Integration of soil protection best practices into management plans

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Abstract

As a result of the "Links4Soils" project, soil management guidelines are being integrated as additional supporting information for forest planners and workers into the forest management plans of Tyrol.

Management plans focus on the distribution of the tree species and their growing conditions, evaluated after activities of samples' collection and reporting in the field. The two preliminary introductive chapters describe the site and the geography of the forest community, including a paragraph on general soil characteristics.

The assignment of forest categories (protection, production, recreation functions), is an important step for defining forest plans and concepts, as well as great contribution for decision makers. Regulating the wood consumption, taking into account the forest categories, is of primary importance for the future productivity of the area. Furthermore, past site evaluations and definition of future needs help suggesting not only the total yearly amount of wood to be harvested for each forest stand, but also the necessary measures to guarantee a long term productive forest. These prescriptions are extensively reported in the following chapters of the management plans.

An important improvement was done in the frame of the project, with the recent addition of a Forest Type-based thematic map, showing the effects on forest soil nutrient availability of "whole-trees" harvesting measures. The traffic light system, refined and applied also in the project Case Study area of Prägraten, defines guidelines both for biomass use and compaction risk effects for each Forest Type. By explaining in detail the methodology for assigning traffic light categories in the Case Study area and specifying the respective measures to adopt in the forest, this report describes a substantial part of the management plans.

In the Annex, examples of two short reports summarising site, vegetation and soil characteristics are included. The short reports of the Forest Types to be found in the forest community are included in the respective management plan. The graphical representation of a typical soil type profile, developed in the frame of the "Links4Soils" project, is shown in the box "Soil Profile", supporting the model-based description of the area with further information on its soils.

Content

1 Biomass use

1.1 Biomass use guidelines integrated in Tyrolean forest management plans

Increasing attention is growing in the forestry sector for the topics of soil quality and soil sustainability, as its health highly influences the wood productivity and the provision of many ecosystem services. The optimization of soil nutrient availability, aided by the application of proper tree harvesting methods, plays a fundamental role in forests. Alpine soils especially require attention, because of the complexity of the mountainous regions, where soil is highly vulnerable while providing important ecological functions (Baruck et al., 2015).

Over the past decades, increasing amount of wood for renewable energy production has been harvested from Tyrolean forests. The uncontrolled removal of stems and branches by harvesting machinery has a damaging impact on the forest productivity, especially on the long-term. This is because available nutrients in soils for trees and plants are not only provided by weathered rocks, but they are also contained in decomposed plant material.

In order to regulate the biomass use, according to the site productivity, forest management guidelines were recently integrated into the Tyrolean Forest Management plans (O.T3.1).

Forest management plans are important output products of the Tyrolean Forest Service of the Office of the Tyrolean Government. By describing forest communities, collecting among others, details on the distribution of the tree species and general soil characteristics, it is a precious tool for supporting forest planners and workers. General forest management prescriptions are included in the plans and the wood consumption is regulated, taking into account the forest categories (protection, production, recreation functions) and the site productivity. Stands with similar potential natural vegetation and forest site characteristics (soil, climatic conditions and topography) are grouped within the forest communities into *Forest Type* units for the whole Tyrolean region (Forest Site Classification Tyrol, 2018). The *Forest Type* classification and description is a precious tool for assessing the site productivity and deciding for the appropriate forest management measures, including those for regulating the biomass removal.

1.2 Application and measures of biomass use guidelines

The biomass use guidelines are structured as traffic light-shaped indicators, where 3 distinctive colours show to the field workers if the whole tree removal for a specific area is followed by (Fig.1):

- Minor negative effects (green)
- Intermediate negative effects (orange)
- Strong negative effects (red)

The traffic light system allows us to provide a simple and direct tool to the field workers, as the colors red, orange and green show the consequences of a whole tree harvest and define the ideal behavior to adopt when harvesting biomass in forest.

The harvesting measures prescribing and allowing specific felling activities for each biomass use category are shown in figure 2, coupled with a stylised graphical representation of the tree cuts. Thematic maps available in the recently produced forest management plans show areas with red background colour, where only logs should be harvested. Only in the presence of green colour, it is suggested to harvest the whole tree, without major negative effects. The map also suggests an intermediate modified tree harvesting, with topping and partial delimbing on site, where the background is orange. The topping diameter plays an important role for maximising the amount of deposited nutrients from cuts: a study estimated the leftover biomass being 16% of the total amount, when the topping diameter of spruce was 15 cm. In this case the leftover biomass contained 38% of total nitrogen, 45% of phosphorus and 35% of potassium, which would be enough to guarantee productive soils (Göttlein, A., 2013).

