Climate Change Effects on Tree Regeneration

SYNOPSIS | NEIL WILLIAMS

Tree regeneration is considerably more sensitive to environmental adversities than are mature trees. Below we briefly summarize a number of key climate change impacts and management responses. Please read the full bulletin for a more detailed treatment of these topics.

DIRECT EFFECTS

Seedling growth and survival are only the final stages in a regeneration process that begins with flowering and includes cone/fruit/seed development, germination, and seedling establishment. Each stage is affected by climate, and conditions that are optimal for one stage in the process are unlikely to be optimal for all stages. Climate change directly effects tree regeneration via changes in temperature and moisture availability, amongst other factors.

Changes in temperature

In the absence of moisture limitations, moderate warming is likely to increase regeneration potential. Reasons for this include increased rates of key physiological processes and longer growing seasons. In simulations of projected climate change, warming is particularly beneficial to the early stages of the regeneration process (from flowering to germination). By contrast, high temperatures are likely to hinder regeneration by damaging flowers, fruits, and sensitive seedling tissues, and increasing germination times. A more significant concern is the effect of climate warming on soil moisture.

Changes in soil moisture

Soil moisture is critical for all stages of the regeneration process, but changes in climate are likely to reduce soil moisture availability at season or annual timescales across much of North America. By increasing atmospheric demand for moisture, climate warming will increase evaporation from the soil surface. Reductions in growing season soil moisture may depress seedling growth and increase mortality rates. In semi-arid to arid areas, further increasing aridity will result in sites crossing thresholds above which successful tree regeneration can no longer occur.

MEDIATING FACTORS

Mediating factors, including tree species life history traits, natural disturbances, and biotic interactions (competition, mutualism, for example) can either amplify or dampen the impact of climate change on tree regeneration.

Life history traits that may influence the realized effects of climate change on regeneration include shade tolerance and drought tolerance, as well as attributes relating to seed physiology and phenology.

Interactions between climate change and wildfire are a concern for regeneration in many western dry forests. High-severity fires may accelerate changes in forest structure composition that would otherwise have occurred over much longer timeframes in response to climate change. High-severity fire may combine with drought and high temperatures to create a potent stress complex that depletes seed sources and exposes seedlings to extremely challenging regeneration conditions. Together, these stressors increase the likelihood of forests transitioning to non-forest on some sites.

MANAGEMENT IMPLICATIONS

- Modify silvicultural systems and harvest planning to ameliorate site conditions for regeneration.
- Adjust harvest configuration and retain dead wood to influence microsite conditions.
- Re-evaluate trade-offs between practicality and species diversity to maximize regeneration outcomes.
- Recognize the increased risk of regeneration failure.
- ABOVE ALL: draw on the forester's knowledge of the site, and of species biology and silvics, as the foundation for understanding potential climate change effects and managing risks.