the preparation of the Guidelines for sustainable soil management on ski runs (link), which can help land planners and ski area operators in selecting the best management procedures and techniques to minimise the impact of ski run construction on soil and ecosystem quality. The results obtained have been discussed with the ski resort staff operating in the ski area in order to understand their specific problems and needs. Additionally, the main outcomes have been presented in national and international conferences and published in peer-reviewed journals (see References and further reading).

Transferability and applicability to best soil management practice

The best practices which result from the case study can be transferred to other ski areas in the Alps. The obtained results will provide a foundation for best practices and guidelines for soil restoration in similar environmental conditions.

Environmental and climate change impact

In Alpine countries where ski resorts are already widespread (e.g., Italy, Austria, France), construction of new ski runs is becoming a strategic investment. They predominantly target mountain sites at higher altitudes to secure their resorts occupancy by providing guaranteed snow reliability throughout the entire season due to lesser impact of climate change. Soils at high altitude are extremely fragile and vulnerable to degradation, therefore a particular attention should be paid during the ecosystem restoration. In parallel, there is a growing trend of ski slopes abandonment at lower and mid altitudes due to reduced snowfall caused by climate change. The recovery of soil and vegetation on previously machine graded slopes is difficult to predict even decades after abandonment. In some cases, due to poor recovery rates of vegetation and soil properties even after they have been abandoned for several decades, active restoration of disturbed sites is required.

Photos / illustrations / maps

Figure 48: Plots for the vegetation survey along the ski runs. Photos: Csilla Hudek

Figure 49: Vegetation and soil surveys along the ski runs. From top to bottom: plot for the vegetation survey, a topsoil sampled along the ski runs. *(Photos: Csilla Hudek).*

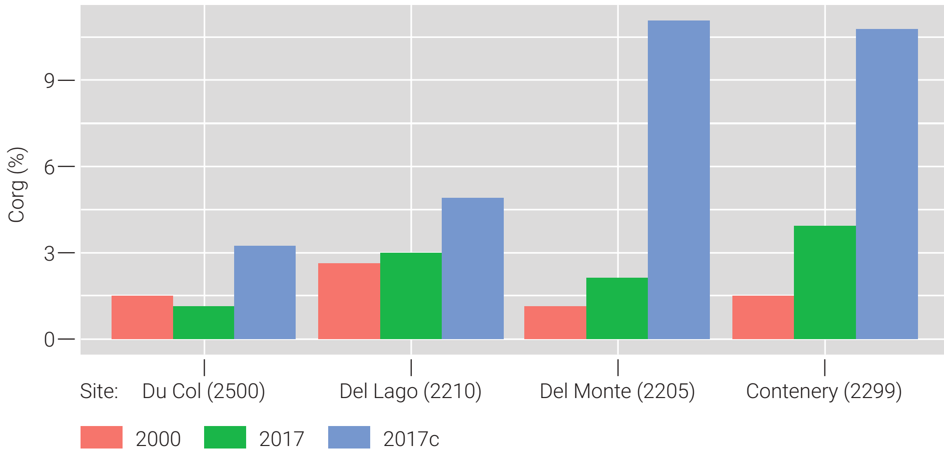

Figure 50: Soil organic C concentration (%) in the 4 ski runs. The mean altitudes are indicated in brackets (m a.s.l.). The different colours represent the organic C concentration (Corg %) in the topsoil in 2000 and 2017, in the latter case both in ski runs (2017 – green) and undisturbed/control sites (2017c – blue).

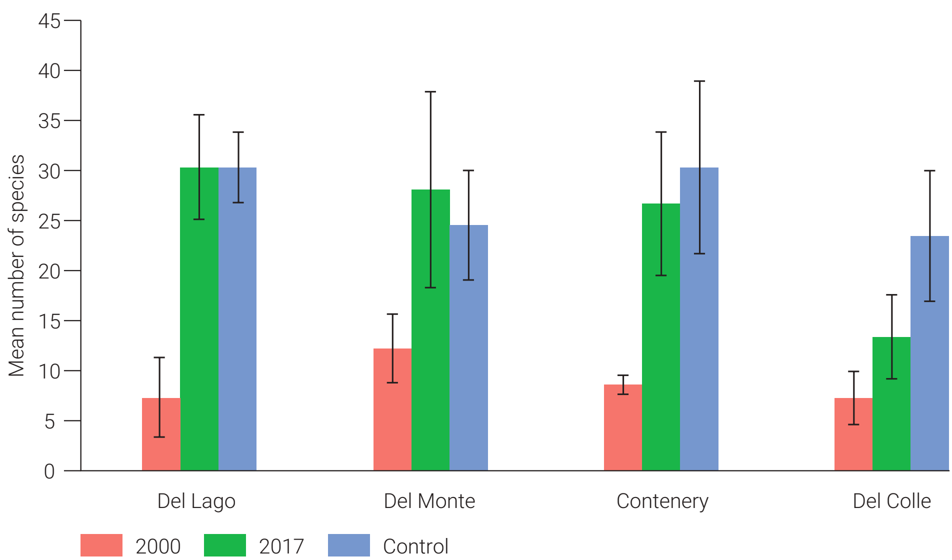

Figure 51: Mean number of plant species on the four machine-graded ski runs in 2000 and 2017; in the latter case both in ski runs (2017-green) and undisturbed/control sites (Control). Bars indicate standard deviations.

