SVEUČILIŠTE U ZAGREBU - ŠUMARSKI FAKULTET
ZAVOD ZA ŠUMARSKE TEHNIKE I TEHNOLOGIJE

Projekt: Optimizacija sustava pridobivanja drva i šumske prometne infrastrukture na strateško-taktičkoj razini planiranja

Interaktivna baza recentnih izvora literature strojne sječe i izrade

1. Aedo-Ortiz, D. M., Olsen, E. D., Kellogg, L. D., 1997: Simulating a harvester-forwarder softwood thinning: a software evaluation. Forest Products Journal 47(5): 36–41. https://search.proquest.com/publication/publications_25222?accountid=168605

Sažetak

A discrete-event simulation model of a mechanized forest harvest system was evaluated with special attention given to the effectiveness of using statistical distributions derived from field-study data as input. The simulation language, Promodel PC, demonstrated the wide variability in weekly production that can be expected even under similar operating conditions. The simulation model was particularly well suited to tracking the flow of materials during the processing steps. Because the field-study data had been collected without anticipating its use as input to a simulation model, the capability of the model to simulate different operation situations was severely limited. A process in which data collection and model building are interactive is recommended for improving both field studies and simulations.

2. Alam, M., Walsh, D., Strandgard, M., Brown, M., 2014: A log-by-log productivity analysis of two Valmet 475EX harvesters. International Journal of Forest Engineering 25(1): 14–22. https://doi.org/10.1080/14942119.2014.891668

Sažetak

Productivity of a mechanized harvesting system is influenced by stand and terrain conditions, operator performance, and machinery limitations or design. The purpose of the study was to compare the productivity of two near-identical single-grip harvesters in similar Australian Pinus radiata clearfell harvesting operations on a log-by-log basis. The study first compared the productivity of each harvester against tree volume for cycle times and for tree processing times only. Significant differences in productivity between the harvesters were found to be largely due to significant differences in tree processing times. Comparisons between each component of processing time (dragging-out time, disc-cutting time, cross-cutting time, harvester head travel time and delimbing time) for a subset of 6.1 m sawlogs at each study site found operator working technique differences to be the main driver of productivity differences between the harvesters. In particular, the operator of the less productive harvester dragged out most trees after felling and cut discs on most trees to reset the length-measuring device, whereas the operator of the other, more productive harvester rarely carried out these activities.

3. Alam, M. M., Strandgard, M. N., Brown, M. W., Fox, J. C., 2012: Improving the productivity of mechanised harvesting systems using remote sensing. Australian Forestry 75(4): 238–245. https://doi.org/10.1080/00049158.2012.10676408

Sažetak

Mechanised harvesting operations are popular in Australia because of their productivity and efficiency, improved worker safety and reduced cost of operations. Most research has found that the productivity and efficiency of a mechanised harvesting system is affected by a number of factors such as forest stand characteristics, terrain variables, operator skill and machinery limitations. However, current studies did not quantify these factors sufficiently to evaluate the productivity and efficiency effects that can guide allocation of different harvesting equipment. This article reviews the literature on how major forest stand characteristics such as tree size

and undergrowth affect the productivity and efficiency of a harvesting machine and/or system in clearfelling operations, and explores the application of remote sensing technology including multi-spectral imagery and LiDAR (light detection and ranging) to identify and quantify these characteristics to allow for better harvest planning and harvest system allocation. It is concluded that by evaluating the interactions between each of these factors and different types of harvesting equipment, an empirical model could be developed to optimise the use of current harvesting systems and assist the selection of more cost-effective harvesting machinery, using remote sensing.

4. Amishev, D., Murphy, G. E., 2008: Implementing Resonance-Based Acoustic Technology on Mechanical Harvesters/Processors for Real-Time Wood Stiffness Assessment: Opportunities and Considerations. International Journal of Forest Engineering 19(2): 48–56. https://www.tandfonline.com/doi/abs/10.1080/14942119.2008.10702567

Sažetak

Acoustic technology has been successfully used as a nondestructive technique for assessing the mechanical quality of various wood products and species based on stiffness. Many mechanical harvester/processor manufacturers have implemented mechanical sensors to measure tree diameter and length as well as optimal bucking algorithms on their equipment. There is a growing interest in incorporating technologies for measuring internal stem features into a harvester head. The objectives of this study, therefore, were to i) determine and investigate the factors arising from incorporating acoustic instruments on a mechanized harvester head that might influence resonance- based acoustic signal and velocity readings and quality in Douglas-fir, and ii) investigate the issues and considerations associated with suggested working strategies in regard to harvest productivity impacts and processing decisions. After taking into account some feasibility considerations, it was determined that the hold of the machine grapple would not compromise the accuracy of resonance-based acoustic velocity readings. There were three working procedures suggested for measuring resonance-based acoustic velocity: 1) after the stem is delimbed and run through the measuring equipment, 2) once a portion of the stem is measured and the length of its unmeasured portion is forecast, and 3) after the tree is felled by the harvester but before any further processing is done. Regardless of the working procedure, it was determined that logs produced from lower sections of the tree are stiffer than those from upper portions. If the processor head traverses the stem partially or completely, the removal of bark and branches and their effect on acoustic velocity readings should be taken into account. Forecasting routines could be developed to account for imperfect and even non-existing information about tree length with the second or third working procedure. Results yielded by the two methods used for stem height (and consequently acoustic velocity) prediction in this study (linear regression model and a K-nearest-neighbor) were considered rather promising. Testing feasibility concerns with the resonance-based acoustic technique were observed if the entire stem was intact to the very top offshoot bud.

5. Athanassiadis, D., Lidestav, G., Wästerlund, I., 1999: Fuel, Hydraulic Oil and Lubricant Consumption in Swedish Mechanized Harvesting Operations, 1996: Journal of Forest Engineering 10(1): 59–66.

https://www.tandfonline.com/doi/abs/10.1080/08435243.1999.10702725

Sažetak

When subjecting forest products to certification the total environmental load of wood harvesting machinery should also be assessed. In this study fuel hydraulic oil and lubricant consumption in harvesting operations in Sweden has been examined by using machine data acquired through a questionnaire. The objectives of the study were to assess the contractor and forest company owned harvesters' and forwarders' average oil consumption in practical harvesting operations in Sweden, ascertain if the ownership and size of the machines give different consumption figures and estimate the use of environmentally acceptable hydraulic oils as well as the amount of oil spilled outdoors. Diesel consumption was found to be 9351/1000 m3 ub for forwarders and 1 1671/1000 m3 ub for single-grip harvesters. Hydraulic, transmission and chainsaw oil consumption was significantly higher in forest company owned harvesters while no significant differences were observed among forwarders. Hydraulic oil spillage was estimated for both harvesters and forwarders at 201/1000 m3 ub. For felling and crosscutting trees a further 351/1000 m3 ub of chainsaw oil is spilled. Ninety percent of the utilized hydraulic oil was environmentally compatible.

6. Athanassiadis, D., Lidestav, G., Wästerlund, I., 2000: Assessing Material Consumption Due to Spare Part Utilization by Harvesters and Forwarders. Journal of Forest Engineering 11(2): 51–57. https://www.tandfonline.com/doi/abs/10.1080/08435243.2000.10702754

Sažetak

The aim of this study was to i) develop and examine a methodology to handle spare part utilization data for work machinery for future inclusion into a life cycle assessment study and ii) assess the material consumption per 1000 m3ub harvested and transported to the roadside due to spare part utilization by three types of forest machinery. Thirteen forwarders, 14 single-grip harvesters and 10 two-grip harvesters operating in northern Sweden were followed up by repair records that covered a period from half a year up to 3.5 years. The replaced machine components were sorted in seven material categories - steel and iron, aluminum, other metals (brass, copper), plastics, rubber, glass and batteries. Two scenarios with different assumptions on the consumption of saw chains, guide bars and tires were developed. According to the low scenario about 46 kg of material will be consumed for harvesting and transporting 1000 m3ub to the roadside. The corresponding figure for the high scenario is 58 kg. The total component mass expected to be replaced during the operational lifetime (18000 E15 hours) of the machines was also calculated. According to the low scenario 38- 45% of the mass of a machine will be changed during its operational lifetime. The corresponding figure for the high scenario is 50-56%.

7. Bergström, D., 2009: Techniques and systems for boom-corridor thinning in young dense forests. PhD Thesis, Swedish University of Agricultural Sciences, 53 p.

https://www.researchgate.net/profile/Dan_Bergstroem/publication/38444645_Techniques_and_Systems_for_Boom_Corridor_Thinning_in_Young_Dense_Forests/links/57ea8afc08ae5d93a48150f7/Techniques-and-Systems-for-Boom-Corridor-Thinning-in-Young-Dense-Forests.pdf

Sažetak

Young dense stands could be thinned and the cut trees could be sold for bioenergy purposes, thus generating an income at an early stage of rotations. However, to make the utilization of young stands competitive, the costs of harvesting must be reduced while the value of the remaining stands is maintained at high levels. A possibility could be to develop a strip road and boom-corridor system for thinning young stands with high biomass, as an alternative to conventional pre-commercial thinning. The objectives of the studies underlying this thesis were to evaluate the effects of using new methods and techniques intended to promote efficient felling, bunching and compression of trees in boom-corridor thinning systems. As shown by simulations, combining boom-corridor thinning methods with conventional accumulating felling heads (AFHs), improved AFHs for multiple felling (AFH2m2) and new techniques for continuous felling boom-corridor-wise (AFH-corr) would provide higher productivity in the order AFH-corr > AFH-2m2 > AFH (the AFH-corr system gave about two-fold higher productivity compared to the AFH system) (I). In field studies, boom-corridor thinning using a conventional AFH gave a significant, 16%, increase in productivity compared to a standard thinning from below treatment (II). The potential utility of a prototype felling head designed for continuous felling in boom-corridors in the field was also studied (III). The results show that felling speeds of about 1.3 m×s-1 can be achieved if cranes that allow higher movement speeds are used. Further, the performance of a prototype compression processing device was investigated in field studies, and the results show that the density of fresh Scots pine bunches could be increased by up to 160%, while reducing their ash contents (and hence nutrient losses) by 50% (IV). It was also found that load compression techniques can raise payloads (IV). In conclusion, if new techniques especially designed for boom-corridor thinning are developed and used in appropriate harvesting systems the productivity, costefficiency and profitability of the operation can be greatly increased.

8. Bergstrom, D., Bergsten, U., Nordfjell, T., Lundmark, T., 2007: Simulation of geometric thinning systems and their time requirements for young forests. Silva Fennica 41(1): 137–147.

https://s3.amazonaws.com/academia.edu.documents/40176807/sf411137.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1527152623&Signature=Vqejpy79K6%2BtAwpx9vN6wMhBbb0%3D&response-content-disposition=inline%3B%20filename%3DSimulation_of_geometric_thinning_systems.pdf

Sažetak

In Fennoscandia, large areas that have not been subjected to pre-commercial thinning (PCT), and thus support dense stands, are becoming suitable for harvesting biomass. However, efficient systems for harvesting biomass from young stands have not yet been developed. In order to optimise biomass harvesting it is here hypothesized that the handling unit should not be a single tree but a corridor area, i.e., all trees in a specific area should be harvested in the same crane movement cycle. Three types of corridor harvesting approaches (using accumulating felling heads for geometric harvesting in two different patterns) were compared in terms of time required to fell a corridor of standardised size. Corridors are defined as strips of harvested areas between conventional strip-roads. Harvests were simulated in two types of stands, first thinning (FT) and delayed PCT stands, in which the spatial positions of the trees had been mapped. The differences in simulated time consumption per corridor were minor when the only variable changed was the corridor pattern. However, there were ca. 2-fold and 3-fold differences in simulated time consumption per corridor between the harvesting approaches for the FT stand and the PCT-stand, respectively. Furthermore, area handling

(felling head accumulating all trees corridor-wise, with no restrictions on the accumulated number of trees except for a certain load limit) was found to give up to 2.4-fold increases in productivity compared to a single-tree (reference) approach for the FT stand. In conclusion, the simulation results clearly show the benefits of applying area-harvesting systems in young, dense stands.

9. Bolding, M. C., Lanford, B. L., 2002: Productivity of a Ponsse ergo harvester working on steep terrain. In Proc. 25th Annual Council on Forest Engineering Meeting, Auburn, Alabama, USA.

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.466.2378&rep=rep1&type=pdfž

Sažetak

The objective of this study was to analyze the productivity of a Ponsse Ergo harvester using a H73 head working in a mixed pine and hardwood forest on steep slopes in north Georgia. Productivity data were collected on the harvester from five one square chain plots. Each plot presented a different stand and slope condition. Slopes ranged from 0 to –46 percent. The harvester was videotaped performing the operations of felling, limbing, and bucking. Time and tree data were extracted for an elemental time study. Estimated quantities were defined in units of time per tree and included move time, swing time, fell time, process time, and total productive time. The possible predictor variables were identified as DBH, total height, number of bucks, tons per acre, trees per acre, slope, and species. Slope was found to be a significant variable for predicting move time, swing time, and total productive time. The variables of DBH2, total height, slope, and trees per acre with a square-root inverse transformation were found to be significant for predicting total productive time per tree when total height was known. Number of bucks, tons per acre, and species were found to be non-significant variables for predicting any of the dependent variables. It was not surprising that slope had an effect on the productivity of the harvester. Interestingly though, the analysis found species variation to be non-significant for predicting any of the analyzed dependent variables. That is to say that even on steep slopes, the Ponsse Ergo harvester harvested upland, hard hardwoods equally as well as pine.

10. Chiorescu, S., Gronlund, A., 2001: Assessing the role of the harvester within the forestry-wood chain. Forest products journal 51(2): 77–84.

https://search.proquest.com/openview/5c0c90098eaa1d9d5ab89855f48523d6/1?pq-origsite=gscholar&cbl=25222

Sažetak

In recent years, a lot of effort has been devoted to implementing the concept of an integrated forestry-wood chain. Good management of such a complex system requires a clear understanding of the effects that different factors involved may have on the final output of the chain. Raw material databases and simulation software capable of spanning the wood-processing operations have now been developed and are being used as a support tool in understanding and optimizing the forestry-wood chain. This paper reports results of simulation tests using the virtual SawMill software and the Swedish Pine Stem Bank database. The simulated scenario tries to mirror a very customer-oriented production philosophy. The

bucking, the sawing, the crosscutting, and the board-grading procedures were simulated for different end-user requirements and a statistical model was built. The purpose of the model was to investigate the theoretical sensitivity of the final product to parameters such as external sawlog features (taper, ovality, bow), harvester measurement accuracy (for length and diameter), sawing pattern optimization, and log positioning in the saw line. Special emphasis was put on evaluating the role of the harvester within this "puzzle." The results show that small improvements of the harvester's measuring performance could lead to considerable improvements in the wood transformation chain.

11. Conradie, I. P., Greene, W. D., Murphy, G. E., 2004: Value recovery with harvesters in southeastern US pine stands. Forest products journal 54 (12): 80–84.

https://search.proquest.com/openview/c11338e4775690bcdf8489d98ada39c8/1?pq-origsite=gscholar&cbl=25222

Sažetak

Cut-to-length is not the harvesting system of choice in the southeastern United States although it is perceived by many to have the ability to recover more value from cut stems. In this paper, the value recovery aspect of harvesters is addressed by comparing the optimal recoverable value, as calculated by optimization software, to the actual value recovered by harvesters at three harvest sites. The actual values recovered at the sites were 93 percent, 90 percent, and 94 percent, respectively, of the optimal recoverable value. Value losses were caused by the harvesters' tendency to cut fewer but longer logs than the optimal solution suggested, making logs that did not adequately meet product specifications, and harvester measuring errors.