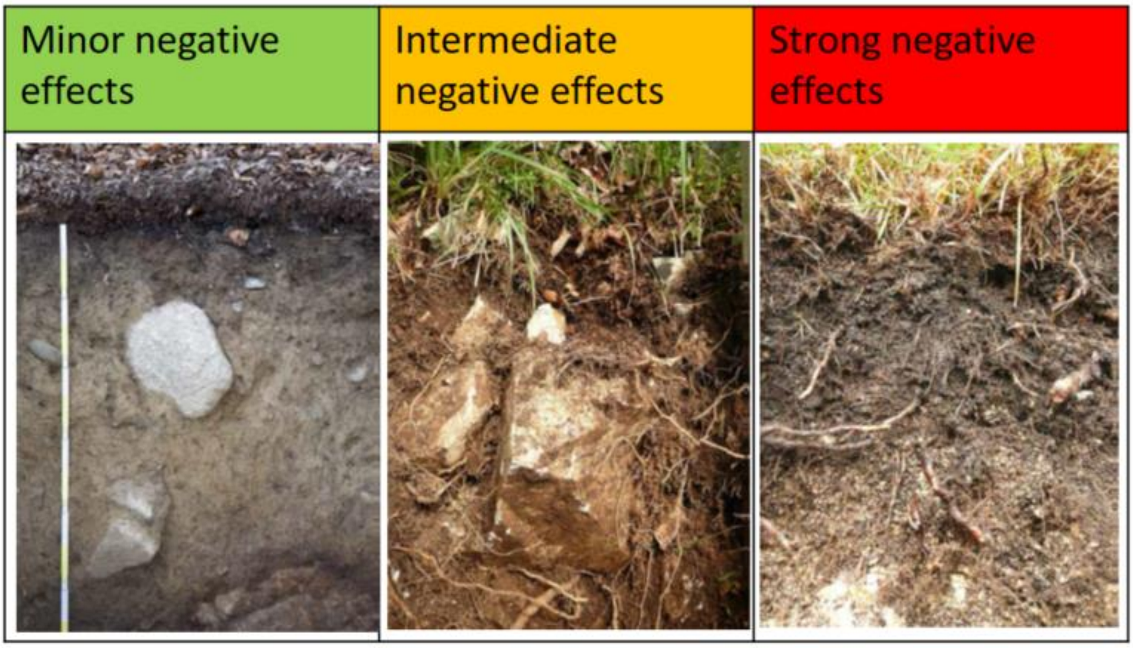

Figure 1: Effects of whole tree removal on different soils

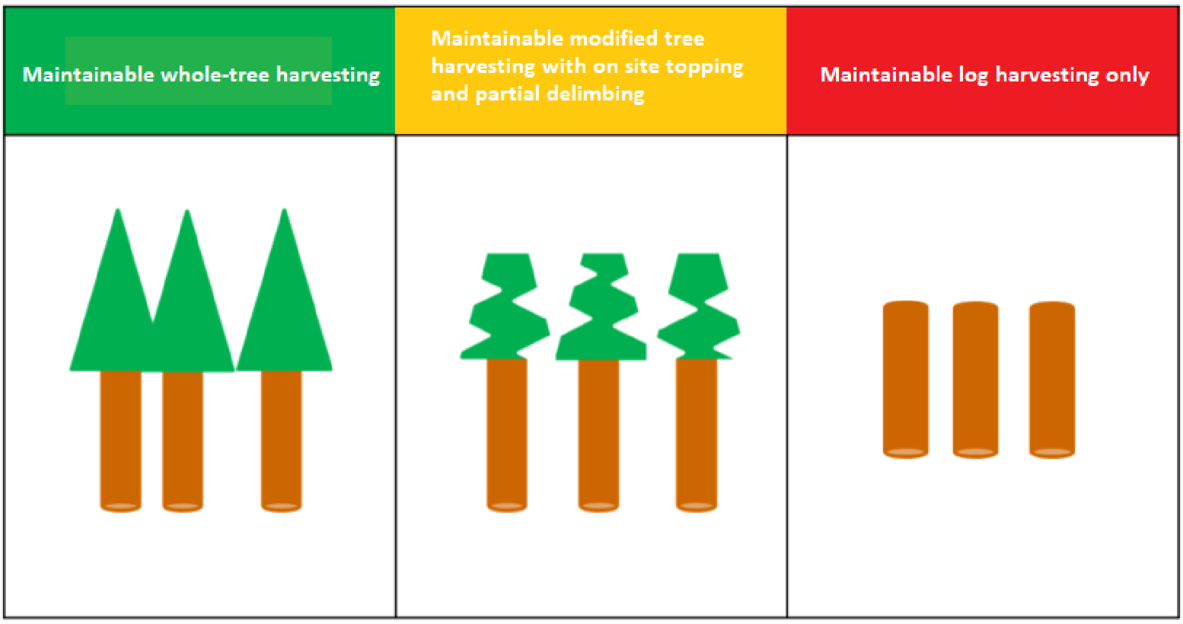

Figure 2: Suggested measures for tree felling for each biomass use category

1.3 *Forest Type* descriptions as basis for biomass use categorisation

The principle underlying the forest biomass use guidelines is to prescribe conservative measures (red colour category) in areas not favouring tree or plant growth. On the contrary, whole tree cuts should be advised on already productive sites. The model-based concept of *Forest Type* helps forest planners defining areas as more or less productive, making use of a combination of general soil characteristics, climate factors and topography, typical of each unit. Following the same traffic-light structure used for the guidelines, groups of soil types, depths, geology, coarse fragments, landforms are categorized into 3 classes (green-1, orange-2 and red-3) (See table 1). Isolating for example only the geological aspect, siliceous-carbonate material with high rate of impurities produces high nutritious soils, while *Forest Types* with most soils developing from dolomitic, pure rocks would categorize into the third category of our traffic light system (red). As some characteristics are more relevant than others when considering the site productivity, expert knowledge established case by case the weight of each parameter and defined a specific category of biomass use for each *Forest Type* unit (Hotter et al., 2015).

As an example of biomass use thematic map based on Forest Types, Figure 4 shows the map of the Municipality of Prägraten. This area is covered mostly by spruce forest, subdivided into different mountainous and subalpine types (*Fi* and *Fs* Forest Type groups). On the southern slope, the forest at lower elevation is categorised at a big extent with the two types *Fi5* and *Fi6*, which were assigned respectively colours green and red of the biomass use categories. Reason for this difference are the poorer carbonate rocks typically characterising type Fi6, together with its general low stand productivity. On the contrary, type Fi5 is characterised by an optimal moist water regime and base saturation and considered a productive Forest Type.

The information on the biomass use category is included in a database of Forest Type characteristics and retrieved when producing the traffic light box of the short one-page report in Annex 1.

The one-page report is a useful and handy tool, that forest planners and workers can easily access when working in the field. It does not only show the traffic light boxes for biomass use and compaction risk, but it also summarizes site characteristics like exposition, slope, water balance, typical soil type, parent material and bioclimatic growth regions. It also describes the productivity of the potential natural vegetation and the dominant tree species. Suggestions for natural rejuvenation techniques are evaluated based on their success rates. Risks and limiting factors are listed as final considered aspect in the report.

Table 1: General factors defining biomass use categories of Forest Types

Class	Soil Types (Ö)	Depth	Substrate: chemical-physical entities	Water regime	Coarse fragments	Climate	Slope	Land forms
1	Deep, base-rich Braunerde on loose sediments, Pseudogleye, Gleye; deep Braunlehme and clayey Braunerde	Medium – deep, deep	Calcite, highly impure (K+); siliceous - carbonate rocks, impure (C0); siliceous carbonate-rocks, highly impure (C+); carbonate - siliceous rocks, impure (M0); carbonate - siliceous rocks, highly impure (M+)	Very wet, wet, moist	< 40%	---	---	Middle-, lower slope
2	Semipodsol, base-rich medium-deep Braunerde, rich silicious Braunlehme, deep Auböden, deep, fine grain sized Braunlehm-Rendzina	Shallow – medium deep	Calcite, impure (K0), carbonate - siliceous rocks, pure (M-), mafic rocks, impure (B0), intermediate siliceous rocks, impure (I0)	Slightly moist	> 40%	---	---	Upper, toe slope
3	Ranker, base-poor shallow Braunerde, Podsol, Bachauboden, Rendzina, Gesteinsrohböden	Shallow	Calcite, pure (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)	Dry, very dry	> 70%	Cold and dry (at high elevation)	> 70%	Crest, bottom

