Harvesting in uneven-aged stands

Matti Sirén

Future forests workshop, Uppsala 21.08.2013

Photo: Juhani Korhonen
The key questions: what kind of harvesting conditions we have now and in the future? What are the volumes?

- Harvesting conditions of selection cuttings have features of later thinnings/shelterwood cuttings
- Large variation in stand structures – in and between stands: first steps towards uneven-aged structure <> stands with uneven-aged structure
- In selection cuttings information on stand structure is needed for harvesting planning and operation
- First actual large scale operation gives us knowledge on best practices. Anyhow, in the 1980s we discussed very much, is the harvester operator able to select the removed trees in even-aged thinnings – operators are good to learn!
Harvesting productivity – very different views

Vesa Imponen (Metsäteho, Monta-experiments)

- Harvester productivity in selection cuttings 20% lower than in clearcuttings with same tree size due to avoiding damage, planning and increasing machine movings.
- In selection cuttings the average stem size is often larger than in clearcuttings > productivity only little lower and harvesting costs little higher than in clearcuttings (10%).
- In cost comparisons we must remember compare all the costs of the generation period.
- Monta-experiment stands had mostly near even-aged structure – how this affected the results?
The view of Metsäkonepalvelu manager Timo Tolppa (Metsäkonepalvelu is the largest contracting company in Finland with more than 50 machines)

Harvesting cost factors of selection cuttings:

- Harvesting planning – negative
- Site size – negative
- Stem size - +/- , not known
- Undergrowth – negative
- Seasonal variation of harvesting – negative
- Knowledge/schooling of personnel – negative

**Summary:** "Stories" on costs only a bit lower than in clearcuttings are not from real life
Timo Tolppa on pricing of harvesting

- Machine contractor does, what the client orders
- The economic position of contractors does not allow long training and testing times
- Finding best practices takes often too much time
- We have no models for pricing the work
- The costs of selection cuttings are much higher than with same tree size in even-aged thinnings; up to this comes extra planning
- **Who pays the extra costs: the forest owner in lower timber price**

There is also one positive factor: in selection cuttings large machinery is a must – large machines are OK for contractors
Study topics of harvesting research in the program

1. Structure and amount of selection cuttings
2. Clarify the possibilities of laser scanning and other sophisticated methods in estimating the structure of uneven-aged stands and in planning and operator tutoring of selection cuttings
3. Comparison of productivity and silvicultural quality of harvester working methods
4. Criteria for harvesting quality monitoring
5. Estimate the influence of selection cuttings on timber procurement
We have very low knowledge on selection cuttings, but we can utilize "overall" knowledge on harvesting

Some new experiments at Metla give useful information for selection cuttings:

- New experiments of Norway spruce harvesting:

- Much research on soft soil harvesting, carrying capacity of soil (Jari Ala-Iломäki et al.)

- Ways to reduce seasonal variation of harvesting (Kari Vääätäinen et al.)

- FIBIC (Finnish Bioeconomy Cluster) EffFibre-program (2010-2013) WP3: Possibilities of operator tutoring, more effective forwarding utilizing the GIS-data produced by harvester, LoggingMap (Kari Vääätäinen et al.)

- This knowledge can be utilized also in selection cuttings
Norway spruce thinning in unfrozen soil – root rot risk

- In even-aged Norway spruce thinnings we get a good residue mat to cover soil and roots, 15-20 kg/m²
- In selection cuttings the removal changes; the residue mat not so dense
- Do we have a permanent strip road network in selection cuttings (Silva Skog, Sweden), do we use wider strip roads (tests in peatland harvesting on heavily trafficked primary strip roads)
- We need information on soil carrying capacity for forwarding; we are testing possibilities to collect data on carrying capacity with harvester power transmission, sensors (Jari Ala-Iломäki)

Influence on working method on rut formation on spruce stands: Method 1 = normal working method, Method 2 = all residues to strip road

Source: Sirén et al. 2013/IFJE
Literature reviews, damage models

- We started with literature review:
- Study on sapling damage (Surakka et al. 2011):
  http://www.informaworld.com/smpp/content~db=all~content=a933216056~frm=titlelink
- Results similar with Fjeld and Granhus

  Sapling damage depend on (Surakka et al. 2011):
  - Distance to strip road
  - Removal, m²/ha (25 m radius from the sample plot
  - Distance to nearest remainig tree
  - Sapling height

