Soil management practices in the Alps

A selection of good practices - Case Study 4

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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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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

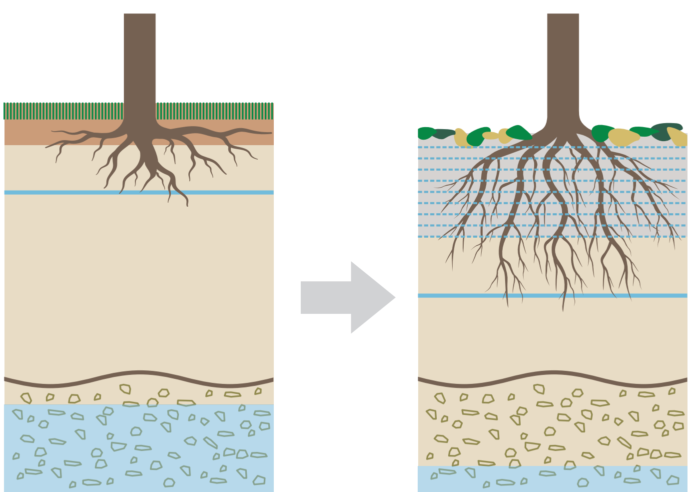

Figure 17: The same preconditions; on the left: coniferous tree with a shallow root system and thus low water uptake; on the right: broadleaf tree with a deep root system enabling a "living soil" with higher organic matter content and a lot of fine roots leading to higher water capacity and uptake.

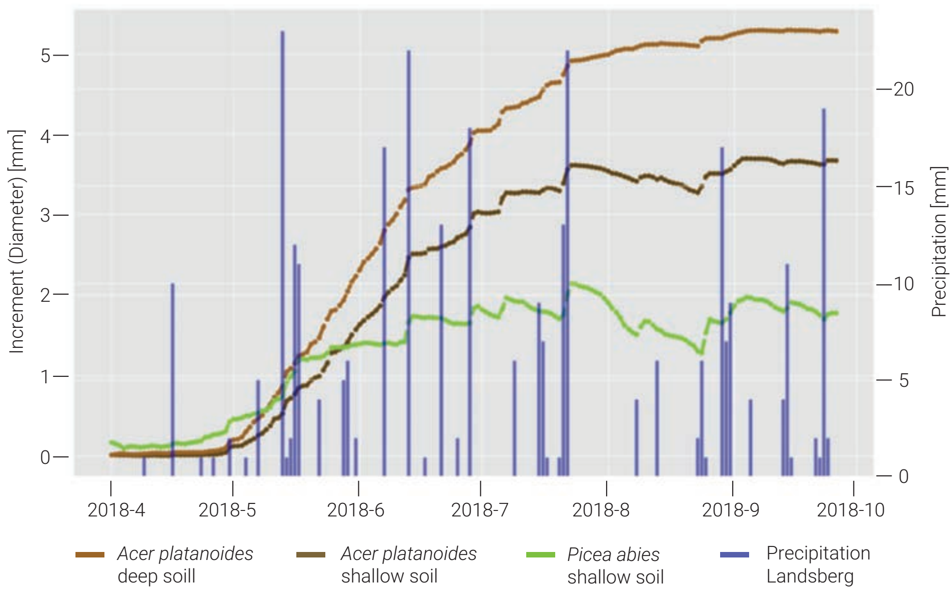

Figure 18: Growth of spruce (green) and maple (brown) at the same precipitation in the community forest of Scheuring 04.-10.2019 *(source: measurements by D. Behrendt, Graphic by L. Hänchen)*

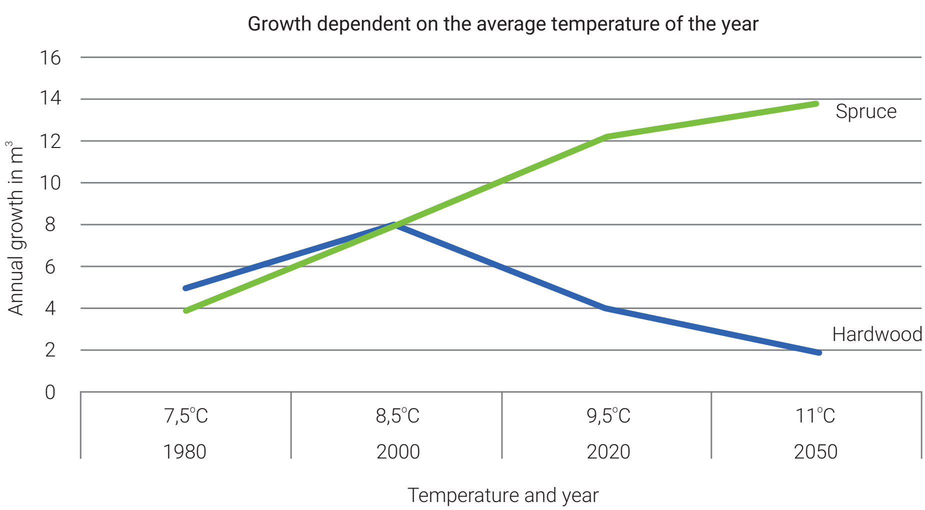

Figure 19: Growth development *(source: measured till 2020, then estimated by L. Pertl)*

Caring for Soils
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