Extraction racks: contents

- The situation in Germany
- Silvicultural concepts as starting point
- Reasons for extraction racks
- Planning, marking and documentation of extraction racks (ER)
- Use of ER (time of harvesting)
- Maintenance and rehabilitation of ER
Situation in Germany 1

Extraction racks are standard now due to:

• Research into soil compaction
• Awareness of forest owners
• Certification of forests
• Stipulation by laws (Forest Laws, Soil Protection Law)
• Wide-spread acceptance of CCF

But this has been a long-term process!!
Guidelines for extraction racks (State Forest Service of Baden-Württemberg)
Soil Protection and Harvesting (State Forest Service of Thuringia)
Situation in Germany 2

• This has been facilitated because a wide range of harvesting systems has been developed and is available – either provided by forest enterprises or by contractors.

• There is at least one harvesting system for every terrain and stand situation.
Situation in Germany 3

• Disasters like big windfalls (e.g. caused by “Lothar” in 1999 or by “Kyrill” in 2007) initiated or pushed the development and acceptance of new harvesting systems (e.g. of fully mechanised systems) and the documentation of extraction racks.
Context to be seen

- Terrain + stand (silvicultural concept + assortments)
- -> harvesting system
- -> (system of) extraction racks
- -> when (time of operation) and how (type of machines and equipment) to use them
Role of silvicultural concept

• Avoid unnecessary/uneconomic interventions (time of intervention, trees to be cut, amount to be cut)!
• Define clear objectives for every intervention!
• Differentiate acc. to stand and site!
• Practice “adaptive management”!
Adaptive management

• Define clear objectives for each operation!
• Select the optimal measure to realise the objective!
• Execute this measure!
• Check the result and compare it with the objective!
• Determine corrections if necessary!
Management Guideline for Mixed Stands of Sycamore, Ash and Beech

<table>
<thead>
<tr>
<th>Top height [m]</th>
<th>Age [yrs]</th>
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<tbody>
<tr>
<td>6-9m</td>
<td>25</td>
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<tr>
<td>9-12m</td>
<td>50</td>
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<tr>
<td>12-16m</td>
<td>75</td>
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<tr>
<td>&gt;16m</td>
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<table>
<thead>
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<th>THT = 6-9m</th>
<th>THT = 9-12m</th>
<th>THT = 12-16m</th>
<th>THT &gt; 16m</th>
<th>THT &gt; 30m</th>
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<tbody>
<tr>
<td>Removal of ‘wolf’ and damaged trees</td>
<td>Selection of 200 frame tree candidates/ ha</td>
<td>Selection of 80-120 final frame trees</td>
<td>Constant control of the performance of the frame trees</td>
<td>Target diameter harvesting</td>
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<tr>
<td>No tree number reduction</td>
<td>Removal of frame tree competitors (dominant trees)</td>
<td>1\textsuperscript{st} and 2\textsuperscript{nd} thinning as heavy selective crown thinning</td>
<td>Improvement of frame tree crowns</td>
<td>Steering of natural regeneration through group shelterwood cuts</td>
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<tr>
<td></td>
<td></td>
<td>Removal of competing beech trees</td>
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</tr>
</tbody>
</table>

Prof. Dr. H. H. Höfle, CCF and Extraction Racks, 12./13.05.2010

~ Jänich, 2003
Regeneration

• What role does it play at a certain point in time? Don’t let the regeneration push you!
• Regeneration cannot be everywhere. There should be some sort of spatial arrangement (“räumliche Ordnung”) within a stand.
• Harvesting cannot take place without causing some damage to the regeneration. But it can be concentrated and it is mostly less serious than envisioned before.
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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Cause

Indicator

Effect

Source: WSL
Green: soil, no traffic
Orange: track, one turn
Red: track, several turns

The compaction reaches to this soil depth

Source: WSL

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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
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Elastic deformation

Plastic deformation

Viscoplastic deformation

Source: WSL
(Track type 1) Elastic deformation

(Track type 2) Plastic deformation

(Track type 3) Viscoplastic deformation

Source: LWF

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<table>
<thead>
<tr>
<th>Merkmale</th>
<th>Spurtyp 1</th>
<th>Spurtyp 2</th>
<th>Spurtyp 3</th>
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<tr>
<td>Wassergehalt</td>
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<td>Bodenart</td>
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<td>fein</td>
<td>steil</td>
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<td>Hangneigung</td>
<td>flach</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Anstieg der Tragfähigkeit</td>
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</tbody>
</table>

**Einflussfaktoren Boden**

- **Elastische Verformung** meist nur Stollenabdrücke
- **Plastische Verformung** deutliche Eintiefung
- **Grundbruch** ausgeprägte randliche Aufwölbung

