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| **Effects of forest management on the microclimatic buffering in boreal forests** |
| The majority of Fennoscandian boreal forests are managed. Traditionally, forest management has been based on even-aged rotation forestry, characterized by periodic clear-cut harvests. On the other hand, uneven-aged management, or continuous cover forestry, has recently emerged as an alternative that may lead to more diverse and resilient forests. Forest management inherently changes the physical structure of forests, affecting not only the carbon storage but also light regimes, local temperature and humidity variability (i.e. microclimate), and thus habitat availability inside forests, which all contribute to the regulation of ecosystem functioning, services, and biodiversity. Yet, the effects of management on microclimate, which is one of the key drivers of local biodiversity patterns, has not been comprehensively studied.  In this study, our goal was to increase the understanding of the effect of forest management on the large-scale temperature (macroclimate) buffering capacity of boreal forests. First, we quantified fine-scale structural differences between uneven-aged and even-aged forests. Next, we investigated how these structural characteristics affect the temperature buffering capacity of forests and what are their spatiotemporal microclimate dynamics. In the final step, we upscaled the analysis over the whole of Finland to estimate the area of forests where temperature buffering has not reached its maximum. To achieve these goals, we used both field measurements and modelling approaches. Our study area in Southern Finland represents both uneven-aged forest stands as well as even-aged stands of various age categories. We used terrestrial laser scanning for assessing the structural differences between management types, and microclimate measurements to estimate the temperature buffering capacity. Finally, we used almost 800 microclimate loggers located in different forests across Finland to train a machine-learning model for spatializing the analysis over Finnish forests. As an input, we use the Multi-Source National Forest Inventory data from the year 2021, which includes management-related variables such as forest age, canopy cover and tree height.  The results show that although different management types result in similar patterns in total plant material, they differ significantly on its vertical distribution. This vertical allocation of plant material was also found to be an important determinant of temperature buffering capacity: increasing canopy layers and the density of the understory led on average to more buffered temperature variability compared to clear-cuts and forests with fewer layers. Our results highlight the dynamic nature of even-aged forests, where the structural characteristics and buffering capacity change drastically with the rotation, whereas uneven-aged forest structures and microclimate remain more stable over time. Since the buffering capacity is highly dependent on stand age and Finnish forests have become younger, we hypothesize that the machine-learning model will reveal a significant number of forest area where the temperature buffering has not reached its maximum. We expect our results to increase the understanding of the impacts of forest management practices on forest microclimates and consequently their ecological functions, shedding light to a less considered aspect in the ongoing forest discussions. |