Optimum tree-stem bucking of Brutian Pine (Pinus brutia) Trees in Antalya, Turkey

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To satisfy the demands of today’s and future generations, forests should be managed by modern methods.

Bucking the trees in an optimum way is very important factor to increase productivity and maximum tree value.

In producing forest products, the process of cutting the trees into shorter logs is defined as bucking operation.
Bucking a tree into the sections that maximize the total value is called the optimum bucking method.
The previous studies indicated that optimum bucking method can increase tree values up to 22%.
The optimum bucking problems are categorized in 3 levels:

1. Determining the optimum bucking for each stem in *stem-level* problems
2. Determining the best bucking result with maximum value in *stand-level* problems
3. Maximizing the global profit in *forest-level* problems
Computer-based methods are used to generate large number of bucking combinations even for a single tree.

The modern optimization methods such as network analysis, linear programming and dynamic programming are used.

Especially, dynamic programming has been used to solve stem-level optimum bucking problems.
OBJECTIVE

- In Turkish forestry, bucking operation is generally performed based on logger’s experiences.

- In this study, Dynamic programming method was used to apply stem-level optimum bucking during a selective cutting of Brutian Pine (Pinus brutia) in the city of Antalya in Turkey.
METHOD

DATA

- Main input data include; log price, log grade, and log size (i.e. diameter and length)
- Current information about the market prices should be available for each log grade with various sizes

<table>
<thead>
<tr>
<th>Length Classes</th>
<th>Length (m)</th>
<th>Diameter Classes</th>
<th>Middle Diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short (S)</td>
<td>1.5-2.5</td>
<td>Small (SD)</td>
<td>19-29</td>
</tr>
<tr>
<td>(N)</td>
<td>3.0-5.0</td>
<td>Medium (MD)</td>
<td>30-39</td>
</tr>
<tr>
<td>Long (L)</td>
<td>5.5-8.0</td>
<td>Large (LD)</td>
<td>40-49</td>
</tr>
<tr>
<td>Very Long (VL)</td>
<td>≥ 8.5</td>
<td>Very Large (VLD)</td>
<td>≥ 50</td>
</tr>
</tbody>
</table>

Table 1. Length and diameter classes used for coniferous trees in Turkey
OPTIMUM BUCKING

- Stem-level optimum bucking algorithm was developed by using dynamic programming method.
- In this algorithm, possible bucking points are considered as “nodes”, and each “arc” between nodes is considered as the length of the possible logs.

**Nodes, representing possible bucking points**

**Arcs, representing lengths of the bucked logs**
METHOD

- The value of the arc represents the value received from the log.
- To produce the highest total value from the whole tree, the “path” that yields maximum value is identified.
- The decision variables in the algorithm;
  1. Minimum and maximum acceptable log lengths
  2. Minimum acceptable log diameter at the mid point of a log
  3. Permissible defects are considered to determine feasible alternatives.
METHOD

- Statistical analysis was performed to investigate if there is a significant difference between traditional and optimum bucking methods considering values and volumes of harvested trees.
- The effects of diameter classes and log length classes on value and volume of optimally bucked logs were also investigated.
- The breast height diameter classes:
  - small = 30-40 cm
  - medium = 40-50 cm
  - large = 50-60 cm
- The average log length classes:
  - very short = 2.0-2.5 m
  - short = 2.5-3.0 m
  - medium = 3.0-3.5 m
  - long = 3.5-4.0 m
The optimum bucking application was performed during a selective cutting of Brutian Pine (Pinus brutia) stands in Demirtas Forest Enterprise located in Alanya district of Antalya in Mediterranean coast region of Turkey
METHOD APPLICATION

- The average ground slope and ground elevation were 29% and 710 m, respectively.
- 30 Brutian Pine trees were randomly selected out of over 300 trees that were bucked by logging crew using chain saw.
- The maximum acceptable log length was 4 meters due to limiting capabilities of using traditional logging methods in the region.
- The minimum acceptable log length and log diameter were 2 m and 19 cm, respectively.
METHOD APPLICATION