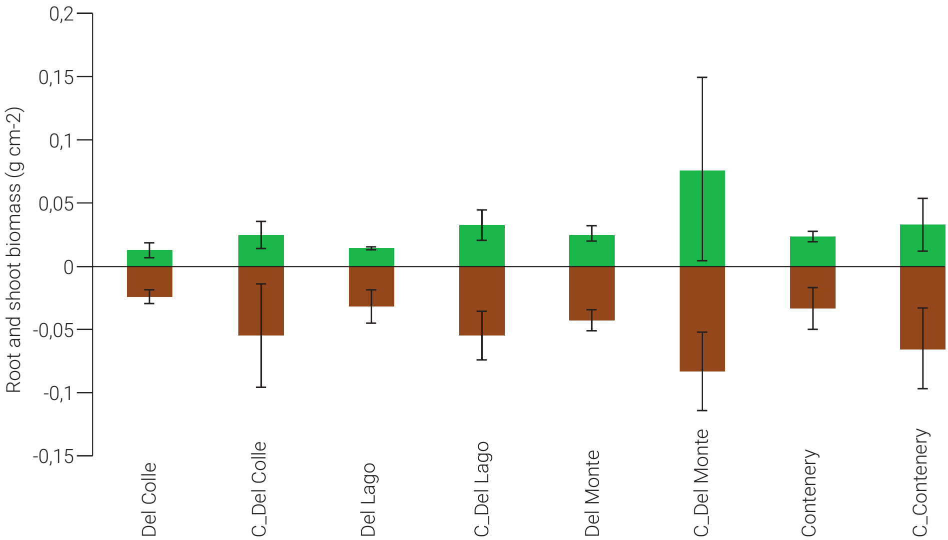

Figure 52: Average root and shoot biomass of the four machine-graded ski runs and their corresponding undisturbed control sites (C_). Positive values (green colour): aboveground biomass; negative values (brown colour): belowground biomass.

References and further reading

Publication in national media:

Hudek C., Barni E., Stanchi S., D'Amico M., Pintaldi E., Freppaz M (2017)
How high-zone restoration of machine-graded ski runs affects ecosystem properties in the mid and log-term. Convegno Società Italiana della Scienza del Suolo. Firenze, 5-7 December 2017.

International:

Hudek. C., Barni E., Stanchi S., D'Amico M., Freppaz M (2018)
Plant Functional Traits and Soil Properties of Machine-Graded Ski Runs over Mid and Long-Term Site Management. 10th Symposium of the International Society of Root Research.
Israel, 8-12 July 2018.

Scientific journals:

Pintaldi E., Hudek C., Stanchi S., Spiegelberger T., Rivella E., Freppaz M (2017)
Sustainable soil management in ski areas: threats and challenges. Sustainability, 9(11), 2150; doi:10.3390/su9112150

Hudek C., Barni E., Stanchi S., D'Amico M., Pintaldi E., Freppaz M
Plant Functional Traits and Soil Properties of Machine-Graded Ski Runs over Mid and Long-Term Site Management. Submitted.

CS15.
Environmental management of the Skilifte Lech

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Country, Region:	*Austria, Vorarlberg Austria, Vorarlberg*
Organisation:	*Skilifte Lech Ing. Bildstein GmbH*
Sector:	*ski resort and (nature) tourism; reconstruction and conservation*
Land uses:	*agricultural land and forest, infrastructure*
Main soil threat:	*erosion, compaction, sealing, loss of biodiversity*
Key soil ecosystem services:	*protection forest, biodiversity, (nature) tourism, recreation area*
Summary:	*Tourist land use in the Alpine region has a major environmental impact on the Alpine environment leading to issues like erosion, compaction, sealing and loss of biodiversity. With a focus on both sustainable environmental management and tourist use, this project aims to promote and develop methods and procedures to be included in Skilifte Lech's existing environmental programme, and to be promoted throughout all business divisions. The anticipated activities include as follows: infrastructure development using minimal logging, demarcation of wildlife areas, and the preservation of sufficient snow cover through snowmaking. A desired result is the renewal of the EMAS certification.*
Keywords:	*erosion, loss of biodiversity, protective forest, recreation area, Lech*

Background and description of the problem

The Alpine region enjoys great popularity with summer and winter tourists. This means the touristic land use, such as the development and connections with ski areas, represents a major burden on the Alpine environment. Known problems concerning soils are erosion, compaction, sealing and loss of biodiversity.

The Skilifte Lech Ing. Bildstein GmbH (SLIBG), a service provider for summer and winter tourism and operator of one of the largest ski areas in Austria, focuses on a sustainable and careful environment management parallel to tourist use of their facilities by promoting and developing methods and procedures for securing the indigenous, high-alpine flora and fauna and to conserve soil and landscape. For the SLIBG, ecological aspects in addition to economic aspects, are major criteria in making business decisions.

Expected improvements / contribution to better soil management

Goals and implemented measures / an asset for the area and the people:

- Building installations only where hardly any or as little logging as possible is necessary

- Making buildings and (lift) stations fit the landscape.

- Logging and making changes to terrains for ski slopes only to an absolutely necessary extent, and adapting them to the surrounding area.

- Measures for protection of slopes and embankments; since 2008, the company Skilifte Lech is also active in farming and manages of about 48 hectares of private land and leased, no longer managed "problem areas". On the "Schottenhof", an innovative farm operated by the SLIBG, live more than 30 Scottish highland cattle, which secure the steep areas against sliding of snow and erosion by grazing. The Schottenhof is visited by many farmers and authorities from all over Austria.

- Working towards a healthy tree population and conservation, as well as rehabilitation of the protection forest; in the forest management reforestation and fertilisation with helicopter and organic fertilisers is used with advice from public and private research institutes.

- Consideration of the geological and hydrogeological situation when implementing projects.