12. Di Fulvio, F., Bergström, D., 2013: Analyses of a single-machine system for harvesting pulpwood and/or energy-wood in early thinnings. International Journal of Forest Engineering 24(1): 2–15. https://doi.org/10.1080/14942119.2013.798935

Sažetak

Harwarder systems used in roundwood harvesting can be useful at sites where there are low volumes per hectare to be removed or a small total removal volume and where frequent or long-distance machine relocations are required. As well as being suitable for conventional roundwood harvesting, a multi-purpose forest machine can have its configuration changed, so that it can function as a harvester, forwarder, or harwarder, and thus can be considered viable for use in young stands when harvesting pulpwood or energy-wood or combining assortments. Accordingly, in this study we compare the time consumption and productivity of a Ponsse Dual machine system with two harvesting heads and one loading grapple (three machine configurations) when harvesting and forwarding pulpwood and/or energy-wood during early thinning at sites in northern Sweden. Our aim is to analyze costs and profitability under a range of site conditions. Working as a harvester, the machine reached the same level of productivity (trees per hour) whether it was operating with an accumulating felling head or a harvester head able to accumulate some trees; productivity was also independent of work method. The forwarding efficiency was highly correlated with biomass concentration and forwarding distance; whole-tree (tree section) removal over short forwarding distances resulted in the highest productivity. The system achieved the greatest cost-effectiveness when only energy-wood was removed. At current market prices, pulpwood extraction produced the highest net income per hectare, but even this was economically unprofitable. The Ponsse Dual

achieves similar productivities to specialized harvesters and forwarders during thinning operations, but at a much higher cost per operating hour. Thus, a single-machine system would need to have ca. 20-30% lower operational costs than the Ponsse Dual to be an economically viable option for early thinning.

13. Dimou, V., Malivitsi, Z., 2015: Strategic decision model for the evaluation of timber harvesting systems. International Journal of Forest Engineering 26(2): 146–157. https://doi.org/10.1080/14942119.2015.1083750

Sažetak

Selecting a suitable timber harvesting system can generate conflicts especially when multiple objectives have to be pursued. One of the possibilities to minimize this problem is to adopt a multi-criteria methodology that will eventually enable decision makers to select the system that best fulfils the objectives to be achieved. In the present study a strategic decision model was used in order to evaluate and classify timber harvesting systems for the forests of Northeastern Greece. The decision model was considered necessary as it is particularly difficult to choose among the different harvesting systems available the one that both fulfils the objectives of a given Forest Service and takes into consideration local conditions and possible social limitations. Within the frame of this model, five systems were selected through literature review in terms of suitability for the afore-mentioned forests. The systems were subsequently evaluated against certain assessment criteria, which fell into three groups: financial, ecological and social. In accordance with the method developed at the Department of Forest Technology, University of Dresden, the criteria had been customized to suit the specific needs of the Greek population and the given environmental conditions in which they were to be applied. The systems under investigation were rated at an initial stage by experienced foresters with the use of the Delphi method. Subsequently they were ranked by ten Forest Services according to goals set by each Service. The results of the study indicate that harvesting systems employing less technologically advanced machinery occupied low positions in the rank.

14. Drews, E. S., Hartsough, B. R., Doyal, J. A., Kellogg, L. D., 2001: Harvester-Forwarder and Harvester-Yarder Systems for Fuel Reduction Treatments. Journal of Forest Engineering 12 (1): 81–91. https://www.tandfonline.com/doi/abs/10.1080/08435243.2001.10702766

Sažetak

Two harvesting systems were compared for reducing fuel loadings in overstocked conifer stands in eastern Oregon; forest managers also set a high priority on minimizing soil disturbance. Both employed cut-to-length (CTL) harvesters; one used a forwarder and the other a small skyline yarder. Both systems produced very similar and acceptable results in terms of fuels reduction and soil disturbance, but at different stump-to-mill costs: $46/green ton for the forwarder system versus $80/green ton for the yarder system.

15. Dvořák, J., Karnet, P., 2007: Preliminary technical time standards for harvesters working in premature and mature stands. Forestry 10(1): 1.

http://www.ejpau.media.pl/volume10/issue1/index_sabs.html

Sažetak

Assessment of performance standards for logging operations is a foremost task of the technical standardization. In this paper we deal with preliminary technical time standards for harvesters working in particular felling&technology and natural conditions. Monitoring of unsuitable time utilization is hand in hand with elaborated correction proposals another objective of this work. The chronometry was analyzed during the work of medium-scale harvester Timberjack 1070 in natural environment of Krusné hory during felling works in premature and mature forest stands. Preliminary paper is worked up for tree-volume of coniferous species from 0.44 to 0.73 m3, which require for manufacturing operation time from 91 to 118 seconds. More operation time is needed when greater trunks are processed. Total standards lies for intermediate (improvement, advanced) fellings within the interval 0.033-0.043 Standard hour/m3 for main felling 0.030-0.039 Sh/m3 depending on tree-volume. Propounded findings should not be generalized; they are typical for the use of medium-scale harvesters in such natural conditions that are similar to nature territory Krusné hory.

16. Ehlert, D., Pecenka, R., 2013: Harvesters for short rotation coppice: current status and new solutions. International Journal of Forest Engineering 24(3): 170–182. https://doi.org/10.1080/14942119.2013.852390

Sažetak

Mechanization in the harvesting of short rotation coppice on farmed land is a prerequisite for the expansion of short rotation coppice cropping. Existing harvest lines can be classified as log, bundle, bale, or chip lines; the latter are widely considered the most economical. Despite the development of more than 20 different harvesting machines and assemblies for chip lines in the past decade alone, only a few have progressed beyond the prototype stage. In addition to special mower tools already available for conventional forage harvesters, there is a great need for low-cost tractor-mounted chip harvesters. Therefore, a novel working principle for a mower-chipper was developed and tested. In contrast to most other solutions, the trees remain in an upright position while mowing and chipping. The harvest machine has a compact single rotor bearing a circular saw blade with a diameter of approximately 1000 mm. Knives arranged radially are attached to the saw and offset above the disk with spacer blocks. To ensure even feeding of the mower-chipper unit, numerous passive and active machine elements were tested to find a reliable solution for practical application. With the investigated harvester, trees with stem diameters up to 15 cm and 10 m in height could be successfully harvested at very promising working speeds of 3-5 km/h. The Class P45 wood chips produced satisfied the CEN/TS 14961:2005 standard.

17. Eliasson, L., 2000: Effects of Establishment and Thinning of Shelterwoods on Harvester Performance. Journal of Forest Engineering 11(1): 21–27. https://www.tandfonline.com/doi/abs/10.1080/08435243.2000.10702741

Sažetak

An increased use of shelterwoods in regeneration has generated a demand for knowledge of how single-grip harvester performance is affected by shelterwood treatments. Time consumption and productivity of a large single-grip harvester working in shelterwood

establishment and thinning was studied using work sampling. Five treatments were studied, 1) shelterwood establishment, thinning of 2) sparse, 3) medium and 4) dense shelterwoods and 5) clear-cutting. Each treatment was replicated three times. Results shows that time consumption for the average harvested tree increased with tree volume and declining number of harvested trees per ha. Productivity was higher in clear-cutting than in any of the shelterwood treatments. Harvesting costs in the shelterwood system thus becomes higher than in the clear-cutting system. These costs must be carefully weighted against the ecological and silvicultural benefits of the shelterwood, including the possible reductions of the regeneration costs.

18. Eliasson, L., Bengtsson, J., Cedergren, J., Lageson, H., 1999: Comparison of Single-Grip Harvester Productivity in Clear- and Shelterwood Cutting. Journal of Forest Engineering 10(1): 43–48. https://www.tandfonline.com/doi/abs/10.1080/08435243.1999.10702723

Sažetak

An increased interest in the use of shelterwood stands to promote regeneration has led to an interest in how single-grip harvester productivity is affected by shelterwood cutting compared to clearcutting. A comparative time study of a large single-grip harvester was made in a spruce stand in northern Sweden. Three treatments were used. Shelterwood cutting leaving: 1) a sparse stand, 2) a dense residual stand, and 3) clearcutting. Each treatment was replicated three times. Results show that productivity decreases from 64 m3 per effective hour in clearcutting to 54 and 41 m3 per effective hour when shelterwoods with 259 and 381 stems ha-1, respectively, were retained.

19. Eliasson, L., Lageson, H., 1999: Simulation Study of a Single-grip Harvester in Thinning from Below and Thinning from Above. Scandinavian Journal of Forest Research 14(6): 589–595. https://www.tandfonline.com/doi/abs/10.1080/02827589908540824

Sažetak

The time consumption and productivity of a single-grip harvester were studied, using a simulation model, when thinning from below and above in eight randomly selected stands. The model estimated the time required for each work element, given machine and tree positions, and tree size. A 2-5 factorial design was used with factors thinning type [from below (Tb) and above (Ta)] and tree size. Trees were subjectively selected for harvest according to thinning type. Total basal area removal was 30% plot-1. Approximately 50% more trees were harvested in Tb than in Ta Time consumption tree-1 was higher for Ta than Tb. Time consumption for machine and boom movements decreased with increasing number of harvested trees, and time for felling and processing of trees increased with harvested mean stem volume. Harvester productivity was 36% higher for Ta, since the increase in harvested mean stem volume was higher than the increase in time consumption tree-1.

20. Eriksson, M., Lindroos, O., 2014: Productivity of harvesters and forwarders in CTL operations in northern Sweden based on large follow-up datasets. International Journal of Forest Engineering 25(3): 179–200.

https://doi.org/10.1080/14942119.2014.974309

Sažetak

Modern computerization facilitates data-gathering from forest machines, and offers new opportunities to develop models for predicting productivity in forest harvest operations. In this study, we analyze the productivity of cut-to-length harvesting and forwarding in thinning and final felling using a routinely recorded follow-up dataset. The data originate from over 700 machines that, over a 3-year period, harvested and forwarded more than 20 million m3 of round-wood from upwards of 20 thousand stands, making the dataset larger than any that has previously been used for productivity modelling. Results comprise a range of stand-based productivity models of varying complexity for both harvesters and forwarders. Mean stem size was the most influential variable for harvesting productivity: modelling based on mean stem size explained 57.6% of the variance in thinnings and 55.3% in final fellings. However, accurate predictions of forwarding productivity required the simultaneous consideration of several variables. For instance, modelling of forwarder productivity based on the variables mean stem size, mean extraction distance and forwarder load capacity explained 26.4% of the variance in thinnings and 35.2% in final fellings. Results should be of interest to both practitioners and researchers interested in the study and modelling of forest operations.

21. Evanson, T., McConchie, M., 1996: Productivity Measurements of Two Waratah 234 Hydraulic Tree Harvesters in Radiata Pine in New Zealand. Journal of Forest Engineering 7(3): 41–52. https://doi.org/10.1080/08435243.1996.10702690

Sažetak

Two Waratah 234 single-grip harvester heads were assessed for productivity and log-processing accuracy while working in radiata pine clearfell operations in New Zealand forests. Estimated productivity, processing stockpiled trees into logs on a landing in a ground-based operation, was 77 m3 per productive machine hour (PMH) in an average tree size of 1.63 m3. In a yarder-based trial, processing trees into logs on a landing, productivity was 77 m3/PMH in an average tree size of 3.1 m3. Length-measuring accuracy in a later trial was shown to be within ± 5 cm for 93% of logs. In a second ground-based trial, estimated productivity for an average extracted tree size of 1.95m3 was:

51 trees/PMH (100m3) for felling, tree-length delimbing and bunching.

73 trees/PMH (143m3) for tree-length delimbing (butt-first) and bunching of manually felled trees.

22. Fjeld, D., Granhus, A., 1998: Injuries After Selection Harvesting in Multi-Stored Spruce Stands – The Influence of Operating Systems and Harvest Intensity. Journal of Forest Engineering 9(2): 33–40. https://www.tandfonline.com/doi/abs/10.1080/08435243.1998.10702716

Sažetak

Mechanical injuries were examined after singletree selection harvesting in multi-storied stands of Norway spruce. Randomised block studies were used to compare the effect of two operating systems and three harvest intensities upon the injury rate to the residual stand. The average

injury rate for mechanised shortwood harvesting was higher than for motor-manual cutting and cable skidding. The largest differences between these two systems were found at high harvest intensities in densely stocked stands. A number of variables were used to quantify this interaction. The variable which best explained the risk for injury in the individual stand was the ratio between removed vertical crown projection and horizontal crown-free projection before harvest. The higher injury rate for mechanised harvesting is attributed to the greater proportion of the stand which is impacted by the handling of trees.

23. Foster, B. C., Wang, D., Keeton, W. S., 2008: An Exploratory, Post-Harvest Comparison of Ecological and Economic Characteristics of Forest Stewardship Council Certified and Uncertified Northern Hardwood Stands. Journal of Sustainable Forestry 26(3): 171–191. https://doi.org/10.1080/10549810701879701

Sažetak

As more forest entities worldwide consider pursuing Forest Stewardship Council (FSC) certification, a critical question remains on whether stand-level management impacts differ between certified and uncertified forests. To begin to answer this question, we measured forest structure on three FSC-certified stands, three uncertified stands, and six adjacent unharvested reference stands (12 stands total) composed primarily of sugar maple (Acer saccharum) on non-industrial private properties in central Vermont, USA. The certified and uncertified partial harvests reduced total tree biomass and live tree carbon storage by one-third compared to reconstructed pre-harvest conditions. Both treatments also contained significantly lower densities of saplings and some mid-size trees compared to non-harvested references due to similar impacts from harvesting. The net present value of merchantable sugar maple over 10 year projections was consistently lower on certified than uncertified stands, but this difference was insignificant at discount rates from 4-8%. The certified stands contained significantly greater total residual volumes of coarse woody debris (standing and downed) than uncertified stands, although the debris was smaller than that found in unmanaged mature forests. Overall, our data suggest that FSC-certified harvested stands in northern hardwood forests have similar sugar maple timber value, aboveground live tree carbon storage value, similar live tree structure, and greater residual coarse woody debris than uncertified harvested stands.

24. Frisk, M., Flisberg, P., Rönnqvist, M., Andersson, G., 2016: Detailed scheduling of harvest teams and robust use of harvest and transportation resources. Scandinavian Journal of Forest Research 31(7): 681–690.

https://doi.org/10.1080/02827581.2016.1206144

Sažetak

Planning activities of harvest teams (harvesting and forwarding) and transportation is critical for efficient procurement of roundwood from forests to mills. The planning process involves many integrated decisions that consider process, spatial and temporal aspects. The spatial aspect concerns which area to harvest, which machine team to use, the mill to which the timber should be allocated and where to store the timber. The process decisions involve which bucking instruction to use. The temporal aspect concerns when to harvest, when to transport

in order to meet specific demand at mills, and when to store the timber. Temporal decisions also include determining a detailed schedule for each harvest team. Such a schedule includes starting time and movement time between harvest areas. This is complicated by the harvest team having different home bases and different machine systems with their specific performance description and capacities. The overall planning problem can be formulated into one optimization model, but such a model is too large for practical use and cannot be solved in a reasonable time. We propose a decomposition scheme where a sequence of aggregated models, or limited parts of the model, is solved to find high-quality solutions quickly. We test the scheduling in cases involving two large Swedish forest companies.

25. Gasser, D., Swift, D. E., 2014: Initial Effects of Intensity and Severity of Balsam Fir Tip Harvesting on Harvesting Intensity at the Stand Level, Tip Production, and Tip/Foliage Removal at the Tree Level, and Harvesters' Production and Productivity. Journal of Sustainable Forestry 33(2): 99–126. https://doi.org/10.1080/10549811.2013.833805

Sažetak

Balsam fir (Abies balsamea [L.] Mill.), which is widely used for floral greenery, is an important source of nontimber forest products (NTFP) from the northern forests of North America. Nonetheless, additional information is needed to refine and revise commercial tip-harvesting management guidelines to promote sustainable forest management. Therefore, a study was initiated to: (a) examine the socioeconomic impacts of and anticipate the potential biological responses to four contrasting harvesting practices; (b) discuss the implications of the results for the relevance and applicability of some specifications of management guidelines; and (c) assess the compatibility of tip harvesting while pursuing an objective of timber production.

