Skidding tracks as forest infrastructure – promoting natural regeneration processes with regard to economic and ecological issues

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Summary
The German research project RÜWOLA aims at integrating the skidding track regeneration into an optimized management of forest logging. The spontaneous regeneration of soil structure is being assessed in a space-for-time substitution covering nearly 4 decades since last traffic impact. Field trials have been set up on acidic silty soils where wheeling tracks were subjected to various treatments in order to promote the regeneration of soil structure (soil perforation, liming, seeding of grasses and herbs, earthworm inoculation, tree planting). A further subproject is elaborating planning issues integrating issues of commercial value production, recreation, and nature protection into a general concept.

The RÜWOLA project

RÜWOLA is an acronym for a German research project in the field of forestry and soil protection. The English translation of the explicit project title is roughly: “Skidding tracks as development lines in forests – optimization by means of natural regeneration and technical measures with reference to the interests of nature conservation and landscape planning.” In a cooperation between the Universities of Applied Sciences ‘Hochschule Osnabrück‘ and ‘HAWK Hildesheim/Holzminden/Göttingen’ together with external partners we are aiming for the sustainable protection of soil functions in skidding tracks in accordance with economic, ecological and social demands on forests in the German federal state of Lower Saxony. Figure 1 shows the subprojects and involved persons of the project which is running from 2012 to 2016.

<table>
<tr><td>SP 1 (C. Ebeling, T. Gaertig)
Spontaneous regeneration of soil structure</td><td>SP 2 (H. Merkel, H. Schacht)
Plant species for skidding tracks</td><td rowspan="3">SP 5 (M. Müller-Inkmann, A. Averdiek, H.C. Fründ)
Measures and options to enhance soil structure regeneration</td></tr>
<tr><td>SP 3 (D. Schneider, Merkel)
Value production on skidding tracks</td><td>SP 4 (R. Riggert, B. Kietz)
Technical reduction of driving impact</td></tr>
<tr><td colspan="2">SP 6 (F. Moczia, G. Clemens, H. von Dressler)
Ecological evaluation and optimization of forest development</td></tr>
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Figure 1 Subprojects (SP), involved persons, and goals in the RÜWOLA project

Structure regeneration in forest soils with high biological activity

Although up to 20 % of the forest production area is affected by regular skidding trails, it is widely unknown if or how those compacted soils will regenerate.

In SP 1, on the one hand the natural regeneration of soil structure is being assessed. On the other hand changes in soil biological activity are investigated. In a space-for-time substitution covering nearly 4 decades since the last traffic impact, CO_2 concentration in 5 cm soil depth was measured to assess soil aeration status. Acid soil phosphatase activity was assessed to estimate soil microorganism behavior.

At a test area with high natural regeneration potential (clay content approx. 25 % and soil-pH between 5 and 7) our results indicate regeneration within 25 years (Kohn et al. 2013). At the 7-year-old skid trail the pattern of soil CO_2-concentration reflect the traffic intensity very well.

24 and 38 years after the last impact no differences between the skidding trail and the undamaged reference soil can be identified

The acid phosphatase activity shows similar pattern: 5 years since last trafficking, the enzyme activity is the lowest on the wheel tracks and the side strips. On the wheel tracks of the 24-year-old skid trail, enzyme activity is even higher than in the reference soil. This may be due to a higher content of accumulated organic matter and a better nutrient mineralisation in the deepening of the track.

Apparently, clayey soils with a high biological activity tend to regenerate within 3 decades. In further studies it will be investigated, if and how soils with lower biological or physical regeneration potential (i.e. acidic silty soils or loamy sandy soils) regenerate.

Promotion of soil structure regeneration

Soil perforation is tested in SP 5 for its effect on soil restructuring in the skidding track. Fig. 2 shows hypothesized effects and interactions. The main idea is, to create starting points for soil penetration by roots and macrofauna at a depth that is otherwise only sparsely colonized by roots and soil biota.

