Silva Fennica vol. 57 no. 3 article id 23074
Category: editorial
https://doi.org/10.14214/sf.23074
SILVA FENNICA
http://www.silvafennica.fi
ISSN-L 0037-5330 | ISSN 2242-4075 (Online)
The Finnish Society of Forest Science

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Are productivity studies in forest operations old fashioned and no more publishable?

Kanzian C. (2023). Are productivity studies in forest operations old fashioned and no more publishable? Silva Fennica vol. 57 no. 3 article id 23074. 2 p. https://doi.org/10.14214/sf.23074

Productivity studies are one fundamental method within the field forest engineering for investigating forest operations. The basic principles of scientific productivity studies seem to be applied and published since more than a century. By the principles, I am referring to the process of measuring the efficiency by quantifying resource input, output production, and the influencing variables that explain variations in performance or efficiency. Similarly, Vuoristo's studies published in 1934 and 1935 aimed to provide functions for estimating wages and efficiency in felling and hauling. These studies reveal the early ambitions of forest work studies – the evaluation of worker performance as a major focus. However, the evaluation of work performance in productivity studies has raised ethical concerns. In addition, the effort to produce standardized performance ratings led to major concerns about this type of study. The human influence on productivity – now commonly referred to as the operator effect – is still a controversial topic (Manner 2021). Apart from ethical issues, scientific work studies in forest operations have often been questioned for their lack of reproducibility, repeatability, and transferability, and for being of only regional interest because they observe a single system at a single site.

In order to overcome some of the aforementioned limitations of scientific scholarship, nomenclatures for work studies have been developed and published with a focus on harmonizing time concepts and terminology. However, there seems to be a lack of broader discussion about statistical methods and common practices for reporting results in scientific publications. Over the past few decades, forest engineering as a research discipline has evolved into a complex field of research with many interfaces to other disciplines. Researchers in this field are forced to adapt to rapid technological changes and to seek new methods to advance data collection and analysis in order to translate technological developments, new working methods, and other system changes into facts and figures. With the increasing mechanization of operations, environmental issues such as fossil fuel use, soil damage, and residual stand damage have been added to the study proposals of forest operations studies. Especially in highly mechanized operations, machine sensors and black box algorithms record all kinds of data during the operation. When researchers have access to such data, an impressive number of records can be statistically analyzed, as shown in the work of Eriksson and Lindroos (2014), which used 20 hm^3 of roundwood from more than 20 000 stands as basis for the statistical analysis. Because of these developments, some may claim that the time of forest work studies is over. However, caution should be exercised as machine sensors and algorithms

only see what they are supposed to see. Also, only a fraction of the world's forest operations are fully mechanized and allow for automated data collection. Furthermore, I don't see any change in the basic approaches to how researchers analyze and report machine-recorded data sets.

The days of using analog stopwatches in the field are truly over, and all types of sensors, including video, can be used to record forest operations and perform many post-operation data analyses. Along with the data collection design, the model hypothesis and statistical methods to be used should be clarified prior to fieldwork. Unfortunately, current guidance on the full study cycle is scarce, posing a challenge to researchers new to this area of research. Recently, Heinimann (2021) published a tutorial focusing on statistical modeling in productivity studies that summarizes the history and provides the basics of how to design studies and develop predictive models. Another movement in publishing toward openness and transparency may indirectly facilitate reproducibility and repeatability by making study data and analysis scripts available to other researchers. If we consider typical harvesting operations, the trees are gone after the study and it is impossible to repeat the study with the same conditions. However, if video footage, collected stand data, and other possible sensor data were released along with analysis scripts, other researchers could at least re-analyze the data, new researchers could use the available material to train themselves, test new analysis methods, and long-term research could be established. Starting with 2024, Silva Fennica will require openness and transparency, and I look forward to submissions related to forest engineering where authors accept this new challenge and see it as an opportunity to advance forest productivity and related studies.

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