26. Gellerstedt, S., 2002: Operation of the Single-Grip Harvester: Motor-Sensory and Cognitive Work. International Journal of Forest Engineering 13(2): 35–47. https://www.tandfonline.com/doi/abs/10.1080/14942119.2002.10702461

Sažetak

This article describes the interface between a one-grip harvester and its operator as it relates to motor-sensory and cognitive activities of the operator when carrying out thinning and regeneration harvesting in Sweden. Work tasks are described, as are operator data gathering, cognitive and motor-sensory processes. Descriptions of motor- sensory inputs and control manipulation are based on digital data gathering from machine controls combined with parallel, multi-camera video taping of work activities. Work element descriptions, data gathering and cognitive processes were inferred based on interviews with 20 operators and operator instructors. Work features found to limit an operator's efficiency were: few breaks in the work; very intensive handling of controls (4000 control inputs per hour in our study) due to lack of automatic functions in the boom and harvester head; restricted view from the cab; lack of information about the stand and log; and skewed and twisted work postures. The main part of the operator's cognitive work was found to be done through automated skills. The experienced operator acts upon the global situation and seldom analyses it explicitly. Their chunks of information (memory aggregates recognized in toto) guide them in what to do, and usually they see only one course of action to follow in a particular situation. Key future technical development needs and opportunities include additional automation to reduce operator control

inputs, developing means of improving visibility such as 3-D laser scanning and additional use of stand inventory and historical data about log properties to improve automation of cross-cutting. One of the key future research areas regarding training and robotization is to determine the data contained in the 'chunks' of information used by operators in making machine location, harvesting and processing decisions.

27. Gerasimov, Y., Senkin, V., Väätäinen, K., 2012: Productivity of single-grip harvesters in clear-cutting operations in the northern European part of Russia. European Journal of Forest Research 131(3): 647–654.

https://link.springer.com/article/10.1007/s10342-011-0538-9

Sažetak

A field-based study was carried out to broaden our knowledge of fully mechanized cut-to-length harvesting productivity in naturally grown forests in the northern European part of Russia (NEPR). The recorded data comprised 38 midsized single-grip harvesters (JD 1270D) in clear-cutting operations in the Karelia, Komi, Vologda, Leningrad, Tver, and Kirov regions in NEPR, 4.3 million felled trees, and 1.4 million m3 u.b. (under bark) of processed timber. Harvesting operations were conducted in forest stands composed of spruce (48% on average), pine (19%), birch (22%), and aspen (11%), with an average stem volume 0.31 m3 u.b. The cut-to-length harvesters produced from 4.3 to 14.9 m3 u.b./productive machine hour (PMH) and 16.0–49.5 m3 u.b./stem processing machine hour (S proc MH). A machine evaluation analysis and a regression analysis were used to formulate models for predicting cutting productivity of modern single-grip harvester. The regression models were developed to estimate the productivity of the harvesters in the regions taking into account two significant factors influencing the productivity: the stem volume and tree species of the felled trees. Productivity/cubic meter u.b. of processed timber/PMH was calculated according to stem volume and tree species distributions in most forest-covered NEPR regions. Further research is suggested to improve the developed productivity models and to allow prediction of system performance over a broad range of stand and site conditions.

28. Gerasimov, Y. Y., Siounev, V. S., 1997: Harvester Crane Key Parameters: Optimization in European Russian Pines. Journal of Forest Engineering 8(1): 63–74. https://www.tandfonline.com/doi/abs/10.1080/08435243.1997.10702697

Sažetak

The purpose of this study is to find out the effect of using the multiobjective simulation technique for logging technology and machinery optimal design. This topic was identified as important to support forest machinery designers in providing them with the necessary knowledge for carrying out the first drafts without a pilot machinery model. The method is applied to pines growing in the Russian North-West region.

29. Ghaffariyan, M. R., Sessions, J., Brown, M., 2012: Machine productivity and residual harvesting residues associated with a cut-to-length harvest system in southern Tasmania. Southern Forests: a Journal of Forest Science 74(4): 229–235.

https://doi.org/10.2989/20702620.2012.741770

Sažetak

The cut-to-length method is a preferred method for harvest of pine plantations in Australia. The cut-to-length method studied in southern Tasmania consists of a feller-buncher, processor, forwarder, grapple loader and tractortrailers that were producing only pulp logs for the plantation owner Norske Skog. An elemental time study method was applied to evaluate the productivity of the machines within the flat terrain, Pinus radiata plantation. Multiple regression was used in SPSS to develop the productivity prediction models. The productivity of the feller-buncher and processor averaged 122.20 m3 per productive machine hours excluding all delays (PMH0) and 84.32 m3 PMH0 -1, respectively. The average productivity for the forwarder, grapple loader and truck were 80.90 m3 PMH0 -1, 100.80 m3 PMH0 -1 and 27.40 m3 PMH0 -1, respectively. The average fuel consumption of the feller-buncher, forwarder and processor were also documented. The trial assessed harvest residue left on the site and found 238.7 GMt ha-1 (31% of total biomass above the stump) was left of which 46% was stemwood. These research findings can be used for harvesting planning and improving logging efficiency.

30. Glade, D., 1999: Single- and Double-Grip Harvesters – Productive Measurements in Final Cutting of Shelterwood. Journal of Forest Engineering 10(2): 63–74. https://www.tandfonline.com/doi/abs/10.1080/08435243.1999.10702736

Sažetak

To compare the performance and cost of two machine types, a time study of single-grip harvesters (SGH) and double-grip harvesters (DGH)| was conducted in the final cutting of three shelterwood stands in central parts of Sweden. A randomized block design was used with one block in each stand and the treatments SGH and DGH, respectively. The stands were characterized by dense to relatively dense advanced regeneration under approximately 200 trees/ha. No significant differences were found in mean harvesting time between SGH and DGH or between stands. Fewer trees, but approximately the same volume per hour, were harvested when shelterwood stands were cut as compared with clear-cutting of ordinary stands. Despite few stems per hectare and the dense regeneration hindering the operator's field of view, final cutting was done with fairly high productivity (15.9-34.0 m3/E15-h)| and a low harvesting cost (2.7 -|6.0 USD/m3). It was concluded that both machine types gave acceptable results regarding cost and productivity. The SGH could be recommended as a good choice in general due to the low cost per machine hour as compared with the DGH, while the properties of the DGH would be beneficial in shelterwood stands with a large proportion of trees with large diameter (e.g. >7| cm) branches.

31. Glöde, D., 2002: Survival and Growth of Picea abies Regeneration after Shelterwood Removal with Single- and Double-grip Harvester Systems. Scandinavian Journal of Forest Research 17(5): 417–426.

https://doi.org/10.1080/028275802320435432

Sažetak

Three stands in Sweden were followed for 7 yrs to study the survival and growth of Norway spruce [Picea abies (L.) Karst.] regeneration after shelterwood removal with single- and double-grip harvester systems. The height of all seedlings within circular plots was recorded before and after final cutting. The tallest seedling and one randomly selected seedling on each circular plot were permanently marked and their annual height growth was measured each year during the period 1993-1999. No significant differences between single- and double-grip harvester systems were found with respect to their effects on regeneration density, survival or annual height growth. The annual height growth of the individual seedlings after shelterwood removal was significantly correlated with seedling height before shelterwood removal. Significant differences were found in annual height growth between seedlings with high and low vitality. Logging damage did not affect the annual height growth. Several practical conclusions were drawn. First, the choice of harvester system does not affect seedling height growth or survival after shelterwood removal. Secondly, the removal of a 200 m3 shelterwood with 200 stems ha-1 does not seem to constitute a serious problem for seedling survival and growth. Finally, estimated vitality and seedling height both seem to be fairly good predictors of postrelease survival and growth.

32. Häggström, C., Englund, M., Lindroos, O., 2015: Examining the gaze behaviors of harvester operators: an eye-tracking study. International Journal of Forest Engineering 26(2): 96–113. https://doi.org/10.1080/14942119.2015.1075793

Sažetak

In forest harvesting, operators must visually monitor the terrain, machinery, the stand and the trees they are cutting in order to plan, evaluate and adjust their tasks. To exploit increasing opportunities to automate these tasks and create decision support systems it is essential to understand not only what forestry workers do, but also what they look at and why they focus on specific aspects during specific tasks. This knowledge may also aid operator training and knowledge transfer between age and experience groups. Eye-tracking (ET) is therefore a potentially valuable technique that may facilitate both extraction of implicit knowledge and elucidation of operators' information acquisition strategies. However, real world ET-recordings are sensitive to environmental variations and analyzing them is time consuming. Thus, the aims of this study were to examine the utility of a head-mounted eye-tracking system in forest harvesting machines in a natural setting and obtain information on operators' visual behavior (gaze patterns) during harvesting. The output from the eye-tracker was affected by large head movements, changes in illumination and (possibly) vibrations. The gaze pattern analysis revealed that the operators looked at the harvester head or forest most of the time, but their gaze behaviors varied during different harvesting operations. They looked at the monitor, canopy and falling trees less frequently during first thinning than during second thinning and final felling. The results suggest that some harvesting information is gathered in advance to get an overview and plan the work, but most eye movements closely follow actions.

33. Häggström, C., Lindroos, O., 2016: Human, technology, organization and environment – a human factors perspective on performance in forest harvesting. International Journal of Forest Engineering 27(2): 67–78.

https://doi.org/10.1080/14942119.2016.1170495

Sažetak

In recent years, concern has been raised that the trend of continuous productivity improvements of forest harvesting has stagnated and even declined in the Nordics. This selective literature review therefore examines human factors research with regard to the performance of the harvesting system, and outlines how human factors research can stimulate continued performance improvements. The focus is on implications for mechanized cut-to-length (CTL) operations and, especially, research of importance to the operation of the single grip harvester and the harvester-forwarder system. Most literature for this review was found in the Web of Knowledge and Google Scholar databases or as a consequence of the snowballing approach also applied. A conceptual framework was used to facilitate the analysis of the interrelated elements ? Human, Technology, Organization and Environment (HTO-E). The right abilities, skills, techniques and training alone are not sufficient for ensuring high performance of the logging system. To address this discrepancy, education, training, (semi-) automation, shift scheduling, harvester-forwarder cooperation, inter- and intra- organizational knowledge exchange were all recognized as important areas for improvement and development. Great difficulties exist in predicting outcomes when introducing change, for example automation, into a system. However, the consequences of not trying may be detrimental to productivity as well as safety in mechanized forestry. Thus, it is important to research into methods, interfaces, forms of interaction, risk analyses and automation technology. HTO-E and a systems perspective provide a good basis for understanding the work today and making educated predictions for the future.

34. Halleux, O. R. M., Greene, W. D., 2003: Setting Analyst: An Operational Harvest Planning Tool. International Journal of Forest Engineering 14(1): 89–101.

https://www.tandfonline.com/doi/abs/10.1080/14942119.2003.10702473

Sažetak

Operational harvest planning in the southern USA has not been widely used in the past due to a lack of state legislation, non-regulatory water quality protection programs, and relatively easy logging conditions. Increased government regulation and market pressures to document sustainable forest management under various certification standards is increasing the need for harvest planning in the region, particularly on private, nonindustrial timber sales. We developed an ArcView extension, Setting Analyst (SA), to assist harvest planners. SA can use spatial information obtained from scanned air photos or detailed data from a geographic information system. It models travel patterns of ground-based machines and compares different harvest settings based on projected average skidding distance, costs of skidding and improvements, and site disturbance levels. In its current form, it does not account for slope. SA can model settings with complex features such as stream crossings, restricted areas, and skidding on designated trails. Travel intensity is assessed since it is highly correlated with site disturbance and soil compaction. To assess the utility of SA, we used it to model ten actual harvesting settings and contrasted each with two proposed settings. SA produced sale plans that were very similar to those observed on the ground. Its primary advantage is that it conveniently documents each alternative setting considered for the timber sale. These can be kept on file to demonstrate the level of planning used when forest certification audits are conducted. SA offers the most potential to harvest planners that already use GIS or GPS but desire additional analysis and documentation capabilities.

35. Hånell, B., Nordfjell, T., Eliasson, L., 2000: Productivity and Costs in Shelterwood Harvesting. Scandinavian Journal of Forest Research 15(5): 561–569.

https://doi.org/10.1080/028275800750173537

Sažetak

Harvesting costs have a significant influence on the application and potential use of the shelterwood system. These costs are strongly related to the time needed for the logging operations. In this study, which was carried out in Norway spruce [Picea abies (L.) Karst.] stands in northern Sweden, the effective time (E 0) of a single-grip harvester in shelterwood cutting, thinning of shelterwoods and clearcutting was measured. Based on these data the costs of shelterwood harvestings and clearcutting were calculated and compared. It was found that (1) the time per tree in shelterwood cutting and thinning of shelterwoods was greater than in clearcutting, (2) the time per cubic metre was higher in sparse shelterwoods than in dense shelterwoods, (3) most of this increase was due to longer driving time because fewer trees were harvested, and (4) the longer time and higher logging costs in the shelterwood system (compared with the clearcutting system) were mostly related to the establishment of the shelterwood. It was concluded that the shelterwood alternative is especially competitive when it is desirable to maximize the share of saw logs at the expense of pulpwood.

36. Holzleitner, F., Stampfer, K., Visser, R., 2011: Utilization rates and cost factors in timber harvesting based on long-term machine data. Croatian Journal of Forest Engineering: Journal for Theory and Application of Forestry Engineering 32(2): 501–508.

https://hrcak.srce.hr/index.php?id_clanak_jezik=108152&show=clanak

Sažetak

Operating forest machines is not only expensive but accurate monitoring of economic variables can be very difficult. Detailed machine data capture of economic variables within a forest enterprise can be used to support accurate decision making processes, especially costing for new investments. The objectives of this study were to analyze economic variables of forest machinery based on long-term recorded data from one of the Austrian federal state forest machinery workshops. The study used data from the enterprise's resource planning system over the period 2004 to 2008. In total 28 tower yarders, 19 skidders, 12 harvesters and 18 forwarders where analyzed for annual utilization, repair costs, fuel consumption and lubrication costs. The average annual utilization of all skidders was approximately 1,150 productive machine hours excluding breaks less than 15 minutes (PMH15) per year. Skidders consumed an average 7.3 L/PMH15 with repair costs of 11.4 €/PMH15. For the fully mechanized harvesting system the harvesters achieved 2,040 PMH15/year and the forwarders 2,070 PMH15/year. The annual utilization of cable yarding systems is between 560PMH15 and 1,500PMH15.

37. Huyler, N. K., LeDoux, C., 1999: Performance of a cut-to-length harvester in a single-tree and group selection cut. Res. Pap. NE-711. Radnor, PA. US Department of Agriculture, Forest Service, Northeastern Research Station. 6 p.

https://www.fs.usda.gov/treesearch/pubs/9393

Sažetak

Presents production and cost data for a mechanized cut-to-length harvester used in a single-tree and group-selection cut on the Groton State Forest in central Vermont. Tree volume or size is an important factor in machine productivity and therefore, cost of production. For trees whose average volume (size) was 7 to 18 ft3 production ranged from 464 to 734 ft3 per productive machine hour. The cycle time for processing trees into bunches to forward to a landing ranged from about 1 minute to 1.72 minutes per tree (average: 1.29 minutes). There was lile aboveground residual stand damage. The results should assist forest planners, loggers, and land managers in their decisionmaking.