- Preservation of natural plant diversity, site-specific greening and planting, since the late 1930s. Methods for the restoration of vegetation cover after earthmoving works have been developed. Additionally, the renaturation after earthmoving works includes the maintenance of an orderly water balance, the use of native seeds, taking into account the geological conditions, altitude and exposure. The first batches of native seeds, which were compiled by Univ. Prof. Erwin Lichtenegger, were co-financed and used by the SLIBG in combination with wild-type vegetation and organic fertilisers for re-greening. At present, crops are planted with seed cannons/liquid seeds and seeding by hand, where necessary.

- Causing as little disruption to the natural water balance as possible when implementing projects.

- Preservation of sufficient snow cover with snowmaking, alternative possibility of closure of ski slopes on time; since 1973, the SLIBG operates snowmaking systems, currently with automated snowmaking equipment. They have a unique test bench system for measuring all the technical parameters of all snowmaking equipment on the market. For example, the snow management for slope preparation is implemented through snow depth measurement, which is based on a laser-scanned terrain model in combination with GPS data.

- For example, existing and newly collected location descriptions were used for an expert report on the time-related beginning of man-made snowmaking and the effects of many years of ski operation. In order to study the effect of 45 years of snowmaking, vegetation recordings of the study area from different years were used as indicators for no vegetation changes under natural and man-made snow layers.

- Demarcation of wildlife areas in cooperation with hunting communities.

- Economical aspect: efforts are made to reduce the negative environmental impact but with respect to economically justifiable costs.

Stakeholders and target groups

- The SLIBG supports knowledge transfer with dedicated environmentalists, farmers, institutions and scientists.

- The cooperation with agricultural partners is of particular importance.

- The SLIBG was Member of the BAUM (Bundesweiter Ausschuss für umweltbewusstes Management; Federal Committee for Green Management). The main topic in the BAUM was a purposeful eco-audit. The BAUM was active from 1995 to 1999.

Data and methods

Due to the range of measures, the SLIBG uses a variety of data sources, for example:

- A comprehensive examination of the soils and the gas exchange under the snow cover were carried out by Prof. Franz Solar.

- The SLIBG use a unique test bench system for measuring all the technical parameters of international snowmaking equipment. They also run tests for the producing industry. For example, the snow management for slope preparation is implemented through snow depth measurement, which is based on a laser-scanned terrain model in combination with GPS data.

Additional activities

The core services of the SLIBG include transport services with ski lifts and cable cars as well as preparation, maintenance and securing of ski slopes.

The company pursues a sustainable corporate policy with the following goals:

- Increasing the safety of customers and employees.
- Increasing the comfort standard.
- Optimising the working conditions of the employees.
- Protection and care of the environment.

For this reason, the SLIBG set up environmental management so that the compliance with legal requirements through special organisational measures is ensured Systematic improvements are planned, which are included in company's annual environmental programme. The efforts to promote sustainable development include all business divisions, in particular the planning of all installations and changes to terrains, the procurement, ongoing operations and the use of resources. Efforts are made to reduce the negative environmental impact with economically justifiable costs.

Part of the environmental management includes a comprehensive energy management with power limitation, CO_2 recording and use of geothermal, solar thermal, photovoltaic and heat recovery.

The SLIBG committed to the principle of waste prevention and waste reduction and takes this into account in planning and procurement. They carry out consistent waste separation across all business divisions and also offer their guests the opportunity to actively participate in environmental protection. With their activities and measures in place, they act as a model for other tourist service providers. In addition, regular training of employees in matters of environmental protection and measures to promote environmental awareness are carried out.

Results

- The SLIBG is the first cable car company in Austria which was certified according to ISO 9001 (it defines requirements for effective quality management in an organisation) and ISO 14001 (this standard specifies requirements for an environmental management system that enables an organisation to improve its environmental performance, fulfil legal and other obligations and achieve environmental objectives).

- The company was also EMAS certified in 1999 (Eco-Management und Audit Scheme, a voluntary instrument of the European Union that helps companies and organisations of all sizes and industry branches to continuously improve their environmental performance) – a renewal is planned.

For example, information boards and brochures are used for communication and information work.

Transferability and applicability to best soil management practice

The methods, procedures and results are relevant not only for other operators of ski areas, but also for dedicated environmentalists, farmers, institutions and scientists. Thus, the SLIBG actively supports knowledge transfer.

Environmental and climate change impact

At the altitude, at which the SLIBG is operating the ski slopes, the snow conditions are favourable and the collected winter data (since 1926/1927 until now at Lech/ 1,480 m a.s.l.) are constant over long periods due to the given weather conditions . The great number of sunny days during the last few summers resulted in relatively high temperatures and good conditions for summer tourism.

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https://www.zukunft-skisport.at/site/assets/files/1019/studie_lech-zurs-warth-schroecken_wintertemperaturen_schnee_g-aigner_2018.pdf

Photos / illustrations / maps

Figure 53:
Photo taken from the expert report on the time-related beginning of artificial snowmaking and the effects of year-long ski operations. It shows the location of the study area; black dotted areas: ski slopes.

