SCENARIO PLANNING FOR SKID TRAIL IMPLEMENTATION AND LONG TERM TRAFFICABILITY

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Content

- Context
- National recommendations for skid trail implementation in France
- Most efficient skid trail implementation for haulage activity
- Cumulated tonnage on skid trails over a 150-year rotation
Context

✓ A request from a French workgroup made up of a Forest Cooperative (Forêt & Bois de l’Est) and public Forest (ONF) in SIMWOOD project

✓ How to implement skid trails in a hardwood stand on sensitive soils in the plains?

⇒ Which orientation ?

⇒ And for which consequences according to haulage productivity and long term trafficability ?

→ A geo-based comparison of skid trail implementation scenarios
**Context**

- A typical rectangular stand of 8,7 ha in the lowlands
- Private forest
- Oak high forest with hornbeam coppice
- Forest soils are heterogeneous and agriculture left us with the most sensitive situations to deal with: Silt, clay, hydromorphy...
- Traffic is frequent (every 5-10 years), so soil recovery is limited

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### Forest Dynamics: Periods Between Harvests

<table>
<thead>
<tr>
<th>Period (years)</th>
<th>Harvested Volume / Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>3, 37 to 45 m³</td>
</tr>
<tr>
<td>Between 30 and 60</td>
<td>3, 37 to 45 m³</td>
</tr>
<tr>
<td>Between 60 and 80</td>
<td>2, 39 to 45 m³</td>
</tr>
<tr>
<td>Between 80 and 100</td>
<td>2, 45 to 51 m³</td>
</tr>
<tr>
<td>Between 100 and 130</td>
<td>1, 430 to 460 m³</td>
</tr>
<tr>
<td>Between 130 and 150</td>
<td></td>
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<tr>
<td>Between 150 and 170</td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- Forest area
- Landing area
- Forest road
- Main skid trail (between 2 stands)
- Stand border (ditch)

**Operations:**
- 14 Operations / 150 years
National recommendations for skid trail implementation in France

- A network of permanent corridors in order to preserve productive area from compaction and rutting
- Implementation of skid trails requires analysis and consequences over the whole forest rotation need to be taken into account
- Characteristics of optimal skid trails
  - width of 4 m
  - 18 m interspace
  - Straight as possible
  - Obliquely to exits
  - Following the slope
- Characteristics to be adapted to field conditions (wetland, stream, existing trails, slope break …)
- Conditioned by forest roads and location of landing areas
What is the most efficient skid trail implementation for haulage operation?

- Focus on a single operation: forwarding of tree crowns (80 m$^3$/ha) after the final cut and after the skidding of logs.

- Seven scenarios were compared (scenarios 1 to 7) in terms of driving distance and productive time, depending on the combination of four conditions:

  - Number of landing areas: one or two
  - Skid trail orientation: longitudinal or transversal
  - Driving direction: one-way drive or loop drive
  - Forwarder speed: same speed on every skid trails or variable speed depending on skid trail status (main skid trail or not)

<table>
<thead>
<tr>
<th>Skid trail status</th>
<th>Load status</th>
<th>V 1</th>
<th>V 2</th>
<th>V 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>First main skid trail (to east border with other stand)</td>
<td>Empty</td>
<td>9</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Loaded</td>
<td>8</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Second main skid trail (inside stand, near west border)</td>
<td>Empty</td>
<td>9</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Loaded</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Other skid trails</td>
<td>Empty</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Loaded</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
→ One-way drive and one landing area

- Shortest driving distance (41 km) is obtained with longitudinal orientation
  ① = reference scenario

- Transversal orientation increases
  - driving distance by 56%
  - driving time by 30%

- Cumulated weight at the entry of a skid trail is 265 tons for longitudinal orientation against 130 tons in the scenario with transversal orientation (-51%)
Loop drive and one landing area

- Drive as a loop by using a second main skid trail
- Driving distance increases by 46% or 10% depending if the driver returns to landing area with the last load of a skid trail partially filled or not
- Driving time decreases by 6% in scenario ④ with full loads and higher speed in the 2 main skid trails
- In all other cases, driving time increases compared to reference scenario (①)
- Cumulative weight at the exit of a skid trail is 75 tons against from 62 tons to 80 tons in case where last load of a skid trail is fulfilled
→ Two landing areas