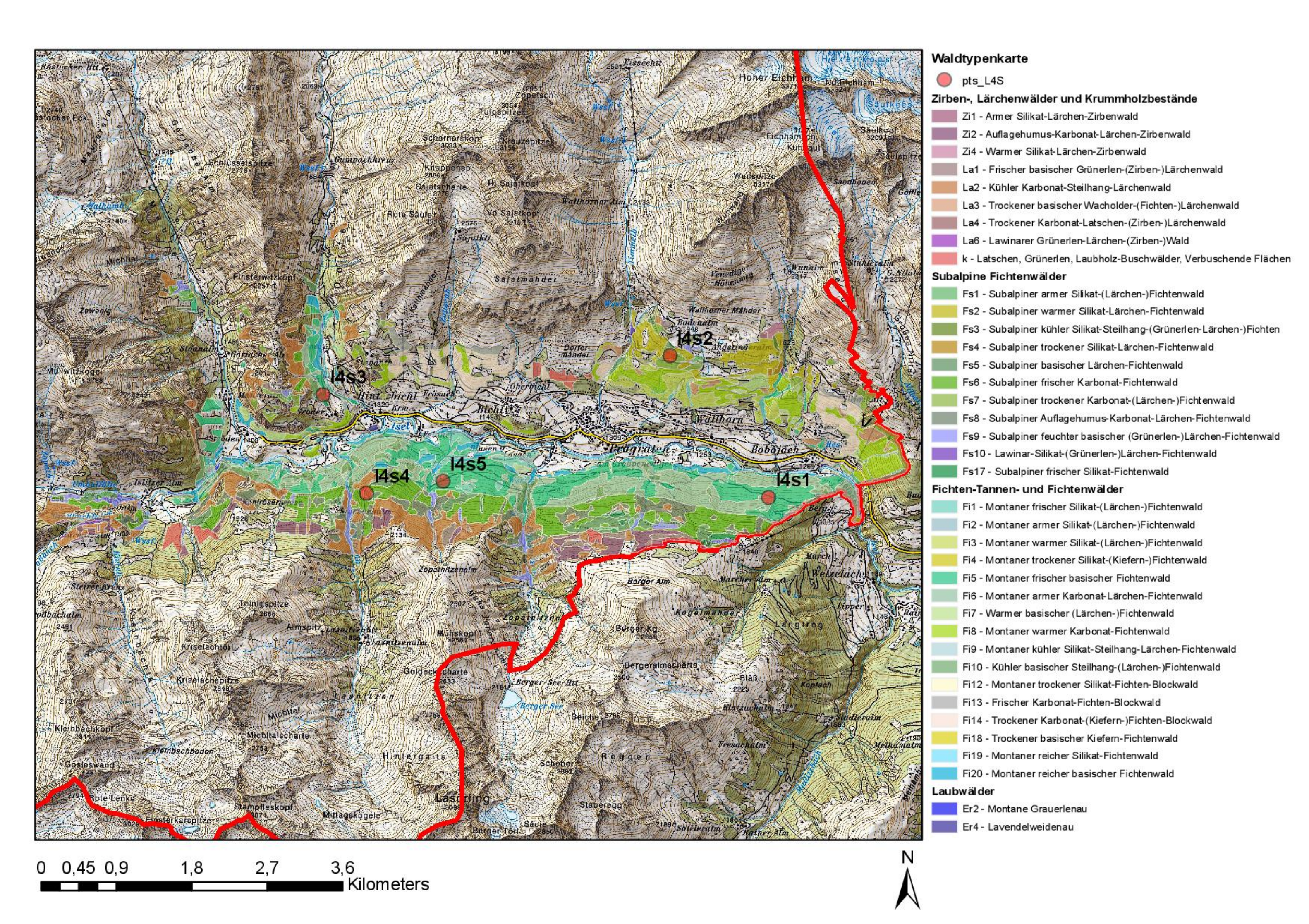

Figure 3: Forest Types map in the Municipality of Prägraten

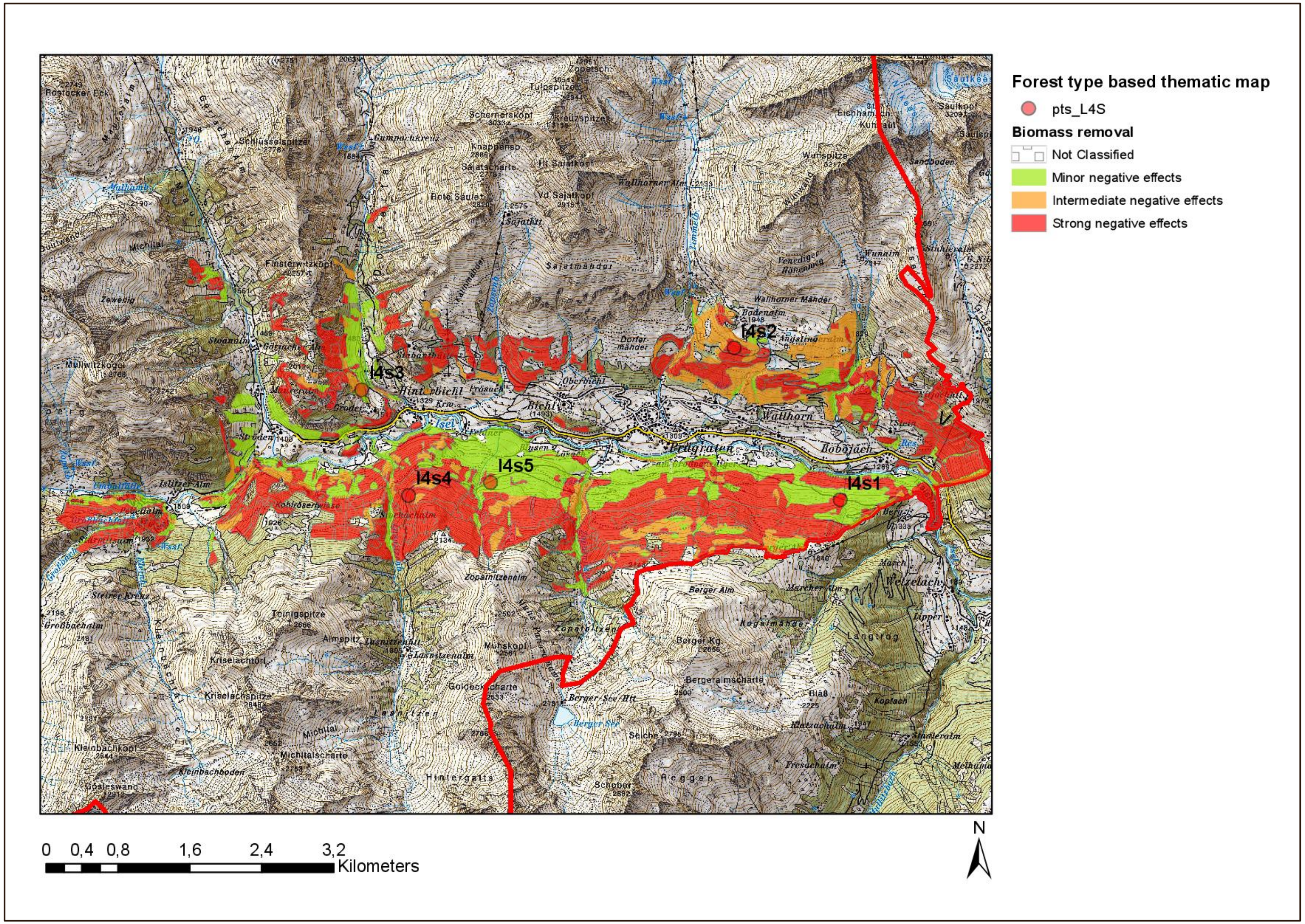

Figure 4: Thematic map of biomass use based on Forest Types

1.4 Subsolum geological substrates (SSGS) as basis for biomass use categorisation

1.4.1 Subsolum geological substrate units: categorisation and analytical approach

In chapter 1.3, we explained how forest management guidelines for biomass use are based on general soil and site characteristics modelled for each *Forest Type* unit. The model is in everyday use at the Tyrolean Forest Service and it has been regularly updated and developed over the years with the addition of newly collected field data. The recent focus was on a deeper evaluation of soil data and geological information in order to produce the guidelines.

Sub-surface geological maps and information are fundamental indicators of the site productivity, being the parent material a determining factor for soil formation and consequently, predicting chemical soil properties.

Table 2: Initials and related description for lithogenetic (EN, DE in brackets), chemical and physical entities.

Lithogenetic entities		Chemical main entities		Impurities	
Sx (Fe)	Solid bedrock	**O**	Organic material	**+**	Highly impure
Gd (Ha)	Debris deposits	**S**	Felsic siliceous rocks	**0**	Impure
Fx (Ki)	Gravel	**I**	Intermediate siliceous rocks	**-**	Pure
Tx (Mo)	Moraine	**B**	Mafic rocks		
Ox (Or)	Organic	**M**	Carbonate-siliceous rocks		
Gb (Bl)	Boulders deposits	**C**	Siliceous-carbonate rocks		
Ex (St)	Eolian deposits	**K**	Calcite		
		D	Dolomite		

The quaternary geological map of Tyrol was categorised over the past decade into an abstraction of geological units called subsolum geological substrates (SSGS). Each unit uses a specific abbreviation that includes information on the lithogenetic, chemical and physical substrate characteristics (see table 2) (Simon et al., unpublished). Samples of unconsolidated deposits, little affected by pedogenetic processes, were collected and analysed all over Tyrol between 2008 and 2018 in order to assign the surrounding area to the respective substrate unit (Forest Site Classification Tyrol, 2018). The areas characterized by the presence of solid bedrock (lithogenetic entity *Sx*) were derived by the digital geological maps (GBA, 2019).

The subsurface geological units play the same role of the *Forest Type* units in this modified characterisation procedure, subdividing the forest area into polygons, which are assigned a category for suggested biomass use and compaction risk (see chapter 3).

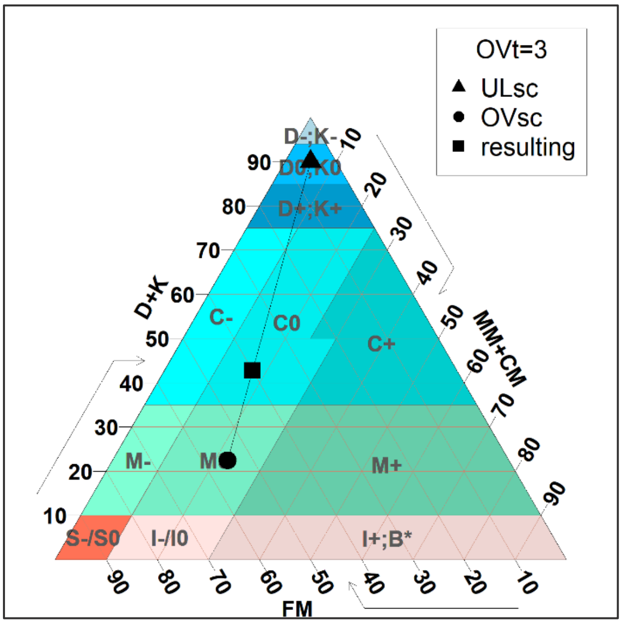

Figure 5: Example of triangular diagram for determining layered subsurface chemical-physical entity

Areas characterized by unconsolidated rocks can have a layered structure, which soils form from very chemically diverse rock material. A layered structure is characterized by an overburden layer having depths ranging from 0 to 1 m. We developed a graphical solution to obtain a *resulting* chemical-physical entity, combining the information on the *overburden* (OVsc) and the *underlying* material (ULsc) with the depth information (OVt). Specific percentage values of mineral component groups are assigned to each chemical-physical entity: calcite (K), dolomite (D), clay mineral (CM), mafic (MM) and felsic minerals (FM). Three combinations of mineral component groups express the coordinates of the points plotted in the triangular diagram of the example in figure 5.

In the following example, the underlying material (impure calcite, K0) is overlaid by a partial cover of carbonate-siliceous rocks (M0). The coordinates of the resulting point are weighted considering the overburden thickness (OVt=3), plotting within the polygon expressing the resulting chemical-physical entity (impure siliceous-carbonate rocks, C0).

The chemical-physical substrate classification based on the triangular diagrams was developed in cooperation with the engineers of the geological engineering company alpECON Wilhelmy e.U. The diagram has been used in parallel to combine the results of the analysis of unconsolidated rock samples, collected for retrieving the quaternary geological map, and assign to them the correct chemical-physical entity. The laboratory analysis determines the mineral component groups, and it is conducted on coarse particles (2 - 36 mm) by petrographic analysis and with x-ray diffractogram on the fine fraction (< 2mm). The results of the two analysis are plotted in the triangular diagram and their resulting chemical-physical entity is determined by integrating the grain size fraction in the calculation (Simon et al., unpublished).

1.4.2 Chemical soil properties of SSGS units as determining factors for deriving biomass use guidelines

A collection of chemical properties of 389 Tyrolean soil profiles was retrieved from campaigns conducted in the past 30 years by experts from the Tyrolean Forest Service and other Austrian authorities. Data of soil properties measured at specific depth steps at these 389 soil pits were grouped and averaged according to the subsolum geological substrate unit from which they developed.

