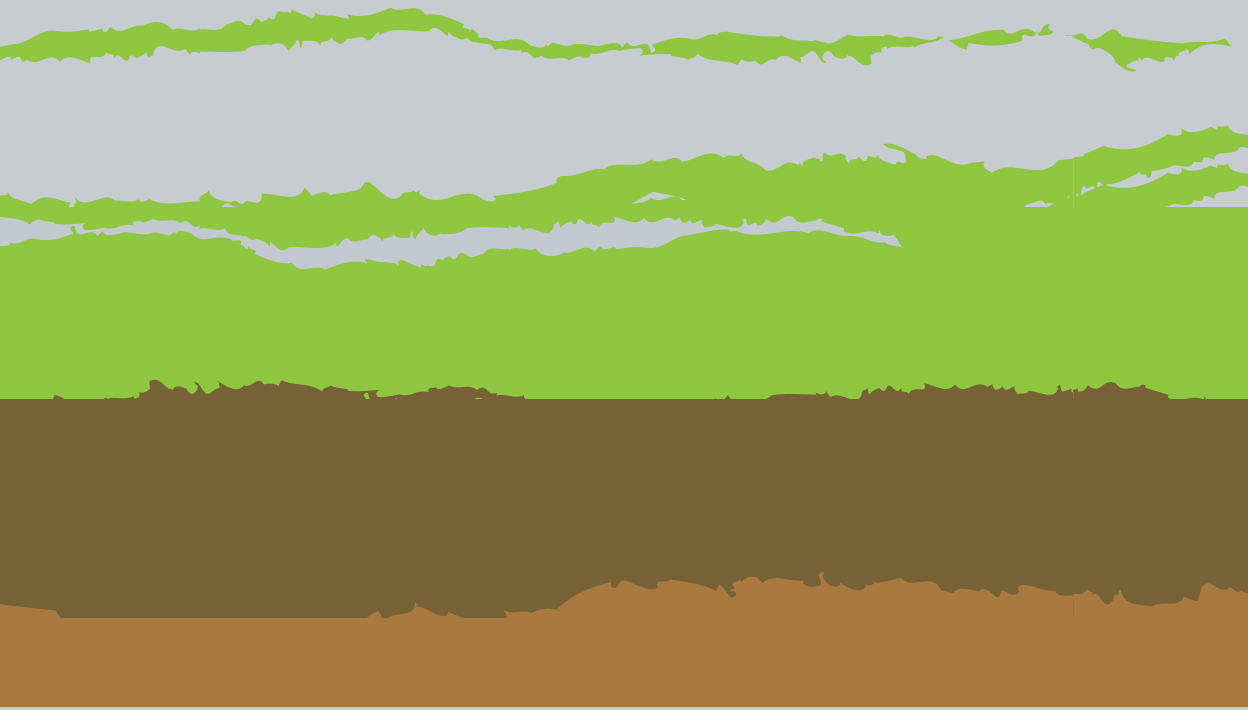
Soil management practices in the Alps

A selection of good practices - Case Study 16



Edited by · Andreja Nève Repe · Aleš Poljanec · Borut Vrščaj

Interreg Alpine Space
EUROPEAN UNION
Links4Soils
EUROPEAN REGIONAL DEVELOPMENT FUND

Excerpt from
SOIL MANAGEMENT PRACTICES IN THE ALPS
A selection of good practices for the sustainable soil management in the Alps

Project and funding
Links4Soils project (ASP399);
EU Interreg Alpine Space

WP, Deliverable
WPT3 (D.T3.5.3)

WP Lead / Publisher
Slovenia Forest Service
(Zavod za gozdove Slovenije)

Editors
Dr. Andreja Nève Repe, Dr. Aleš Poljanec,
Dr. Borut Vrščaj

Reviewers
Dr. Aleš Poljanec, Elena Cocuzza,
Sašo Gorjanc, Elisabeth Schaber,
Dr. Borut Vrščaj, Jurka Lesjak,
Dr. Michele Freppaz, Dr. Silvia Stanchi,
Dr. Andreja Nève Repe

Slovenia Forest Service, Office of the Tyrolean Regional Government, Agricultural Institute of Slovenia, University of Innsbruck, Institute of Geography, University of Torino, Department of Agricultural, Forest and Food Sciences

English review
Miha Odar

Acknowledgments
Special thanks to Mr Thomas Peham, a Links4Soils project partner and member of the EUSALP Action Group 6, who provided several best-case practices.

Layout
Alenka Šubic

Place and date
Ljubljana, April 2020

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

Free copy

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani

COBISS.SI-ID=305185024

ISBN 978-961-6605-41-0 (pdf)

Interreg Alpine Space
EUROPEAN UNION
Links4 Soils
ZAVOD za GOZDOVE SLOVENIJE
Slovenia Forest Service

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

Agricultural Institute of Slovenia:
Jurka Lesjak
Ana Čebin
Marjan Šinkovec
Klara Rekič
Jani Bergant
Borut Vrščaj
Contact:
Jurka Lesjak
+386 (0)1 2805 13
jurka.lesjak@kis.si

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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