Productivity and cost of harvesting short-rotation downy birch

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Content

I Background
II Material and methods
III Results
IV Conclusions
I Background
International climate policy

• 2030 Energy Strategy of the EU
  – A 40% cut in greenhouse gas emissions compared to 1990 levels
  – At least 27% share of renewable energy

⇒ demand of biofuels will increase
  – Availability?
Forest chip potential in Finland

National

Regional

m³/km²/a
Utilisation of marginal land?

• Case Hirvineva (Jylhä et al. 2015)
  – Downy birch (*Betula pubescens*) shows potential for profitable production of energy biomass on cutaway peatland without subsidies
  – Uncertainties in the calculations
    • Continuity of coppicing vigour
    • Biomass production of diverging management regimes
    • Harvesting cost

• Roadsides, field margins, power line corridors
• Coppice production
Harvesting technology in coppice production

• The trend of extending rotations in SRC
  – Quality of biomass
  – Harvesting cost

• Limitations of the SRC harvesters in natural thickets
  – Cutting capacity (max. 15 cm)
  – Lacking harvesting corridors
  – One-process operation → wet chips
  – Narrow field of application → risk to the owner
II Material and methods
Harvesting experiment

• Time study of cutting and forwarding at clear-cuts of naturally afforested downy birch thickes in a former peat production area (Hirvineva)
  – Conventional forest machines
• Regression models for productivity
• Cost calculations of forest chip production
Cutting

- **Valmet 911.3** (2006)
- **Bracke C16.b**
- **17 harvesting units**
Forwarding

- *Ponsse Buffalo (1998)*
- 10 wheels
- *Heightened load space*
- *Carrying capacity 14 t*
- 26 loads from 14 harvesting units
- *Driving unloaded and loaded was excluded*
Stand properties

Even models with stand age as an independent value had high coefficients of determination (91% for cutting, 68% for loading time in forwarding)
III Results
Multi-tree handling

\[ y = 121.185 \times x^{-1.826} \]
\[ F = 422.840, \ p < 0, \ R^2 = 0.966 \]

\[ y = 88.142 \times x^{-0.880} \]
\[ F = 3092.420, \ p < 0.001, \ R^2 = 0.995 \]
Division of effective time into elements / harvester

Mean height (arithm.) ca. 4.5 m

Bucking of standing trees, no grapple feeding

Time consumption, E_g min OD t^{-1}

Number of time study unit

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Miscellaneous
Moving
Bucking
Boom in_HIGH
Boom in_LOW
Boom in_MIXED
Bunching_MIXED
Bunching_HIGH
Bunching_LOW
Boom out_HIGH
Boom out_LOW

Mean height (arithm.) ca. 4.5 m
Cutting productivity

Residual biomass left on site after forwarding (3–8 t ha⁻¹, on average 7% removal) is not included in recovery.

\[ y = 3.552 \times x^{0.279} \]

\[ F = 368.824, p < 0.001, R^2 = 0.961 \]

6–24 m³/E₀·h
Division of effective time into elements / forwarder

Average bunch length 5.7 m (5.5–9.5 m)!!!
Average green mass of even loads 6.6 t (5.3 – 9.0 t)
(the greatest load mass was 11.5 t)
Productivity of forwarding

Mean height of the trees (weighed by basal area)

- 5 m
- 7 m
- 9 m
- 11 m
- 13 m

Forwarding distance, m
100 200 300 400 500

Forwarding productivity, ODt $E_0 \cdot h^{-1}$
4
6
8
10
12
14
16

m$^3$ $E_0 \cdot h^{-1}$
29
25
21
17
13

Ca. 25% higher productivity than assumed by Jylhä et al. (2015)

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Production cost of forest chips

Assumption in Jylhä et al. (2015) 12.4 – 21.0 € MWh⁻¹

Moisture content on delivery 40 %
IV Conclusions

- Biomass can be harvested from dense downy birch thickets in cost-efficient way by clear-cuts
- In downy birch stands located in cutaway peat bogs in northern Finland, 20 years is a threshold age from the point of a) biomass production (Hytönen & Aro 2012), b) profitability (Jylhä et al. 2015) and c) cutting cost (present study)
- The operational cost in Jylhä et al. (2015) was underestimated by 10–20%
- The models are suitable for estimating the efficiency of harvesting small-diameter whole trees from unthinned, dense stands with comparable wood properties and biomass allocation of the trees
Comparison with Jylhä et al. (2015)

New cutting technology can lower the supply cost
- higher cutting speed, accumulation and bucking
Limitations of the clear-cut system

- Seasoning on leafless birch with intact bark?
- Potential soil damage on sites with poor bearing capacity (e.g. mires)
Price development of wood fuels in Finland

PIX Forest Biomass Index Finland / Foex Indexes Oy

→ Fuel chips made from clear-cut natural thickets or coppice stands are competitive without subsidies
Competitiveness of forest chips in heat generation in Finland

(Statistics Finland 2015)
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