The assessment of the soil productivity and the assignment of the suggested guidelines for biomass use to a geological unit, is a result of soil properties data processing (Schaber et al., 2020). Several conditions were taken into account, including that the nutrient-holding capacity of soils is expressed namely by base saturation, cation exchange capacity, pH and carbon over nitrogen ratio. Even though cation exchange capacity is an important attribute describing soil nutrient supply, it is less affecting than the base saturation, which measures the relative abundance of base nutrients on the exchange complex (Schoenholtz et al., 2000). By preliminary setting intervals as in table 3, with the three traffic light colours, the next steps to obtain one final biomass use category, are summarized in the decision tree of figure 6, where the base saturation plays a determining role.

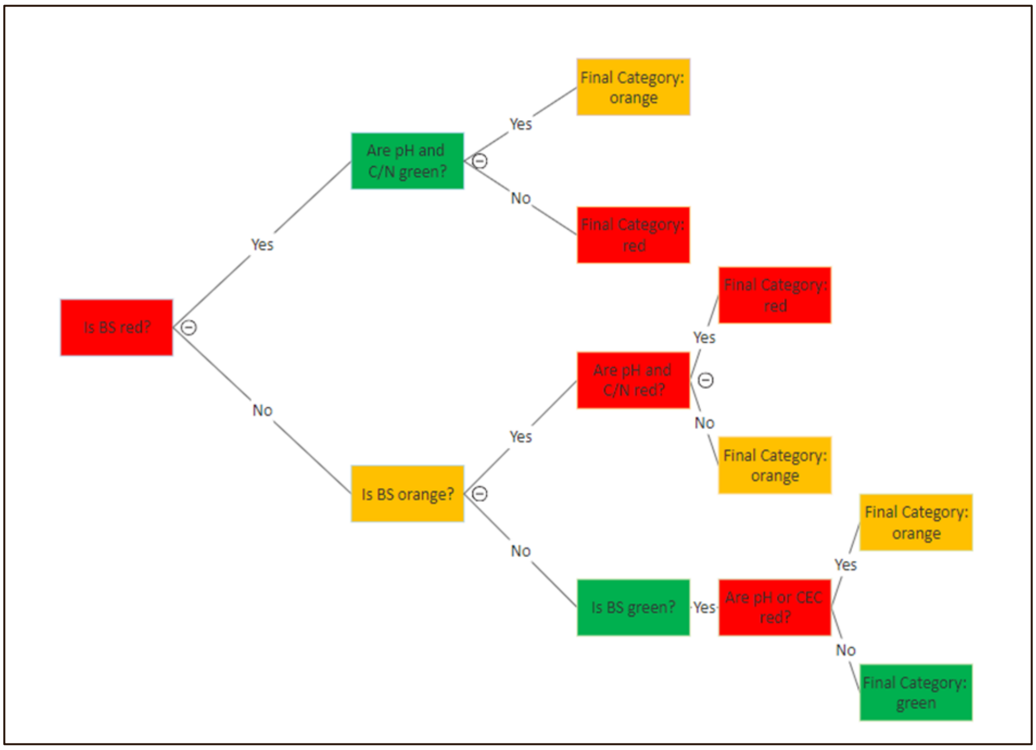

Figure 6: Decision process behind the definition of a final category for biomass use, considering four soil properties (BS, CEC, pH and C/N)

Table 3: Preliminary traffic light categories assigned to value ranges of base saturation, cation exchange capacity, pH, and C/N

Properties	BS [%]	CEC [mmol kg^{-1}]	pH	C/N
Intervals	0 – 25	< 60	< 4.2	> 25
	25 – 70	60 – 200	4.2 – 6.2	25 - 12
	70 – 100	> 200	> 6.2	< 12

1.5 Biomass use guidelines applied to the Case Study of Prägraten

In the Case Study area of the municipality of Prägraten, located in the district of Lienz in East Tyrol, we conducted a deep field investigation of the surface-near geological substrates, coupled with five soil pit surveys. Polygons of unconsolidated and solid rocks of the geological map sheets Nr. 151, 152, 177 and 178 provided by the Austrian Geological Federal Institute were revised using ortho-images and laserscan data of the Government of Tyrol. Based also on the petrographic analysis conducted on sediment samples in the area, a more detailed substrate unit classification is now available (Fig. 8). Solid rock parent material of base-rich silicates with prasinite and schists, characterises the north-western slope (chemical entity B) of the valley of Prägraten. In this area morainic and debris deposits of the same base-rich siliceous material are present. While the solid rock material (see Annex 2) typically forms very nutrient poor soils, having low base saturation and pH, the deposits form richer soils, which are categorised in the orange spectrum for biomass use (Fig. 9).

Intermediate negative effects follow whole tree harvesting in most of the southern slope of the Prägraten Municipality, where we find a prevalence of siliceous rocks with higher carbonate content (unit SxC0). The central green area visible in the thematic map is assigned to the unit SxM0, siliceous rocks with lower carbonate content, having favouring conditions for harvesting biomass, based on the high cation exchange capacity, base saturation and pH of its soils.

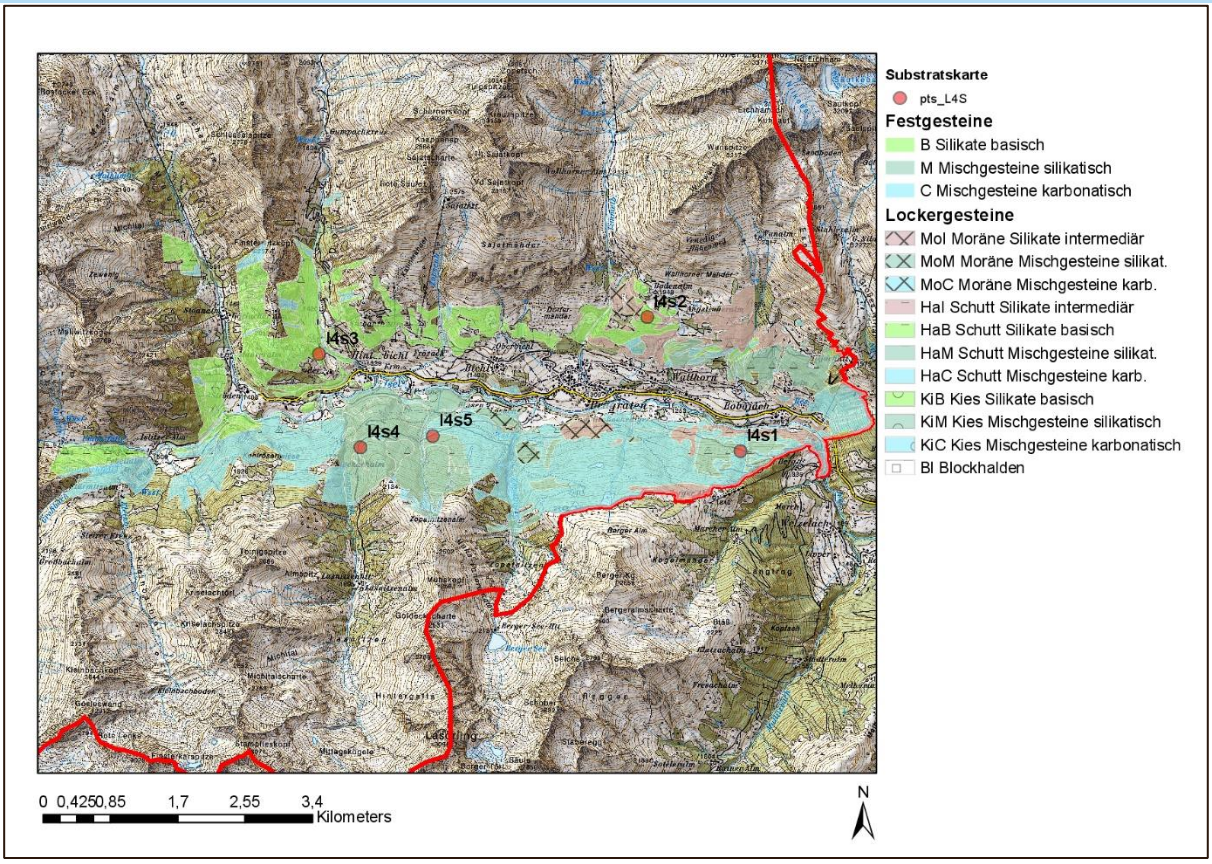

Figure 7: Updated geological substrate map of the forest area of Prägraten with marked soil sampling sites.

