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Scale-dependent variation in forest structures in naturally dynamic boreal forest landscapes

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Natural forest structures vary at multiple spatial scales. This variation reflects the occurrence of driving factors, such as disturbances and variation in soil or topography. To explore and understand the linkages of forest structural characteristics and factors driving their variation, we need to recognize how the structural characteristics vary in relation to spatial scale. This can be achieved by identifying scale-dependent features in forest structure within unmanaged forest landscapes. By identifying these features and examining their relationship with potential driving factors, we can better understand the dynamics of forest structural development.

Here, we examine the spatial variation in forest structures at multiple spatial scales, utilizing data from old-growth boreal forests in two regions with contrasting disturbance regimes: northern Finland and north-eastern Québec, Canada (∼67° 45'N, 29° 36'E, 49° 39'N, 67° 55'W, respectively). The three landscapes (4 km2 each) in Finland are dominated by Pinus sylvestris and Picea abies, whereas the two landscapes in Québec are dominated by Abies balsamea and Picea mariana. Québec's forests are a subject to cyclic outbreaks of the eastern spruce budworm, causing extensive mortality especially in A. balsamea-dominated stands. In the Finnish landscapes, gap- to patch-scale disturbances due to tree senescence, fungi and wind, as well as infrequent surface fires in areas dominated by P. sylvestris, prevail. Owing to the differences in the species compositions and the disturbance regimes, we expect differing scales of variation between the landscapes. To quantify patterns of variation, we visually interpret stereopairs of recent aerial photographs. From the photographs, we collect information on forest canopy coverage, species composition and dead wood. For the interpretation, each 4 km^2 plot is divided into 0.1ha square cells (4096 per plot). Interpretations are validated against field observations and compiled to raster maps. We analyze the raster maps with Bayesian scale space approach (iBSiZer), which aims in capturing credible variations at different spatial scales. As a result, we can detect structural entities (e.g. patches with higher canopy cover), which deviate credibly from their surroundings. The detected entities can further be linked to specific drivers.

Our results show that the role of a particular driving factor varies in relation to spatial scale. For example, in the Finnish landscapes, topoedaphic factors exerted a stronger control on broad-scale forest structural characteristics, whereas recent disturbances (quantified as the amount of dead wood) appeared to play an important role in explaining the smaller scale variation of forest structures. Here, we showcase the methodology used in the detection of scale-dependent forest structural entities and present the results of our analysis of the spatial scales of variation in the natural boreal forest structures.