Climate Change

Human-caused carbon emissions have pushed global atmospheric CO_2 concentrations from a pre-industrial level of 280 ppm to over 400 ppm which in turn is forcing the earth's climate to change due to increased atmospheric trapping of radiant heat. Temperature and precipitation patterns are changing both temporally and physically (snow vs. rain) while intense storm and heat events are exposing forests to new extremes. These changes are directly affecting tree vitality and growth, causing global tree mortality events, as well as influencing fire behavior and burn frequency, and other abiotic and biotic disturbance phenomena.

A general warming trend over the past several decades has been identified as the most probable cause behind a widespread increase in tree mortality rates in unmanaged stands in the western United States. Increased wildfire activity in the same region of North America has been linked to earlier snow melts and longer fire seasons and both of these climatically driven phenomena are consistent with climate change predictions. The combined impacts of increased wildfire activity, drought, insects and pathogens are transforming forested landscapes throughout the circumboreal region and more temperate areas. The loss of sequestered carbon associated with global forest die-off events could further exacerbate climate change through atmospheric feedbacks. Warming alone, in the absence of increased drought and disturbances, may have one of the largest influences on the global carbon budgets of forests. In tropical forests, increased minimum temperatures have been found to be highly negatively correlated with Net Primary Productivity (NPP). As minimum temperatures increase NPP decreases and tropical forests globally become sources rather than sinks for carbon. These climate change impacts on forests could possibly be partially offset by increased water use efficiency and transpiration.

In the absence of biotic disturbance agents, the rate of environmental changes alone is projected to lead to maladapted families of native trees in their place of origin with losses of productivity of up to 80% over the next 70 years. Trees are clearly capable of adapting, particularly in mountainous areas, by migrating short distances among microsites, slope aspects, or elevations, but predicted rates of climate change will likely exceed the scale of local environmental heterogeneity in the longer term in many cases. Although tree species will adapt they will increasingly be challenged by pathogenic microbes and insects that will have a comparative evolutionary advantage over their long-lived hosts due to their shorter lifespans and rapid regeneration rates.

Given the challenges forests face, proactive forest management interventions are clearly needed. Those activities can be most effectively practiced on young managed stands where species selection and stand density manipulations may still be employed. Most forests will have to adapt to climate change autonomously, thus, on forest areas under active management, decisions should be both wise and bold. Silvicultural manipulations including thinning can temporarily reduce drought stress on trees and reduce fire threat but they also involve increasing risk given the greater reliance placed on the remaining trees for meeting volume expectations and other values. Increasing losses to forest insects and disease have led to prescriptions for higher planting densities in some areas. Given the uncertainty associated with which disease or insect disturbance agent might be next to benefit from the changing climate it would be wise to diversify the plantations currently being established. Since the managed forest area is relatively small compared to the rest of the forested land-base, the decisions made regarding new plantations must be bold enough to make a difference. Assisted migration of tree species is a significant initiative but the rate of climatic change and the inertia associated with current climate change mitigation efforts requires accelerated application of such concepts. Given the inherent risks associated with taking these chances, for example exposing hosts to new pathogens and moving species while the environment itself is in flux, it is clear that increased monitoring is required. Extensive monitoring systems that observe changes on multiple scales of forest health are essential. Forestry in general will need to follow an adaptive management approach where forest managers are trained to expect the unexpected.

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