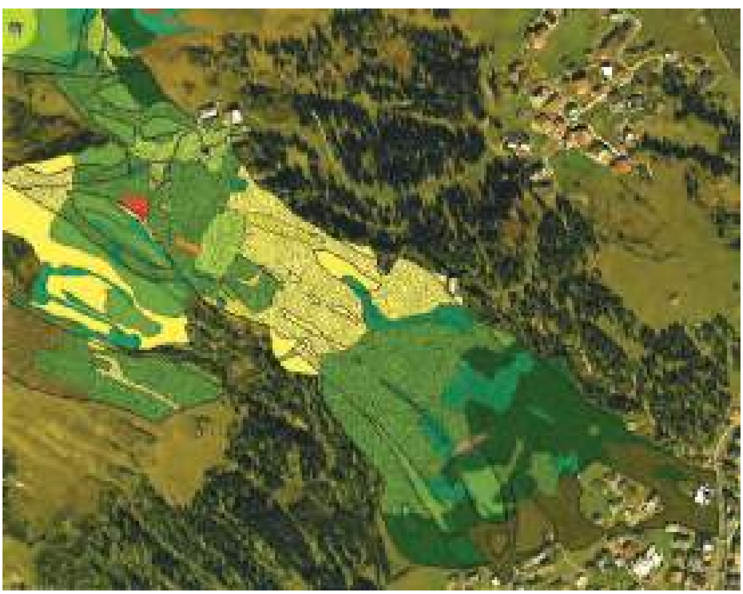

Figure 54:
Taken from the expert report on the time-related beginning of artificial snowmaking and the effects of year-long ski operations. It shows an overlap of the above specified vegetation units with the ski slopes (black dotted).

CS16.
Management practices on ski slopes Vogel and Kranjska Gora (Slovenia)

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Country, Region:	*Slovenia, Triglav National Park: Vogel Ski Resort and Kranjska Gora Ski Resort*
Organisation:	*Agricultural Institute of Slovenia*
Sector:	*agricultural ecology and natural resources*
Land uses:	*ski run, pasture*
Main soil threat:	*soil erosion, soil compaction, rapid loss of soil organic matter, decline in soil biodiversity and nutrient depletion*
Key soil ecosystem services:	*recreation & tourism, biodiversity, water filtration, carbon sequestration and biomass production*
Summary:	*Poor management of (ski) slope stability leads to soil degradation and consequently to reduction of many soil ecosystem services. Therefore, integration of soil protection on designated ski areas, considering soil characteristics, climate conditions and the best available forest harvesting operations is crucial. The available soil data and field data for Vogel and Kranjska Gora ski slopes were used to evaluate current conditions.*
Keywords:	*soil properties, soil erosion, soil compaction, ski areas*

Background and description of the problem

The area

The Vogel (78 ha) and Kranjska Gora (130 ha) ski resorts are located in the Triglav National Park, the only national park in Slovenia that covers 880 km^2 of land in the north-western part of the country, representing a total of 4% of Slovenia. While Kranjska Gora is a lowland ski resort, at altitudes from 800 m to 1,215 m, the Vogel ski resort altitude ranges between 1,535 m – 1,800 m. The natural resources of ski areas provide many ecosystem services (ESS) to the environment and to humans including recreation and spiritual services, habitat provision (biodiversity), water retention, filtration and purification, local climate regulation, biomass production and global climate regulation (the carbon cycle). Therefore, besides sport facilities and human wellbeing these areas are of high value to the environment.

The issue

In recent decades, the highlands and lowlands of Slovenian mountainous area have been dominated by winter and summer tourism, which has strongly influenced and in some areas devalued the typical highland/mountainous landscape. Loss of vegetation cover, erosion and landslides are forms of ecological damage caused by winter and summer sport activities. Construction of new ski lifts, expanding ski areas and the side effects of snow grooming machines are just few of the negative impacts that tamper with ecology of these wilderness areas in the long run (Frepazz et al., 2010). Exposing lower soil horizons by heavy machinery directly affects soil structure and leads to loss of topsoil, what causes erosion and subsequently produces landslides (Frepazz et al. 2013). A stable grassland/vegetation cover contributes to a much easier maintenance of ski slopes and a shallower snow cover is necessary for the start of the ski season (Barni et al. 2007). The success of slope greening techniques and selected plant material on ski slopes plays a decisive role, furthermore, research has shown that richness, abundance and diversity of fauna are lower in areas affected by winter recreation as compared to undisturbed areas (Sato et al. 2013). Therefore, revegetation plays an important role in the rehabilitation of damaged mountainous regions,

The administration of Vogel and Kranjska Gora ski resorts is facing major problems including water erosion, which moves, removes and flushes the surface soil mineral particles and soil organic matter (humus), nutrients, as well as in some areas, well exposed rocks (Stanchi et al. 2012). Surface runoff is primarily caused by rain, which removes soil and even coarser rock particles. At the same time, shallow grooves – gully erosion is formed in the direction of inclination of the slope, which can lead to deep erosion ditches (trench erosion). Such erosion on ski slopes, if not stopped at an early stage, has undesirable consequences and causes additional soil surface damage.

Project goals

The purpose of cooperation with Vogel and Kranjska Gora management teams within the Links4Soils project was to conduct a soil survey at both ski slopes, to excavate and describe soil profiles and collect soil data, to review soil types and detect soil-specific soil properties, inspect the erosion hot-spot areas, and to take samples from the soil profile along the horizons. Collected information will be helpful to fine-tune existing ski slope soil management practices and contribute to better soil protection in these two Slovenian ski resorts.

Both ski areas manage the water movement with drainage canals, which is the first step towards better soil protection. Water causes soil movements, especially when the vegetation layer does not protect the soil; it is therefore important to make more efforts to prevent the soil from being flushed away. The main objective of the Slovenian ski-area management case study was to find and propose practical solutions and provide soil protection management guidance for future soil protection to reduce erosion damage in both ski resorts.

Expected results

The main objective of this management guidelines is to prevent erosion of soil particles and organic matter and loss of nutrients (mainly N, P and K) to the emerald river Sava Dolinka in Kranjska gora, and by this contribute to crystal clean waters, an important water course known for high biodiversity, as well as to groundwater in the valley, used as a source of drinking water in the area. An important problem for both ski resorts is also the restoration of grassland on ski slopes to prevent topsoil from being flushed away, which is a long-term monitoring process. We hope that the recovery of vegetation will be a visible step forward in the next few years.

