Water yields from southern Appalachian watersheds in decline since the 1970s

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In the densely populated southeastern U.S., forested watersheds are particularly important to drinking water supplies. Recent estimates show that forests in the Southeast deliver surface drinking water to an estimated 48.7 million people, with streams from the mountainous Southern Appalachian region alone providing water supplies to 10 million people, many of them living in major cities such as Atlanta, Georgia.

Newly published research from the U.S. Forest Service shows water yields from unmanaged forested watersheds in the southern Appalachian Mountains declining by up to 22 percent a year since the 1970s. Changes in water yield were largely related to changes in climate, but disturbance-related shifts in forest species composition and structure over time also played a role. The study findings have implications for managing the forest composition of watersheds to ensure water supply under future climate change.

"Climate and land use change have long been linked to changes in water yield," said Peter Caldwell, research hydrologist for the Forest Service Southern Research Station (SRS) and primary author of the article recently published in the journal *Global Change Biology*. "This study is one of the first to show that gradual and subtle changes in forest structure and species composition, driven by climate change—as well as invasive insects and pathogens that act on a fraction of tree species within a forest—can also affect water yield."

The scientists analyzed 76 years of data (1938 through 2013) collected from six unmanaged, reference watersheds at the SRS Coweeta Hydrologic Laboratory located in the southern Appalachian Mountains in North Carolina, to determine whether annual water yield from those watersheds has changed over time, and if so, to determine causes for significant changes. They tied measurements of climate and streamflow to data collected in long-term vegetation plots and measurements of water use by individual tree species.

"We found that, from 1938 to the mid-1970s, annual water yield increased by as much as 55 percent, but that was followed by decreases of up to 22 percent by 2013," said Caldwell. "The vegetation survey showed increases in forest basal area (area expressed as the cross-sectional area of all the trees in a stand) since the mid-1970s and a shift from oak and hickory species to poplar and maple, which can use up to four times as much water as oaks and hickories of the same size. Changes in forest structure and species composition alone decreased water yield by as much as 18 percent in a given year since the 1970s after accounting for climate."

The forests in the Coweeta Basin reflect the disturbance history of the region, which in addition to climate change has experienced early 20th century logging, drought, hurricanes, and insect and disease outbreaks, these last including the extirpation of the American chestnut, once the most important species in southern Appalachian forests. In addition, the arrival of hemlock woolly adelgid in the early 2000s has meant, at Coweeta, the almost total loss of a foundational riparian species, and an increase in the dominance of maple and poplar in the overstory and rhododendron in the understory.

"Prior to this work, large, abrupt changes to forest structure and species composition were needed to induce a change in water yield we could detect," said Caldwell. "With the rise of ecohydrology as a discipline, we

can now work across scales - from the individual tree to the mountain stream - to see the actual effects of species change in relation to climate."

Access the full text of the article at www.srs.fs.usda.gov/pubs/51055 .

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