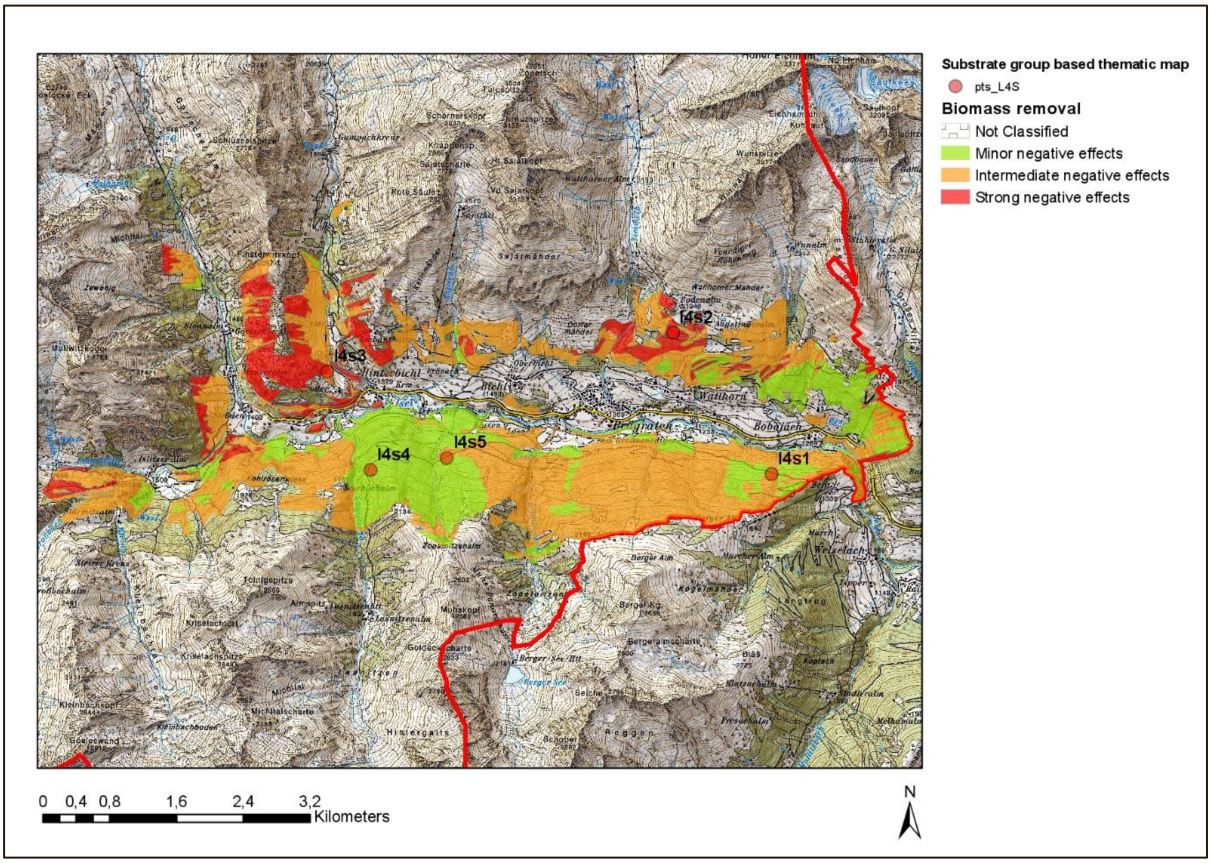

Figure 8: Thematic map of biomass use guidelines of the forest area of Prägraten, based on SSGS units

1.6 Biomass use thematic maps

The conclusion of our analysis can be well summarized in Figure 10, where the percentage of forest area of Prägraten is subdivided into the 3 categories of biomass use. Almost 60% of the Prägraten forest area is classified as 'red' in the traffic light subdivision based on Forest Types. Considering only soil properties of geological units, most of the territory is well suited for modified tree harvesting measures, with almost 60% of the area under the orange category.

A holistic approach, considering all relevant aspects defining forest productivity, is the best choice for improving the assignment of the biomass use categories. The enrichment of the Tyrolean database with soil information is a step further to provide site-based accurate measures to the forest planners and workers and guarantee a sustainable forest management in the future.

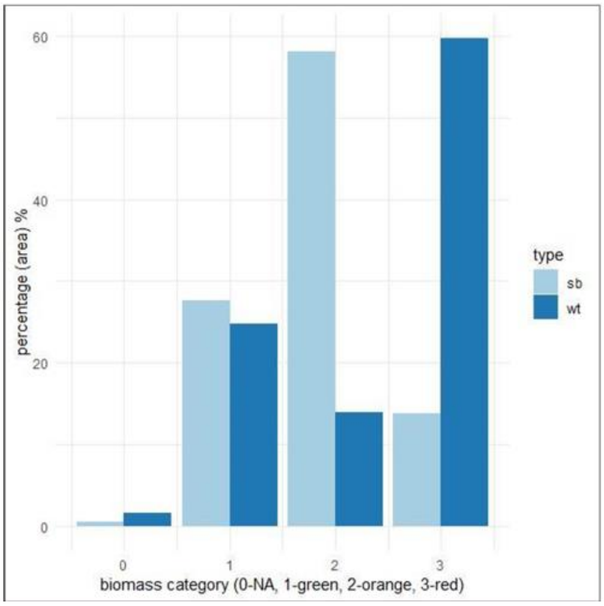

Figure 10: Areal distribution of biomass use categories based on substrate unit (sb) and Forest Type (wt)

2 Compaction risks

2.1 Forest management guidelines for minimising soil compaction

Mechanized harvesting in forest guarantees high productivity and a safe work environment (Akay and Sessions, 2001). Nevertheless, the increasing weight of skidders, forwarders and tractors are one of the main causes of human induced soil compaction in forest and sometimes soils can suffer irreversibly from this damage (Hartmann et al., 2014). Possible consequences are the reduction of water infiltration and hydraulic conductivity, followed by increase waterlog on plane areas and runoff on slopes, which causes erosion (Jansson and Johansson, 1998). Plant growth is also affected by compaction, as the applied pressure reduces soil pore space and restricts plant rooting depth, leading to diminished forest productivity and provision of ecosystem functions.

Minimising the transit of vehicles in forest is the best way to reduce human induced soil compaction: in order to do that, it is important to locate the vulnerable sites and distinguish them from more resilient environments. Below the biomass use traffic light box in the *Forest Type* report of Tyrol (See Appendix 1), a similar concept was developed to suggest how the transit of heavy machines should be regulated according to the Forest Type characteristics.

Three categories classify the Forest Types according to the effects of heavy machine transit on soil:

- Minor negative effects (green)

- Occasionally critical (orange)

- Locations at risk (red).

The compaction risk categories are assigned to the Forest Type units considering general common soil and site characteristics, related to the ability of soil to sustain compaction (table 5).

In the green category are included forest types with slopes below 40%, characterised by soils having a high coarse fraction and reduced humus layers. Dry soils better tolerate compaction, for this reason forest types with water logging tendencies are excluded from the “possible transit” category. Occasionally critical locations require a decision on site: below a 60% slope, forwarders and tractors can transit if the soil carrying capacity is adequate. Weather condition is determining for this category, as transit is not recommended after strong and long precipitations, but it is allowed during winter with frozen surfaces. Locations at risk have more than 60% slope and they are clearly defined by the presence of typically wet soil types as Gleye, Pseudogleye, Hanggleye, Staupodsol, Moore, Anmoore and Auen. To facilitate the distinction of the 3 compaction risk categories and related measures, stylised representations were produced, as with the biomass use categories (fig. 10). It shows harvesting machineries with clear recommendations on their use depending on the category.

Typical soil profiles for each category are shown in Fig. 11: dry soils, rich in rock fragments and roots are well suited against compaction, where the transit of heavy machinery only causes minor negative effects. A clayey, wet soil profile is shown in the category of “Locations at risk” and the intermediate “occasionally critical” soil balances rock fragments and clay content.

Possible transit	Occasionally critical	Locations at risk
Transit when there is no wet soil/limit at logging trails	Transit when there is dry/frozen soil or with technical adjustment (low pressure tires)	Transit should be avoided

Figure 12: Categories describing measures for heavy machinery transit on forest soils

Minor negative effects	Occasionally critical	Locations at risk

Figure 11: Typical soil profiles in locations categorized for compaction risk

Table 4: General factors defining compaction risk categories of Forest Types

Class	Soil Types (Ö)	Depth	Substrate: chemical-physical entities	Moisture	Slope
1	Rendzina, Braunerde, Podsole, Semipodsole	Shallow	Felsic siliceous, pure (S-); intermediate-siliceous rocks, pure (I-); carbonate-siliceous, pure (M-); siliceous-carbonate rocks, pure (C-); calcite, pure (K-)	Dry, very dry, moderately dry, moderately moist	< 40%
2	Pseudovergleyte, Braunerde, clayey Braunerde, Kalkbraunerde	---	Felsic siliceous, impure (S0), intermediate-siliceous rocks, pure (I0), mafic rocks, impure (B0), carbonate-siliceous rocks, impure (M0)	Moist	< 60%
3	Gley, Pseudogley, Hangpseudogley, Staupodsole, Hanggley, Anmoor, Moore, Auflagehumusboden	---	Felsic siliceous, highly impure (S+); intermediate-siliceous rocks, highly impure (I+); mafic rocks, highly impure (B+); carbonate-siliceous rocks, highly impure (M+); siliceous-carbonate rocks, highly impure (C+); calcite, highly impure (K+)	Very wet, wet, moist	> 60%

2.2 Selection of soil data affecting compaction

The integration of specific physical soil properties data to derive appropriate machinery transit measures is essential for improving forest management guidelines and minimise forest soil compaction. Following the principle of the biomass use categories, soil physical properties have been retrieved from previous soil pits investigations (Schaber et al. 2020) and averaged over the same substrate geological unit.