Soil restoration measurements are often a "long-term" process, especially due to season dependency, considering the conditions at higher altitudes. The aim of the Links4Soils project in relation to Slovenian ski resorts is to find solutions for better soil management and mitigation of erosion. It is of great importance to maintain good soil practices in the Triglav Natural Park and to protect this natural environment, despite the ski industry, which undoubtedly has several economic benefits for local people as well as social advantages for tourists visiting the area. During the project, the cooperation between the Agricultural Institute of Slovenia and Vogel and Kranjska Gora Ski Resorts has been strengthened.

The other objective is also to raise awareness on sustainable agricultural practices, in particular grazing of animals. The practices of soil management guidelines will contribute to soil biodiversity, above ground biodiversity and improvement of the organic matter content that is important in higher altitude conditions due to slower litter decomposition. Higher organic matter content also mitigates drought in the summer time, especially if the slopes are not overgrazed.

Topography and soils of Vogel and Kranjska Gora

Parent material on both ski resorts was derived mainly from carbonate rock (dolomite and limestone) as well as non-carbonate parent material. Consequently, two types of soil types have developed in Kranjska Gora area: Lithosol, Renzic Leptosol and Chromic Cambisol on carbonate parent material and Dystric Leptosol, Dystric Cambisol, and rarely Mollic Leptosol on non-carbonate and mixed parent material. Limestone and dolomite slopes are represented on more or less inclined slopes and fans, interwoven with Eutric Cambisol, Chromic Cambisols and spotted with Calcic Cambisol. Beech and spruce forests grow here, and along the forest line, which is lies at a height between 1,600 and 1,800 m, we can find Alpine *Pinus mugo*. In the highest regions, peaks, ridges and steep slopes, Lithosols have developed where *Salix alpina* grows with the association of *Carex firma* with *Thlaspi cepeaeifolium* and the association of *Gentiana terglouensis* with *Papaver alpinum* (Kutnar et al. 2012).

Figure 55: Vogel's Ski area slope at higher altitude: predominantly Lithosol and shallow Leptosol with discontinued grass cover.

The soil and vegetation characteristics of areas are factors that influence the degree of soil erosion. Due to the exceptional geomorphological variations and different types and depth of soils on both ski areas, all forms of erosion including larger surface mass displacements can occur, namely landslides, rockfalls, and debris flows.

Figure 56: Left) Gully erosion on Eutric Cambisol in an early stage; and Right) erosional gravel fan-shaped deposit eroded to foot-slopes; both Kranjska Gora ski areas.

Figure 57: Covering a ski slope that is almost without soil with wood-chips – an initial activity towards gradual restoration of grass cover; Vogel ski area.

Figure 58: Construction to prevent erosion, gravel and soil sliding in Kranjska Gora ski area.

Stakeholders and knowledge transfer

The Kranjska Gora and Vogel Ski Resorts are important stakeholders in the Links4Soils project. Both are among the most popular Slovenian destinations for winter and summer tourism, and from the environment protection aspect this is considered an ecological burden for this Alpine region. Nevertheless, both stakeholders are interested in adapting, transferring and integrating concrete land management practices in order to mitigate the impact of skiing (and hiking) tourism on the soil.

Data and methods

The Agricultural Institute of Slovenia research team examined both ski resorts in October 2019, where standard soil sampling and analysis (pH, soil organic matter, C, N, C/N ratio, K_20, CaO, P_2O_2, physiological activity of P_2O_2, K_20, soil skeleton) and visual evaluation (horizons' depth, vegetation, land use, erosion, surface fluxes, soil biota, etc.) were carried out. We indicated the soil parameters and general soil and site conditions to determine the performance of soil functions. Both ski resorts have a typical Alpine climate (relatively harsh with cold winters and short summers), maximum rainfall in autumn and the clearest days in late winter and early spring, with the thickest snow cover in February and March, and an average annual precipitation (between 1990 – 2019) of 1,700 mm in Kranjska Gora and 2,900 mm on Vogel (ARSO, 2020). The Vogel Ski Resort does not use artificial snowing and therefore depends from natural conditions. The only part where they produce and use artificial snow is the lower part of the Vogel ski area (the last 5 – 6 years), while the Kranjska Gora ski area, situated at the significantly lower attitude, has in the last decade mainly depended on artificial snowing. The ski season lasts from approximately December to the beginning of May, while in June the first animals, manly sheep, goats and cows, are brought for grazing. When there are no animals, the surfaces are mowed and hay, along with wooden chips, is used for covering bare soils. But even these measures are not sufficient to stop soil erosion, and prevent further formation of water gullies, as well as general soil degradation and slope damage.

Results

The management of Kranjska Gora and Vogel Ski Resorts have been for many years faced with problems of slow soil genesis and continuous grass cover on ski slopes, increasing soil erosion and land sliding. The managements are looking to check the existing ski slope management practices and, where possible, to improve them. As found out, they were seeking some additional practical advice – a second opinion, on how to address problems in practice and focused to specifics of soil types present in ski areas.

Figure 59: a) Shallow and organic matter rich Leptosol, developed on coarse limestone gravel.; Vogel; and b) Rendzic Leptosol developed on fine dolomite fan, moderately antropogenised due to ski slope management; Kranjska Gora.

Figure 60: a) Shallow and organic matter rich Chromic Cambisol, developed on bouldery limestone parent material; Vogel; and b) anthropogenised Eutric Cambisol, disturbed (mixed) due to levelling of ski slope; Kranjska Gora.

