Productivity and costs of whole-tree bundling system in early thinnings

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Abstract:
The field studies assessed the competitiveness of industrial roundwood and energy wood procurement based on the Fixteri II whole-tree bundler. The objectives of the studies were: i) to analyse the properties of whole-tree bundles and their correlation with stand parameters; ii) to define the productivity of whole-tree bundling and the forwarding and long-distance transportation of whole-tree bundles; and iii) to determine the procurement costs of the whole-tree bundling supply chain and to compare these costs with those of other industrial roundwood and energy wood supply chains.
The average diameter of the whole-tree bundles measured in the study was 65 cm and the average length 268 cm. The whole-tree bundles harvested from the bundling time-study sample plots averaged a green mass of 476 kg. The average solid volume of the bundles was 495 dm^3, of which branches accounted for 17% on average. The whole-tree bundle size increased in line with increase in average stem size of removals.
The study showed the productivity of the Fixteri II whole-tree bundler to be significantly higher than the first prototype bundler (Fixteri I). An increase in average removal volume from 20 dm^3 to 75 dm^3 nearly doubled the productivity per effective (E_0, excluding delays) hour of whole-tree bundling using the Fixteri II bundler: at a removal of 20 dm^3 the productivity of whole-tree bundling was 3.4 m^3/E_0, and at a whole-tree removal of 75 dm^3, 6.1 m^3/E_0. The considerable improvement in the productivity of whole-tree bundling was due to the fact that the new Fixteri felling head enabled direct feeding of accumulated whole-tree bunches into the bundler, without intermediate bunching or loading. Additionally, the bundler operator applied multi-tree handling during cutting to great extent. Working stages were also effectively overlapped.
Whole-tree bundling increased the size of grapple load in loading and unloading when forwarding, and forwarder load size increased markedly when compared to conventional pulpwood and loose whole trees. In the time study, the average load size was 22 whole-tree bundles. The productivity of whole-tree bundle forwarding was 23.8 m^3/E_0-hour (bundle size 0.5 m^3, whole-tree removal 60 m^3/ha, and the forwarding distance 300 m).
In long-distance transportation, the loading and unloading of whole-tree bundles was slower due to the small bunch size (short bundles) compared to long (5 m) pulpwood, even though the overall load size was approximately the same. With whole-tree bundles, two bundle stacks were placed onto the truck and three onto the trailer in order to achieve approximately the same load size as with long pulpwood. The binding and unbinding of the five bundle stacks took more time than binding and unbinding of three pulpwood stacks. In addition, significantly more time was required for cleaning of loading and unloading sites with whole-tree bundles than with delimbed pulpwood.
In the study, the costs of the whole-tree bundling supply chain were calculated and compared with the costs of optional supply chains in the procurement of small-diameter early thinnings. The lowest pulpwood procurement costs were attained in integrated roundwood and energy wood procurement using the two-pile method. The total costs of whole-tree chip procurement were also competitive in integrated procurement. The procurement costs of fuel chips produced from energy wood bundles were higher than the procurement costs of separately or integrally harvested whole-tree chips.
Comparative calculations indicated that the competitiveness of the whole-tree bundling supply chain increases in line with decreasing first-thinning pulpwood size. The results of the study illustrated that the optimal scope of application for whole-tree bundling is in first-thinning stands with a removal stem size

of 7–10 cm dbh. The relative competitive strength of whole-tree bundling is in the integrated procurement of, in particular, pulpwood and energy wood. The study's cost calculations showed the cost competitiveness of whole-tree bundling in exclusively energy wood procurement to be poor. The efficiency of the whole-tree bundling supply chain must be improved from its current level.

Keywords: bundling, early thinnings, Fixteri, whole trees