NCASI

Fact Sheet

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Climate Change and Historical Forest Growth Changes in the US and Canada

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Introduction

The forest products sector depends on predictable tree growth to ensure the supply of raw materials. Factors associated with climate change, such as rising levels of carbon dioxide (CO_2), a prolonged growing season, and changes in temperature, precipitation, and natural disturbance regimes (duration, intensity, and frequency), are already changing the growth rate of trees, which can alter wood properties, and harvest rotation ages. Furthermore, how these factors interact will vary by species and region, and will change over time. This fact sheet provides a brief overview of current knowledge about historical changes in forest growth and suggests how continuing changes may impact future fiber supply.

Role of CO_2

The earliest experimental demonstration of the critical role CO_2 plays in plant growth was by Wilhelm Pfeffer in his monumental plant physiology textbook of 1897 (Kutshera and Khanna 2021). Subsequent experimental work over the last century has confirmed that elevated CO_2 increases tree growth (e.g., Schlesinger et al. 2006). However, tree species vary in response, and many environmental conditions can affect the response (e.g., nutrient limitations, moisture availability). Precipitation and temperature have also been changing over the past century due to natural and anthropogenic causes. Thus, historical data and growth models are needed to help extrapolate experimental results to actual observed productivity changes in the field.

Regional Responses

Analyses by NCASI staff have revealed historical trends in forest growth using long-term forest data based on inventory plots, tree rings, and site index models. It was found that across the eastern US, tree growth, on average, has increased over the past 100 years by 30-50% (Loehle 2020a). This result was corroborated by Davis et al. (2022). In the western US, Loehle (2020b) found only local evidence for enhanced growth, with definite negative effects from drought and possible increases in wet coastal forests. In eastern Canada and British Columbia, forests were shown to have substantial growth enhancements of 20-40%, while central Canada experienced very little detectable change (Loehle and Solarik 2019). The greatest gains occurred in regions where rising CO_2 was accompanied by warming and rising precipitation, such as eastern North America and British Columbia. Regions where little change occurred in both the US and Canada tended to be dry, with current, ongoing drought obscuring trends. The overall picture based on NCASI studies for both the US and Canada closely matches that developed by Haverd et al. (2020), illustrated in Figure 1.

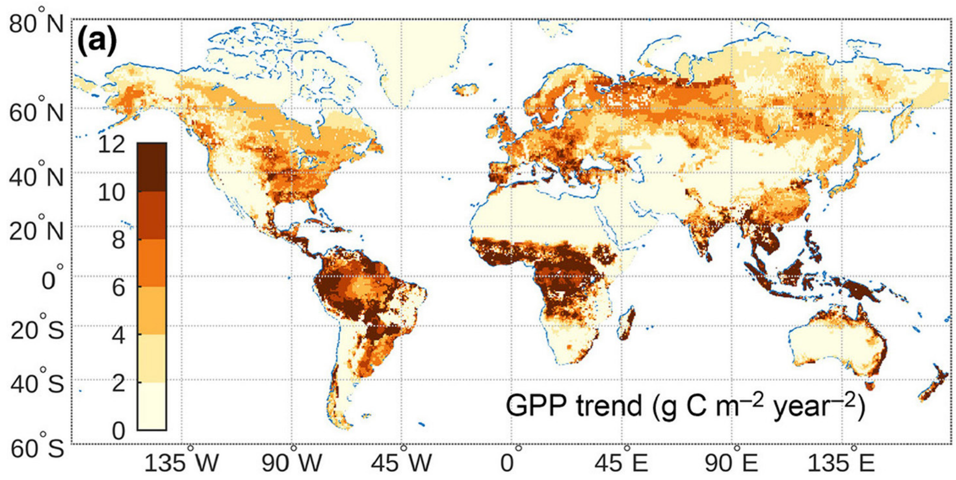

Figure 1: Calculated trend for gross primary production based on leaf model [Figure 3a in Haverd et al. (2020)]

Natural Disturbances

Natural disturbances, such as storms, fire, drought, and insects, also influence forest growth and may be altered due to climate change. Studies that integrate growth over large regions (e.g., Piao et al. 2020) or over the globe (e.g., Campbell et al. 2017) suggest that recent increases in growth (greening) outweigh the possible declines caused by these damaging agents. For any particular forest type or region, it is possible that disturbance agents could have a greater effect on local forest landowners and fiber supply. However, their overall influence is likely to be more regionalized, similar to current drought conditions in the western US and Canada.

Forest Management

Forest management relies on growth and yield models, stand yield tables, and site index curves to provide growth projections of a stand. These projections allow foresters to determine rotation age, financial returns, and appropriate management interventions. While these tools have been hugely successful in accurately projecting growth to date, many were developed decades ago (some over 50 years ago) and are based on past growing conditions, making them possibly obsolete in predicting stand growth over coming decades. Given the uncertainty of future growing conditions, as noted above, these tools may be significantly underestimating forest growth in some regions (Loehle 2018). The net effect is that forest planning based on existing tools and models may be incorrectly estimating current and future timber volumes. We recommend that older site index models and yield tables be updated and growth models consulted periodically for corrections to long-term projections of yield.

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