Introduction

The boreal forests of Canada and Alaska are a vital component of the North American carbon balance, and one whose continued sink strength remains uncertain. Long-term satellite measurements indicate that peak summer productivity of some boreal forests, particularly in the North American interior, has been decreasing over the past three decades. Although still uncertain, evidence points to a strong climatic influence with some trees at the limit of their thermal and drought tolerances. This “browning” phenomenon may have a cascade of ecosystem impacts beyond immediate summer uptake, including long-term carbon balance, tree die-off, and shifts in species composition and forest distributions.

We also assessed relationships between NDVI and trends in tree mortality from the Global Inventory Modeling and Mapping Studies version 3g (GIMMS3g) data set, and the shorter-term but finer-resolution MODIS product. We therefore suggest that at least some of the continent’s browning trends are coarse-resolution GIMMS3g data set, and the shorter-term but finer-resolution MODIS product. We therefore suggest that at least some of the continent’s browning trends are associated with increasing tree die-off.

Hypothesis I: press stress

Press stressors include biotic and abiotic factors that gradually reduce the ability of trees to survive. We hypothesized that mortality events would be more likely to be preceded by press stressors, which would be evident as gradual declines in the NDVI record.

Hypothesis II: pulse stress

Pulse stressors are sudden events that increase the likelihood of mortality, such as drought or insect infestations. We hypothesized that mortality events are more likely to be preceded by pulse stressors, which would manifest themselves as large negative NDVI anomalies.

Hypothesis III: trends

The browning trends across much of boreal North America have been previously linked with productivity proxies such as tree ring widths [e.g., Beck et al., 2014]. We hypothesized that long-term NDVI trends would also be associated with trends in tree mortality.

Data sets

We utilized two satellite products for NDVI. Measurements at 8 km from 1982 - 2012 were taken from the Global Inventory Monitoring and Modeling Studies version 3g (GIMMS3g) data set, and measurements at 250 m from 2000 - 2014 were taken from the Moderate Resolution Imaging Spectroradiometer (MODIS) vegetation indices product (MOD13Q1). We define growing season (June - August) NDVI trends during 1982 - 2012 from the GIMMS3g data set over boreal North America. Agricultural and urban areas are masked out. The locations of the Alaska (CAFPI) and Canadian (PSPs) inventory plots. NDVI trends were calculated using a 9-point moving average (8 years). Relationships between NDVI and mortality are highest priority. Future directions include incorporating more inventory data, assessing the vulnerability and resilience of forests, which species are likely to thrive under a future climate, and what ecosystem services are highest priority. Future directions include incorporating more inventory data, assessing the relationships with climate, and using these results to benchmark Earth system models.

Conclusions

We found compelling evidence that trends and anomalies in the NDVI record are related to stand-level mortality in Alaska and Canada. This was evident with both the longer-term but coarse-resolution GIMMS3g data set, and the shorter-term but finer-resolution MODIS product for plots in Alaska. Given the diversity in stand type and location, this suggests a coherent relationship between tree mortality and productivity as measured by NDVI across boreal North America. We therefore suggest that at least some of the continent’s browning trends are associated with increasing tree die-off.

Combined with a host of other evidence, we likely are witnessing the beginning of a change to northern forests, some of which has potential to feedback to the climate system. It is important to work with management agencies to consider the vulnerability and resilience of forests, which species are likely to thrive under a future climate, and what ecosystem services are highest priority. Future directions include incorporating more inventory data, assessing the relationships with climate, and using these results to benchmark Earth system models.

References