The soil properties mostly affecting compaction are bulk density, soil depth, soil water content, soil structure and particle size distribution (Cambi et al., 2014).

Soil grain size and coarse fragments play a major role in soil water retention (Ampoorter et al., 2012) and they can be considered as properties having a primary role, with regards to soil compaction vulnerability.

Percentage values of coarse fragments, sand and clay (the last two calculated on the total fine soil fraction) of the first 30 cm soil profile depth are taken into account. As compaction has the strongest impact on topsoils, according to several research results (Cambi et al., 2014), the soil grain size relative to deeper soils (below 30 cm) was not included in the analysis.

The abovementioned percentage values are available for almost all already described Tyrolean substrate units, therefore we included a texture triangle to the short geological unit's report (See Annex 2), in order to give an overview of the particle size distribution and the typical texture classes of each substrate unit.

In the same report, physical soil characteristics have been listed, including the coarse fraction, for which we calculated average values according to the following depths: 0-15 cm, 15-30 cm, 30-60 cm and 60-100 cm.

Table 5: Relevant soil properties for defining compaction risk with intervals of percentage values and assigned colors

Properties	Coarse fragments [%]	Clay [%]	Sand [%]
Intervals	0 – 25	> 30	< 25
	25 – 50	15 – 30	25 – 45
	50 – 100	< 15	> 45

In line with the method applied for the biomass use category creation, we defined specific intervals of coarse fraction, clay and sand percentage values and we assigned them a preliminary traffic light colour (Table 5), following the principle that fine-textured soil is more subjected to compaction than the coarse-textured one (Wästerlund, 1985).

When two or more colours define the same substrate texture characteristics, specific conditions are applied in order to select one unique final category for suggested machinery transit (Fig. 13). When coarse fraction is in the green range, the fine texture becomes secondary and the resulting category will be assigned to green. On the contrary, when the coarse fraction is below 50%, clay content becomes critical and it assigns the resulting category. When either coarse fraction or fine texture classification are not available, only one is taken into account for categorising the substrate units.

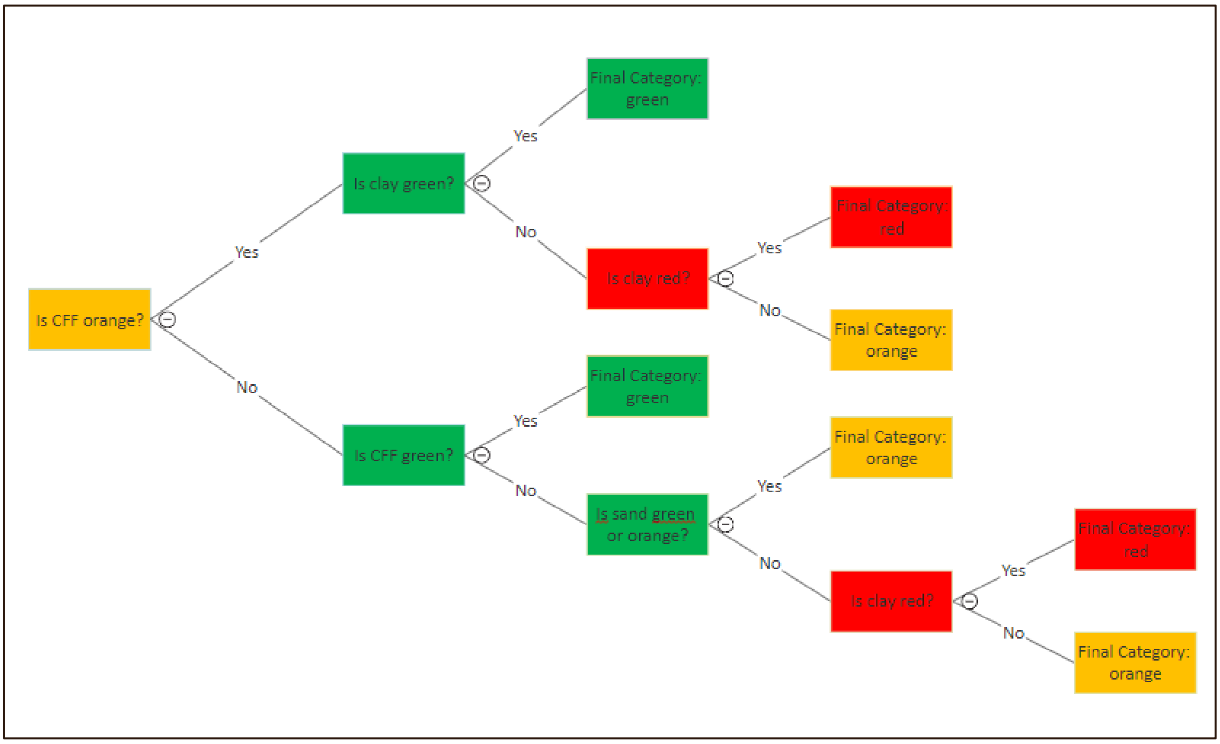

Figure 13: Decision process behind the definition of a final category for compaction risk, considering soil grain size fractions

2.3 Compaction risk thematic maps of Prägraten forest area

Thematic maps of suggested machinery transit were produced for the forest area of the Municipality of Prägraten, both considering the Forest Type's categories (Fig. 15) and the geological substrate units (Fig. 16).

Almost 60% of the forest area of Prägraten is assigned to Forest Types which allow the heavy machinery transit (green category). Types like *Fi3*, *Fi6 and Fs6 and other* montane and subalpine spruce forests, cover most of the norther-east slope and the southern montane slope facing the town of Prägraten. The assessment was conducted considering their typical soil types (Braunerde for Fi3 and Pararendzina for Fi6), their moderately moist soil water regimes and the poor siliceous rocks as parent material. As a result, these Forest Types were evaluated as less vulnerable towards compaction.

In the southern and norther slopes, at higher elevation, we also notice extended areas categorised with red colour. Forest Types being assigned the colour red are Swiss stone pine forests (Zi2), having typically moist soils, with high humus and clay content and therefore unsuitable for heavy machinery transit. Larch forests (La2) are also categorised as locations at risk, because of their steep elevation.

The orange categorised surface covers less than 10% of the total forest area. On the contrary, when considering only the soil grain size of the geological substrate units for evaluating the risk of compaction, in more than 70% of the forest area of Prägraten, intermediate measures are suggested (Fig. 14).

All factors and data considered for producing both maps, contribute in the assignment of the final suggested transit category. In the forest area of Prägraten a more cautious behaviour is recommended to forest workers when transiting in green categorised areas. This is because the soils might not have the necessary structure to resist the machinery weight, as it was proved after a more specific field data evaluation and downgraded categorisation of the substrate units to the orange category. On the other hand, locations at risk could be assigned a less restrictive category, unless the site specific steep slope wouldn't allow it.

