HEAVY RAIN AND UPLAND FOREST

By Alexandra Kosiba. Illustrations by Erick Ingraham.

This article is the last in a four-part series that focuses on climate change impacts and adaptation in forests, supported by the Virginia Wellington Cabot Foundation. A companion series published last year focused on forest carbon. Alexandra Kosiba, a forest ecologist and tree physiologist, is an assistant professor of forestry at University of Vermont Extension. She specializes in climate change impacts to trees and forests and ways that foresters and landowners can incorporate climate change considerations in their decision-making and planning.

Natural depressions in the forest floor, including those left by upturned tree roots, collect water from heavy rain events.

One of the most significant climatic changes that we've experienced in the Northeast is an increase in the frequency and intensity of rainstorms. With these downpours comes a heightened risk of destructive floods, especially in hilly and mountainous areas, where runoff moves swiftly downslope, washing out roads, inundating farm fields, and damaging buildings.

In response to recent storms, many northeastern communities are taking steps to reduce impacts. These efforts include enlarging road culverts, elevating houses, and installing rain gardens that collect and filter water from parking lots.

Water bars divert runoff from road and trail surfaces into areas where water can spread and sink into the soil.

Defining Heavy Rain Events

In order to understand and describe how precipitation patterns are changing, it's important to have a reliable way to compare weather events over time. Unfortunately, common terms that meteorologists and others use to describe heavy rainstorms – for example, "excessive," "extreme," and "heavy" rain events – do not have universal definitions. The Environmental Protection Agency simply defines heavy rain as rainfall that significantly exceeds what is typical for a given location.[1] One way you can gauge a heavy rain event in your location is if more rain falls in a day than is typical in a month. Across much of our region, this is about 3 inches of rain falling within a day. However, lesser amounts of rain may cause damage similar to that of heavy rain events, if they fall in a short amount of time.

Another common way to describe intense rainstorms and other significant weather events is by referring to their return interval, that is, the average number of years between events of comparable size based on historical data. For example, a "100-year rainstorm" means a storm of such intensity that it has only a 1 percent chance of occurring in any given year. However, this description is problematic because, in a period of rapid climate change, historical data about weather patterns is of limited use for making future predictions.

There are several ways to examine how heavy rainfall is changing over time. Heavy rain events may occur more frequently, with greater intensity (individual events drop more rain), or at a different time of the year. For example, a location might experience more heavy rainfall in winter now compared to the past.

Yet other important contributions to reduce flood damage occur upstream. Upland forests play a crucial role in absorbing water and reducing the impacts of heavy rain. Stewards of these forests can enhance this ecosystem benefit and boost their land's resilience to climate change by taking actions that help slow down, spread out, and sink water.

A Forecast for More Heavy Rain Events

A study published in 2017 in the journal *Theoretical and Applied Climatology* looked at changes in the magnitude, frequency, and seasonality of heavy rain events across the United States. The authors found that nearly all of the Northeast has experienced an increase in the frequency of heavy rain events.[2] Some areas in the region have also experienced an increase in the magnitude of heavy rainfall events, meaning that heavy rainfall events in recent years have deposited more inches of rain in each event compared to past years. These changes have been observed primarily in spring, summer, and fall.

Scientists expect this trend to continue as the planet warms.

1 *www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation#tab-2*
2 *Mallakpour and Villarini. 2017. Analysis of changes in the magnitude, frequency, and seasonality of heavy precipitation over the contiguous USA.* Theoretical and Applied Climatology, *130, pp. 345–63.*

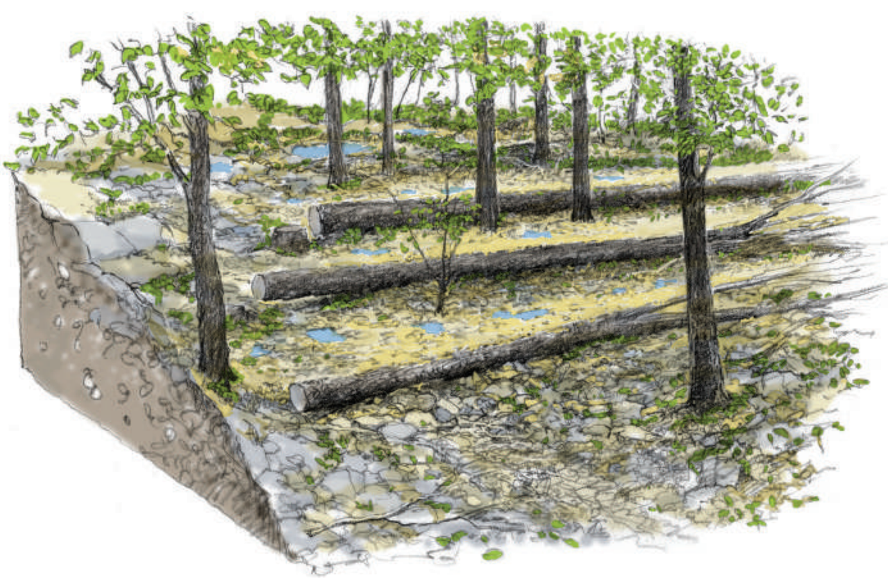
With each degree Fahrenheit of warming, the atmosphere's capacity to hold water vapor increases by about 4 percent.[3] This higher moisture content increases the odds that more intense precipitation events will occur. A report by Dartmouth College researchers, published last year in the scientific journal *Climatic Change*, projects that by the end of the 21st century, total rainfall in the Northeast will increase by 10 percent and that the number of heavy rainfall events will double. The report predicts that the most affected regions will be central New York, the Lake Champlain Basin, and northeastern Maine.[4]

The Impact of Heavy Rain Events in Forests

How heavy rain events affect forests depends primarily on location, topography, and soils. Lowland forests that occur in flat areas often experience flooding and waterlogged soils following a heavy rainstorm. Upland forests, with sloped terrain and soils that drain easily, are less likely to experience flooding but are vulnerable to soil erosion and loss of soil nutrients. In these upland forests, when rain falls faster than it can be absorbed by the soil, the excess rainfall becomes runoff, which flows over the forest floor. This runoff accelerates as it moves downslope, finding the path of least resistance.