Source: LWF

Prof. Dr. H. H. Höfle, CCF and Extraction Racks, 12./13.05.2010
Prof. Dr. H. H. Höfle, CCF and Extraction Racks, 12./13.05.2010
Test of trafficability through throwing a soil sample against a solid surface ("Wurftest")

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 N₂O (nitrous oxide, laughing gas) and methan (CH₄).
Concentration of carbon dioxide - according to the distance from the middle of the extraction rack (in cm)

Source: Schäffer

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

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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
Stand stability

• On critical sites, extraction racks are established at least one year before harvesting.
• In unstable (not optimally thinned) stands with high h/d values and short crowns it might be appropriate to establish the extraction racks one to more years before selective harvesting takes place.
Planning of ER: general remark

- Extraction racks must be planned in the context of terrain and harvesting systems (which are covered separately).
- All - even fully mechanised - harvesting systems allow a certain flexibility with respect to distance between ER – but greater distances might cause higher harvesting costs.
Dimension and alignment of ER 1

- **Width** - 4 m
- **Distance** - at least 20 m
- **Gradient** - up to 20 %
- **Straightness** - exact
- **Crossing with forest roads** - rectangular
- **Role between harvesting operations** – closed
- **Erosion control** - if necessary
- **Extraction roads lean to the mountain side!**
Dimension and alignment of ER 2

- **Width:** 4 m as standard due to width of vehicles
- **Distance:**
  - In flat terrain: min. 20 m, in older stands 40 or 60 m (preferably multiples of 20 m)
  - In steep terrain: extraction racks 20 to 30 m; extraction roads up to 80 m and more
Dimension and alignment of ER 3

• Direction in flat terrain:
  – Straight: no curve around valuable trees!
  – Rectangular to the road system: widening at road crossing if required

• Direction in steep terrain:
  – Extraction racks perpendicular to contour lines
  – Extraction roads adjusted to the terrain and road system
Extraction racks: details

Source: Skogsarbeten
Guidelines for extraction racks (State Forest Service of Baden-Württemberg)

Here: Examples for the alignment of extraction racks
Example for the alignment of extraction roads in steep terrain

Source: Forest Service of Thuringia
Example for a system of extraction roads (in the Black Forest)

Source: Dietz et. al.
Cross section of an extraction road

Source: Forest Service of Thuringia
What to do with old ER?

• If possible, they should be integrated into the new system

• Analysis in various steps (three in Baden-Württemberg):
  – Technical standard (grade, width, status)
  – Optimal type of rack with respect to terrain and to soil structure
  – Alignment: adjustment to the terrain, distance

• Rather to accept an inoptimal system than to make new tracks!? 
The result of unmarked extraction racks

Source: WSL  
Prof. Dr. H. H. Höfle, CCF and Extraction Racks, 12./13.05.2010
Prof. Dr. H. H. Höfle, CCF and Extraction Racks, 12./13.05.2010

Existing ER (documented with GPS)

Final – and optimal - system using the old ER

Source: Hildebrandt
Planning of extraction racks 1

• Unit to be planned for:
  – Not stand, rather
  – Compartment
  – Area for ER (“Feinerschließungseinheit”)

• Time:
  – Before the first harvesting operation.
  – Due to the timing (sequence) of operations, every stand is dealt within about five years.
Planning of extraction racks 2

• Person: forester – worker – contractor
• Criteria:
  – Terrain
  – Stand (age, dimension, density/visibility …)
  – Harvesting system
• Where:
  – on the map
  – in the terrain
Planning of extraction racks 3

In flat terrain:

• Map to start with:
  – Systematic arrangement
  – Avoid sensitive areas
  – Define bearing

• Transfer to the stand:
  – Two-men operation with compass and ranging rods
  – One-man operation with compass
  – One-man operation with compass: „thread method“
SUUNTO compass
Thread measuring device (WALKTAX by HAGLÖF)
Marking of extraction racks 1

• Criteria:
  – Visibility
  – Durability
  – Costs
  – Amenity (reaction of the public)
Marking of extraction racks 2

• At trees at the boundary of ER with ribbons or paint: high enough! – problem that marking has to be repeated (or through pruning of boundary trees)

• Through differentiation of the area of the ER (through not planting or planting with different species - in [re]fforestations -, mulching or “hardening” at the beginning of the rack)

• At the entrance of an ER (even with numbers)

• (Through poles of wood or metal)
Marking of extraction racks 3

- There is no one and optimal way of marking extraction racks in the stand (e.g. what colour? what type of paint? ...).
- Most of the methods must be repeated (ideally just before the next harvesting operation).
- Marking of extraction racks must be seen as an integral part of sustainable forest management.
When to open extraction racks?