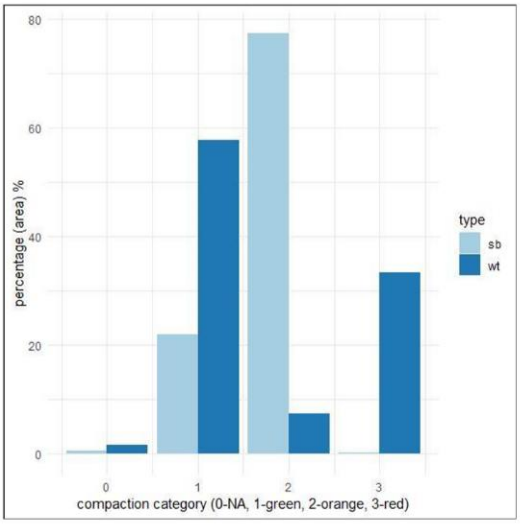

Figure 14: Areal distribution of compaction risk categories based on substrate unit (sb) and Forest Type (wt)

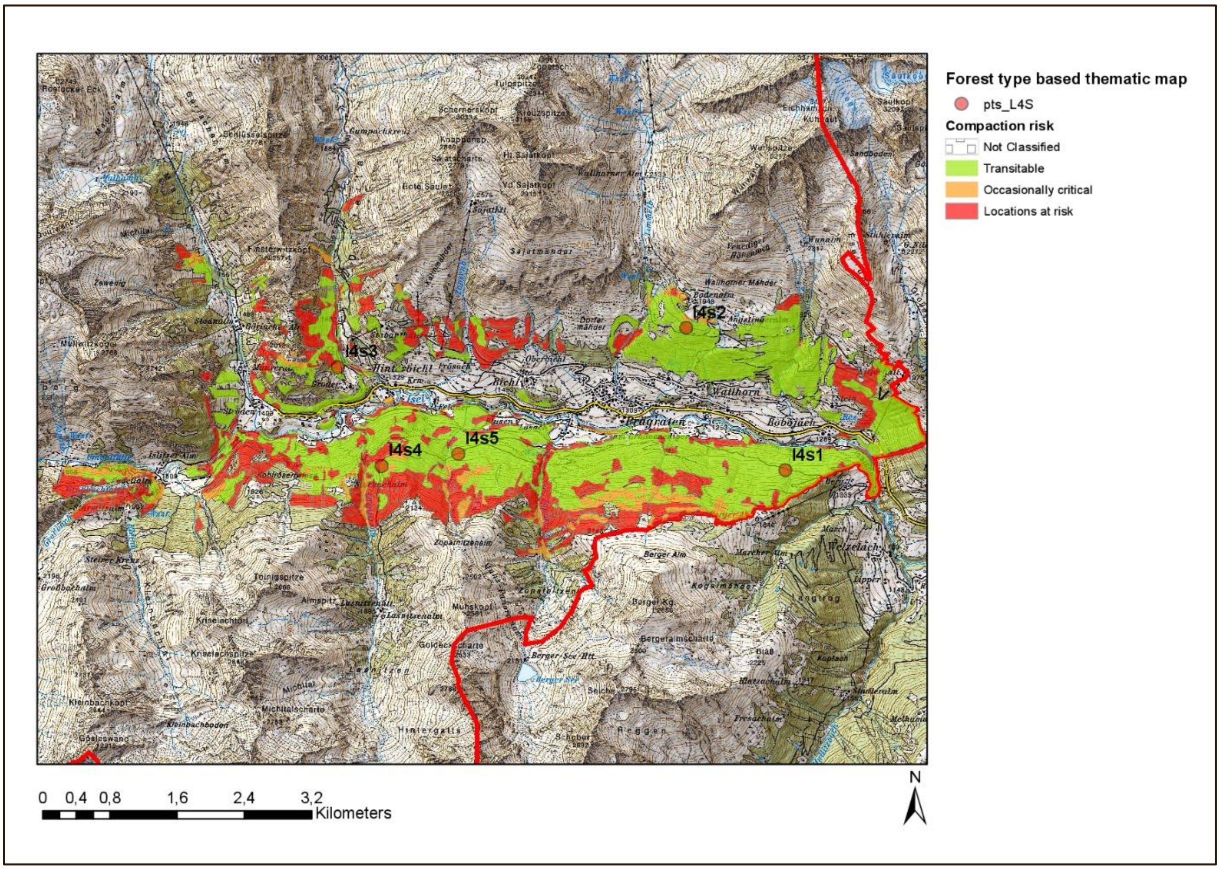

Figure 15: Thematic map of compaction risk of Prägraten forest area based on Forest Types

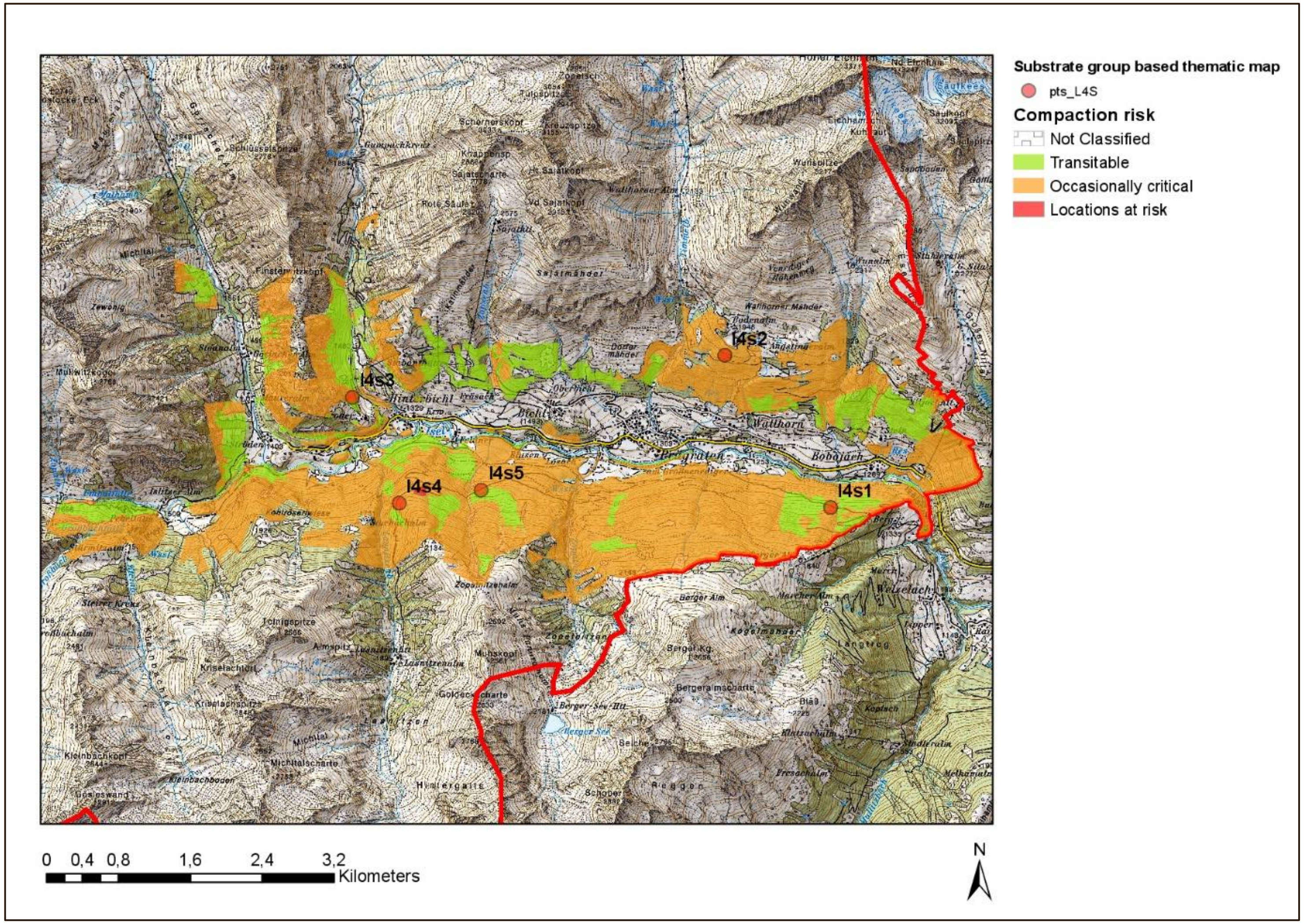

Figure 16: Thematic map of compaction risk of Prägraten forest area based on substrate units

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List of tables

List of figures

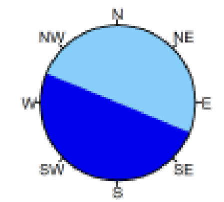
ANNEX

Annex 1

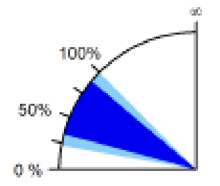
Ftb7 — Moderately fresh carbonate spruce-fir-beech forest

(Adenostylo glabrae-Fagetum caricetosum albae)

Exposition



Slope

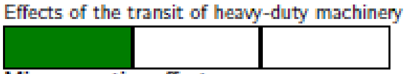


Biomass use & Compaction risk

Effects of whole-tree harvesting

Strong negative effects

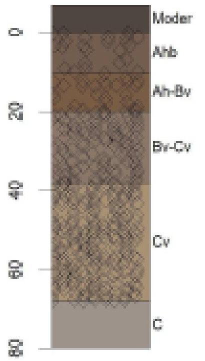
Effects of the transit of heavy-duty machinery



