The effect of corridor-thinning and thinning below method on the harvesting efficiency, remaining stand and removal – results of a literature review

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This presentation is based on:


Topic of this presentation

Schematic description of boom-corridor thinning patterns by Bergström (2009)

 Boom-Corridor thinning vs. traditional thinning from below

- Productivity and costs of cutting
- Removal
- Stand-structure after cutting
- Stand-growth after cutting
- What should be done in the future?
The studies of this literature review

Productivity of cutting

**Study 1** compared the productivity of boom-corridor thinning to traditional thinning below method *(Bergström et al. 2010)*

- An actual time study was conducted with 16 plots
- 30 years old Scots pine dominated study stand
- Valmet 911,1 harvester with Cranab CHR 16-crane and Bracke C16-head

**Study 2** compared three different types of boom-corridor thinning approaches in simulations *(Bergström et al. 2007)*

- Data of 24-years old first thinning stand (FT) and 17-years old pre-commercial thinning (PCT) stand were used in the simulations
- Proportion of tree species: FT-stand pine 50% and spruce 50%, PCT-stand spruce 80% and birch 20%
- In simulations a standard medium-sized harvester was assumed

**Study 3** defined using simulation the time consumption of traditional single tree cutting and multi-tree cutting in FT- and PCT-stands *(Sängstuval et al. 2011)*

- In total 9 different cutting techniques were compared for thinning below and boom-corridor methods
- Thinning intensity 30%, 40% or 50%
- Stand density before thinning 2000-10000 trees/hectare
- Stand density after cutting 1000-4000 trees/hectare
The studies of this literature review

Costs of procurement chain from stump to end use facility

- **Study 4** modelled and analyzed the supply chain cost and energy efficiencies for new and conventional harvesting and handling technologies in early thinnings stands (including cutting-forwarding-truck transport) (Bergström & di Fulvio 2014)
  - The data of previous studies was used for all analysis
  - The thinning method was 'traditional selective strip-road thinning' or 'boom corridor thinning'
  - 8 different harvester-forwarder chain

Future cutting technology for boom-corridor thinning

- **Study 5** evaluated the felling speed of a felling head prototype designed for continuous felling of small-diameter trees in boom-corridors (Bergström et al. 2009)
  - The study stand: 18 years old, 10800 trees/ha, height 5.6 m, dbh 5.6 cm
  - Tested machine: mid-sized harvester of 12 t, crane reach 9.34 m
  - Felling head designed for continuous felling

- **Study 6** evaluated the utility of 1) compression-processing of grapple bunches in cutting and 2) compressing forwarder loads of small trees (Bergström et al. 2010)
  - A multi-tree handling head with feature of compression processing the tree bunches was mounted on a conventional harvester was used in experiment 1
  - A forwarder designed with arms for compressing the load was used in experiment 2
The studies of this literature review

Effects on remaining stand and removal

- **Study 7** compared the effects of systematic thinning and selective thinning on the structure of the remaining stand and the volume and structure of removal (pine and spruce) *(Isomäki & Väisänen 1980)*
  - The studied thinning methods were 1) Fully-systematic thinning, 2) Semi-systematic thinning, 3) Selective thinning based on removal basal area, 4) Selective thinning based on removal density and 5) Unthinned control
  - Study experiments: spruce 34-41 years, pine 24-40 years and
  - Measuring of the 45 observation plots 4-8 years after cutting

- **Study 8** compared the long-term effects of half-systematic and systematic thinnings with the effect of selective thinning on growth (pine and spruce) *(Mäkinen et al. 2006)*
  - Sequel to the study 7 report of same experiments used in study 7
  - Observation plots were measured 4 times during, measuring period 19 years after cutting
  - Thinning treatments: 1) Unthinned control, 2) Selective thinning (removal density), 3) Selective thinning (basal area), 4) Semi-systematic thinning (basal area) and 5) Fully-systematic thinning (basal area)

- **Study 9** compared the long-term effects of corridor thinning and selective thinning on mortality, growth and volume of remaining stand (pine) *(Karlsson et al. 2012)*
  - Pre-commercial thinning IntSI experiments were thinned in 1972 at the age of 14 years (original stand 10 000-14 000 trees/ha) and the LowSI experiments at the age of 25 years (original stand 9 000-11 000 trees/ha)
  - First thinning experiments were thinned 1974-1981 at the age of 21-29 years
  - Observation plots were measured 3-4 times, measuring period 18-30 years after cutting
Study 1 (Bergström et al. 2010)

**Productivity**: boom-corridor thinning vs. traditional thinning below method

- An actual time study was conducted with 16 plots
- 30 years old Scots pine dominated study stand
- Valmet 911,1 harvester with Cranab CHR 16-crane and Bracke C16-head