38. Inberg, J., Mattila, J., Virvalo, T., 2002: Harvester Boom Tip Acceleration Control During a Crosscutting – Theoretical Background. International Journal of Forest Engineering 13(1): 41–49. https://www.tandfonline.com/doi/abs/10.1080/14942119.2002.10702456

Sažetak

The cutting function is an essential part of a harvester's work in the cut-to-length method. The quality of cutting is the most significant feature of a cut. Trees should be cut without causing damage to logs produced. Nowadays end checks of logs are the main problem in the cutting process. It has been observed that end checks are found in as many as 70% of the logs produced by harvesters. Cutting damage reduces the amount of useful material and causes considerable economical loss to the sawmill and veneer industries. This study presents a theoretical background for the boom-lowering function, which is one solution to avoid cutting damage during the timber cutting process. The purpose is to momentarily counterbalance the gravitational force of the log in horizontal timber cutting. The study discusses the feasibility of controlling the boom tip in the vertical plane during the cut. In this study the boom tip motion trajectory along the g-vector is modelled for both one and two linear actuators. On the basis of this theoretical study, it seems that acceleration of one g is possible to realise with certain improvements in hydraulics. However, experimental measurements are required to verify these theoretical results. This will include the more detailed study of the effects of deceleration limits on boom stability.

39. Iwaoka, M., Aruga, K., Sakurai, R., Cho, K. H., Sakai, H., Kobayashi, H., 1999: Performance of Small Harvester Head in a Thinning Operation. Journal of Forest Research 4(3): 195–200. https://doi.org/10.1007/BF02762248

Sažetak

Medium to large size harvester heads mounted on large machines are popular in Japan. These machines encounter some problems during thinning operations, e.g. damage to residual stand and the compaction of soil. The performance of these large harvesters was compared with that of smaller ones operating simultaneously in the same line thinning operation of the same stand. The results of a time study showed that mean cycle times for the smaller and larger harvesters were not significantly different. This means that the work efficiency of the smaller harvester can be at the same level as the larger harvester on sites similar to those of this study. The mean values 'Feed' element of the cycle time, however, were significantly different.

Although this time difference appears to provide an advantage to the larger harvester, simulation results show that the advantage is not great enough to significantly shorten the total cycle times. That is to say, the work efficiency remains essentially the same even if the feeding performance of the small size harvester becomes as high as that of larger ones. The small harvester performs adequately in thinning operations, and is not inferior to the larger ones. This result indicates that there is economic potential for small base machines that can be mounted with small harvester heads, resulting in less damage to residual trees and site soils during thinning operation.

40. Kärhä, K., Rönkkö, E., Gumse, S.-I., 2004: Productivity and Cutting Costs of Thinning Harvesters. International Journal of Forest Engineering 15(2): 43–56.

https://www.tandfonline.com/doi/abs/10.1080/14942119.2004.10702496

Sažetak

High harvesting costs are the main problems in first thinnings. Machines with lower operating costs could be one potential solution for cost-efficient first thinnings. The research investigated the productivity of the four most widely used small harvesters, i.e. thinning harvesters, and their cutting costs. Data were also collected on the productivity relationships between working methods and the differences between operators. In the time studies involving thinning harvesters, the Nokka Profi and Timberjack 770 represented the larger, more expensive machines, while the Sampo-Rosenlew 1046X and Valtra Forest 120 represented the more compact, less expensive thinning harvesters. The productivity per operating hour (E15 including delay times shorter than 15 minutes) of the thinning harvesters was found to be 5.6-10.3 m3/E15 (stem size 50-100 dm3) in first thinnings and 9.1-12.7 m3/E15 (100-150 m3) in second thinnings. The productivity figures of the individual machines were similar. The differences were mainly attributable to the operators. The time study showed that the differences between operators using the same machines were as great as 40%. The cutting costs for the thinning harvesters were 7.5-14.2 US$/m3 (50-100 dm3) in first thinnings when using the Nokka/Timberjack machine group. The corresponding costs for the Sampo/Valtra machine group were 5.7 and 10.5 US$/m3. It would appear that thinning harvesters can be operated at the same productivity level of medium-sized harvesters in thinnings and, consequently, they can be run at cutting costs lower than those of medium-sized harvesters.

41. Kellogg, L. D., Bettinger, P., 1994: Thinning Productivity and Cost for a Mechanized Cut-to-Length System in the Northwest Pacific Coast Region of the USA. Journal of Forest Engineering 5(2): 43–54.

https://doi.org/10.1080/08435243.1994.10702659

Sažetak

A production study of a single-grip harvester and forwarder was conducted in a second-growth thinning operation in western Oregon, USA. Production levels for the harvester exceeded 30 m3/PMH (productive machine hour, delay-free). There was no significant difference in harvester production between stands marked prior to logging and those in which the trees were selected by the operator. Production levels for the forwarder ranged from 10.2 m3 to 14.5 m3/PMH. When landing space was limited, a two-pass forwarding technique (separate

loads of sawlogs and pulpwood) was more productive than a single-pass technique (products mixed on each load and sorted at the landing). Regression equations were developed to predict harvester production per PMH on the basis of tree dbh and to predict forwarder production per PMH on the basis of product type, volume per load, and travel distance. Thinning cost for this cut-to-length system was US $12.49/m3 [US $35.37/ cunit], excluding hauling and a profit-and-risk allowance.

42. Kiljunen, N., 2002: Estimating Dry Mass of Logging Residues from Final Cuttings Using a Harvester Data Management System. International Journal of Forest Engineering 13(1): 17–25. https://www.tandfonline.com/doi/abs/10.1080/14942119.2002.10702452

Sažetak

A method and functions are introduced for estimating the dry mass of logging residues for the most common Scandinavian tree species. Functions were formulated for single trees using different combinations of independent variables that can be measured by standard measuring equipment on harvesters. Cross-validation was used to test the functions and to assess their validity. According to the cross-validation, the total dry mass of logging residues in a clear-cut area could be estimated with a relative standard error of 9.4 - 11.2%. For individual trees, however, the relative standard error for estimating the dry mass of logging residues was as high as 21.5 - 27.6%, depending on the tree species and on the independent variables used in the functions. The models introduced were however more accurate than the generally applied method of estimation, which is based on the average ratio of the dry mass of logging residues to the volume of merchantable wood.

43. Klvac, R., Ward, S., Owende, P. M. O., Lyons, J., 2003: Energy Audit of Wood Harvesting Systems. Scandinavian Journal of Forest Research 18(2): 176–183.

https://doi.org/10.1080/02827580310003759

Sažetak

A computer-based model for the evaluation of energy use in mechanized wood harvesting systems (EnergyCalc) was developed with aid of life cycle analysis methodologies. The system boundaries were determined "from stump to roadside" with wood volume over bark (m3) as the functional unit. The computer model (based on a database system) used a Visual Basic program, and the energy audit was based on fuel and oil consumption, and the energy consumed in the manufacture of the machines and replacement parts. The general scenario from the literature, results from Sweden and a preliminary study from Ireland are presented. In the overall energy audit of mechanized wood harvesting systems in Ireland, fuel consumption was the most significant item (82%), followed by oils (7%) and machine repairs and replacement (11%). The mean energy use from the data for Ireland was found to be 16% higher than the equivalent in Sweden (120 vs 103 MJ m-3). An energy reduction strategy that has the potential to reduce overall energy consumption for Irish systems by up to 13% was suggested.

44. Lageson, H., 1997: Effects of Thinning Type on the Harvester Productivity and on the Residual Stand. Journal of Forest Engineering 8(2): 7–14.

https://www.tandfonline.com/doi/abs/10.1080/08435243.1997.10702699

Sažetak

Harvester productivity, extraction rate, selection criteria for harvesting a tree, and logging damage after different thinning types were studied in northern Sweden. Thinning operations were mechanized and carried out according to normal Swedish practice. The treatments were supervised thinning from below, supervised thinning from above, and unsupervised thinning from above. Time consumption per tree and harvester productivity in thinning from below were significantly different from thinning from above. Extraction rate was higher than the desired level in one plot for unsupervised thinning from above. One plot had a thinning ratio high enough to fit the definition for thinning from above, due to trees harvested independently of thinning type. Mean diameter for damaged and suppressed trees harvested was not different between treatments. No differences in the frequency for size and type of logging damage was found between treatments. For thinning from below, damage was located higher up on the stem than for thinning from above. This study concludes that differences in thinning ratio may be reduced when carried out in commercial forestry, due to the harvest of damaged, suppressed, and, to some extent, strip road trees. Harvester productivity increases with increased thinning ratio. To attain the desired stand densities and to keep damage level down, a skilled and motivated harvester operator is needed.

45. Laitila, J., Väätäinen, K., 2013: The cutting productivity of the excavator-based harvester in integrated harvesting of pulpwood and energy wood. Baltic Forestry 19(2): 289–300.

https://www.balticforestry.mi.lt/bf/PDF_Articles/2013-19[2]/The%20Cutting%20of%20the%20Excavator-based%20Harvester%20in%20Integrated%20Harvesting.pdf

Sažetak

The purpose of the study was to determine the productivity of multi-stem cutting of pulpwood and delimbed energy wood, along with the time consumption of cutting work phases performed with a tracked, forestry-equipped excavator as the base machine and a Naarva EF 28 as the harvester head. On the basis of the time-study data collected, per-stem time-consumption and productivity models were prepared for the multi-stem cutting of delimbed wood. In the multi- stem cutting time-consumption model, productivity was explained in terms of stem volume and harvesting intensity (number of stems removed per hectare). Productivity was expressed in solid cubic metres per effective hour (m3/E0h). In the time studies, the multi-stem cutting productivity per effective hour was 12.8 m3/E0h and 233 stems/E0h, on average. Cutting productivity per effective hour (m3/E0h) increased as the stem volume of trees grew. On the time-study sample plots, the lowest and highest values recorded for multi-stem cutting productivity per effective hour were 8.7 m3/E0h and 19.9 m3/E0h, respectively. The corresponding stem-number figures for the extremes of cutting productivity were 347 and 183 stems/Eih. On average, the harvester head processed 1.9 stems per grapple cycle, while grapple loads processed via the multi-stem method (at least two stems in the grapple at a

time) accounted for 57% of all time-study data. In total, 2,267 stems were cut in the time studies consisting of 71 m3 of pine pulpwood and 53 m3 of multi-stem delimbed energy wood.

Calculations using the time-consumption model have shown that when the harvesting intensity was tripled from 800 to 2,400 trees/ha, the productivity of multi-stem cutting per effective hour increased by about one solid cubic metre, whereas increasing the stem volume from 23 dm3 to 89 dm3 doubled the cutting productivity per effective hour. If the results of this study are generalised or compared with those of other studies, the amount of material and the effects of the harvesting site and operators must be taken into account. The results indicate that the productivity of the excavator-based harvester and the Naarva EF 28 harvester head was very high: at the same level as, or even better than, that of wheeled harvesters equipped with a conventional multi- stem harvesting equipment. The machine concept studied is a highly viable option for integrated harvesting of pulpwood and energy wood. Operation of the machine unit was problem-free throughout the time studies, with no interruptions caused by breakdowns. Moreover, the harvesting quality met the recommended standards.

46. LeDoux, C. B., Huyler, N. K., 2001: Comparison of Two Cut-to-Length Harvesting Systems Operating in Eastern Hardwoods. Journal of Forest Engineering 12(1): 53–60. https://www.tandfonline.com/doi/abs/10.1080/08435243.2001.10702763

Sažetak

We compared production rates, operating costs, and break-even points (BEP) for small and large cut-to-length (CTL) harvesting systems operating at several machine utilization rates (MUR) in mixed hardwood and softwood stands in Vermont. The small CTL harvester produced 11. 08 m3 [391.4 ft3] per productive machine hour (PMH) compared to 14.83 m3 [523.80 ft3] per PMH for the large harvester. The impact of average tree size (volume) on cost was substantial but similar for both CTL systems. At a fixed stump-to-landing logging cost of about $14.12/m3 or [$0.40/ft3], the BEP tree size was 0.14 m3 [5.0 ft3] for the small harvester and 0.26 m3 [9.33 ft3] for the large system at the 85 percent MUR. At an MUR of 70 and 85 percent, the processing cost for trees that averaged 0.08 m3 [3.0ft3] was $22.19 and $18.28/m3 [$0.6285 and $0.5176/ft3], respectively, for the small CTL harvester. Results were similar for the large harvester. Either CTL system would be effective in helping managers meet forest management goals in eastern hardwood stands.

47. Liski, E. P., Nummi, T., 1995: Prediction of tree stems to improve efficiency in automatized harvesting of forests. Scandinavian Journal of Statistics: 255–269.

http://www.jstor.org/stable/4616356

Sažetak

The problem of predicting future observations on a statistical unit given past measurements on the same and other similar units is frequently encountered in practical applications. When computer-based marking for bucking routines is used in a forest processor, it is usually not feasible to run the whole tree stem through the measuring device before the first cutting decisions have to be made. However, for optimal conversion of single stems into smaller logs, the whole stem should be measured in advance. To this end we have developed a predictor for the unknown part of the stem under the mixed model for repeated measurements. Our

prediction-based approach provides an eminently satisfactory solution to this important marking for bucking problem under incomplete information.

48. Marshall, H. D., Murphy, G. E., Boston, K., 2006: Evaluation of the economic impacts of length and diameter measurement error on mechanical harvesters and processors operating in pine stands. Canadian Journal of Forest Research 36(7): 1661–1673.

https://doi.org/10.1139/x06-064

Sažetak

Value recovery studies from around the world have shown that on average mechanical log-making systems lose 18% of the potential value compared to 11% for motor manual systems. One of the potential reasons for their poor value recovery performance is the level of accuracy of their stem diameter and length measurements. Numerous studies have looked at the level of error in both the diameter and length measurements made by mechanical harvesters and processors; however, few have looked at the economic impacts of these errors. The paper investigates the economic impacts in terms of value loss of six different harvesting operations in three different pine species. The accuracy and precision of the measurements recorded in this study were similar to those of other studies from around the world. A simulation model was developed to estimate the value loss caused by these errors. The results of the simulation model showed that the operations were losing between 3% and 23% of the potential value because of measurement errors. Further analysis showed that the industry should concentrate on increasing the precision of the length and diameter measurements to optimize gains from reducing the measurement error rates.

49. McNeel, J. F., Ballard, T. M., 1992: Analysis of Site Stand Impacts from Thinning with a Harvester- Forwarder System. Journal of Forest Engineering 4(1): 23–29. https://doi.org/10.1080/08435243.1992.10702641

Sažetak

The use of a harvester-forwarder system for commercial thinning operations in a Douglas-fir plantation had little detrimental impact on the residual stand. Less than five percent of the sample trees in the residual stand exhibited damage from the thinning operation. Trails occupied less than 20 percent of the harvested area with significant portions of the developed trail, over 13 percent of the harvested area, in lightly disturbed harvester trails. Trail spacing was consistent and averaged 26 metres between trails for the area studied. Changes in bulk density were greater for harvester trails, increasing an average of 25 percent in the first 10 centimetres of soil depth. Bulk densities on forwarder trails averaged 20 percent greater than measurements on adjacent control sites for the first 10 centimetres of soil depth. These bulk density values, when compared against magnitudes from the literature, suggest that little site damage was caused by thinning operations with this system.

50. McNeel, J. F., Rutherford, D., 1994: Modelling Harvester-Forwarder System Performance in a Selection Harvest. Journal of Forest Engineering 6(1): 7–14.

https://doi.org/10.1080/08435243.1994.10702661

Sažetak

A harvester - forwarder system was studied in a selection harvest operation conducted in an interior forest stand composed of Douglas fir (Pseudotsuga menziesii), Ponderosa pine (Pinus ponderosa), and Grand fir (Abies grandis). A time-study analysis was used to develop models for predicting individual machine productivity over time for both the harvester and forwarder involved in the study. Analysis indicates that harvester productivity (13.85 m3 per SMH) closely matched forwarder production (14.10 m3 per SMH) during the study. Further analysis yielded models that can be used to predict system productivity across the range of stand values observed during the study. The results suggest that system productivity is balanced when operating in stands averaging 15 to 25 cm DBH. In stands of larger or smaller average diameter, productivity for the system becomes unbalanced and affects machine operation, particularly the forwarder. Further research is suggested to improve the developed predictor models and allow for prediction of system performance over a broad range of stand and site conditions.

