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| **Investigating growth response to drought in a Canadian boreal forest using permanent sample plots, Landsat time series and airborne laser scanning data.** |
| Amidst increasing uncertainty surrounding the productivity of forest ecosystems under climate change, timely and accurate information on forest condition is critically important. Capitalising on the known relationships between spectral indices and the physiological responses of trees, several studies have utilised satellite imagery data to investigate changes in canopy condition. Although the possibility to detect and characterize abrupt changes due to disturbances and mortality has been widely demonstrated using various satellite-based sensors, observing the latent effect of climate change on forest growth remains a challenge due to its gradual nature. The current changes in temperatures and precipitation regimes are generating pervasive but heterogeneous responses across forest ecosystems, with the effects on canopy spectral reflectance only becoming noticeable after several years of observation. In boreal forests, there is growing evidence that water deficits caused by warmer summer temperatures are leading to decreases in the growth rate of some species, influenced by multiple factors such as stand development stage, structural attributes, and site characteristics. While this phenomenon has been observed in a variety of studies involving the analysis of tree rings and permanent sample plots (PSPs) data, our understanding of its extent and magnitude at the scale of the Canadian boreal forest remains largely unknown. The objective of this study was to develop spatially explicit estimates of net forest growth rates over a forest management unit in Canada using Landsat time series data, and to examine the changes in predicted growth rates during a period of repeated drought episodes. We also examine how the observed changes are related to forest structure and site characteristics derived from airborne laser scanning (ALS) data.  Data from Landsat time series and PSPs was first used to develop estimates of annual net basal area growth over the study site from 1984 to 2021 at a 30m spatial resolution. Predictions were generated for ten-years moving windows with an ordinary least square regression model developed using data from 120 PSPs and validated on an independent set of 60 PSPs, with R2 values of 0.61 and 0.58, respectively. Applying the model over the 586,607 ha study area revealed considerable temporal and spatial variability in the predicted growth rates and their evolution through time. We then specifically examined the growth response to abnormally dry years recorded between 2001 and 2010 by comparing the predicted growth rates in the 10 years prior to drought periods, during the 10 years when droughts occurred, and in the 10 years following the last recorded drought event. Using these variables, we conducted a spatial segmentation of closed-canopy forests within the study site to delineate areas with homogeneous growth responses to the repeated drought events. We then examined how the growth response varied considering the structural attributes of forests in the delineated segments and site characteristics derived from ALS data. The results provide a better understanding of the effect of environmental stress on forest growth and offer a means to identify target areas where silvicultural interventions aimed at maintaining or enhancing growth could be conducted. |