Past land use may have degraded a forest's capacity to absorb and store water. For example, past agricultural use may have left a legacy of flattened forest floors that lack deadwood. An uneven forest floor with depressions, undulations, and dead plant material has more capacity to slow down and soak up runoff. Forest roads and trails also can be problematic if they channelize water. Many forest streams in our region lack an abundance of logs and other dead plant material that would naturally accumulate over centuries. The lack of these materials in streams can be due to the relatively young age of many of the region's forests as well as the cultural practice of intentionally "cleaning" streams of dead logs and branches. We now recognize that deadwood in streams provides critical ecological functions, including reducing downstream flood impacts. Without this material, streams can act as high-speed channels that incise streambeds over time.

Across the forest floor and in streams, water speed matters, both because it reduces the opportunity for runoff to seep back into the soil and because faster moving water causes more damage. Every time water doubles in speed, it can exert four times as much force. As water moves downslope, it can become strong enough to wash away leaf litter and soil, expose tree roots, dislodge rocks, and topple trees. Even relatively small flows, moving sufficiently fast, can carry large objects, including logs and boulders, and cause significant damage to both forests and downstream infrastructure.


Contour-felled trees slow surface water runoff and trap leaves, twigs, and soil.

Strategies You Can Use to Slow, Spread, and Sink Water

Walking through the woods during or immediately after a rainstorm can help you identify areas where water travels, moves debris, or causes erosion. You can then address these problem areas by making changes to slow, spread, and sink water. These actions can help move water into depressions where it can be absorbed, increasing the infiltration of runoff into the soil.

One strategy you can use to help address runoff is to place logs and other downed wood on the forest floor in such a way that they deflect, slow, and pool runoff. You can also implement a technique called contour felling, which involves cutting down and leaving trees perpendicular to the slope.

3 *www.ncei.noaa.gov/news/warming-earth-also-wetter-earth*
4 *Picard et al. 2023. Twenty-first century increases in total and extreme precipitation across the Northeastern USA.* Climatic Change*, 176(6), p. 72.*

Strategic wood additions in streams slow, spread, and filter floodwater.

Other effective tactics to reduce soil erosion and to trap sediment and debris are to maintain trees and other plants in a wide buffer area along streams, wetlands, and other waterbodies and to restore natural stream conditions through strategic wood addition. This practice involves adding large, downed trees to streams to counteract the effects of past erosion and human alterations to stream channels. These logs create debris dams that slow water flow, re-engage the floodplain, reduce soil erosion, improve water quality, and create habitat for fish and other wildlife. With these structures in place, stormwater can flow more slowly over the streambanks, dissipate energy, and sink into the soil. It is important to consult with an expert if you are interested in strategic wood addition, as there are some important considerations based on the stream's width and slope, and this practice requires adherence to local regulations.

To prepare forest roads and trails for heavy rain events, install culverts and bridges large enough to accommodate extreme flows – and regularly inspect them to ensure they remain free of mud and debris. If sections of roads or trails are used infrequently, consider converting these structures to low water crossings, such as fords, which are designed to be overtopped during high water flows and require less cost and maintenance compared to culverts. On sloped sections of roads and trails, use water bars or broad-based dips[5] to divert water from the traveled surface. The required spacing of these water diversion structures, and which type is best, will depend on the road's slope and layout. Refer to your state forestry office for best management practices or consult with a forester.

Also consider closing out old roads and trails in the forest that you no longer use. You can add dead logs and branches in the old road or trail to reduce channelization and runoff, or if you are able to access the area with equipment, consider installing water bars or removing the compacted road surface entirely. Keep in mind that even if a road or trail hasn't yet experienced runoff or erosion issues, the increasing frequency and intensity of heavy rain events means that this could change. Being proactive can help avoid costly fixes in the future.

Resources

As with so many forest management decisions, expert guidance can help you determine what is achievable for your land and how to move forward efficiently with implementation.[6] If you're interested in exploring these flood reduction strategies, consider reaching out to a local service or county forester, or visit your nearest Natural Resources Conservation Service (NRCS) office. As noted above, expert guidance is especially important for stream restoration projects. For example, strategic wood addition requires careful planning during installation to maintain streamside integrity and prevent logs from dislodging during high flows, and may require permits. The NRCS offers technical assistance and cost-sharing opportunities for this work, along with other strategies mentioned in this article.

While we can't prevent heavier rainstorms, we can adapt. By understanding how water moves through our forests and employing methods to slow, spread, and sink it, we can enhance forests' resilience to heavy rain events and reduce the risk of damage on-site and downstream. Together, we can take meaningful steps to protect our landscapes and communities from the impacts of intense weather.

Special thanks to our reviewers of this article: Samantha Myers, Fellow – USDA Northern Forests Climate Hub and Forest Adaptation Specialist – Northern Institute of Applied Climate Science and the University of Vermont; and Erin Rodgers, Vermont/ Massachusetts Program Manager, Trout Unlimited, Northeast Coldwater Habitat Restoration Program.

5 Broad-based dips are like water bars in that they direct water off the road and into a discharge area but are designed to allow vehicles to pass over them more easily.
6 For more information on strategies, see Shannon et al. 2019. Adaptation strategies and approaches for forested watersheds. Climate Services*, 13, pp. 51–64.*