51. Moskalik, T., 2004: Influence of cutting form on the harvester productivity and costs. Age [years] 100 (105): 105.

https://www.researchgate.net/profile/Tadeusz_Moskalik/publication/266180009_Influence_of_cutting_form_on_the_harvester_productivity_and_costs/links/54b936490cf253b50e28ff8b/Influence-of-cutting-form-on-the-harvester-productivity-and-costs.pdf

Sažetak

One of the principles of realization of sustainable forest management, in Polish conditions, is a reduction of forest area harvested on the clearcuts. Instead of that some kinds of other complex cutting forms are preferred. The aim of this paper is to present how different kinds of cuttings influence on the harvester productivity and what are the economical consequences of bringing of these balanced forestry guidelines into effect. Three Scots pine stands were taken under consideration, in which by harvesting Timberjack 1270B was applied. Each stand was cut other way: on the clear cut, in group cutting and in selection cutting. The reached harvester productivity was the highest on the clear cut, amounting 32,6 m3/h. In two others cutting forms harvester productivity decreased adequately about 11,3 and 27,0%. Thi situation will affect an economic running of forest operations activity.

52. Murphy, G. E., 2014: Priority list bucking on a mechanized harvester considering external properties and stiffness of Douglas-fir. International Journal of Forest Engineering 25(3): 214–221. https://doi.org/10.1080/14942119.2014.973177

Sažetak

Although the author is not aware of any formal markets paying a differentiated price for logs with a specified minimum stiffness level, some forest products markets show a clear preference for products with a higher stiffness. Bucking and sorting logs based on stiffness measurements will require changes to the bucking algorithms and work procedures on mechanized harvesters. Acoustic velocity is a surrogate measure for stiffness. The effects of three threshold levels for minimum acoustic velocity for veneer logs and two approaches - one more conservative than the other - for predicting acoustic velocity were evaluated using priority list bucking simulation.

Log-type distribution and value recovery were the performance measures used. Real external stem descriptions and acoustic velocity data from six Douglas-fir stands were used in the simulation. k-nearest neighbor (kNN) and regression methods were used to predict the acoustic velocity of the first and subsequent veneer logs, respectively, cut from each stem. The conservative approach for predicting acoustic velocity for the first veneer log used the minimum value from its nearest neighbors. The less conservative approach used the average acoustic velocity. A 5% increase in the threshold minimum acoustic velocity resulted in a 50% reduction in the number of veneer logs cut and a 3-5% reduction in value recovery, depending on the approach used to predict the acoustic velocity of the first log to be cut. Considerable variation in value recovery, and changes to value recovery, were noted between stands.

53. Nakagawa, M., Hamatsu, J., Saitou, T., Ishida, H., 2007: Effect of Tree Size on Productivity and Time Required for Work Elements in Selective Thinning by a Harvester. International Journal of Forest Engineering 18(2): 24–28.

https://www.tandfonline.com/doi/abs/10.1080/14942119.2007.10702547

Sažetak

The effect of diameter at breast height (DBH) on the time required for work elements in felling, delimbing, and bunching by a harvester was studied. Move and boom, position, felling and tree fall, and cross cutting were not affected by the DBH of the harvested tree. On the other hand, the greater the DBH of the harvested tree, the significantly longer the time required to delimb because of increasing tree height and decreasing delimbing speed. Nonetheless, the total time required to fell, delimb, and bunch one tree was not affected by its DBH, because the proportion of time for delimbing was only 16 percent of the total time. As a result, the productivity of the harvester was 9.2 m3 per productive machine hour, about 33.4 times the piece volume of the harvested tree. This study demonstrated that harvester productivity varied in a roughly linear manner with the piece volume of the harvested tree in a single tree selective thinning that removed only a small percentage of the stand volume.

54. Nakagawa, M., Hayashi, N., Narushima, T., 2010: Effect of tree size on time of each work element and processing productivity using an excavator-based single-grip harvester or processor at a landing. Journal of Forest Research 15(4): 226–233.

https://doi.org/10.1007/s10310-010-0180-2

Sažetak

We studied the effect of tree diameter at breast height (DBH) on the time required for the work elements in processing trees and on overall processing productivity at a landing. The times required for swinging with the tree, determining the butt-end cut, cutting the butt end, feeding and measuring, and cross-cutting were affected by the DBH of harvested trees. The time needed to process each tree was significantly longer for larger trees. However, the piece volume of trees increased as the diameter increased, and the rate of increase in volume was greater than the rate of increase in the time required to process one tree. Thus, processing productivity increased with increasing DBH (or piece volume) of harvested trees.

55. Nicholls, A., Bren, L., Humphreys, N., 2004: Harvester Productivity and Operator Fatigue: Working Extended Hours. International Journal of Forest Engineering 15(2): 57–65. https://www.tandfonline.com/doi/abs/10.1080/14942119.2004.10702497

Sažetak

Falling financial margins have prompted many owners of Australian harvesting businesses to extend normal working hours. After brief trial periods, most companies have again reverted to short-term and ad hoc solutions to meet peaks in demand. The harvesting industry is also being persuaded to operate extended hours under the guise of service-delivery and the '24-hour society', in response to customer demand. A poor understanding of human factors poses a threat to profitable harvesting, and contributes to low productivity on extended hours work regimes. Decreased operator productivity was observed in both shifts of a shiftwork operation. Experience in other industries have noted reduced operator alertness led to increases in the risk and severity of accidents and machine damage. Successful implementation of extended hours work regimes relies on addressing operational needs as well as recognising the human needs, managing productivity, safety, communications and maintenance.

56. Nieuwenhuis, M., Dooley, T., 2006: The Effect of Calibration on the Accuracy of Harvester Measurements. International Journal of Forest Engineering 17(2): 25–33. https://www.tandfonline.com/doi/abs/10.1080/14942119.2006.10702533

Sažetak

Almost all timber in Ireland is harvested using mechanical harvesting heads. All new harvesters come equipped with computerized measurement systems. The objective of the research reported in this article was to assess the impact of calibration on the accuracy of harvester head measurement systems in Irish forestry conditions. The research was carried out on a site in Co. Cork. The harvester was a Timberjack 1270D with a 762C harvester head and the Timbermatic 300 control and measurement system. The harvester measurement system was assessed on its accuracy in measuring the length and volume of individual stems and logs in 9 check runs of 7 or 8 stems. The harvester head measurements were compared to values obtained by caliper-and-tape measurements. The main point that can be taken from this research is that regular calibration will greatly improve the accuracy of the harvester measurement system. After calibration, length measurement by the harvester measurement system of individual logs was very accurate, while volume measurement was unsatisfactory for the pulp log assortment. The differences between the harvester measurements and the caliper-and-tape measurements fluctuated greatly, varying from positive to negative differences within a check run, even after calibration. These fluctuations could indicate an inherent problem associated with the design of the calibration procedure, as the positive and negative differences cancel each other out and the calibration, based on mean values, appears to indicate accurate measurements. More work needs to be done on reducing to impact of the roughness and branchiness of smaller dimension logs on the accuracy of diameter and length measurements in Irish conditions.

57. Nurminen, T., Korpunen, H., Uusitalo, J., 2006: Time consumption analysis of the mechanized cut-to-length harvesting system. Silva Fennica 40(2): 335–363.

http://jukuri.luke.fi/bitstream/handle/10024/532609/time.pdf?sequence=1

Sažetak

The time consumption and productivity of harvesting are dependent on stand conditions, the operators' skills, working techniques and the characteristics of the forestry machinery. Even if the basic methods and machine types of the cut-to-length harvesting system have not changed significantly in 10 to 15 years, improvements in the operators' competence, technical solution in forest machinery and changes in the working environment have undoubtedly taken place. In this study, the objective was to discover the special characteristics in the time consumption of mechanized cutting and forest haulage in Finnish conditions. The empirical time study was conducted with professional operators and medium-sized single-grip harvesters and forwarders in final fellings and thinnings in easy terrain in central Finland. The models for effective time consumption in the work phases and total productivity were formed. Stem size, tree species and bucking affected the cutting, whereas timber density on the strip road, the average driving distance, load capacity, wood assortment and the bunching result of the harvester operator had an effect on the forest haulage performance. The results may be used in simulations, cost calculations and education.

58. Öhman, M., Miettinen, M., Kannas, K., Jutila, J., Visala, A., Forsman, P., 2008: Tree measurement and simultaneous localization and mapping system for forest harvesters. In: Field and Service Robotics. Springer, Berlin, Heidelberg, 369–378 p.

https://link.springer.com/chapter/10.1007/978-3-540-75404-6_35

Sažetak

For the last decades, measurement and automation systems in Nordic cut-to-length forestry machines have evolved gradually. These heavy duty machines are lighter, faster and more accurate than ever before but the basic technologies and operation have remained the same. In many respects, their current automation systems have reached their limits. The Forestrix project studies how advances in mobile robotics could be applied in the field of forestry machine automation. Machine vision systems and scanning laser range finders have established themselves as standard equipment in mobile robotics. With the new sensor and computing technologies it is possible to get information about the surrounding forest, such as tree diameters, positions and stand density. This information can be used on-line in operator's decision support system, or off-line in a forest asset management system. This paper describes the prototype measurement platform and the software algorithms developed in the Forestrix project. Results from tests with an all terrain vehicle are also presented.

59. Olivera, A., Visser, R., Acuna, M., Morgenroth, J., 2016: Automatic GNSS-enabled harvester data collection as a tool to evaluate factors affecting harvester productivity in a Eucalyptus spp. harvesting operation in Uruguay. International Journal of Forest Engineering 27(1): 15–28. https://doi.org/10.1080/14942119.2015.1099775

Sažetak

Uruguay has adopted cut-to-length (CTL) machines in forest harvesting operations, especially in large scale, fast-growing plantations. The majority of modern CTL machines have on-board computers that capture individual tree data and can be coupled with global navigation satellite systems (GNSS). This provides the opportunity to collect data for research purposes and to

improve operations. In this study, we retrieved data (StanForD stm and drf files) from a GNSS-enabled harvester working in CTL operations in Eucalyptus spp. plantations in Uruguay. With two thirds of this data we fitted a mixed effects model to evaluate harvester productivity as a function of stem diameter at breast height (DBH), species, shift (day/night), slope, and operator. A slope surface derived from a digital terrain model was overlaid with GNSS stem records. Slope values were assigned to each stem using the Spatial Analyst toolbox in ArcGIS. The reserved third of the data were used to validate the model. DBH was the most influential variable in harvester productivity, showing a positive correlation and a R2 value of 0.73 in the validation model. Operator and species also had significant effects. There was no significant slope effect, whereby the study area only had flat and mildly sloping terrain. Shift did not have a significant effect, indicating there was no drop in night shift productivity. The model developed constitutes the first published harvester productivity model in South America based on data automatically collected by harvesters. In addition, the forestry company may benefit from using the model for operator management.

60. Olsen, E., Pilkerton, S., Garland, J., Sessions, J., 1991: Computer Aided Bucking on a Mechanized Harvester. Journal of Forest Engineering 2(2): 25–32.

https://doi.org/10.1080/08435243.1991.10702625

Sažetak

During June 1989, researchers from the Forest Engineering Department at Oregon State University evaluated the feasibility of using the computer program BUCK- to aid the Hahn Harvester operator in determining the best bucking cuts. The computer was able to increase the total value by 7.5%. This is about US $6.40 per tree for the 38-cm [15-in] diameter trees we processed. This increase was from improved log quality and increased scaling volume when Scribner rules were used. The computer solution cuts roughly 16% more logs. The computer solution increased the volume in the best export sort by 8%. The computer solution could increase the total value by 19.6% if more accurate tree quality information were sent to the computer before the bucking cuts were made.

61. Ovaskainen, H., 2009: Timber harvester operators' working technique in first thinning and the importance of cognitive abilities on work productivity. Dissertationes Forestales 79: 62 p.

https://www.researchgate.net/profile/Heikki_Ovaskainen/publication/255636270_Timber_harvester_operators'_working_technique_in_first_thinning_and_the_importance_of_cognitive_abilities_on_work_productivity/links/0a85e53a3459c46f4d000000.pdf

Sažetak

The working environment of timber harvester operators has changed dramatically over the past fifteen years. The operator's physical workload has decreased while the proportion of mental load has increased, as a consequence of the increased responsibilities involved in the cutting work. The decision making during the work has also increased and speeded up considerably. Therefore, the importance of the operator, with regards to harvester productivity, has been emphasized as a result of the equalization of the different harvester brands. For this reason, more and more attention is paid to the operator with the expectation

of reaching certain productivity levels. This also places extra expectations on the operator's training; especially in demanding cutting conditions, such as in first thinning, where the operator's abilities are tested the most. The principal objective of this research was to discover and describe a productive working technique for harvester work in first thinning and to improve harvester operator training by highlighting the problems of harvester simulators and determining the important cognitive abilities needed in harvester work. The work of six professional harvester operators was studied using numerous data collection methods: time study, working technique observation, helmet camera video recording, virtual harvester simulator cutting and psychological tests. In addition, 40 harvester operator students participated in the psychological tests. The results indicated that when working productively, in first thinning conditions, the moving distance of the harvester head is minimized. In positioning the harvester head to a removable tree the positioning distance should be short. In felling a removable tree, the tree should be moved only the distance that fluent boom work necessitates. The work should be planned so that reversing is avoided and non-productive time, such as clearing of small trees, is minimal. From the fluent boom working point of view the results showed the operators' consistent method to locate the harvester optimally according to the edge trees of the strip road. Based on this a productive working technique for harvester work in first thinning was created and described. A productive working technique can increase productivity by 10 to 15%. In addition, the handling of trees located in different places around the harvester was theorized. The results also indicated that the virtual harvester simulators are applicable for harvester training when the trainees are conscious of the limitations of the simulators. From the point of view of harvester operator training and operator selection the psychological tests indicated that productive and skilful harvester operating is not solely explained by one cognitive ability, instead, the mastering of different kinds of abilities appears to be more important. By combining the productive working technique with the operator training and taking into account the cognitive challenges faced in harvester work, for example, work planning and perception, the graduated students are likely to be more productive and ready to meet the challenges of working life.

62. Ovaskainen, H., Uusitalo, J., Sassi, T., 2006: Effect of edge trees on harvester positioning in thinning. Forest Science 52(6): 659–669.

https://academic.oup.com/forestscience/article-abstract/52/6/659/4617658

Sažetak

The objective of this study was to discover the influence of edge trees, the trees along the side of the strip road, on the positioning of modern single-grip harvester during the first commercial thinning. The results indicate that there is one main working location in the strip road where the harvester is positioned in a distance of two consecutive edge trees. This main location is determined by an edge tree located about 1.2 m behind the boom base. There are also other working locations within a certain distance but in most cases the harvester was positioned same way to the main location, which enables the least restricted boom operations in the boom working sector. Positioning the harvester according to the edge trees does not explain the considerable productivity differences among experienced harvester operators, but the awareness and significance of the edge trees give trainees a valuable basis for outlining and planning work in early stages of training. The present findings are also beneficial from the cutting damage and harvester configuration points of view.

