Why extraction racks?

- Avoid/reduce soil damage
- Avoid/reduce negative effects on growth and yield
- Avoid/reduce damage to remaining stand and/or regeneration
- Stipulated by certification
- Public opinion ("green movement")
Objectives of extraction racks

• Sustainability of soil fertility and sustainable production of timber through:
  – protection of soils through limited damages to soils during skidding and fully mechanised harvesting operations
  – limited damages to remaining trees and regeneration

• Orientation:
  – Stratification of stands and compartments
  – Easier set-up and definition of work areas
  – Support for silviculture through spatial arrangement (e.g. where to start regeneration)
Effect on soils 1

Soil compaction:

• Already the first pass compacts the soil (traffic on soils is no “trivial offence”; don’t leave extraction racks [“keine Mogelgassen”])
• Further passes aggravate the damage.
• The vehicle configuration influences the extent of compaction.
• Soil rehabilitation is a long-term process.
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Source: WSL
The compaction reaches to this soil depth

Source: WSL

Green: soil, no traffic
Orange: track, one turn
Red: track, several turns
Effect of vehicle configuration 1

More axles reduce the wheel load by 42 %.

Source: LWF
Effect of vehicle configuration 2

The reduction of the tyre pressure by 2 bar increases the contact area of the tire by 70 %.

Source: LWF
Effect on soils 2

Type of soil damage:
- Elastic deformation (track depth < 10 cm; soil keeps crumbly ...): pores are maintained
- Pastic deformation (track depth < 10 cm; soil forms a “sausage” ...): pores are lost
- Viscoplastic deformation (track depth > 10 cm; soil dissolves,...): pores are realigned and, thus, blocked
(Track type 1) Elastic deformation

(Track type 2) Plastic deformation

(Track type 3) Viscoplastic deformation

Source: WSL
(Track type 1) (Track type 2) (Track type 3)

Spurtyp 1 Spurtyp 2 Spurtyp 3

Elastic deformation Plastic deformation Viscoplastic deformation

Source: LWF

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Source: LWF
### (Track type 1)
- **Erscheinungsbild**: Risse in der Oberfläche, fällt u.U. ab
- **Typisches Spurbild**: Spurtyp 1
- **Wassergehalt**: gering
- **Tragfähigkeit**: hoch
- **Risiko**: gering
- **Befahrung**: immer
- **Water content**: low
- **Bearing capacity**: high
- **Risk**: low
- **Traffic**: always

### (Track type 2)
- **Erscheinungsbild**: Oberfläche geschlossen, flach
- **Typisches Spurbild**: Spurtyp 2
- **Wassergehalt**: mittel
- **Tragfähigkeit**: mittel-gering
- **Risiko**: mittel-hoch
- **Befahrung**: zu prüfen
- **Water content**: medium
- **Bearing capacity**: medium to low
- **Risk**: medium to high
- **Traffic**: to be checked

### (Track type 3)
- **Erscheinungsbild**: „Spritzer“, unregelmäßig und flach
- **Typisches Spurbild**: Spurtyp 3
- **Wassergehalt**: hoch
- **Tragfähigkeit**: nicht ausreichend
- **Risiko**: Bodenschaden unvermeidbar
- **Befahrung**: nie
- **Water content**: high
- **Bearing capacity**: insufficient
- **Risk**: extreme
- **Traffic**: never

Source: LWF
Test of trafficability through throwing a soil sample against a solid surface (“Wurftest”)

Surface with cracks  Surface closed  Irregular, flat

Source: LWF

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Effect on soils 3

Consequences of soil damage:

• Loss/disruption of pores stops the flow of air and water in the soil.
• This leads to lower concentrations of oxygen and higher ones of carbon dioxyde
• and a different set of micro-organisms that are adjusted to anaerobic situations -> more N$_2$O (nitrous oxide, laughing gas) and methan (CH$_4$).

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Concentration of carbon dioxide - according to the distance from the middle of the extraction rack (in cm)

Abb. 1: Kohlendioxidkonzentration in der Bodenluft im Bereich einer Fahrtrasse

Source: Schäffer

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Discoloration and rust stains indicate the loss of porosity underneath a track.

Source: WSL
Effect on soils 4

In total:

• Negative effects on mineralisation and humification processes
• Loss of crucial soil properties
• (Loss of soil carbon)
Effect on growth and yield 1

- Growth depends on the structure of the soil where conifers and broadleaves react somewhat differently to various soil parameters.
- Soil compaction leads to fewer fine roots (= a deficit in the fine root system).
- Damages of soil and of roots possibly lead to reduced growth rates (few studies exist!).
- Damaged roots are attacked by fungi which cause root rot that finally reaches the stem.
Concentration of fine roots in an extraction rack - compared to an undisturbed area

Verteilungsmuster der Feinwurzeln (Ø < 2mm) unter einer Rückegasse und einer unbefahrenen Fläche.

Source: Schäffer

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Effect on growth and yield 2

- The minor timber quality caused by the root and stem rot may reduce the timber revenue at the time of harvesting (some model calculations assume a range of 1 to 3% of total revenues).
Negative effects of ER 1

• Stands might become unstable
• Reduced amenity through:
  – the extraction rack itself (visible in the stand or in the landscape)
  – marking of the extraction rack
  – mulching of the extraction rack
• Yield loss?
Negative effects of ER 2

• Up to 20 % of a stand are covered by extraction racks (if distance between them is 20 m at a width of 4 m).

• Trees at the edge of the racks and beyond show higher growth rates (differentiation between species: spruce – Douglas fir – pine) what might compensate the yield loss due to the area of the racks.

• Thus, no yield loss might be expected if the extraction racks are opened up in young stands. But yield loss might occur in old(er) stands.
Relative diameter increment in rows besides extraction racks.

Source: Spellmann and Nagel

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