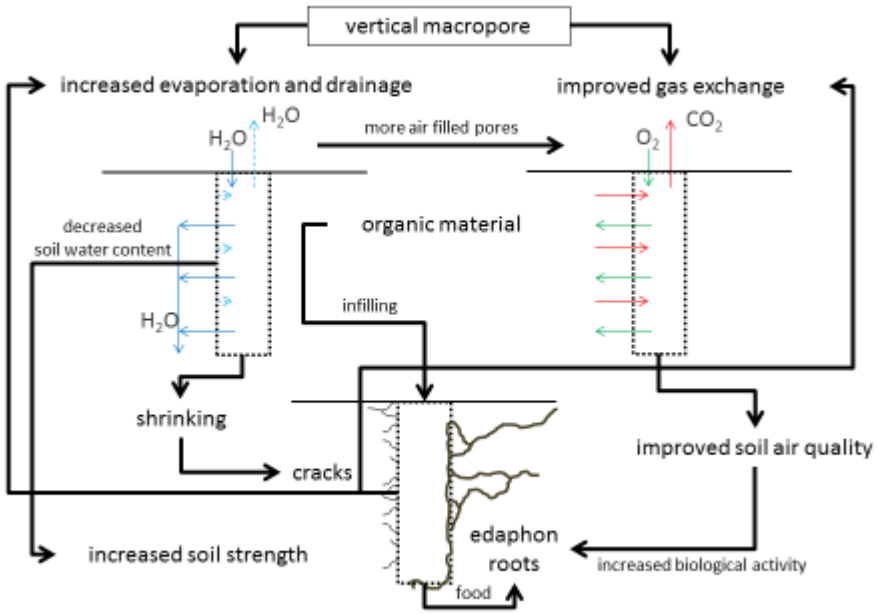

Figure 2 Conceptual model of soil perforation effects on processes of soil structure regeneration

Three field trials were set up on acidic silty soils. Soil perforation was done in the wheel track of skidding lines by manually punching 20 cm deep holes (diameter 2.5 cm) with a steel tube which was modified from a lawn-aeration tool (www.rasenspecht.de). Holes were punched in treatments with grids of 15 cm, 20 cm, 50 cm distance respectively. Additional treatments were set up with liming (equivalent to 12 t ha^{-1} dolomitic lime) and seeding of a grass-herb mixture, each singly and in combination with soil perforation. In a special treatment holes were filled with burnt lime (50 % CaOH). In another treatment holes were filled with composted manure and amended with one adult earthworm (*Aporrectodea caliginosa*). In the field experiments CO_2 and soil water tension are monitored with data logging from permanent sensors at 6 cm depth. Iron rods were driven to 25 cm depth into the soil and exposed for 3 to 6 weeks. Rust formation on these rods varied and indicated differences in soil aeration (cf Owens et al. 2008). Root distribution, pH, organic matter, and earthworm colonization in and around punched holes after one year are being investigated in depth at the two short-termed field trials. The third experiment is planned to be observed for 10 years (up to 2023).

Results for the first vegetation period (Fründ et al. 2013) showed very high concentrations of CO_2 in the soil air (up to 11 % v/v) in the wheel tracks irrespective of the experimental treatment. Examination of holes after one year (Müller-Inkmann in prep.) showed the accumulation of organic matter and the occurrence of roots indicating that punched holes may serve as starting points for soil structuring biological processes.

Ecological evaluation and concept development for an optimized forest development integrating aspects of soil protection, forest economy, human recreation, and nature conservation

Windfall, forest decline from air pollution, and other calamities in the past have been remediated by concepts for ecological silviculture. Society's increased perception of nature and soil protection was translated into strengthened environmental legislation. On the other, hand rationalization and economic pressure on forest management led to fully mechanized harvesting techniques with ever larger and heavier machines resulting in soil damages and causing conflicts with nature protection, recreation-seekers and other stakeholders. SP 6 aims at a contribution to conflict prevention by an a optimized concept for forest infrastructure taking into account site characteristics (e.g. susceptibility for compaction), requirements for and restrictions of nature conservation (Nature reserve, Natura 2000, protected species and habitats) and recreation as well as the capability for regeneration of soils.

Options for action in managing forest infrastructure depend on their objectives and can be divided into activities for prevention or for control. Preservation of all ecological soil functions can only be achieved by refraining from any logging activities - "zero-option", while the impacts can be controlled by avoiding driving activities e.g. by using cable yarding systems. Technical provision targets the preservation of the soil trafficability. Prevention can be achieved e.g. by selecting the harvesting technique while impacts of driving activities can be controlled by auxiliary traction winches, bogie tracks and tire pressure control systems.

Regeneration of forest soil structure becomes highly relevant, when skidding tracks are left open for statutory requirement e.g. when widening the distance of skidding tracks is enforced by certification, or if soils were damaged dramatically so that their ecological as well as technical function are disabled. Natural regeneration potential and soil regeneration supported by (eco-) technical measures is subject of subproject 1 and 5, respectively.

The impact of forest infrastructure will be described and evaluated in three research areas with different hierarchy of main forest functions. These are in the first human recreation and timber production (Göttingen), in the second nature conservation and timber production (Solling) and in the third nature conservation, recreation and timber production (Bad Iburg) are combined. The development of the optimized concept will be based on this evaluation.

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