63. Ovaskainen, H., Uusitalo, J., Väätäinen, K., 2004: Characteristics and Significance of a Harvester Operators' Working Technique in Thinnings. International Journal of Forest Engineering 15(2): 67–77. https://www.tandfonline.com/doi/abs/10.1080/14942119.2004.10702498

Sažetak

Productivity levels between harvester operators have been noted to vary significantly, by up to 40% in similar stands. It is believed that differences originate from the operators cutting techniques, motoric skills, planning of work, experience, felling order of removable trees, decision processes at the working location, machine properties and the surrounding environment. The objective of this study is to examine and compare six harvester operators and to detect those features of working technique that improve and rationalise the work. Consequently, improving the basic working technique can raise average productivity. The harvester operators' work was examined by using the normal stopwatch study method and the operators' working technique was registered for each handled tree. Working technique observations were adjoined to stopwatch the study time units as a large matrix after data collection. Results indicate that unnecessary stem movements in the felling phase should be avoided. The stem should be processed close to the stump so that the positioning-to- cut distance to next removable tree is short. This reduced positioning-to-cut time for the next felling. In processing, a productive operator can operate without big delays and the variations in processing times for same stem sizes are small. Furthermore, the productive operator avoids reversing when he is doing normal harvesting work.

64. Purfürst, F. T., Erler, J., 2011: The Human Influence on Productivity in Harvester Operations. International Journal of Forest Engineering 22(2): 15–22.

https://www.tandfonline.com/doi/abs/10.1080/14942119.2011.10702606

Sažetak

It is well-known that machine operators vary in their performance when undertaking mechanized forestry harvesting operations. Nevertheless, the human factor is still largely disregarded in productivity calculations. In the present study, operator performance is evaluated by analysing archived production data collected automatically by computers on-board single grip harvesters driven by 32 operators working in 3,351 stands over a period of three years. The experimental conditions were all approximately the same. The effect of the operators is modelled by a multilinear regression analysis. Seventeen operators were found to have performance levels that differed significantly from the mean model. Together, 'tree volume' and 'operator' explained 84% of the overall variance. However, since 37.3% of the variance in productivity is explained by the operator, the influence of the operator on productivity is quite large. The minimum and maximum significant mean productivity values for all the operators differed by a factor of 2.2, which reduced to a factor of 1.8 if only data from experienced operators were analysed, although this still demonstrates that the best operators are nearly twice as productive as the worst. The operator, therefore, has an important influence on productivity and should be considered a key factor in productivity models.

65. Puttock, D., Spinelli, R., Hartsough, B. R., 2005: Operational Trials of Cut-To-Length Harvesting of Poplar in a Mixed Wood Stand. International Journal of Forest Engineering 16(1): 39–49. https://www.tandfonline.com/doi/abs/10.1080/14942119.2005.10702506

Sažetak

Cut-to-length harvesting systems offer an alternative to conventional mechanical systems for thinning mixedwood stands. We evaluated the performance of a single-grip harvester and forwarder in a poplar-dominated mixedwood stand in Southern Ontario to quantify the effect of tree size and tree form on harvester productivity and harvesting cost, and to assess the damage caused by the harvesting operation to advance regeneration and residual trees. A single-tree selection silvicultural system was used. Individual trees were assigned a form index based on their visual estimates of limb size and stem form. The cut-to-length harvester produced 23.1 m3 per productive machine hour (PMH). Forwarder productivity was 17.2 m3/PMH. The results indicate a significant and positive relationship between harvester productivity and tree size (dbh) and tree form. Tree size (dbh) has the greatest influence on the unit cost of harvesting. At an average 27 cm dbh and extraction distance of 200 m, the stump-to-landing cost was approximately 10 US$/m3 As tree size increased, the unit cost of wood produced decreased. Damage to residual trees and advance regeneration was minimal. The results suggest that single-grip cut-to-length harvesting systems can be effective in managing poplar-dominated mixedwood stands.

66. Ramantswana, M., McEwan, A., Pauw, J., 2012: Determining the effect of tree size, bark-wood bond strength and tree form on the productivity of an excavator-based harvester in Acacia mearnsii in the KwaZulu-Natal forestry region of South Africa. Southern Forests: a Journal of Forest Science 74(3): 151–157.

https://doi.org/10.2989/20702620.2012.722823

Sažetak

The aim of this study was to determine the effect of tree size, bark-wood bond strength and tree form on the productivity of cut-to-length harvesting of Acacia mearnsii, using an excavator-based harvester with a SP Maskiner harvester head in the KwaZulu-Natal forestry region of South Africa. Tree diameter and height measurements were used to determine individual tree volumes, after which the trees were classified into different bark-wood bond strength and tree-form classes. Time studies were carried out to determine harvester productivity. The results showed that tree size plays a crucial role in the productivity of the harvester, but bark-wood bond strength and tree form also influence productivity. The harvester productivity varied from 5.5 m3 per productive machine hour (PMH) in 0.05 m3 trees to 16.9 m3 PMH-1 in 0.25 m3 trees The bark-wood bond strength did not influence harvester productivity when handling small trees of less than 0.1 m3. In small trees, the productivity of the harvester was also not affected by different form classes, but as tree size increased, there was greater productivity variation between the different form classes.

67. Rämö, J., Tahvonen, O., 2014: Economics of harvesting uneven-aged forest stands in Fennoscandia. Scandinavian Journal of Forest Research 29(8): 777–792. https://doi.org/10.1080/02827581.2014.982166

Sažetak

This study analyzes the optimal harvesting of uneven-aged Norway spruce (Picea abies (L.) Karst.), Scots pine (Pinus sylvestris L.), and birch (Betula pendula Roth. and B. pubescens Ehrh.) stands. The analysis is based on an economic description of uneven-aged forestry using a size-structured transition matrix model and a single-tree model. The optimization problem is solved in its general dynamic form using gradient-based interior point methods. Increasing the harvesting interval decreases the annual volume yield. Assuming natural regeneration, this suggests that volume yield is maximized by uneven-aged rather than even-aged management. The present value of stumpage revenues is maximized after saw timber and pulpwood prices, interest rate, and a 15-year harvesting interval are included. The economically optimal solution with a 3% interest rate produces an annual yield of 1.9, 6.2, and 3.1 cubic meters for Scots pine, Norway spruce, and birch, respectively. Both the optimal volume yield and net present value maximization solutions converge to unique species- and site-type-specific steady states with constant harvests. The transition matrix model typically used in optimization studies is computationally less demanding than the single-tree model, but the differences in optimal solutions are more remarkable than earlier studies suggest.

68. Rasinmäki, J., Melkas, T., 2005: A method for estimating tree composition and volume using harvester data. Scandinavian Journal of Forest Research 20(1): 85–95. https://doi.org/10.1080/02827580510008185

Sažetak

This research article introduces a method that can be used to estimate tree composition and volume of arbitrary subdivisions of a logged stand. The method uses spatial data that is generated with a harvester to simulate individual tree locations. The simulation uses two probability density functions: the distance and the angle from the harvester at which the tree is cut. The average estimated volume root mean squared error varied from 4% for 0.4 ha subregions to 29% for 0.03 ha subregions. The stand subdivision method affected the accuracy of volume estimation only in the smallest subregions. Compared with the use of harvester data as such, i.e. without tree location simulation, the improvement in total and species-wise volume estimates varied between 5 and 35%. The data produced by the method can be used as a field data source for remote sensing methods as well as a verification data set for field inventories. However, a question remains over the generality of the model parameters used.

69. Sängstuvall, L., Bergström, D., Lämås, T., Nordfjell, T., 2012: Simulation of harvester productivity in selective and boom-corridor thinning of young forests. Scandinavian Journal of Forest Research 27(1): 56–73.

https://www.tandfonline.com/doi/abs/10.1080/02827581.2011.628335

Sažetak

Forest management practices may change in the future, due to increases in the extraction of forest fuel in first thinnings. Simulation models can be used to aid in developing new harvesting systems. We used such an approach to assess the productivity of innovative systems in various thinnings of young stands with wide ranges of mean breast height diameter (1.5-15.6 cm), stems per hectare (1000-19,100), and mean height (2.3-14.6 m). The results show that selective multiple-tree-handling increases productivity by 20-46% compared to single-tree-handling. If the trees are cut in boom-corridors (10-1 or 2 m strips between strip roads), productivity increases up to 41%, compared to selective multiple-tree-handling. Moreover, if the trees are felled using area-based felling systems, productivity increases by 33-199%, compared to selective multiple-tree-handling. For any given harvesting intensity, productivity increased the most in the densest stands with small trees. The results were used to derive time consumption functions. Comparisons with time study results suggest that our simulation model successfully mimicked productivity in real-life forest operations, hence the model and derived functions should be useful for cost calculations and evaluating forest management scenarios in diverse stands.

70. Schweier, J., Becker, G., 2012: New Holland Forage Harvester's Productivity in Short Rotation Coppice: Evaluation of Field Studies from a German Perspective. International Journal of Forest Engineering 23(2): 82–88.

https://doi.org/10.1080/14942119.2012.10739964

Sažetak

Modified forage harvesters are a common technology used to harvest short rotation coppice (SRC). This paper describes results of time studies from harvest trials with the New Holland forage harvester equipped with the cutting head 130 FB. Seven fields comprising a total of 13.6 ha SRC were harvested, and data from 22h 41 min were collected. In the studies, 0.77 hectares were harvested per productive machine hour (pmh-1). The share of productive times was 74% of the total work time. The average harvesting productivity was 20.5 odt pmh-1. Under good conditions, productivities up to 30 odt pmh-1 were reached. The harvesting costs were 19.70- odt-1 on average, excluding the costs for the transport of the chips and of the harvesting machine to the fields.

71. Sherwin, L. M., Owende, P. M. O., Kanali, C. L., Lyons, J., Ward, S. M., 2004: Influence of tyre inflation pressure on whole-body vibrations transmitted to the operator in a cut-to-length timber harvester. Applied Ergonomics 35(3): 253–261.

http://www.sciencedirect.com/science/article/pii/S0003687004000316

Sažetak

The influence of tyre inflation pressure on whole-body vibrations transmitted to the operator during the movement of a cut-to-length timber harvester was evaluated. Vibration measurements were taken in three orthogonal (x, y, z) axes at tyre pressure settings of 138, 345 and 414kPa. Vibration was predominant in the vertical (z) direction with the peak rms acceleration value for the operator seat (0.281ms−2) occurring at approximately 3.2Hz.The corresponding peak value for the operator cabin chassis was 0.425ms−2 at 4Hz.At 414kPa, there was potential health risk on the operator for exposures above 8h duration. The vibration

total values recorded for the operator seat at the maximum tyre inflation pressure setting were classed as "fairly uncomfortable" (ISO standard 2631-1), and vertical seat vibration transmissibility was highest between 4 and 8Hz at the 345kPa tyre pressure setting. The recorded values of WBV were significantly reduced by a reduction in tyre inflation pressure which may therefore be used to moderate the magnitude of WBV on wheeled timber harvesters.

72. Sikström, U., Glöde, D., 2000: Damage to Picea abies Regeneration After Final Cutting of Shelterwood with Single- and Double-grip Harvester Systems. Scandinavian Journal of Forest Research 15(2): 274–283.

https://doi.org/10.1080/028275800750015091

Sažetak

Logging-related damage to forest regeneration is a problem during final cutting in the shelterwood system. In order to compare the effects of logging methods, damage to natural Norway spruce [Picea abies (L.) Karst.] regeneration caused by single- (SGH) and double-grip harvester (DGH) systems was studied in three shelterwoods (132-234 m3 ob ha-1) in Sweden. Between 38 and 65% of the original seedlings (6 400-25 400 ha-1)

73. Siren, M., 1999: One-grip harvester operations, silvicultural results and possibilities to predict tree damage. In: Keane, M. & Kofman, P. (eds.). The thinning wood chain. Proceedings of a IUFRO 3.09.00 Conference on Harvesting and Economics of Thinnings. Ennis, Ireland, 4-7th May, 152–167.

http://jukuri.luke.fi/handle/10024/507618

74. Sirén, M., 2000: Silvicultural Result of One-Grip Harvester Operation. Journal of Forest Engineering 11(2): 7–14.

https://www.tandfonline.com/doi/abs/10.1080/08435243.2000.10702749

Sažetak

A new method for measuring the silvicultural result of thinning is presented in the study. The measuring method was based on rectangular sample plots measured parallel to strip roads. An individual sample plot consisted of eight zones, each 30 m2 in area. Due to its considerable importance in Finland, the one-grip harvester operation was the harvesting system examined. The research material was collected from 15 stands amounting to a total area of 14.7 ha. The post-harvesting inventory provided good information on the removed and standing trees, their size and distribution. The number and distribution of standing and removed trees were according to Finnish thinning instructions, and thinning was typical low thinning, in which smaller trees and trees of low quality are removed. The average tree damage percentage, 4.6, is acceptable. However, the proportion of damage varied from 1.1% to 9.1% with different operators. The damage was highest during the summer. Small, superficial damage was typical. The average strip road width was 4.8 m, the distance between strip roads 19.8 m and the rut depth 0.6 cm. The economic consequences of the damage was estimated using a calculation

model. The model estimates the losses caused by strip roads, tree and soil damage. The economic consequences of harvesting damage during the rotation period was 1158 FIM (1 U$ = 5.60 FIM). Strip roads make a significant contribution to the amount of costs. Due to the high variation in the harvesting quality, both the continuing supervision of the silvicultural thinning result and the training of machine operators are necessary. Thinning spruce stands during the sap period should be avoided due to the high risk of tree damage, and decay following damage. Generally, it is possible to obtain a good silvicultural thinning result with one-grip harvester operation.

75. Sirén, M., 2001: Tree Damage in Single-Grip Harvester Thinning Operations. Journal of Forest Engineering 12(1): 29–38.

https://www.tandfonline.com/doi/abs/10.1080/08435243.2001.10702760

Sažetak

Tree damage in a one-grip harvester operation was assessed by observing the number of contacts with standing trees and damage resulting from these contacts. The processing phase for a single tree was called a cycle. On average, 19.3% (14.5-25.4%) of cycles involved contacts with standing trees. One third of the contact trees were removed during harvesting. Of the struck trees left standing, 28.2 % were damaged. The probability of contact damage was 1.5 times higher in the summer than in other seasons. Mean damage percentage in the study stands was 3.4 (range 0.0-8.6%). Contacts with standing trees were explained by machine operator, stem volume of processed tree and the number of trees on the working area. The probability of damage resulting from contact was explained by harvesting season and size of processed tree. A model was developed to predict tree damage. The model consisted of a contact model and a damage model formulated using logistic regression. The tree damage model and the productivity models can be used, for example, in comparing different thinning regimes in model stands. The operator had considerable influence on both the harvesting quality and productivity, and there was a large variation between machine operators. High productivity and a good silvicultural result were highly correlated.

76. Sirén, M., Aaltio, H., 2003: Productivity and Costs of Thinning Harvesters and Harvester-Forwarders. International Journal of Forest Engineering 14(1): 39–48. https://www.tandfonline.com/doi/abs/10.1080/14942119.2003.10702468

Sažetak

Machines with lower investment and operating costs can be one solution in solving the harvesting costs problem of first thinnings. The long-term productivity of thinning harvesters and harvester-forwarders was investigated in a joint project between Finnish research institutions. In the follow-up study, three harvester-forwarders and five thinning harvesters were studied. The total harvested volume was almost 30000 m3. The work performed by harvester-forwarders includes both cutting and forwarding. The average productivity of a harvester-forwarder varied from 3.81 m3/E15 hours in first thinnings to 7.87 m3/E15 hours in regeneration cuttings. The productivity was calculated for a 250 m forwarding distance. Average stem size of the stand, removal per hectare, and number of timber assortments were the factors affecting productivity when the forwarding distance was standardized. The

productivity of thinning harvesters varied from an average of 6.92 m3/E15 hours in first thinnings to 16.18 m3/E15 hours in clear cuttings. Some of the harvesters were well capable in small dimensioned clear cuttings, the smallest machines being solely designed for thinnings. Harvesting costs were compared at the harvesting system level. The costs of a medium-sized forwarder were added to the costs of harvesters. Cost data for the widely used medium-sized harvester system were added to the comparisons made for the forwarding distance of 250 metres. The thinning harvester system had the lowest costs for both two and five timber assortments. In the case of five assortments, which is the typical number in thinnings in Finland, the medium-sized harvester system had lower costs than the harvester-forwarder above a stem size of 60 dm3. At an average stem size of 200 dm3 the difference between the harvester systems was minimal. In the case of two assortments, the competitiveness of the harvester-forwarder was better, and below a stem size of 100 dm3 its costs were lower and between 100-200 dm3 at the same level as for the medium-sized harvester system. The thinning harvester system was still the cheapest alternative. Thinning harvesters and harvester-forwarders are interesting alternatives for thinnings. The high capacity and all the properties of medium-sized harvesters cannot be fully exploited in thinnings. Thus machinery with lower capital costs and reasonable productivity can be competitive. Some of the studied machines can be used effectively in clear cuttings with a reasonable stem size. The harvester-forwarder is an interesting type of machine that is currently undergoing rapid development. The harvester-forwarder is most competitive in small stands with a short forwarding distance.

