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Effects of tree-to-tree variations on sap flux-based transpiration estimates in a forested watershed

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To estimate forest stand-scale water use, we assessed how sample sizes affect confidence of stand-scale transpiration (E) estimates calculated from sap flux (Fd) and sapwood area (AS_tree) measurements of individual trees. In a Japanese cypress plantation, we measured Fd and AS_tree in all trees (n = 58) within a 20 $\times$ 20 m study plot, which was divided into four 10 $\times$ 10 subplots. We calculated E from stand AS_tree (AS_stand) and mean stand Fd (JS) values. Using Monte Carlo analyses, we examined potential errors associated with sample sizes in E, AS_stand, and JS by using the original AS_tree and Fd data sets. Consequently, we defined optimal sample sizes of 10 and 15 for AS_stand and JS estimates, respectively, in the 20 $\times$ 20 m plot. Sample sizes greater than the optimal sample sizes did not decrease potential errors. The optimal sample sizes for JS changed according to plot size (e.g., 10 $\times$ 10 m and 10 $\times$ 20 m), while the optimal sample sizes for AS_stand did not. As well, the optimal sample sizes for JS did not change in different vapor pressure deficit conditions. In terms of E estimates, these results suggest that the tree-to-tree variations in Fd vary among different plots, and that plot size to capture tree-to-tree variations in Fd is an important factor. This study also discusses planning balanced sampling designs to extrapolate stand-scale estimates to catchment-scale estimates.