Microclimatic gradients cause phenological variations within temperate tree canopies in autumn but not in spring

JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

ID 4694354
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Year 2023
Title Microclimatic gradients cause phenological variations within temperate tree canopies in autumn but not in spring
Journal Agricultural and Forest Meteorology
Volume 331
Pages / **Article-Number** ARTN 109340
Keywords Leaf phenology; Temperate trees; Canopy gradients; Phenological avoidance; Microclimate
Tree crowns experience strong vertical microclimatic gradients, particularly in light availability. Surprisingly, little is known about whether these gradients cause within-crown variation in leaf phenology and whether such variations represent different light-use strategies of sun-and shade leaves.In a temperate mixed forest at the Swiss Canopy Crane II site in Switzerland, we measured over three years the annual leaf phenology in the upper and lower crowns of mature trees from six broadleaved and three conifer species. We further recorded the microclimate (temperature, humidity, light) continuously in various positions within the canopy.We found microclimatic canopy gradients to be strongest during summer, but negligible in winter and spring, indicating that any phenological gradients in autumn, but not in spring, might be driven by microclimatic dif-ferences. Budbreak timing did not differ within the crowns of any of the broadleaved trees. However, in the three species with deeper crowns, leaf unfolding was up to 10 days faster in the lower crown but showed no difference in the more shallow-crowned species. Surprisingly, only the evergreen conifers Abies alba and Picea abies showed earlier bud break in the lower crowns. In autumn, senescence in all broadleaved species progressed from the upper crown downwards, resulting in up to two weeks longer vegetation seasons in the lower crown.With this first broad assessment of within-tree phenology, we show how microclimatic gradients and different light-use strategies lead to a considerable variability of within-crown phenological gradients. We interpret the faster leaf unfolding in the lower crown of three broadleaved species as a shade avoidance strategy, allowing shade branches to improve their C balance early in the season. In contrast, longer retention of lower leaves in autumn is unlikely to significantly improve the C balance, and more likely caused by higher summer temperature and irradiance in the upper leaves.
Publisher Elsevier Masson
ISSN/ISBN 0168-1923 ; 1873-2240
edoc-URL https://edoc.unibas.ch/95234/
Full Text on edoc No;
Digital Object Identifier DOI 10.1016/j.agrformet.2023.109340
ISI-Number 000964518700001
Document type (ISI) Article