- The average breast height diameter and average height of the sample trees were 41.89 cm and 16.07 m, respectively.
- The size (i.e. length, diameter) and grade of the each log were recorded to run optimum bucking method for each tree.
METHOD APPLICATION

- After extracting and hauling the logs to the depots, they were sold through public auctions.
- The average log price for each log grade obtained from Demirtas Forest Enterprise

<table>
<thead>
<tr>
<th>Length - Diameter Classes</th>
<th>I. Grade (TRY/m³)</th>
<th>II. Grade (TRY/m³)</th>
<th>III. Grade (TRY/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-SD</td>
<td>210.00</td>
<td>175.00</td>
<td>125.00</td>
</tr>
<tr>
<td>S-MD</td>
<td>215.00</td>
<td>180.00</td>
<td>130.00</td>
</tr>
<tr>
<td>S-LD</td>
<td>225.00</td>
<td>185.00</td>
<td>135.00</td>
</tr>
<tr>
<td>S-VLD</td>
<td>235.00</td>
<td>195.00</td>
<td>145.00</td>
</tr>
<tr>
<td>N-SD</td>
<td>230.00</td>
<td>180.00</td>
<td>135.00</td>
</tr>
<tr>
<td>N-MD</td>
<td>240.00</td>
<td>190.00</td>
<td>140.00</td>
</tr>
<tr>
<td>N-LD</td>
<td>250.00</td>
<td>195.00</td>
<td>150.00</td>
</tr>
<tr>
<td>N-VLD</td>
<td>260.00</td>
<td>205.00</td>
<td>160.00</td>
</tr>
<tr>
<td>L-SD</td>
<td>260.00</td>
<td>210.00</td>
<td>165.00</td>
</tr>
<tr>
<td>L-MD</td>
<td>265.00</td>
<td>220.00</td>
<td>175.00</td>
</tr>
<tr>
<td>L-LD</td>
<td>275.00</td>
<td>225.00</td>
<td>185.00</td>
</tr>
<tr>
<td>L-VLD</td>
<td>285.00</td>
<td>235.00</td>
<td>190.00</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

- For all of the bucked trees, bucking combinations generated by optimum bucking method was different from the bucking combinations generated by the traditional bucking method.
- However, there was no significant difference for volume yield of bucked trees between two bucking methods ($p = 0.962$).
- The potential gross volume of the harvested trees using optimum bucking method was 0.61% more than that of using the traditional bucking method.
RESULTS AND DISCUSSION

- The statistical results indicated that the difference for values of bucked trees between traditional bucking and optimum bucking methods was not significant ($p = 0.733$)
- Using optimum bucking method increased the potential gross value of the harvested trees by 4.65%
RESULTS AND DISCUSSION

- There was a significant difference for the average lengths of bucked logs between two bucking methods ($p < 0.005$).
- The average length of bucked logs of harvested trees by traditional and optimum method were $2.28$ m and $3.08$ m.
- The effects of different log length classes on value and volume gain of harvested trees were not statistically significant ($p = 0.760$ and $p = 0.489$, respectively).
- However, average value gain of harvested trees for long logs ($5.5\%$) was greater than that of harvested trees for medium, short, and very short logs.
RESULTS AND DISCUSSION

- Statistical analysis indicated that value and volume gain of harvested trees was not significantly changed with diameter classes ($p = 0.837$ and $p = 0.186$)
- The maximum average value gain was for medium diameter class (5.19 %), followed by small (5.16 %), and large diameter (4.22 %) classes
- The volume gain varied increasingly from small diameter class (2.11 %) to large diameter (0.43 %) and medium diameter (0.17 %) classes
CONCLUSIONS

- The results suggested that there was no significant difference for value and volume of bucked trees between traditional bucking and optimum bucking methods.
- However, optimum bucking method provided 4.65% and 0.6% increase in potential gross log value and volume, respectively.
- The value gain of the bucked trees tends to increase as the length of the bucked logs increases.
- Thus, optimum bucking method provides better results for large size logs.
Thank you for your attention