- **Productivity**
  - The productivity of boom-corridor thinning (4.6 Odt/PMh) was 15.8% higher than for thinning from below (4.0 Odt/PMh)
  - Time consumption per tree: boom corridor thinning 7.66 sec/tree and thinning from below 7.93 sec/tree

- The productivity of Fixteri using thinning below method was in same level as in Study 1
  - Productivity 3.9 Odt = 9.7 m³/PMh
  - Time consumption of cutting 8.2 seconds/tree
STUDY 1:
Why was the productivity of Boom-corridor thinning higher

- ‘Felling & collecting’ and ‘Transfering crane between trees’ were most important work-cycle for Boom-corridor and for Thinning from below

- Time consumption of ‘Felling and collecting’ was 7% less for Boom-corridor than for Selective thinning

- Time consumption of ‘Transfering crane between trees’ was 17% less for Boom-corridor than for Selective thinning
**STUDY 2 (Bergström et al. 2007)**

**Productivity:** Boom-corridor thinning vs. Selective thinning using *AFH-5tr* harvesting approach (Simulation study)

- The productivity of selective thinning was approx. 30% lower than that of Boom-corridor.

<table>
<thead>
<tr>
<th>Stand before cutting</th>
<th>Trees/hectare</th>
<th>first thinning stand (FT)</th>
<th>pre-commercial thinning (PCT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees/hectare</td>
<td>3590</td>
<td>8600</td>
<td></td>
</tr>
<tr>
<td>Dbh, cm</td>
<td>9.3</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Average tree, dm³</td>
<td>46</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Removal</th>
<th>Trees/hectare</th>
<th>1290</th>
<th>3100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand after cutting</td>
<td>Trees/hectare</td>
<td>2300</td>
<td>5500</td>
</tr>
</tbody>
</table>

- The proportion of work element 'Felling and collecting' decreased as the productivity increased.

<table>
<thead>
<tr>
<th>First thinning (FT)</th>
<th>Productivity [m³/PHam]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FT/Boom-corridor</td>
<td>FT/Boom-corridor</td>
</tr>
<tr>
<td>perpendicular/AFH-5tr</td>
<td>fanshaped/AFH-5tr</td>
</tr>
<tr>
<td>FT/Boom-corridor</td>
<td>FT/Boom-corridor</td>
</tr>
<tr>
<td>fanshaped/AFH-5tr</td>
<td>fanshaped/AFH-corr</td>
</tr>
<tr>
<td>FT/Selective/AFH-5tr</td>
<td>FT/Selective/AFH-5tr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First thinning (FT)</th>
<th>Proportion of work elements, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving</td>
<td>Boom-out to first tree</td>
</tr>
<tr>
<td>Felling &amp; collecting</td>
<td>Bunching</td>
</tr>
</tbody>
</table>
STUDY 3 (Sängstuval et al. 2011)

Compared effect of thinning methods and harvesting techniques on productivity in simulations

- In total 9 different cutting techniques were compared for thinning below and boom-corridor methods
- Thinning intensity 30%, 40% or 50%
- Stand density before thinning 2000-10000 trees/hectare
- Stand density after cutting 1000-4000 trees/hectare

- Thinning method had the biggest influence on productivity
STUDY 4 (Bergström & di Fulvio 2014)
Harvester cost in PCT stands: Boom corridor thinning vs. selective thinning

- For modelling the data of previous studies was used for all analysis
- Tree species mixture Pine, Spruce, Birch with dense undergrowth
- The thinning method was ‘traditional selective strip-road thinning’ or ‘boom corridor thinning’
- 8 different harvester-forwarder chain
  - Whole-trees were cut using traditional harvester
  - Whole-tree bundles were cut using Fixteri bundle-harvester

The smaller stem volume – The lower is cost of Boom-Corridor thinning

- AFH-whole-trees-BC costs were 2-22% lower that AFH-whole trees-selective thinning for stem size 22-8 dm³
- AFH-CF-whole trees-BC costs were 24-47% lower that AFH-whole trees-selective thinning for stem size 17-8 dm³

The graph shows the cost in PCT stands for different stem volumes and thinning methods. The smaller the stem volume, the lower the cost of Boom-Corridor thinning.
STUDY 7 (Isomäki & Väisänen 1980)

Effects of corridor-thinning and selective thinning on removal and structure of the remaining stand

