Managing ecosystem damage from extreme events

Virginia H Dale[1], Steven P Norman[2], and Rebecca A Efroymson[3]

[1]Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN; [2]USDA Forest Service, Southern Research Station, Asheville, NC; [3]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN

Large disturbances to ecosystems can severely impact the stability of a region's natural resources, habitats, and outdoor recreation. Because extreme events can be large and relatively infrequent, they test institutional capacity to support recovery and restoration. When hurricanes and other large-scale disturbances like wildfires occur, much of the impacted landscape receives little to no active management. Ecosystems are often allowed to either recover or transition without much direct intervention, and successional dynamics are sometimes altered by novel invasive species, management history, or other environmental changes.

Recovery and restoration are especially challenging for landscapes with highly fragmented private ownership, such as the forests of the eastern US. Acting alone, non-industrial private forest landowners have little capacity to effectively respond to unexpected forest loss and to oversee forest recovery, as the scale of actions needed after extreme events may require cooperation across ownerships or jurisdictions.

In September 2024, Hurricane Helene exposed these underlying vulnerabilities of southern Appalachian forests. In western North Carolina alone, about 196,000 hectares of forest received major damage from Hurricane Helene, with most impacts occurring on private lands and in unusually large blowdown patches with no known regional precedent. Not since the widespread forest loss of the late 19th and early 20th centuries due to extensive logging and the American chestnut blight have so few trees covered the region's slopes.

This enormous damage to southern Appalachian forests raises concerns about loss of wildlife habitat, increased wildfire risks due to the abundance of fuel, reduced water quality from erosion and sedimentation, and spread of invasive species. Damaged forests are likely to reestablish as novel ecosystems composed of new species assemblages with a suite of interactions and processes that differ from prior conditions. On public and private lands, the duration of forest recovery will take decades or more and will be highly dependent on management choices and market incentives.

Since Hurricane Helene, disaster relief crews continue to work hard to remove fallen trees and debris near structures, roads, trails, and recreation areas as time and funds are available. However, removing downed and damaged wood is more costly and dangerous than typical forest harvesting. Piles of downed, unused wood may be burned, but combustion releases smoke and carbon into the atmosphere. Historically, debris burning and arson are the region's primary sources of wildfire ignitions, and it is hard to control burns when so many of the surrounding forests have high flammability.

A major dilemma is what to do with all this downed wood and debris from Hurricane Helene and how to pay for its removal. There is ongoing timber demand for large intact boles, at least where they can be accessed, but demand is much lower than supply. Also, demand for damaged wood and small-diameter trees in the southeastern US has sharply declined with recent closures of papermills. In limited locations, damaged trees can be sold to biomass heat and power facilities, artists, or furniture makers. Wood with low commercial value from regions near coastal ports can be absorbed by overseas wood pellet markets—but only for a limited time before the wood quality degrades. Even in the absence of damage from large disturbances, the abundance of such "unloved wood" is a big challenge.

With reduced demand for small-diameter trees and reduced access to large-diameter trees, damaged forest lands may be at high risk of development and/or fragmentation into smaller ownership parcels. Without positive net income, some forest owners cannot afford to keep their land. Cost-share payment programs such as the Emergency Forest Restoration Program of the US Department of Agriculture's Farm Service Agency only offer payments, and not the means, to remove damaged trees. Other emergency management funding is unlikely to match the extent of the problem.

Management practices must be scaled up, for threats like hurricanes, fire, disease, insects, and invasives are already doing so. Inferences about effects of scaled-up disturbance, recovery, and response cannot simply be drawn from past experiences, and future actions will require greater cooperation between landowners and government agencies.

As ecologists, we need to investigate how to manage for restoration and make use of damaged material after a large-scale disturbance. For example, the use of low-quality downed wood for bioenergy not only exploits an underutilized source of energy but also can incentivize better forest management and create jobs in rural areas where much of the employment related to forestry disappeared with the loss of papermills.

Scientists can develop appropriate management responses and adaptation strategies for extreme events in light of the changing scale of disturbances. By working with resource managers, economists, social scientists, and engineers, ecologists can help determine the costs and benefits of environmentally appropriate and socially acceptable ways to restore damaged ecosystems.

This research was supported by the US Department of Agriculture, Forest Service, and the US Department of Energy.