Transversal orientation with full last loads is always the most efficient organization (scenario 6)

• total driving distance decreases by 19% and productive time by 15% (V3) or by 25% (V1)

Longitudinal orientation allows saving 16% on driving distance and 15% on productive time (scenario 7)

• Same weight at the exit of a skid trail in 5 and 6 than in 3 and 4.
  But cumulated weight decreases in the 2 main skid trails

With longitudinal orientation (7), cumulated weight at the entry of a skid trail is 116 tons and is 156 tons at the exit
What are the cumulated tonnages on skid trails over a 150-year forest rotation?

- **Forwarder** (18 tons + 8 tons load)
- **Skidder** (11 tons + 7 tons load)

### Rules to complete last loads:
- **Load <20%**: added to the previous forwarding load
- **20% ≤ Load ≤ 60%**: completed in next skid trail
- **Load >60%**: not completed

### 14 operations

<table>
<thead>
<tr>
<th>Stand age</th>
<th>Operation</th>
<th>Storey</th>
<th>Product</th>
<th>Haulage machine</th>
<th>Harvested volume (m³/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Skid trail implementation</td>
<td>Wood</td>
<td>Forwarder</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1st thinning</td>
<td>Wood</td>
<td>Forwarder</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>2nd thinning</td>
<td>Wood</td>
<td>Forwarder</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>60, 70, 80, 90, 100, 110, 120, 130</td>
<td>8 increment fellings</td>
<td>High forest</td>
<td>Logs, Wood energy</td>
<td>Forwarder 25 / operation</td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>Regeneration felling</td>
<td>Coppice</td>
<td>Wood</td>
<td>Forwarder 10</td>
<td></td>
</tr>
<tr>
<td>145</td>
<td>Regeneration felling</td>
<td>High forest</td>
<td>Logs, Wood energy</td>
<td>Forwarder 85</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>Final felling</td>
<td>High forest</td>
<td>Logs, Wood energy</td>
<td>Forwarder 80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 operations in total</td>
<td></td>
<td></td>
<td></td>
<td>1 250</td>
</tr>
</tbody>
</table>
200 passes adding-up 3 663 tons at the end of a skid trail (for an average of 14 drives and 262 tons per operation and per skid trail)

Cumulated weights are equally distributed from one skid trail to the next but not along a skid trail
→ Transversal orientation, one main skid trail

At the end of a skid trail: 104 passes adding-up 1,887 tons (for an average of 7 drives and 135 tons per operation and per skid trail).

Cumulated weights and numbers of passes are focused on the main skid trail.

Main skid trail must be capable to support heavy loads.
Transversal orientation, two main skid trails

- Haulage as a loop for forwarding but not for skidding (logs and tree crowns obstruction)

At the end (left) of a skid trail 55 passes adding-up from 1 002 to 1 028 tons (for an average of 4 passes and approximately 72 tons per operation and per skid trail)

Cumulated weight on the ends of skid trails is divided by 2
Conclusion / lessons learnt from the scenario approach

- In studied conditions, all forest machineries must drive on permanent corridors to preserve soils from compaction and rutting

- With a typical rectangular hardwood stand of oak high forest with hornbeam coppice on sensitive soil, best implementation is:
  - two landing areas (one at each opposite side of the stand),
  - transversal orientation of skid trails
  - and loop-drive instructions

- If only one landing area is possible,
  - then longitudinal orientation of skid trails is better than a transversal one,
  - but the traffic is high at the entrance of each skid trail

- Nevertheless, transversal orientation is to be preferred despite its impact on productivity when considering the need to maintain the long term trafficability
Conclusion / lessons learnt from the scenario approach

- Forest cooperative changed skid trail orientation to transversal

- Results published in ONF’s technical journal

- Traffic simulation is now used as a part of training session to increase professional know-how and to contributes to getting agreement of forest owner
Thank you for your attention

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