![Graph showing injury probability against distance from strip road with three lines representing different removal levels: 10 m²/ha⁻¹, 6 m²/ha⁻¹, and 2 m²/ha⁻¹.]
Future harvesting possibilities are based on mid-sized trees

- The number of mid-sized trees (diameter classes 5-20 cm) is often limited
- Survival of these trees is important
- In cutting tops of these trees are easy to damage
- Fjeld & Granhus (1998): 10 - 15 % of larger trees are damaged in harvesting
- (Juha Hyvönen et al. 2013): 21.5 % of larger trees damaged, includes also severe debranching).
- Percentage of damage in height classes:
  - 2.5-10 m: 28 %
  - 10-20 m: 19 %
  - > 20 m: 12 %
What are the goals of forest owner – how they are delivered to harvester operator

- Does the forest owner living in town know, how does the forest having 10 m² BA looks like
- One of the main concerns of industry/contractors: how the forest owner feels about the silvicultural harvesting results; how we monitor and classify the results in selection cuttings?
- ”Systematic approach” of even-aged thinnings does not always suit for selection cuttings
- In selection cuttings the harvester operator must somehow see behind the corner; where to go, possibly not everywhere
- New tools can give advise
Removal can vary a lot in stands (Source: Surakka et al. 2011)
Intelligent forest machine

Operator assistant systems
- Tutoring and feedback on work cycles
- Economic driving
- Driver drowsiness

Cooperative systems
- Sensing of trees, soil
- Obstacle, power line, hiker warning

Location based systems
- Tree map generation
- Machine to machine communication (location of timber, soil trafficability)

Slide: Antti Asikainen
Tutoring assistance possibilities may be on the way - f.ex. LoggingMap. With LoggingMap site slopes, bearing capacity and stand structure can be visualised to operator (Photos Sami Lamminen/Metla)
LoggingMap-demonstrations
Rautavaara
November 2012

Sami Lamminen, Kari Väätäinen, Jari Ala-Illomäki, Matti Sirén ja Antti Asikainen
Demo-stands
Harvester instrumentation

- LoggingMap in harvester cabin
Different ways to tutor operator

BA before thinning

Guidance for BA after thinning
Tutoring of slopes/poor bearing capacity places helps in positioning of strip roads, locating storages.
Strip road network after thinning
In forest haulage harvester GIS-data on the amount and position of timber assortments can be utilized in tutoring of forwarder operator. With optimal driving tactics we can spare fuel and soil and increase productivity (Slide: Kari Vääätäinen et al. /Metla)
Two forwarding methods, minimized driving method  (calculated and analyzed from the work study data)

Driving during loading

1. load
2. load
3. load
4. load

Slide: Kari Väätäinen, Metla
Advantages of minimized driving (Whole stand, VRP-optimizing, slide Kari Väätäinen)

<table>
<thead>
<tr>
<th>VRP-optimizing (12 loads)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Save in time</td>
</tr>
<tr>
<td>Save in fuel use</td>
</tr>
<tr>
<td>Save in BTnkm</td>
</tr>
<tr>
<td>Save in drivings</td>
</tr>
<tr>
<td>Save in driving time</td>
</tr>
<tr>
<td>Increase in loading time</td>
</tr>
</tbody>
</table>
Structure of selection cutting stands (9 stands)

<table>
<thead>
<tr>
<th></th>
<th>Trees/ha</th>
<th>BA, m²/ha</th>
<th>Volume, m³/ha</th>
<th>Average tree size, dm³</th>
<th>Median tree size, dm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remaining stand</td>
<td>814,8</td>
<td>13,4</td>
<td>126,3</td>
<td>204,7</td>
<td>448,1</td>
</tr>
<tr>
<td>Removal</td>
<td>401,8</td>
<td>14,2</td>
<td>138,9</td>
<td>420,2</td>
<td>644,7</td>
</tr>
</tbody>
</table>

Large variation: BA of remaining trees 6,5-22,2 m²/ha
Number of saplings, 0.5-2.5 m, 897/ha (255-2164/ha)
Measurement system (Slide: Esko Oksa/Metla)
Stand visualization (Slide Esko Oksa/Metla)
Remaining stand and removal (Slides Esko Oksa/Metla)