Minor negative effects

Soil Profile

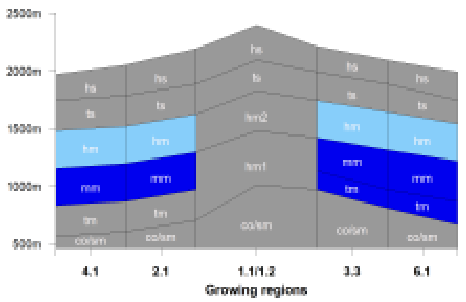
Kalklehm-Rendzina



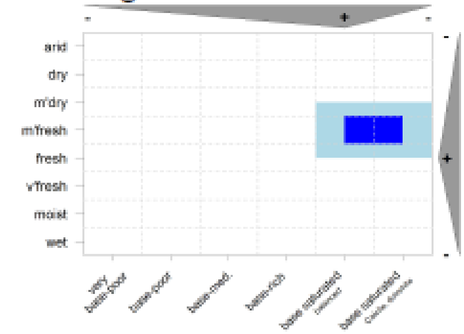
Bedrock material

Pure calcite and dolomite, in dry sites also impure carbonate substrate, mostly unconsolidated deposits

Distribution

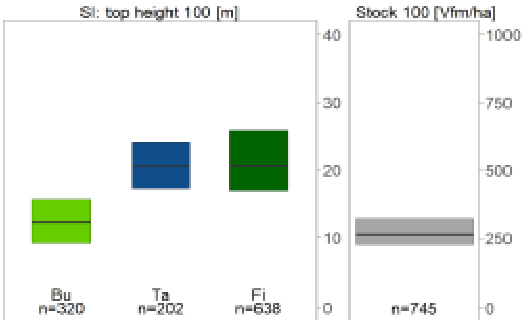


Water Regime & Base Saturation



Silvicultural care

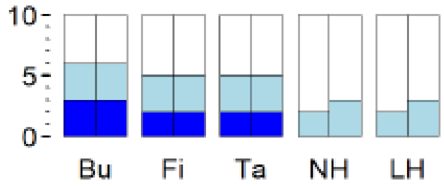
Productivity:
Stands with minor growth. The average stock of the potential tree species combination at 100 years is 264 Vfm/ha at fully stocked stands. Within this forest type the top heights (at 100 years) are 12 m for beech (Bu), 21 m for fir (Ta) and 21 m for spruce (Fi).



Tree Species	dgz 100 [Vfm/ha]	dgz 150 [Vfm/ha]
Bu	3.3	3.4
Ta	5.4	6.8
Fi	4.9	5.7

Values as median: 50% of the values shown

Tree Species:
Spruce, fir and beech are the dominant tree species. For maintaining the site potential, beech should however reach 30 percent of the tree species, even at a temporary dominance of another tree species. Other deciduous trees like sycamore, wych elm, birch, mountain ash, white beam, at lower elevation ashes, to some extent oaks and wild cherry contribute to the variety of tree species and structures. According to varying site conditions, other conifers can appear, like yew, larch and white pine. For soil-related reasons, deciduous trees should have a minimum of 40 percent of this forest type. In the regeneration, deciduous tree species should be 1-2 tenth higher than the planned tree species composition. In the transition zone with Fkb1, fir trees can drop in favour of deciduous tree species.



Forest stand/regeneration targets
NH: other conifers; LH: other deciduous trees

Suggestions for regeneration methods:

Clear cut	Strip cut	Shelter cut	Cable line patch selection	Slit cut	Femel selection	Single-tree selection
▼	○	◐	●	●	◐	●

Appropriate silvicultural methods
●: Recommended; ◐: Conditionally recommended
○: Not recommended; ▼: Locations at risk

Risks & limiting factors:
- Competing vegetation
- Snow movement
- Humus depletion after extensive cutting
- Drought

Annex 2

SxB0

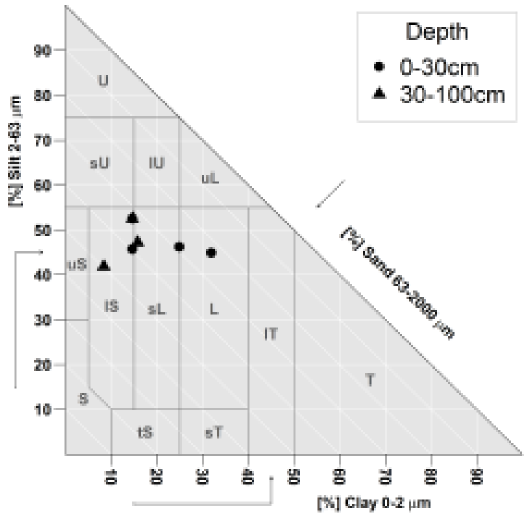
Solid rock, mafic rocks, intermediate clay minerals

General parameters

Area	59.68 km2
Percentage on total forest mapped area	1.23 %

Physics - mean values of all considered profiles (11)

Depth [cm]	Coarse fraction [%]	Field capacity [l/m2]
0-15	25 ± 20	62 ± 33
15-30	40 ± 20	
30-60	60 ± 25	
60-100	80 ± 10	



Chemistry - stock of available profiles (2)

Ctot	Ntot	Ca	Mg	K	P
t/ha	t/ha	kg/ha	kg/ha	kg/ha	kg/ha
119.04	5.65	461.8	66.18	64.56	1438.93

All stock values, 0-80 cm including humus layers (F,H), are short term available, except for phosphorus, which has long term availability

Chemistry - mean values of all considered profiles (3)

Depth [cm]	CEC [mmol/kg]	Base Saturation [%]	(Mg+Ca)/CEC	Ntot [%]	TOC [%]	C/N	pHCaCl2
0-5	160.09	29.35	0.26	0.83	21.51	25.92	3.4
5-10	124.81	26.99	0.24	0.42	13.71	32.64	3.67
10-20	80.7	26.19	0.23	0.23	5.86	25.48	3.97
20-40	32.57	27	0.21	0.15	2.79	18.6	4.3
40-80	15.4	36.36	0.27	0.08	1.53	19.12	4.5

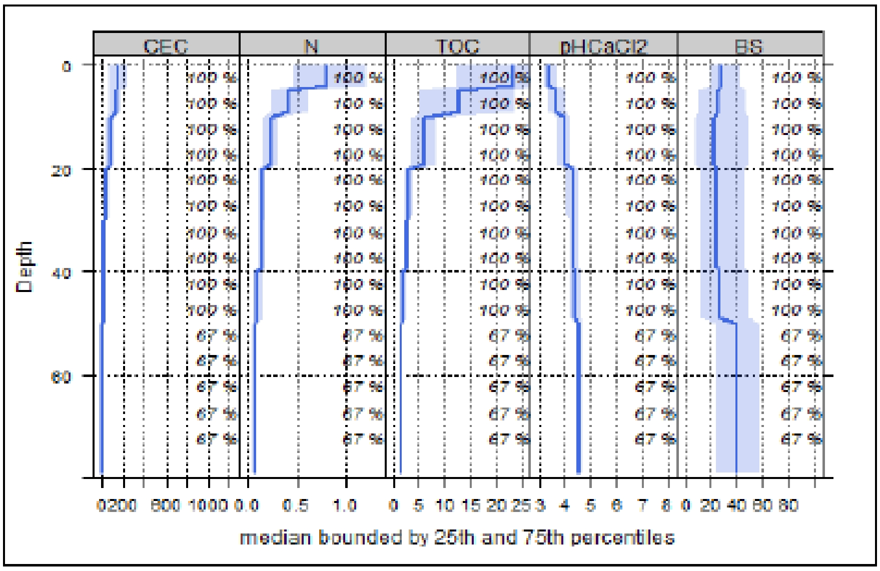


Figure 1: Profile's depth variation of the following median chemical properties, bounded by 25th and 75th percentiles: cation exchange capacity (mmol/kg), nitrogen (%), total organic carbon (%), pH and base saturation (%). The percentage values indicate how many profiles contribute to the median calculation at each depth step.

Biomass use

Effects of whole-tree harvesting

Strong negative effects

Compaction risk

Effects of the transit of heavy-duty machinery

Occasionally critical

Imprint

What this is about

This output document is a detailed explanation on how biomass use and compaction risk guidelines were developed and are in use in the Case Study area of Prägraten. By doing so, we describe soil management guidelines, which were recently integrated as additional supporting information for forest planners and workers into Tyrolean forest management plans.

Acknowledgements and credits

We would like to thank the Municipality of Prägraten and the Department of Forest Planning

WEB links

Links4soils main web page:

alpinesoils.eu/

About the Linjks4Soils project

Interreg Alpine Space
EUROPEAN UNION
Links4Soils
EUROPEAN REGIONAL DEVELOPMENT FUND

Links4Soils Internet IIIC Alpine Space web page:

www.alpine-space.eu/projects/links4soilsge

Links4Soils project partners

Agricultural Institute of Slovenia, SI (project leader)
Kmetijski inštitut Slovenije

Slovenian Forest Service, SI
Zavod za gozdove Slovenije

Office of the Tyrolean Government, AT
Amt der Tiroler Landesregierung

Climate Alliance Tirol, AT
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