We were able to inspect both ski slopes within the Links4Soils project, which will be the basis for a review of existing practices and further collaboration to prepare sound soil protection and erosion mitigation management protocols over the next few years. By doing this, Vogel and Kranjska Gora Ski Resorts will gradually improve landslide stability, restore grassland where possible; improve the biodiversity of slopes and more importantly improve topsoil erosion and other soil degradation processes.

An important but, on the first hand, not apparent result of the Linsk4Soils project was the increased focus of importance of soil diversity and soil ecosystem services in both areas as well as needed adaptation of slope management that meet soil specifics. Namely, so far, the slope management was focused to stop mass displacement and grass-cover maintenance. Other soil ecosystem services were not considered.

Transferability and applicability to best soil management practice

The management guidelines will be a case example that will call out to better soil management also on other ski areas in Slovenia. Both ski resorts were willing to share their knowledge on their problems in practice, and in addition we were able to acquire information that will help us with the preparation of our guidelines. What is important, both ski slopes have different soils, different topography, parent material that requires tailored management guidelines – case-by-case tailored approach in designing soil management and protection practices.

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CS17.
Managing ski area Schmitten (Austria)

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Country, Region: *Austria, Salzburg*

Organisation: *Schmittenhöhebahn AG*

Sector: *cable car company*

Land uses: *180 ha ski slopes, 28 cable cars and lifts*

Main soil threat: *ground stability and erosion*

Key soil ecosystem services: *ecological ski piste management*

Summary: *Knowledge of geological and geomorphological conditions of ski areas, such as slope stability, regenerative capacity, soil erosion, and growth rate, is imperative in determining the negative environmental factors that must be rectified. Recognising the increasing negative effects of the climate change on soils, this project launched a vegetation and soil-related inventory, which led to an action plan and subsequent implementation over a five year period, thus renewing the EMAS certification of the ski areas — an EU accreditation for organisations that have evaluated, reported, and improved upon their environmental performance.*

Keywords: *ski resort, ground stability, erosion*

Background and description of the problem

Negative environmental effects that are related to soils in ski areas mainly concern ground stability and erosion – issues that can lead to damage and liability problems, as well as negative effects on groundwater. The geological and geomorphological conditions of a ski area therefore play an important role, as does its formation history. These factors allow inferences to be drawn regarding:

- slope instability or stability
- the sites' regenerative capacity
- growth rate
- potential consequential effects following construction measures (e.g. grading)

Information on soil formation is important to assess the regenerative capacity of the sites and to evaluate potential restoration options. Aspects of soil protection have gained significance in Europe thanks to the Environmental Liability Directive. The protocols of the Alpine Convention – in particular the tourism protocol – also focus on sensitive sites. Regarding ecological stability and naturalness, past construction measures conducted in connection with winter sports, such as grading or clearing, play a decisive role.

A survey of the construction measures conducted in the ski areas carried out in the past is a part of the important basic data. Depending on the intensity of the construction measures, machine-graded pistes can exhibit:

- altered soil drainage properties
- altered soil structure
- modified plant cover
- modified fauna in the soil

Expected improvements/ contribution to better soil management

The consideration of environmental conditions, especially soil and vegetation, is an important element of an environmental management system for ski resorts. In this case the ski-resort Schmittenhöhe-Bahn was EMAS certified and in this context the situation on the slopes was analysed in detail and improved in form of a detailed action plan.

Stable soil conditions and vegetation are important for the provision of stable pistes in winter, they reduce the need for summer management and improve the aesthetic quality for summer guests as well. The positive effects also extend to the agricultural use in those parts of the slopes that are still in agricultural use.

Stakeholders and knowledge transfer

The entire project was led by an environmental advisory board including experts with expertise from different environment-related areas. In order to scientifically clarify the value of ski slopes regarding biodiversity and nature conservation, an investigation programme started to analyse the exact value. The collection of studies on Alpine fauna, butterflies, wild bees and grasshoppers is called “Ökologischen Pistenmanagement” (ecological piste management) and can be downloaded from the website www.schmitten.at/ecology.

Data and methods

The project was started in 2013. Meanwhile the second certification has been obtained.

Costs for study, certification, training, report: approx.. €150,000

Costs for activities: approx. €100,000 (additional costs for snow depth measurement, hybrid piste devices, etc.)

The Ski auditing and EMAS certification included a detailed inventory of vegetation and soil conditions in the entire ski resort Schmittenhöhebahn. The inventory of the current vegetation in the Schmitten ski area was made at the beginning of August 2011. According to Braunblanquet (1928, 1964), the vegetation stocks were assigned to the societies or local units described in the literature Oberdorfer (1993) using lists of the characteristics of dominant species. This was followed up by an action plan and implementation in the last 5 years. Furthermore, the external evaluation and certification will be renewed after 3 years.

The soil related inventory first considered the ground covered by plants (in percent) at the time of the survey, which identified "areas without vegetation" and "areas with sparse vegetation", defined as areas with a vegetation cover of between 15–50%. In this respect, the time of the survey plays an important role. The assessment was not made in early spring, immediately after winter, but in summer (July/August). Thus, vegetation has had time to fill the gaps, and the natural regenerative capacity of the site could be deduced. Another benefit of conducting damage surveys in summer is that impacts from summer use, e.g. damage due to grazing animals or summer tourism, will already have become effective. Thus, damage due to overlapping use can also be recorded. In addition, also large-scale erosion forms such as slope cracking, slumping or soil creep were detected. These are mostly due to natural causes (geologically unstable underlays, overly steep slopes, etc.) . The affected areas were mapped during the field surveys at a scale of 1:5,000. Finally, we also analysed point-based damage. In contrast to the larger-scale forms of damage, which are mostly explained by a number of different causes (machine-grading measures, ski edge abrasion, grazing, unstable sites), the linear and point-based forms of damage can usually be attributed to single causes. Point-based forms of damage are not only differentiated by cause but also by the extent of the damage.

