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Sapwood biomass carbon in northern boreal and temperate forests

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Information on the amount of biomass carbon stored in the living tissue of tree stems (sapwood) is critical for carbon and water cycle applications. Recent advances combining information from remote sensing and forest inventory databases have led to spatially continuous estimates of stem biomass in northern boreal and temperate forests. However, a separation of stem biomass into sapwood and heartwood mass has remained unsolved, despite their important differences in biogeochemical function, for instance concerning their contribution to tree respiratory costs. Here we 1) develop a theoretical framework to estimate sapwood biomass for a given stem biomass, 2) collect measurements of sapwood proportions from a biomass and allometry database (BAAD) and an additional extensive literature review, and 3) derive a sapwood biomass map based on remote sensing products, inferred allometric relationships, and a global tree density product that allows scaling from measurements at tree level to areal estimates. Relationships between sapwood area and stem cross-sectional area can be approximated by power laws (with exponents lower than 1) with moderate to high modelling efficiency on a leaf type level (MEF = 0.397 for broadleaf trees, MEF = 0.398 for needleleaf deciduous trees, MEF = 0.722 for needleleaf evergreen trees). The variation in these relationships is mostly explained by differences among tree genera, and secondarily by climatic conditions. The total estimated sapwood biomass carbon equals 12.4 PgC in boreal (54.9 % of stem biomass) and 14.2 PgC in temperate forests (58.2 % of stem biomass) of the northern hemisphere. The derived sapwood biomass map is the first of its kind and can be the basis for novel spatial estimates of plant respiration and transpiration.