Issue of Concern: Extreme Precipitation & Weather Events

Extreme precipitation and more frequent and intense weather events are expected in the Northeast throughout the next century. An increase in these phenomena has the potential to impact the species composition and structure of forests, as well as their soils and hydrology. Where forests are used for recreation, damage from extreme precipitation and weather events can create hazards and increase the need for costly safety interventions. A variety of forest adaptation practices may be able to prevent or ameliorate the negative impacts of increasingly extreme precipitation and storm damage on forest ecosystems.

Climate Change Impacts

Climate change is resulting in a number of changes to precipitation and weather patterns. Between 1901 and 2014, total annual precipitation increased by 7% in the northeastern U.S. (Huang et al. 2017). Because of rising temperatures, a greater proportion of precipitation is arriving as rain rather than snow; heavy rainfall events, which have become substantially more frequent and severe across the region over the last century, are expected to continue increasing (Huang et al. 2017, Easterling & Kunkel et al. 2017, Spierre and Wake 2010). The Northeast in particular has seen a greater increase in heavy precipitation events than any other part of the country, with the amount of precipitation coming in extreme events increasing by 41% between 1901 and 2014 (Huang et al. 2017). The fall season has exhibited the largest increase in precipitation, followed by spring (Easterling et al. 2017).

Extreme precipitation and intense storm events can negatively impact forest ecosystems in a variety of ways, and the effects will depend on site-specific characteristics, such as the current health of the forest, its topography, and location within the landscape. Heavy rain events can lead to intense erosion—resulting in soil loss and sedimentation in nearby streams—as well as flooding, which can damage trees by breaking stems and limbs (Groffman et al. 2014, Furniss et al. 2010). The increased occurrence of these heavy rain events in fall and spring, when there is little to no vegetation to intercept excess precipitation, can lead to greater erosion in forests and riparian areas.

A variety of storm types occur in the region, including thunderstorms, ice storms, tropical cyclones and hurricanes, and nor'easters (Kunkel et al. 2013). Potential impacts from storms include tree damage and mortality, altered forest structure, and altered tree species composition and diversity (Xi and Peet 2011, Holzmueller et al. 2012). Winter ice storms can be particularly damaging, and are expected to become more severe (Klima & Morgan 2015, Campbell et al. 2020). The accumulation of ice on trees can lead to extensive damage to tree limbs, especially in oaks and other species with wide crowns and secondary trunks (Turcotte et al. 2012). High wind events in oak dominated forests within the midwest and central Appalachians have accelerated successional transition, where high levels of damage and mortality in the overstory oak allow for the abundance of shade-tolerant species in the understory, such as red maple and American beech, to dominate (Holzmueller et al. 2012). Fire exclusion from oak dominated forests due to suppression efforts has also contributed to this successional transition.

Forests stressed by other disturbances are likely to be more vulnerable to impacts from extreme precipitation and weather events. For instance, where vegetative cover is reduced by disturbance events such as pest infestations or wildfire, the forest is more susceptible to erosion during extreme precipitation. Likewise, forests impacted by extreme precipitation and weather are likely to be more vulnerable to other disturbances; physical damage to trees can leave them more susceptible to negative impacts from forest pests and diseases (Janowiak et al. 2018).

These conditions also make it more challenging to conduct forestry operations while minimizing impacts on soil and water resources. Decreased climate stability could lead to less predictable seasonal planning of harvesting activities, which could in turn increase logistical costs and enforcement considerations (Giesler et al. 2016, Janowiak et al. 2018). These events can compromise stream crossings, which hinders operations and can negatively impact water quality and aquatic organisms (Gillespie et al. 2014, Boston 2016).

Adaptation Actions in Forests

Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Site Condition	Adaptation Approaches	Example Adaptation Actions
Steep slopes and/or unvegetated areas are susceptible to erosion	• Reduce soil erosion and sediment deposition • Respond to or prepare for excessive overland flows (surface runoff)	• Strategically place downed wood to deflect, slow and pool overland flow water as snow melts over saturated soils and frozen soils • Use wattles and water bars to slow overland flow water velocity and increase retention and recharge into soils • Create anchors with fabric, wire, or natural materials to stabilize eroding stream banks
Trees are exposed to wind and storms due to topography, landscape position, and/or previous harvesting practices	• Alter forest structure to reduce severity or extent of wind and ice damage • Promptly revegetate sites after disturbance	• Thin in order to alter forest composition and structure for increased resistance to blowdown or ice damage • Create canopy gaps that have an orientation and shape informed by the prevailing winds to reduce the risk of windthrow
Harvest operations may exacerbate soil and hydrology impacts	• Maintain and enhance infiltration and water storage capacity of forest soils	• Decommission or temporarily close roads to reduce erosion and

	• Maintain or restore hydrology • Reduce impacts to soils and nutrient cycling	sedimentation and to restore permeability and soil hydrology • Incorporate ecologically based stream crossing designs that allow passage for aquatic organisms

Adaptation Actions in Streams and Adjacent Riparian Areas

Additional actions are described in the Adaptation Strategies and Approaches for Forested Watersheds.

Site Condition	Adaptation Approach	Example Adaptation Action
Stream edges are unstable or susceptible to erosion and failure during extreme events	• Maintain and restore hydrologic connectivity • Maintain and restore stream channel form and function • Maintain and restore floodplain connectivity • Reduce soil erosion and sediment deposition	• Install large wood additions into streams to improve habitat structure, increase stream complexity, and maintain or improve thermal refugia • Stabilize banks along the main stem of a waterway to prevent further erosion, sedimentation, and bank failure • Use wood additions and other modifications to reconnect the river to its natural forest floodplain

On-the-Ground Examples

- Massachusetts Dept. of Conservation & Recreation: Protecting Riparian Zones with a Focus on Stream Crossings
    - Many of the culverts for streams that enter the Deerfield River within the South River State Forest have already failed or are threatened by increasingly heavy precipitation events. Managers are removing failing culverts and replacing them with bridges, while ensuring stream connectivity and a naturalized stream bottom.
- Franklin Land Trust: Crowningshield Conservation Area Habitat Restoration Project
    - Managers with the Franklin Land Trust are improving conditions on a farm that includes a tributary of the Deerfield River. They are stabilizing banks along the main stem of the river to prevent further erosion, sedimentation, and bank failure, as well as adding large wood to the river to help reconnect it to its natural forest floodplain.

Potential Monitoring Items

- Frequency of intense precipitation and storm events
- Tree damage and mortality after extreme weather
- Streambank erosion and changes in water quality

Additional Resources

- CoCoRahs is a grassroots volunteer network of backyard weather observers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow) in their local communities.
- The Northeast River Forecast Center produces Quantitative Precipitation Forecasts that can be useful to track during significant rainfall events or times of increased flood potential.
- Emergency Erosion Control on Private Forest Land trials are being conducted by the University of New Hampshire.
- The USDA Northeast Climate Hub hosts information and cost analysis related to storms and stream-crossings.