This inventory also included an evaluation of the naturalness of the vegetation, in order to include it later in a GIS system on vegetation and the respective forms of damage. For the detail methodological approach see Pröbstl-Haider et al. 2018 in the book "Environmental Management in Ski Areas".

Results

If an enterprise is EMAS certified the related reports describing the situation, action plans and responsibilities as well as the achieved results must be published in a brochure that is publicly available. In this case, the respective recent report can be downloaded from the website www.schmitten.at under the following link: Ökobericht 2018.

Transferability and applicability to best soil management

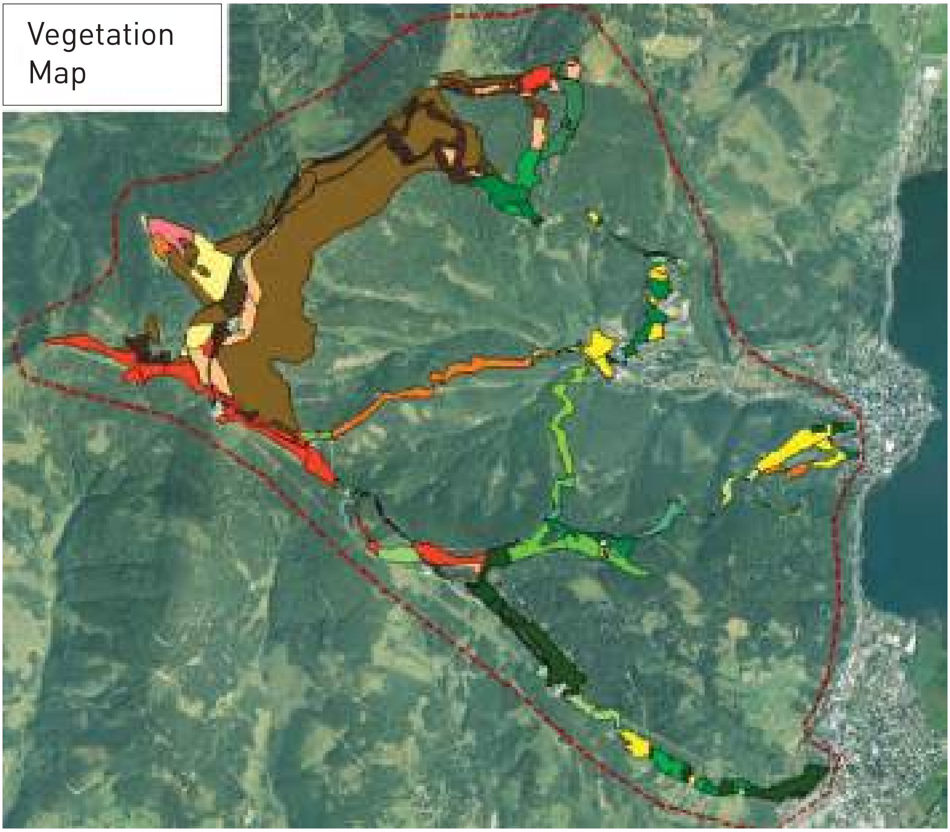
The methodological approach can be applied to any ski resort. We recommend the book which offers helpful explanations and case studies. Pröbstl-Haider et al 2018 in the book "Environmental Management in Ski Areas".

Environmental and climate change impact

A stable vegetation cover offers a good protection against erosion and damage which may occur more often due to increasing rainfall events in summer (July), which are likely to increase because of global warming.