- The studied thinning methods were 1) Fully-systematic thinning, 2) Semi-systematic thinning, 3) Selective thinning based on removal basal area, 4) Selective thinning based on removal density and 5) Unthinned control
- 7 separate study experiments: spruce 34-41 years, pine 24-40 years
- Measuring of the 45 observation plots 4-8 years after cutting

Experiments before thinning

- After fully-systematic thinning stem size varied from –1 to +2%
- Semi-systematic thinning increased the average stem size 5-12% and selective thinning 8-13%

Average stem volume
- Fully-systematic
- Semi-systematic
- Selective thinning

Relative average stem volume after thinning
- Fully-systematic
- Semi-systematic
- Selective thinning

Experiments/thinning intensity-%
STUDY 8 (Mäkinen et al. 2006)
Effects of corridor-thinning and selective thinning on growth

➤ Sequel to the study 7 report of same experiments used in study 7
➤ Observation plots were measured 4 times during, measuring period 19 years after cutting
➤ Thinning treatments: 1) Unthinned control, 2) Selective thinning (removal density), 3) Selective thinning (basal area), 4) Semi-systematic thinning (basal area) and 5) Fully-systematic thinning (basal area)

<table>
<thead>
<tr>
<th>Characteristic of the experiments</th>
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<tbody>
<tr>
<td><strong>Experiment</strong></td>
</tr>
<tr>
<td>Tree species</td>
</tr>
<tr>
<td>Regeneration method</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Trees/hectar</td>
</tr>
<tr>
<td>Basal area m2/ha</td>
</tr>
</tbody>
</table>
STUDY 8: Pine experiments

Volume per hectare for stand before thinning, removal and stand after thinning

- **In Pine, growth was highest on the unthinned experiments (11.0 m³/hectar) followed by Selective N thinning (10.2 m³/ha).**
- Previous had also highest standing volumes (300.1 m³/ha/282.3 m³/ha).
- The standing volume and growth of Semi-systematic thinning and Selective B thinning were in the same level.
- The growth of Fully-systematic thinning was lower 3% than selective B thinning, their standing volumes were in the same level.

Corridor thinning vs. selective thinning:
*No significant differences in Pine growth*

- In Pine, growth was highest on the unthinned experiments (11.0 m³/hectar) followed by Selective N thinning (10.2 m³/ha).
- Previous had also highest standing volumes (300.1 m³/ha/282.3 m³/ha).
- The standing volume and growth of Semi-systematic thinning and Selective B thinning were in the same level.
- The growth of Fully-systematic thinning was lower 3% than selective B thinning, their standing volumes were in the same level.
STUDY 8
Spruce experiments

Volume per hectare for stand before thinning, removal and stand after thinning

- In Spruce, the growth of Fully-systematic thinning was 10% lower than Selective B thinning, however the standing volume was also bigger.
STUDY 8: The effect of corridors of growth

- The effect of corridor opening on the volume growth of individual trees was examined in the following zones from the corridor: 0-2 m, 2-4 m, 4-6 m, >6 m.
- The strips between corridors were at least 8 m wide.
- The tree-measurements were conducted five times: 5, 8, 12, 16, 20 years after thinning.

Results

- Trees located up to 4 m from the corridor increased their growth.
- Corridor width 3-5 m:
  - The growth of the edge trees (0-2 m) exceeded the growth of the trees in centre 40-60%.
- Fully- and Semisystematic thinning/corridor width 4-5m
  - The growth-increment of edge trees compensated 40% the loss caused by the corridor.
- Semi-systematic thinning/corridor width 3 m
  - The growth-increment of edge trees compensated 70% the loss caused by the corridor.
STUDY 9 (Karlsson et al. 2012)
Effects of corridor-thinning and selective thinning on growth, mortality and yield

- Pre-commercial thinning IntSI experiments were thinned in 1972 at the age of 14 years (original stand 10 000-14 000 trees/ha) and the LowSI experiments at the age of 25 years (original stand 9 000-11 000 trees/ha)
- First thinning experiments were thinned 1974-1981 at the age of 21-29 years
- Observation plots were measured 3-4 times, measuring period 18-30 years after cutting

Stand ang growth characteristic IntSI 27 years after PCT and LowSI 29 years after PCT

- In corridor thinning the growth was 11% lower than in selective thinning for LowSI experiments
- In corridor thinning the growth was 17% lower than in selective thinning for IntSI experiments
What should be done in the future?

- The study results so far indicate that the boom-corridor thinning is a potential harvesting and forest management method.
- Boom-corridor thinning method would be worth further studying/developing.

**Visio:**

A development project of boom-corridor thinning in small-diameter thinnings

- To adapt/put into practice boom-corridor thinning method in different stands and for current harvester technology in cooperation with forest owners and contractors.
References


Thank you!