77. Sirén, M., Ala-Ilomäki, J., Mäkinen, H., Lamminen, S., Mikkola, T., 2013: Harvesting damage caused by thinning of Norway spruce in unfrozen soil. International Journal of Forest Engineering 24(1): 60–75.

https://doi.org/10.1080/19132220.2013.792155

Sažetak

Two harvester working methods and two types of forwarder equipment (tracks and chains) were compared with respect to harvester productivity, logging residue on strip roads, rut formation, and logging damage in the thinning of two Norway spruce stands in Southern Finland. In the normal harvester working method, trees removed further away from the strip roads were processed outside the strip roads. In the protective method, the harvester operator processed as many trees as possible on the strip road and turned some of the treetops parallel to the strip road. The protective harvester working method increased harvester time consumption by approximately 5%, but a higher proportion (86-92%) of the total logging residue potential was brought to the strip roads. The logging residue mass obtained to cover the strip roads was approximately 14-19 kg/m2. According to the recommendations for forestry practice in Finland, damaged trees should not exceed 4% of the number of the remaining trees, and ruts deeper than 10 cm should not exceed 4% of the total length of the strip road network. In our study, the proportion of damaged trees clearly exceeded the limit. After two to four forwarder passes, the proportion of deep ruts generally remained below that threshold. Neither logging damage nor rut depth differed between the harvester working methods. The prerequisites for a successful thinning operation performed on unfrozen soil are favorable weather, soil, and stand conditions. On dry soils with high bearing capacity, ruts remain shallow and the proportion of deep ruts is low. Furthermore, a high amount of logging residue decreases rut formation.

78. Spinelli, R., Magagnotti, N., 2010: Comparison of two harvesting systems for the production of forest biomass from the thinning of Picea abies plantations. Scandinavian Journal of Forest Research 25(1): 69–77.

https://doi.org/10.1080/02827580903505194

Sažetak

This study compares two principally different harvesting systems used for the thinning of Norway spruce [Picea abies (L.) Karst.] plantations in the Alps. The first system was whole-tree harvesting (WTH), producing only whole-tree chips for energy purposes. This system minimizes the production costs by simplifying the harvesting process. The other system was cut-to-length (CTL) mechanical harvesting with an excavator-based harvester. This system maximizes value recovery by producing both short sawlogs and quality fuel chips. Trials were conducted on two similar sites in the Dolomites, in northern Italy, and demonstrated that the CTL system resulted in slightly higher harvesting costs, and also higher revenue. The price differences between the different products determine which system offers the best economic results. If the delivered price of sawlogs does not exceed [euro]25 t-1, WTH and CTL harvesting offer very similar economic performances, and become profitable only if the delivered price of raw chip wood exceeds [euro]40 t-1. If the delivered price of sawlogs increases to [euro]50 t-1, the mechanized CTL system always becomes preferable, and it will turn some profits when the price of raw biomass exceeds [euro]35 t-1. The CTL system is less sensitive to long extraction and transport distances than the WTH system.

79. Spinelli, R., Magagnotti, N., 2013: The effect of harvest tree distribution on harvesting productivity in selection cuts. Scandinavian Journal of Forest Research 28(7): 701–709. https://doi.org/10.1080/02827581.2013.821517

Sažetak

The study explored the effect of tree-selection pattern on harvesting productivity, under specific site conditions typical of mountain forestry and suitable for mechanized cut-to-length harvesting. In particular, the experiment tested two different single-tree-selection principles, namely, uniform spatial distribution across the whole site and clustered distribution, where selection trees were concentrated along presumed strip roads. The test was conducted on two different sites, representative of two different stand-development stages. Ten plots were located on each site, and randomly assigned to the two spatial distribution treatments (uniform and clustered). Great care was taken to maintain even conditions for the test. Mean tree size and removal intensity were the same on all plots from the same site; all plots were harvested by the same harvester and forwarder team; data were collected by the same researchers in all plots. Under the specific conditions of the study, the spatial distribution of harvest trees had no significant effect on harvesting productivity and cost. In contrast, harvesting performance was affected by tree size and possibly removal intensity. Anecdotal evidence about the effect of spatial distribution on harvesting cost may derive from its possible association with the other above-mentioned factors (e.g. tree size or removal intensity).

80. Spinelli, R., Magagnotti, N., Nati, C., 2009: Options for the Mechanized Processing of Hardwood Trees in Mediterranean Forests. International Journal of Forest Engineering 20(1): 39–44. https://www.tandfonline.com/doi/abs/10.1080/14942119.2009.10702574

Sažetak

In this study, three different processing options for trees yarded whole at the roadside in a beech thinning operation, typical of the Italian Apennine mountain, were studied. Trees were delimbed, crosscut, and stacked, respectively, by a four- man crew equipped with chainsaws and a hydraulic loader (motor-manual control thesis), by a small stroke harvester head mounted on a light excavator, and by a dedicated 6-wheel harvester. Under the conditions of the study, mechanized processing was less expensive than the motor-manual control thesis, regardless of the specific option. Cost reductions amounted to 27 percent and 38 percent, respectively, for the light processor and the heavy harvester. Annual usage is a crucial factor for the introduction of industrial mechanization: the heavy harvester is preferable to motor-manual processing only when the annual output exceeds 5,000 metric tonnes (t) per year. When this figure grows above 13,000 tonnes per year, it will profitably replace the light processor, not just for monetary gain, but for the inability of the lighter unit to cope with such a heavy workload. On the other hand, the light processor was always less expensive than the motor-manual control, while requiring an additional investment of only (US)$47,000. Therefore, the acquisition of a light processor represents the most viable option, at least for immediate deployment. Its productivity closely matches that of the yarder, allowing for hot-deck (synchronic) operation. All of the options can efficiently process beech trees within the full range of diameters normally obtained from thinning operations, and up to a 30 cm diameter at breast height. As expected, productivity increases with tree size, and even more so for the mechanical units, which normally handle just one or a few trees at a time. Under the conditions of this study, both mechanized options have a potential for bringing processing cost near (US)$10 per tonne, which is half the cost of traditional motor- manual processing.

81. Spinelli, R., Magagnotti, N., Picchi, G., 2010: Deploying Mechanized Cut-to-Length Technology in Italy: Fleet Size, Annual Usage, and Costs. International Journal of Forest Engineering 21(2): 23–31. https://www.tandfonline.com/doi/abs/10.1080/14942119.2010.10702595

Sažetak

The authors conducted a survey of mechanized harvesting and processing machinery in Italy, with the purpose of understanding if the close-to-nature small-scale forestry typical of this country may prevent a reasonably intense utilization of modern technology, or entail a significant increase of its operating cost. Despite the challenging work conditions offered by Italian forestry, modern forest technology has already made significant inroads, as witnessed by a small yet substantial harvester and processor fleet, counting more than 80 units, 75% of which are mounted on general-purpose carriers. Usage levels are lower than those reported for northern and central Europe, but still in excess of 1000 machine hours year-1, at least for the prime movers. Insurance, repair, and maintenance costs are significantly lower than generally reported in current literature. However, empirical data on machine costs is very scarce, and most studies report estimates rather than measured values. Such estimates are often obtained with the same basic methods derived from agriculture, thus raising the question of whether their adaptation to forestry use should be further refined.

82. Spinelli, R., Magagnotti, N., Picchi, G., 2011: Annual use, economic life and residual value of cut-to-length harvesting machines. Journal of Forest Economics 17(4): 378–387. http://www.sciencedirect.com/science/article/pii/S1104689911000316

Sažetak

Recognizing the absence of up-to-date empirical data on the economic life, the annual use and the residual value of dedicated cut-to-length (CTL) harvesting machinery, the authors gathered a large database of second-hand machine sale offers containing over 1000 records, coming from Europe and North America. The statistical analysis of these data pointed at an economic life in the vicinity of 18,000h for both harvesters and forwarders, which confirms previous assumptions. The average annual use for the machines in the database is 1424 and 1581h year−1, respectively for the harvesters and the forwarders. Nordic users achieve a higher annual use than central European users, and the difference is statistically significant. Nevertheless, the average annual use recorded for both groups falls below the levels commonly adopted in current estimates, which may therefore represent ideal reference figures rather than actual averages. Residual value is strongly related to machine age, and the authors calculated some simple functions for estimating it. The study points at a better retention of the original value, compared to the figures reported in previous literature. At 5 years of age the harvesters and forwarders in the study keep respectively 38% and 44% of the new value. The information contained in the study is crucial to machine rate calculation, which has often been based on rule-of-thumb assumptions, in the absence of empirical data.

83. Spinelli, R., Visser, R., 2008: Analyzing and Estimating Delays in Harvester Operations. International Journal of Forest Engineering 19(1): 36–41.

https://www.tandfonline.com/doi/abs/10.1080/14942119.2008.10702558

Sažetak

Time and motion studies have been and still are frequently used to describe, understand, and improve forest operations. Delays are recognized as being one of the major factors that limit productivity in most operations and are, therefore, an integral part of most time studies. But, delay events are erratic in both occurrence and magnitude and are, therefore, difficult to precisely quantify within the relatively short observation period of a typical time and motion study. Thus, delay information from individual studies have limited transferability. This paper analyzes the delay component of 34 harvester time study data sets that were recorded between 1998 and 2006. All of the studies were designed and carried out with the same principal investigator. The data sets were all based on harvesters either harvesting and or processing. Three delays categories were used: mechanical, operator, and other. Delays averaged 28.9 percent of the total scheduled time for all 34 studies, comprising of 7.1 percent mechanical, 4.7 percent operator, and 17.1 percent other delays. Delay averages were compared within category descriptions assigned to each data set for statistical significance. Example results include: total delays were higher for operations working on hot decks versus cold decks and operations working in mixed stands had more than twice the overall delays compared to operations in plantations. Considering only mechanical delays, machines that both felled and processed, compared to just processing, had higher mechanical delays.

Interestingly, dedicated harvesting machines versus harvesting heads mounted on an excavator base had on average higher operator delays.

84. Stendahl, J., Dahlin, B., 2002: Possibilities for Harvester-based Forest Inventory in Thinnings. Scandinavian Journal of Forest Research 17(6): 548–555.

https://doi.org/10.1080/02827580260417206

Sažetak

This study investigated the possible estimation of forest characteristics using the information collected by the harvester in first thinnings. For the analysis a complete forest inventory was carried out in a stand, which was subsequently thinned. The global mean values of tree diameter, tree height, basal area and stem density were estimated, and further, a spatial analysis was carried out to investigate whether the data collected by the harvester could be used to generate a continuous spatial model of the forest. The results indicated that the global mean diameter and height may be estimated, whereas area-related properties, such as basal area and stem density, are more difficult to estimate. The spatial distribution of the diameter and height remained similar after the thinning, whereas the basal area and stem density had become more homogeneous after the thinning. From the trees removed in the thinning a continuous spatial model of tree diameter was developed. It reproduced the spatial structure of the original trees to some extent (R 2 = 0.27, RMSE = 14.3 mm).

85. Strandgard, M., 2009: Evaluation of Manual Log Measurement Errors and Its Implications on Harvester Log Measurement Accuracy. International Journal of Forest Engineering 20(2): 9–16. https://www.tandfonline.com/doi/abs/10.1080/14942119.2009.10702578

Sažetak

Previous studies of harvester measurement accuracy assumed traditional manual log measurements were accurate and represented true log dimensions, which relies heavily on the assumption that logs are regular in shape. The objective of this study was to quantify the level of variability in manual log measurements and consider its impact on harvester calibration and accuracy assessments. Log length was measured along the top and each side and small-end diameter with callipers, a diameter tape, and a steel ruler in two radiata pine stands near Mt. Gambier in Southern Australia. Observed variability in manual log measurements was sufficient to affect harvester accuracy studies and calibration. Length variability on different sides of a log occurs mainly from non-square log ends. Differences due to observer were minor. Diameter measurement variability occurs mainly from the effect of stem eccentricity on each instrument, which is dependent on its number of stem contact points. Callipers have fewer contact points than a diameter tape and hence more variability. This variability was evident in comparisons between observers and instruments. Harvester accuracy studies need to minimize manual measurement variability to identify harvester measurement errors. Length should be measured on the same side measured by the harvester. Diameter should be measured with a diameter tape in preference to callipers as they have greater stem contact and less variability. Harvester calibration needs to minimize manual and harvester measurement variability to identify harvester measurement bias with the least number of logs to minimize the time required for

these activities. In addition to the above suggestions relating to harvester accuracy study measurements, logs selected for calibration must be the most uniform in shape available to highlight harvester measurement biases.

86. Talbot, B., Nordfjell, T., Suadicani, K., 2003: Assessing the Utility of Two Integrated Harvester-Forwarder Machine Concepts Through Stand-Level Simulation. International Journal of Forest Engineering 14(2): 31–43.

https://www.tandfonline.com/doi/abs/10.1080/14942119.2003.10702476

Sažetak

The relative performance of two integrated machine concepts (combined harvesting / forwarding capabilities) was assessed against a conventional harvester / forwarder CTL system in a simulated thinning regime. Multiple-regression based on the simulation output was used in deriving time-consumption functions at the systems and machine level. Descriptive stand variables could be reduced to; harvest volume (m3/ha), stem volume (m3), lead distance (m) and object volume (m3/stand) while maintaining acceptable statistical rigour (R2 > 0.95). The ability of one of the integrated machines to process logs directly onto the bunk provided it with an advantage that more than compensated for its reduced harvesting efficiency. Both integrated machine systems show a competitive advantage in forest structures with low object volumes and long or frequent relocations. Factors negatively affecting forwarding productivity (e.g. long lead distances) favour the conventional two- machine system. A break-even economic analysis showed that integrated machines could present a feasible alternative to contemporary mechanised CTL systems.

87. Tikkanen, L., Ovaskainen, H., Palander, T., 2009: Adaptive tree bucking using group-guiding of harvesters: A simulation approach. Scandinavian Journal of Forest Research 24(3): 258–263. https://doi.org/10.1080/02827580902932811

Sažetak

The objective of this study was to test harvester group-guiding methods by comparing how the total log output distribution of independent harvesters differs from the total log output distribution of group-guided harvesters. In this simulation study four harvesters worked in their own stands in the same region for an identical target, given by a sawmill. Group-guiding was done by utilizing other harvesters' bucking outcomes to fulfil the target log distribution better. Harvesters were combined to form a group in an adapting phase where a new price list was formed. For group-guiding, four different price list adapting methods were developed. There were five different simulations: four with adaptation and one reference simulation without adaptation. Apportionment degree and log/pulpwood proportions were calculated to compare the difference between the methods and reference simulation. With group-guiding, by adapting the price list harvesters reached the target distribution better than working independently. The best group-guiding method fulfilled the target distribution almost 9% better than independently working harvesters. However, the pulpwood proportion increased as a result of using the group-guided method.