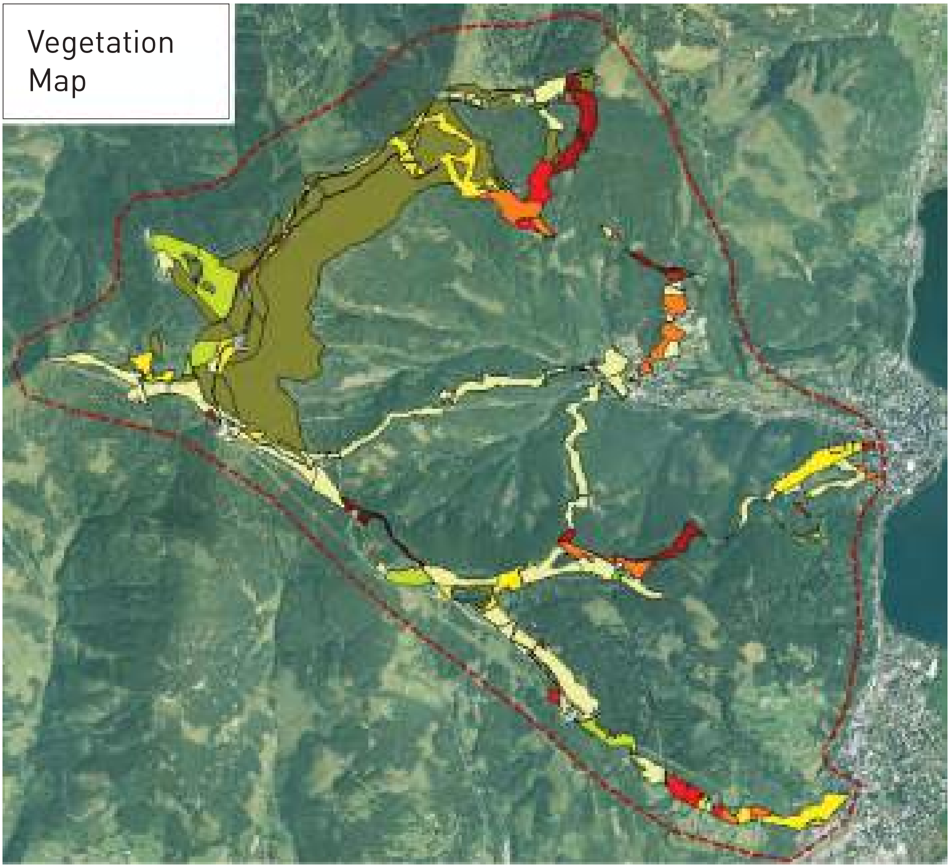
Photos/ illustrations/ maps

Figure 61: Damage related to grazing *(Photo: Ulrike Pröbstl-Haider)*



1. Red fescue-rough hawkbit meadow
2. False oatgrass meadow
3. Meadow fescue-timothy fertile meadow
4. Meadow fescue-white clover fertile meadow
5. Oatgrass meadow
6. Bentgrass mowed pasture
7. Villar's chervil-cat's ear rough meadow
8. Bushy chervil meadow
9. Cottongrass-reedgrass-bentgrass plots
10. Montane dogstail pasture
11. Rough pasture, acidic soil
12. Sea milkwort pasture
13. Subalpine-alpine matgrass meadow
14. Procession flower-matgrass meadow
15. Matgrass with alpine dock
16. Tussock haigrass-matgrass meadow
17. Wind ridge community on acidic soil
18. Alpine rose heath
19. Alpine rose heath with blanket bogs
20. Black sedge swamp
21. White cottongrass fen
22. Deergrass sloping fen
23. Cleared plots
24. Stinging nettle-butterbur shrubby plot
25. Pioneer vegetation with supina bluegrass
26. Grass seeding
27. Legume seeding
28. Oat seeding

Figure 62: Extract from the vegetation survey in the ski area Schmittenhöhe in Zell am See/Austria *(Pröbstl-Haider & Dorsch 2013)*



Classification of value (9 point scale) / Naturalness of vegetation

Value class 1 — unnatural / low value
Value class 2
Value class 3
Value class 4
Value class 5
Value class 6
Value class 7
Value class 8
Value class 9 — near-natural / high value

Figure 63. Naturalness of vegetation communities in the ski area Schmittenhöhe in Zell am See/ Austria *(Pröbstl-Haider & Dorsch 2013)*

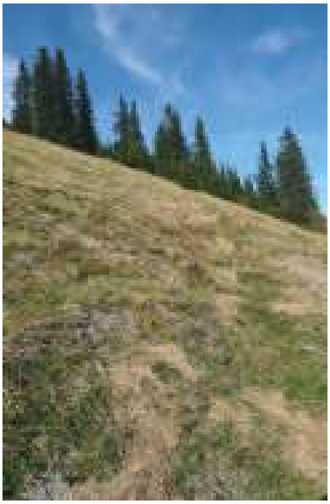


Figure 64: Damage related to mulch mowing
(Photo: Ulrike Pröbstl-Haider)

Figure 65: Damage related to skiing operation (characteristic piste groomer marks)
(Photo: Ulrike Pröbstl-Haider)

Figure 66: The documentation in the environmental declaration within EMAS was in 2017 and 2019 selected as the best one in Austria and awarded by the Ministry of Environment.

Figure 67. The environmental policies of the company, that can be downloaded at: https://www.schmitten.at/Downloads/Oekologie/2018_Oekobericht.pdf

IMPRINT

WHAT THIS IS ABOUT

Soil is the basis of Alpine ecosystems; it is a fundamental natural resource especially in the vulnerable Alpine Region. Through the sustainable management and protection of soil, we enhance the sustainable management of the Alpine environment, considerably contribute to the performance and resilience of key ecosystem services, preserve biodiversity, and ensure the well-being of humans. Soil management and protection is provided for in the framework of the Soil Conservation Protocol of the Alpine Convention, which is aimed at safeguarding the multifunctional role of soil based on the concept of sustainable development.

ABOUT THIS BOOK

In a modest way, this booklet presents seventeen soil management practices in Alpine countries: i.e. Austria, Italy, France, Germany, Switzerland and Slovenia. It reflects the diversity of soil and environmental management approaches in the area, and presents sustainable soil and nature protection management in different sectors and industries; mainly in agriculture, forestry, sports and tourism.

ABOUT THE LINKS4SOILS PROJECT

The Links4Soils project is focused on raising awareness of soils in the Alpine Region, reviewing the existing regional and national soil data, transferring knowledge and best management practices to policymakers, decision-makers, and other stakeholders, and promoting efficient soil protection strategies. Links4Soils aims to overcome existing gaps in soil-awareness, information, knowledge, and networking and to contribute to better implementation of the Alpine Convention Soil Protection Protocol.

LINKS4SOILS PROJECT PARTNERS

Agricultural Institute of Slovenia, SI (project leader) • Office of the Tyrolean Provincial Government, AT • Autonomous Region of Aosta Valley, IT • Municipality of Kaufering, Department of Environment and Nature, DE • National Research Institute of Science and Technology for the Environment and Agriculture, Grenoble Regional Centre, Mountain Ecosystem Research Unit, FR • Slovenian Forest Service, SI • Institute of Geography, University of Innsbruck, AT • Climate Alliance Tirol, AT • University of Torino, Department of Agricultural, Forest and Food Sciences, IT

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WEB LINKS

Links4Soils, an Interreg III VB Alpine Space project:
www.alpine-space.eu/projects/links4soils

Alpine Soils:
alpinesoils.eu/

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Caring for Soils
- Where Our Roots Grow