How Much Forest Carbon is Lost after a Major Hurricane?

by Stephanie Worley Firley

Near the end of the 20th century, many scientists began to realize the importance of forests as a sink for storing, or sequestering, the carbon dioxide that continues to increase in the Earth's atmosphere, estimating that U.S. forests sequester approximately 200 million metric tons of carbon each year. These calculations were based on models of forest growth and productivity, but disturbance effects from hurricanes such as Katrina were not taken into account. **Steve McNulty**, **SRS Southern Global Change Program** team leader, saw this omission—and seized a research opportunity.

The Damage Done

Intense hurricanes occur often enough in the Eastern United States—2 out of 3 years on average—to have significant effects on forest carbon sequestration. A single storm can do a lot of damage to a forest, but size alone doesn't determine how much live tree mass ends up as debris. High winds and heavy rainfall followed by flooding are the key factors responsible for the most severe storm damage.

These intense hurricanes cause direct and immediate forest carbon loss. First, because downed wood resulting from a hurricane is often difficult or impossible to access—and the wood's quality may be compromised—relatively little is salvaged following a catastrophic storm. The carbon tied up in those trees is released into the atmosphere as the trees decompose rather than being stored in wood products originating from the salvaged wood. Additionally, the trees left standing may take 5 to 10 years to recover the prehurricane growth rates and leaf area required for healthy levels of photosynthesis and full carbon sequestration capacity. Forest carbon can also be lost over time following a major hurricane as damaged trees become more susceptible to insect attacks. Dead, dry wood can also fuel wildfires that release even more carbon into the atmosphere.

A New Carbon Source

In 2000, McNulty set out to estimate the potential changes in forest carbon sequestration due to these direct and indirect losses of forest carbon. "I began by looking at forest damage estimates from hurricanes making landfall in the United States since the 1920s," says McNulty, who notes that very little forest damage information is available prior to that decade.

Many Federal and State agencies now track hurricane-caused forest damage using a variety of methods including field surveys, aerial photography, and remote sensing imaging. Damage estimates are typically expressed in economic terms based on board or cubic feet of timber and cords of wood lost. To determine the impacts on carbon sequestration following a storm event, McNulty used timber data to estimate carbon lost from tree leaves, roots, and stems. Carbon losses vary by species, age, and region.

"Hurricanes are indeed a major source of regional carbon loss as well as a significant factor in the reduction of short-term carbon storage in U.S. forests," says McNulty. He concluded in a 2002 study that a single storm can convert the equivalent of 10 percent of the total annual carbon sequestered by forests across the United States into dead and downed biomass.

"Hurricane Katrina may have caused a loss of 40 million metric tons of forest carbon. That's 20 percent of annual forest carbon sequestration capacity lost," according to McNulty, whose most recent assessment used data derived from post-Katrina ground crew measurements of forest damage as well as aerial photography available from the Alabama and Mississippi Forestry Commissions. "Forest lost to Hurricane Katrina will be a carbon source to the atmosphere for years to come," he says.

Add Climate Change to the Mix

McNulty believes that carbon sequestration in U.S. forests has been overestimated in the past. He has found that carbon sequestration has generally been decreasing in recent decades as a result of storms and a range of other factors: wildfires, forest loss due to land use change, increasing fuel loads, and climate change effects. "Most carbon sequestration models assume a constant forest mortality rate of approximately 0.5 percent each year. This rate is definitely not constant because it is dependent on many disturbance factors," says McNulty, who has developed new forest carbon sequestration equations incorporating longer term, episodic forest disturbance rates.

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Several climate scenarios predict that the Southern United States will be warmer and dryer in the future. "Even if the South receives more rain in the future than predicted, higher air temperatures will probably lead to more drying in forests, and, therefore, greater wildfire risks, more insect generations, and ultimately even less carbon sequestration capacity," says McNulty. Higher air temperatures are already warming the oceans. Since hurricanes are born out of warm ocean water, some predict that hurricanes will be even more intense in coming years.

Filling the Carbon Sink

McNulty's research on disturbance effects and forest carbon sequestration in the United States will help land managers develop strategies for keeping carbon in forests given a future of changing conditions. McNulty plans to continue examining forest carbon loss scenarios by building his carbon sequestration equations into process models such as those used to examine forest water use and growth.

"Managing our forests so that they are able to capture and store more carbon—and increase the net amount of carbon sequestered—is going to be part of the solution to global climate change. If we understand how carbon sequestration is impacted by major hurricanes and other disturbances, we can anticipate and respond to these impacts. In other words, we can manage our forests so that they can be resilient in the face of disturbance," says McNulty.

For more information:

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Recommended reading:

McNulty, S.G. 2002. **Hurricane impacts on U.S. forest carbon sequestration.** Environmental Pollution. 116 (Suppl. 1): S17–S24.

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Aerial view of downed trees after Hurricane Katrina. (Photo courtesy of NOAA)