88. Väätäinen, K., Sikanen, L., Asikainen, A., 2004: Feasibility of Excavator-Based Harvester in Thinnings of Peatland Forests. International Journal of Forest Engineering 15(2): 103–111. https://www.tandfonline.com/doi/abs/10.1080/14942119.2004.10702502

Sažetak

In the next twenty years in Finland, annual cuttings on peatland forests are foreseen to increase by up to 30 % of the total cuttings. Cost effective harvesting methods on low yield peatland forests coupled with low ground bearing capacity are required. One solution to improve the feasibility of harvesting could be excavators tailored for forestry use and equipped with a harvesting head. In the study, cost competitiveness and productivity of the excavator-based harvester were investigated. The cost analysis focused on operating hours of harvester use, shift arrangements and purchase prices for the base machine and harvesting equipment when the base machine was used partly as a harvester and an excavator. Results were compared to conventional wheeled harvesters. If the base machine is used more than 3 working months as a harvester in addition to normal (6-8 months) excavator work, the harvesting method would be cost competitive compared to purpose-built harvesters (if 1 V and 2 shift arrangements were used). The 25 % increase of the base machine's and harvester equipments' purchasing costs did not eliminate the cost competitiveness of harvesting, when harvesting was carried out in 1 V shifts for at least 4 months. It would be feasible and profitable to invest in harvesting equipment for the excavator and therefore diminish the winter lay-days of the base machine by utilizing it in logging operations. Conditions on peatland sites mean that during the winter time the use of the excavator-based harvester is ideal, when the utilisation of all logging machines is at its highest.

89. van der Merwe, J.-P., Ackerman, P., Pulkki, R., Längin, D., 2016: The impact of mechanical log surface damage on chip size uniformity during debranching and debarking Eucalyptus pulpwood logs using a single-grip harvester. Southern Forests: a Journal of Forest Science 78(2): 159–167. https://doi.org/10.2989/20702620.2016.1152532

Sažetak

Mechanised harvesting operations are becoming more prevalent in South Africa with the realisation that motormanual and manual harvesting operations pose significant health and safety risks to workers. The damage inflicted by single-grip harvester feed rollers and delimbing knives on log surfaces during debranching and debarking eucalypts, may affect eventual chip quality. Chip quality influences pulp quality and recovery in the kraft pulping process. This study investigates the influence of two mechanised debranching and debarking treatments on Eucalyptus pulp logs (threeand five-feed roller passes along the stem surface) by feed rollers and delimbing knives on chip uniformity, size and purity. The two mechanised treatments to three log classes (base, middle and top logs) were compared with chips produced from manually debarked logs. Manually debarked logs produced significantly less undesirable-sized chips than both three and five-pass processed logs. The volume of undesirablesized chips produced during chipping also increased with decreasing log size. Manually debarked logs produced chips with significantly less bark than three-pass-processed logs (0.008% vs 0.062%), and five-pass-processed logs produced chips with significantly less bark than three-pass-processed logs (0.018% vs 0.062%). Middle logs also produced chips with significantly less bark than base logs (0.016% vs 0.056%), and top logs produced chips with significantly less bark than base logs (0.017% vs 0.056%). In all cases the bark content

on logs was considerably less than the maximum of 1.0% generally specified by kraft pulp mills.

90. van der Merwe, J.-P., Pulkki, R., Ackerman, P., 2015: Fibre losses during debranching and debarking of Eucalyptus pulp logs using a single-grip harvester. Southern Forests: a Journal of Forest Science 77(4): 309–313.

https://doi.org/10.2989/20702620.2015.1077416

Sažetak

Mechanised harvesting operations are becoming more prevalent in South Africa, with the realisation that motor- manual and manual harvesting operations pose significant health and safety risks to workers. However, the potential damage caused by single-grip harvester feed rollers and delimbing knives on the log surface during debranching and debarking of eucalypts pulp logs may negatively affect fibre recovery as opposed to manually debarked logs, which show little or no log surface damage. Compared with manual debarking, this study investigated the influence of two mechanised debarking treatments on wood fibre loss on eucalypt log assortments debarked by harvester head feed rollers and delimbing knives. The two mechanised debarking treatments consisted of three and five feed roller passes along the stem surface. In addition to quantifying the magnitude of this fibre loss, a financial evaluation was done to calculate the value of these losses. The three- and five-pass debarking treatments caused significant fibre losses of 1.425 green tonnes per hectare (gt ha-1) and 2.275 gt ha-1, respec- tively, as opposed to manually debarked logs, which produced no fibre losses. Wood fibre losses in terms of total potential (or available) wood mass for three- and five-pass mechanically debarked trees were 1.06% and 1.70%, respectively. These represent a fibre value loss of R441.75 ha-1 and R705.25 ha-1 for three- and five-pass operations, respectively. For the 6.48 million gt y-1 currently mechanically debarked for the South African pulp and paper industry, this equates to fibre value losses of R21.36 million and R34.10 million annually for three- and five-pass operations, respectively.

91. Vanclay, J. K., 1996: Assessing the Sustainability of Timber Harvests from Natural Forests. Journal of Sustainable Forestry 3(4): 47–58.

https://doi.org/10.1300/J091v03n04_05

Sažetak

The concepts of sustainable original harvest (SOH) and sustainable disturbance harvest (SDH), and simple indices such as the ratio of successive harvests do not provide a reliable indication of the sustainability of a harvest. Some limitations of these concepts are illustrated in the context of selection harvesting of timber from natural forests. Four models are used to demonstrate that maintaining an SOH or SDH indicates little about the long-term sustainability of a timber harvest. The concepts may offer greater utility in evenaged systems harvested by clear-felling, but still suffer the limitation that many factors may mask any change in site productivity. Any measure of sustainability should include an appraisal of the condition and vitality of the residual resource. Simple indices based on successive harvests do not consider the residual stand, and can be misleading.

92. Vanclay, J. K., 2011: Future harvest: what might forest harvesting entail 25 years hence? Scandinavian Journal of Forest Research 26(2): 183–186. https://doi.org/10.1080/02827581.2010.545828

Sažetak

A review of current literature offers a basis for forecasting some future trends in forest harvesting. It is likely that major gains will be achieved through closer integration between informatics and harvesting technology. New sensing technology will allow harvesting machines to better optimise both vehicle movements and handling of harvested material, and to provide a comprehensive inventory of the residual stand and of soil data to assist the management of the residual forest. Such speculation about future harvest possibilities is important to foster planning and research. Industry-wide agreement about data protocols could facilitate the development and adoption of new technologies.

93. Visser, R. J. M., Stampfer, K., 1998: Cable Extraction of Harvester-Felled Thinnings: An Austrian Case Study. Journal of Forest Engineering 9(1): 39–46. https://www.tandfonline.com/doi/abs/10.1080/08435243.1998.10702710

Sažetak

A time study of the cable extraction of thinnings in short corridors was carried out in the Neuberg an der Mürz forest area, Austria. Both the yarder and the choker-setter(s) were studied. Six options were compared. For the 'standard' option the timber was felled, cut to length, and pre-bunched by the harvester on a 20-meter-wide corridor, and was yarded downhill. Two choker-setters were employed. The five variations included: (1) 'larger' bundles, (2) increased lateral hauling distance, (3) one choker-setter, (4) the harvester cutting-to-stem length and the timber yarded uphill with only one choker setter, and (5) trees in a 30-meter-wide corridor felled and bucked by motor-manual methods. The harvester used was a Skogsjan 687 XL with a 601 head; the medium-sized yarder was a Syncrofalke with a Sherpa U3 carriage. The time study results showed that the corridors felled and cut to length by the harvester, in comparison to the motor-manually cut corridor, provided a significant improvement in the cable extraction cycle times: 3.7 min compared to 4.6 min. Additionally, an average turn volume increase of 26% was achieved by the improved presentation of the timber. A 20-meter lateral-hauling distance increased the cycle time by only 7%. The use of one choker-setter increased the delay-free cycle time by just 10%, however it significantly decreased the work-related waiting time for the choker-setter to just 5%. Uphill stem extraction using one choker-setter had the same cycle time as the downhill cut-to-length extraction using two choker-setters, although a 5% greater average turn volume was recorded.

94. Wang, J., Haarlaa, R., 2002: Production analysis of an excavator-based harvester: a case study in Finnish forest operations. Forest Products Journal 52(3): 85–90.

https://search.proquest.com/openview/5bc51d5d370eeebaeb0d8b42f6f920bd/1?pq-origsite=gscholar&cbl=25222

Sažetak

A production study was conducted for an excavator attached with a harvesting head under two stand conditions in northern Finland to determine and examine hourly productivity, unit cost, and working pattern. Before clearcutting, stand l was a natural stand composed of birch and spruce. Stand 2 was a pine plantation that was to be thinned a second time. Felled trees had an average diameter at breast height (DBH) of 17 .8 and 15.8 cm, 7.64 m and 10.69 min total merchantable height, and volume per tree of 0.18 and 0.20 m3, in stands land 2, respectively. The results indicated that the productivity of this machine in forest operations was at the same level as that of Nordic purpose-built harvesters. Hourly productivity averaged 12.24 m3 per productive machine hour (PMH) in stand land 10.43 m3/PMH in stand 2 and was affected primarily by DB Hand the number of cuts or logs from a tree. Hourly costs were estimated at FIM 466.21/PMH ($84.8/PMH), which provided a cost estimate of FIM 69.47/m3 ($12.6/m3) in harvesting stand I and FIM 74.35/m3 ($13.5/m3) in harvesting stand 2. Working pattern of the excavator was also examined. The average boom reach was between 6 m and 7 m and the maximum vertical revolving angle was about 130 to 140 degrees. Moving distance between harvested stops averaged 16.11 m and the cutting width of a strip ranged from 8.0 to 10.0 m

95. Wang, J., LeDoux, C. B., Li, Y., 2005: Simulating Cut-to-Length Harvesting Operations in Appalachian Hardwoods. International Journal of Forest Engineering 16(2): 11–27. https://www.tandfonline.com/doi/abs/10.1080/14942119.2005.10702510

Sažetak

Cut-to-length (CTL) harvesting systems involving small and large harvesters and a forwarder were simulated using a modular computer simulation model. The two harvesters simulated were a modified John Deere 988 tracked excavator with a single grip sawhead and a Timbco T425 based excavator with a single grip sawhead. The forwarder used in the simulations was a Valmet 524 machine with 2.4-meter log bunks. Production rates and costs were examined for a wide range of even-age oak forest stand conditions. The simulation results suggest that when the tree's DBH is less than 26 cm, harvesting using the Timbco T425 is about 30% more expensive than using the John Deere 988. However, if the tree is larger than 26 cm of DBH, the unit cost of the Timbco T425 was about 8% less than that of the John Deere 988. The balanced John Deere 988 CTL system was 31% more productive and 8% more expensive than the balanced Timbco T425 CTL system in the 20 to 36 cm DBH range. General regression equations were developed for estimating the productivity and cost for the range of conditions simulated. The results should be valuable to managers, planners, and loggers considering the use of CTL systems in this region.

96. Wester, F., Eliasson, L., 2003: Productivity in Final Felling and Thinning for a Combined Harvester-Forwarder (Harwarder). International Journal of Forest Engineering 14(2): 45–51. https://www.tandfonline.com/doi/abs/10.1080/14942119.2003.10702477

Sažetak

During the last decade, the interest for a combined harvester forwarder (Harwarder) has increased and a quite rapid machine development has taken place in the Nordic countries. In 2000 a new prototype equipped with a rotatable and tiltable load carrier was built in order to enhance the possibilities for processing logs directly into the load carrier. A time study was

done to test the hypotheses that 1) the rotatable and tiltable load carrier decreases total time consumption, and thus increases productivity, compared to a fixed load carrier, and that 2) the difference in time consumption between the two harwarder configurations is larger in final felling than in thinning. Results showed that harwarder productivity was increased by 6 per cent in final felling and 20 per cent in thinning by the introduction of a rotatable load carrier. In final felling with the fixed load carrier, the operator changed work method in order to process as many trees directly into the load carrier. It is suggested that this explains why the difference between machine configurations was lower for final felling than for thinning. Calculated harvesting costs for the harwarder were higher than the expected harvesting costs for a harvester and a forwarder in the studied stands. However, there is a large potential to increase harwarder productivity by both further development of the machine and the work methods used.

97. Williams, C., Ackerman, P., 2016: Cost-productivity analysis of South African pine sawtimber mechanised cut-to-length harvesting. Southern Forests: a Journal of Forest Science 78(4): 267–274. https://doi.org/10.2989/20702620.2016.1183096

Sažetak

The South African forestry industry is experiencing an increase in the number of fully mechanised timber-harvesting systems. Understanding the productivity of these systems, for which data is currently limited for South Africa, is an important step to maximise the utilisation of machines being used. A time study of a mechanised cut-to-length system was conducted in Pinus elliottii sawtimber plantations in the Southern Cape forestry region of South Africa. A harvester and a forwarder were studied with the intention of analysing the division of work time amongst work elements, modelling each machine's productivity and cost, and estimate fuel consumption. For the harvester's productivity, a multiple regression model was developed using diameter at breast height (DBH), average distance moved per work cycle and slope class as predictors (adjusted R2 = 0.80). The harvester had a mean productivity of 33.6 m3 per productive machine hour (PMH0) under the current conditions with most of the productive time being used in the moving element. It consumed 25.5 L PMH0 -1 of diesel on average. The forwarder's fuel consumption was calculated as 16.8 L PMH0 -1, while productivity was 46.8 m3 PMH0 -1. The forwarder spent the longest portion of the work cycle in the loading and unloading phases. A productivity regression model was created that included load size and distance moved during the driving in the loaded phase (adjusted R-2 = 0.78).

98. Wolf, D. P., Meek, P., Jones, T. A., Cormier, D., Caspersen, J. P., 2014: Forest harvest residue recovery in semi-mechanized hardwood selection operations. International Journal of Forest Engineering 25(3): 229–237.

https://doi.org/10.1080/14942119.2014.957019

Sažetak

Semi-mechanized single-tree selection operations make important contributions to wood supply in parts of the northern hardwood forest region of northeastern North America. However, harvest residue recovery has not yet been integrated within this silvicultural system, due to low recovery rates, low mechanization, and small harvest blocks. As bioenergy policy

incentives and markets continue to strengthen, there is a need to determine whether these partial harvest systems can contribute to local and regional energy wood supply. We assessed residue recovery and procurement costs during semi-mechanized single-tree selection operations in central Ontario, Canada. Logging contractors recovered 1.7-3.5 oven dry tonnes (ODt) of harvest residue per hectare by reducing the diameter at which trees were delimbed and topped. The time spent delimbing and topping increased by 10.8% but no extra time or machinery was required to recover the residue to roadside landings. Supply chain scenarios that included terminal chipping indicate that the harvest residue could be brought to market at a delivered cost <USD $75 per ODt for transport distances up to 150 km.

99. Zundel, P., Lebel, L., 1992: Comparative Analysis of Harvesting and Siliviculture Costs Following Integrated Harvesting. Journal of Forest Engineering 4(1): 31–37. https://doi.org/10.1080/08435243.1992.10702642

Sažetak

This paper presents a hypothetical case in which the positive and negative impacts of intensive forest harvesting (using the full tree method rather than the shortwood method) are evaluated over the long term using financial criteria. The full tree harvesting system collects branch and top material for use as a fuel as well as the roundwood. The analysis shows that the silviculture cost savings and energy biomass value more than offset the loss in long term value due to slower growth of the stand following intensive harvest. This conclusion is robust to changes in discount rate, value of roundwood and volume growth loss. The price of energy biomass had a major effect.