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Influences of the local landscape on drought effects in Swedish primary forests

Topographic controls of drought impact on Swedish primary forests

Climate change has increased the frequency of extreme drought events and leads to “hotter” droughts. The most recent drought of this type in Sweden was the 2018 summer drought. The form of the landscape or “topography” controls how water flows and how much radiation from the sun a location receives. Therefore, the climate that a plant experiences differs depending on its position in the landscape. However, topography is rarely included as a factor in research investigating vegetation dynamics. Primary forests offer the opportunity to study the influence of topography on the impact of droughts on vegetation in natural ecosystems. They are forests that have been spared from human intervention, often growing in topographically complex terrain, where management is not feasible.

This study investigated the role of the local environment and topography in controlling drought impact of the 2018 summer drought in primary forests in Sweden by building a model predicting droughts effects on vegetation with potential explanatory variables. Drought effects on vegetation were quantified using satellite data (Landsat EVI2). Explanatory variables that could potentially influence drought effects included terrain indices e.g. elevation, slope and compass direction of the slope (aspect) and forest properties (stand age, canopy height, species composition). The most influential variables were selected and their relationships with drought effects were analysed.

Forest located on steep slopes, high topographic positions, and south facing aspects were associated with negative drought effects, indicative of reduced photosynthetic activity. Additionally, drought effects,were more negative with increasing distance to wetlands. Valley bottoms and north-facing aspects mostly showed no or positive drought impact. These topographic and wetland effects on drought impact were seen across all forest types and latitudes, however the severity of negative drought impact differed between forest classes and was more pronounced in the south. Simple terrain indices e.g. slope, described the spatial variability of drought effects better than more complex terrain indices e.g. topographical wetness index (TWI). The results clearly show that the impact of the 2018 summer drought was strongly controlled by the local terrain in Swedish primary forests, highlighting the importance of incorporating topography in studies aimed at quantifying and predicting drought impact on vegetation. Previous research suggests that primary forests were less affected by the 2018 drought than managed forests were. This analysis suggests that the widespread drainage of wetlands and establishment of monocultures in managed forests may explain this difference. Forest management may therefore exacerbate the future impact of potentially more severe and more frequent droughts.

Keywords: Physical geography, ecosystem analysis, primary forest, boreal forest, drought impact, topography, drainage, climate change, random forest, terrain index

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