

Soil management practices in the Alps

A selection of good practices - Case Study 3



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

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Forest soil protection and management in Prägraten, Austria

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Country, Region:	<i>Austria, East Tyrol, Lienz, Prägraten</i>
Organisation:	<i>Forest Group – Office of the Tyrolean Government</i>
Sector:	<i>forestry</i>
Land uses:	<i>forest</i>
Main soil threat:	<i>compaction, nutrient depletion, erosion, water logging</i>
Key soil ecosystem services:	<i>wood production, biodiversity</i>
Summary:	<i>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.</i>
Keywords:	<i>biomass, harvesting, compaction, Tyrol, soil management</i>



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 (Bodenzustandsinventur) 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 (Bundesforschungszentrum 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 1451/2013). 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 adaptations, 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

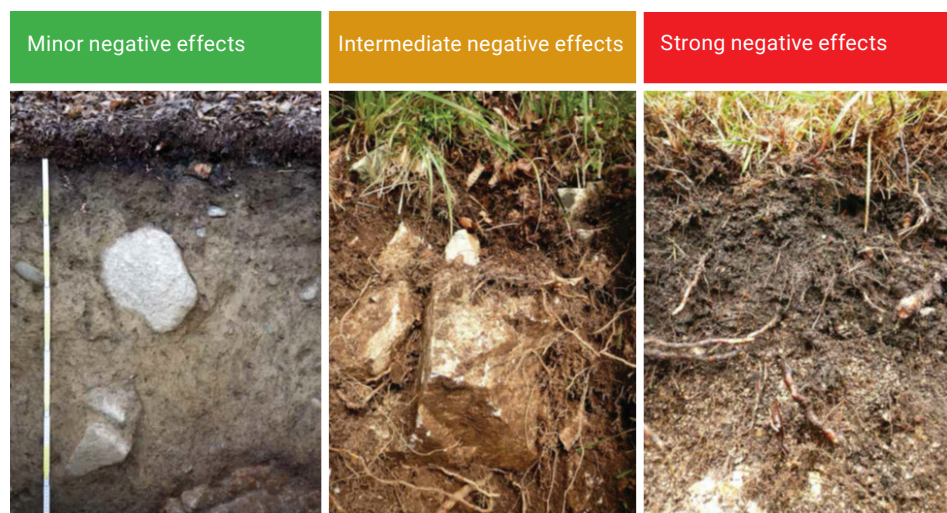


Figure 10: Typical soil profiles to be found in areas classified with classes 1, 2 and 3

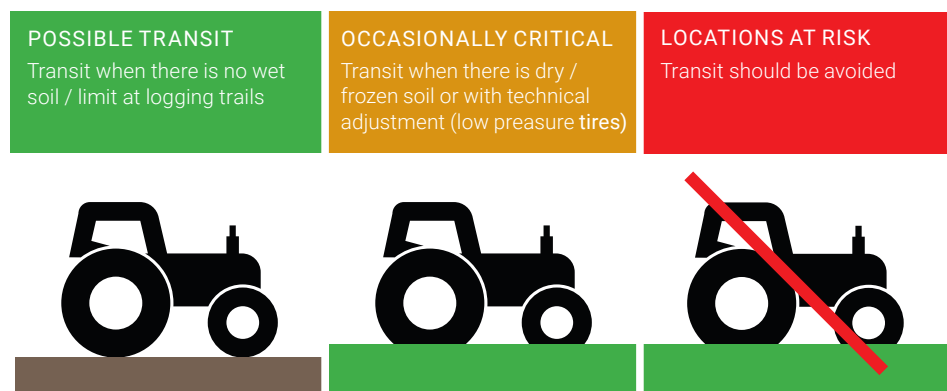


Figure 11: Technical measures for transit in areas with classes 1, 2 and 3

BIOMASS

Effects of whole-tree harvesting /
Minor negative effects



COMPACTION RISK

Effects of the transit of heavy-duty machinery
on the soil / Occasionally critical



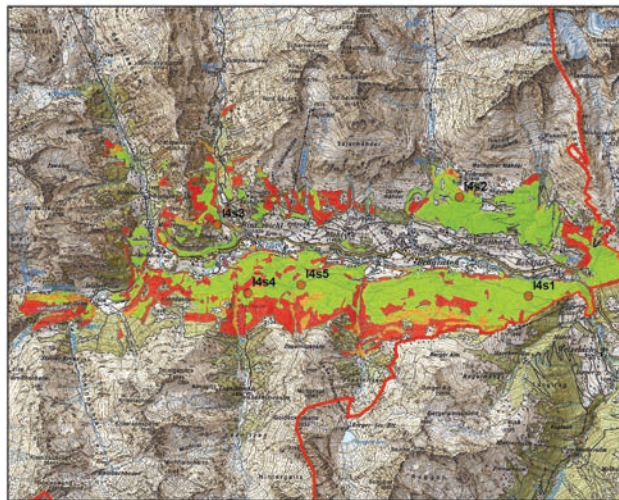
Figure 12: Examples of traffic light indicator of biomass use and compaction risk included in the forest management report.



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*).



0 0,4 0,8 1,6 2,4 3,2 Km

Forest based thematic map

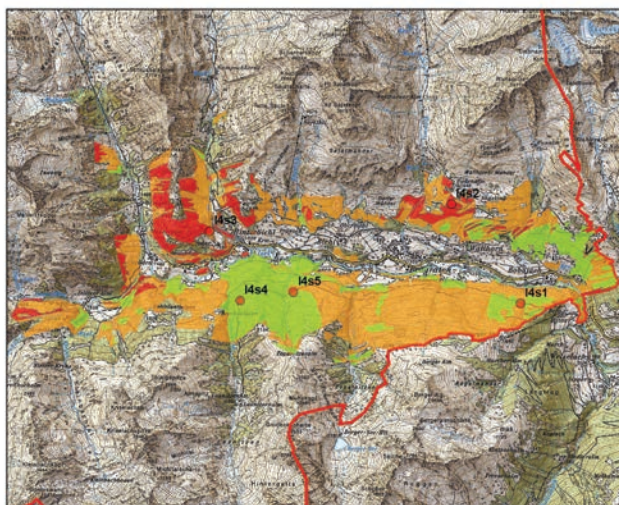
● pts_L4S

Compaction risk

□ Not Classified
 ■ Transitable
 ■ Occasionally critical
 ■ Location at risk

Figure 15:

Thematic map of compaction risk of Prägraten, based on forest types



0 0,4 0,8 1,6 2,4 3,2 Km

Substrate group based thematic map

● pts_L4S

Biomass removal

□ Not classified
 ■ 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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