- Depends on the silvicultural concept (see model for ash and sycamore)
- Already before the first precommercial thinning?
- Together with the first precommercial thinning?
- Simultaneously with the first (commercial) thinning
- One or several years before the first thinning
Source: Forest Service of Thuringia
Documentation of ER

• In the classical way through distance and bearing -> map
• Using GPS during marking
• Using GPS afterwards
• Using GPS during harvesting operations (receiver on the machines)
• Via remote sensing (areal photographs)
Time of harvesting operations 1

• (Application of) Knowledge and organisation are the most important means for avoiding soil damages and maintaining the trafficability of extraction racks.

• To be followed by forest enterprises as well as by contractors
Time of harvesting operations 2

• Basis: Sensitivity of sites known as result of site mapping

• Examples:
  – Classification of site types of Lower Saxony (based on the results of site mapping)
  – Table in the guidelines of Baden-Württemberg
  – In the UK!?
Time of harvesting operations 3

• “Intelligent” plans for sensitive sites:
  – Not to be “used” for just-in-time delivery
  – To be taken up in plans as “reserve” (= additional stand to be harvested -> if the situation allows, harvesting should start immediately)
  – Alternative areas (work) to be included in the harvesting plan
  – Easier to attain if larger areas are combined (within an enterprise or as a combination of enterprises)
Time of harvesting operations 4

• Check trafficability at a certain point in time -> choose another date of harvesting if required:
  – Sensitivity of sites as basis
  – Weather during the period before harvesting should take place
  – Tests like the one proposed by LWF
  – (Use of the software package PROFOR)
Decision support-tree for „drive or not to drive“

Soil sample

Result: track type 1 or 2

Optimisation of machines

Drive! Talk to forest owner!

Source: LWF
Time of harvesting operations 5

• Other areas (or work) available?
• Delays and change of work place lead to additional costs which must be born by enterprises and paid to contractors.
• Control during and after harvesting operations (ideally using checklists and forms)
• Just-in-time delivery may create problems because skidding might not be delayed in order to meet deadlines.
After disasters

- Old tracks should be used in harvesting operations after disasters!

- This requires that the extraction racks are properly documented!
Contracts

• Contracts between forest enterprises and contractors should include:
  – quality standards! (“Quality standards pay”)
  – additional payment if contractors run into higher costs
  – penalties or a bonus-malus-system (a good example has been developed in Austria)
Maintenance of ER 1

• Opening them for consecutive interventions (e.g. removal of shrubs or natural regeneration):
  – manually (expensive!)
  – by mulching
Maintenance of ER 2

• For technical trafficability:
  – Stop water flow (“Querableitung”)
  – “Smoothening” (Planing)
  – Let alone (“Ruhenlassen”)
  – Add material to harden the ER
Rehabilitation of ER

• It takes decades if it is possible at all (no roots, no biotic activity!)
• Greater chances at sites with clay (due to dwelling and shrinking)
• Promising results from planting of alder (“Schwarzerle”) in the tracks (roots of this species are able to penetrate the compacted soil)
• Greater chances for regeneration under tracks caused by track-type vehicles compared to those caused by wheeled vehicles
Means to avoid soil damages

- Time of operation (organisation!)
- Necessity and number of trips (see harwarder)
- Branches in the extraction racks – but the dimension of the branch layer which is necessary to completely avoid soil damages is rarely reached
- Type and equipment of machines
Technical means to reduce soil damages

• Harvesting systems (e.g. traction support winch [“Traktionshilfswinde”])
• Training and monitoring (incl. use of GPS)
• Tyres and tyre pressure (reduced tyre pressure; radial tyres better than diagonal tyres; tyre profile!)
• In the case of slippage: chains, ..., traction support winch)
• Undercarriage (number of axles, crawler tracks of different versions)
• Weight of vehicle and weight distribution
A sort of summary

• **Definition**: extraction racks = lines to which vehicle movements are restricted to

• **Purpose**: to concentrate soil and other damages to as small an area of a stand as possible

• **Reason**: every vehicle movement causes soil damages (e.g. compaction, ruts …)
A sort of summary: problems

- Soft ground which cannot bear vehicles
- Ruts in the extraction racks
- Maintenance of the „technical trafficability“
- To what extent lead extraction racks to root damages (consecutively to root rot and yield loss)?
- Do vehicles really stay on the extraction racks (control of operation)?
A sort of summary: use

• Drivers must not leave the extraction racks (stipulated by certification schemes such as PEFC and FSC)
• Time of operation according to soil type and moisture content
• Various suggestions as decision-support-systems
• Interruption of skidding during bad weather periods (problems with just-in-time delivery – this policy requires large areas)