Determining the number of replicates in experimental studies with wood samples: how low can we go?

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Summary (max. 500 words)
When designing experiments with wood products, it is important to provide a high enough number of replicates as wood specimens, even if taken from the same tree, may differ in their physical properties. On the other hand, conducting experiments with many wood specimens is time consuming, expensive, and researchers want to keep the cost and waste to the minimum. To determine the optimal number of replicates needed in experiments, an estimate of variance obtained from previous experiments is needed. However, in the field of wood science, these previous experiments with a comparable design are often rare, undocumented, or non-existent. Thus, the decision on the number of replicates is usually based on limited evidence. Sometimes researchers in wood science limit their replicate number to five or fewer.
To improve the design of further experiments in wood science, we analysed the data of two previous experimental studies in wood science that used 8 and 10 replicates, respectively. The first study was an investigation of the impact of different manufacturing decisions in the production of plywood panels with decorative veneers. As an indicator of quality, the development of cracks in the veneer was measured using the digital image correlation (DIC) technique. Four manufacturing factors were examined: veneer type (4 levels), core type (4 levels), adhesive type (3 levels), and lathe check orientation (2 levels), resulting in 96 combinations, each replicated 8 times.
The second study tested chemically modified lampante oil as a potential wood preservative. In this study, weight changes were recorded after leaching tests. Two factors were examined: wood species (2 levels) and modification treatment used (4 levels), resulting in 8 combinations, each replicated 10 times. For both studies the bootstrap resampling technique was used to generate subsamples with a lower number of replicates. Specifically, we observed the effect of reducing the size to 6 and 4 replicates in the first study and to 8, 6, and 4 replicates in the second study. We observed the increase in error in the reduced samples and the effects on the results of the two experiments. In addition, we compared it to the decrease of costs and calculated the optimal number of replicates for both. The results of the analysis will help researchers to optimize the design of further experiments that involve wood products.

Relevance to conference theme
Researchers in wood science often work with small samples.

Keywords (max. 3): Sample size, Statistical power analysis, Cost and error optimization