Productivity norms for harvesters and processors used in Italy

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Italian harvesters: the series
Productivity norms

- Beyond single tests
- e.g. Brunberg 1995-97
- Nurminen et al. 2006
The study

- 10 years
- 38 tests, 19 operators
- 15,148 cycles
- 60% excavator-base
- Partitioned 70-30
- Same investigators
Six equations

- Move at Deck = f (vol)
- Move in stand = f (slope, power, type, tree density)
- Brush = f (forest or plantation)
- Grab = f (vol, power, machine)
- Fell = f (vol, power, slope, machine)
- Process = f (vol, slope, tree, power, machine, processor)
- Accessory time % = 15 (harvest) or 30 (process)
## Validation

<table>
<thead>
<tr>
<th>Eq. no.</th>
<th>Element</th>
<th>Actual</th>
<th>Predicted</th>
<th>Δ %²</th>
<th>t-test p</th>
<th>r² val.</th>
<th>r² pred.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Move at deck</td>
<td>7.5</td>
<td>7.1</td>
<td>-5.3</td>
<td>0.559</td>
<td>0.009</td>
<td>0.008</td>
</tr>
<tr>
<td>2</td>
<td>Move in stand</td>
<td>19.6</td>
<td>14.4</td>
<td>-26.5</td>
<td>&lt;0.0001</td>
<td>0.098</td>
<td>0.091</td>
</tr>
<tr>
<td>3</td>
<td>Brush</td>
<td>1.2</td>
<td>1.1</td>
<td>-8.3</td>
<td>0.458</td>
<td>0.051</td>
<td>0.020</td>
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<tr>
<td>4</td>
<td>Grab</td>
<td>22.0</td>
<td>21.2</td>
<td>-3.6</td>
<td>0.158</td>
<td>0.121</td>
<td>0.162</td>
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<tr>
<td>5</td>
<td>Fell</td>
<td>29.2</td>
<td>26.8</td>
<td>-8.2</td>
<td>&lt;0.0001</td>
<td>0.401</td>
<td>0.472</td>
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<tr>
<td>6</td>
<td>Process</td>
<td>67.6</td>
<td>68.2</td>
<td>0.9</td>
<td>0.701</td>
<td>0.685</td>
<td>0.670</td>
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<tr>
<td>-</td>
<td>Total at Deck</td>
<td>99.7</td>
<td>97.8</td>
<td>-1.9</td>
<td>0.068</td>
<td>0.684</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>Total in Stand</td>
<td>114.5</td>
<td>110.5</td>
<td>-3.5</td>
<td>0.002</td>
<td>0.558</td>
<td>-</td>
</tr>
</tbody>
</table>
Strengths and Weaknesses

- Representative (large number of units)
- Reliable (large number of obs., same investigator)
- Reasonably accurate ($r^2$ process)
- Simple (few variables)
- Missing parameters

- Compromise btw. accuracy & simplicity
Harvesting productivity

![Graph showing tree volume (m³) vs. m³ SMH⁻¹ for Poplar, Forest, and Coppice]

- **Poplar**:
  - Starts with a lower volume but increases rapidly.
  - Reaches a higher volume compared to **Forest** and **Coppice**.

- **Forest**:
  - Begins with a moderate volume.
  - Shows consistent growth throughout.
  - Slightly lower volume than **Poplar**.

- **Coppice**:
  - Starts with the lowest volume.
  - Grows steadily.
  - Ends up with a volume between **Poplar** and **Forest**.
Steep-terrain harvester

![Graph showing the performance of different harvester models across varying slope gradients.](image)

- **Dedicated** harvester
- **Spider** harvester

Graph details:
- **Y-axis**: m$^3$ SMH$^{-1}$
- **X-axis**: Slope gradient (%)
Comparison of other norms

- Brunberg
- Nurminen
- Purfurts
- Spruce

Tree volume (m³) vs. m³ SMH⁻¹
Conclusions

- Mechanized harvesting established in Italy
- Good body of knowledge
- Base for further R&D