

Ecological Drought in the Southeast United States

Balancing competing demands for water supplies

Southeast Climate Science Center Workshop
November 16-17, 2016
Raleigh, NC

The Department of the Interior Climate Science Centers (CSCs) and their managing organization, the National Climate Change and Wildlife Science Center at the U.S. Geological Survey, have chosen the emerging climate science field of Ecological Drought as a research focus area. This workshop is part of a series of meetings at each of the nation's eight CSCs aimed at collating our existing knowledge of the ecological impacts, resistance, and recovery from drought. The eight CSCs provide a fantastic opportunity to compare the ecological effects of drought, related research activities, and management options at different regions, spatial scales, and biomes.

Water is needed at the right time, in the right place, and in the right amount

The Southeast and Caribbean regions of the United States are generally considered water-rich areas; however, due to large-scale patterns of atmospheric processes, drought is a natural part of the hydrological cycle. Ecological drought can be defined as a prolonged and widespread deficit in naturally available water supplies that create multiple stresses across ecosystems. Southeastern ecosystems are dependent on abundant and predictable water supplies, and as climate change influences temperature, precipitation, and circulation patterns within the region, drought conditions may become more prevalent. Ecological drought drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedbacks in natural and human systems.

Cultural values and biodiversity depend on abundant water supplies

The Southeast United States is diverse, stretching from the Appalachian Mountains to the coastal systems of the Atlantic Ocean, Caribbean, and Gulf of Mexico. The region experiences abundant precipitation in each season under normal conditions. The water that flows over and underground supports lush, diverse natural communities, recreation, and economic drivers for this region. But there is enormous demand for water by ecosystems (plants, fish, and wildlife) and humans (drinking water, recreation, industry). While projected changes in temperature and precipitation vary regionally, adaptation strategies are necessary to address the needs of both human and natural systems.

Rapid growth drives land use change, leading to impacts on hydrology

Rapid population growth is changing land use from rural and natural areas to developed land. The continued urbanization of rural areas will increase water demands, degrade water quality, exacerbate saltwater intrusion, and threaten environmentally sensitive areas. Increases in water demand by the energy, agricultural, and urban sectors will increase competition for water, particularly in situations where ecological needs conflict with human uses.

Extremes in water supplies result in a mismatch in water availability for natural and human uses

Water supply and demand in the Southeast is influenced by many changing factors, including climate, population, and land use. A supply-demand mismatch may occur when most water recharge (precipitation) occurs during the dormant season and most of the water demand (ecological and human) occurs during the growing season. Extended and recurring droughts disrupt ecological processes with cascading impacts to natural communities, recreation, and the economy of this region. Competing demands for water are amplified during drought.



Joanna Gilkeson, USFWS



Photo by Martin Bravenboer / CC BY



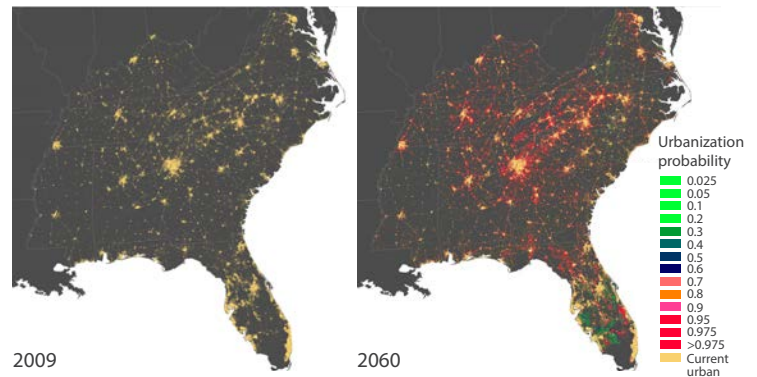
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Water, water everywhere, but not as much as you think

Balancing the needs of human and natural systems

Water resources within the Southeast U.S. have been abundant and sufficient to support heavily populated urban areas, rural communities, unique ecosystems, and economies based on agriculture, energy, and tourism. As the population and economy of the Southeast continue to grow, it is imperative to understand how climate change and drought will further influence water availability.

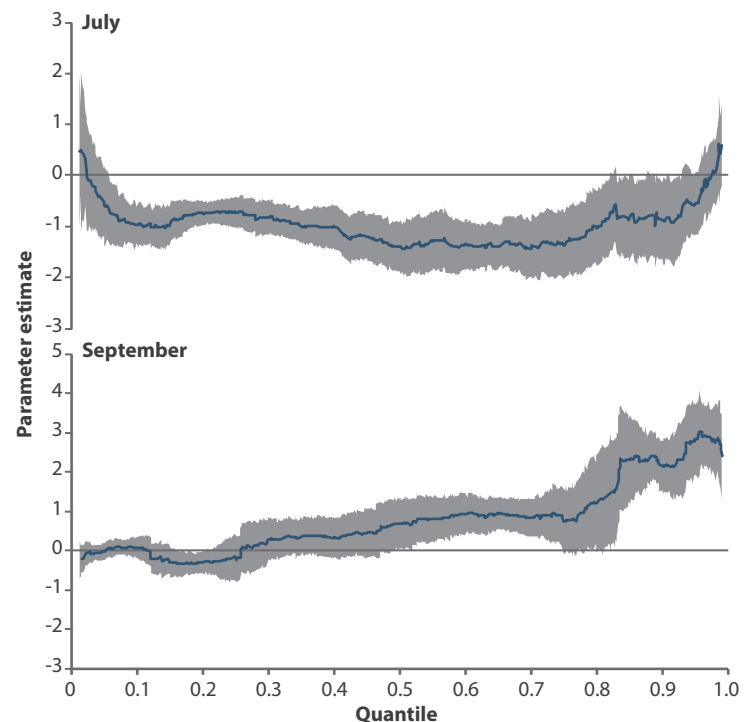
Right: Urban land cover in 2009 in the Southeast United States and projected urban land cover in 2060. Scale indicates probability of urbanization. Source: Terando et al. 2014.



Precipitation patterns are changing

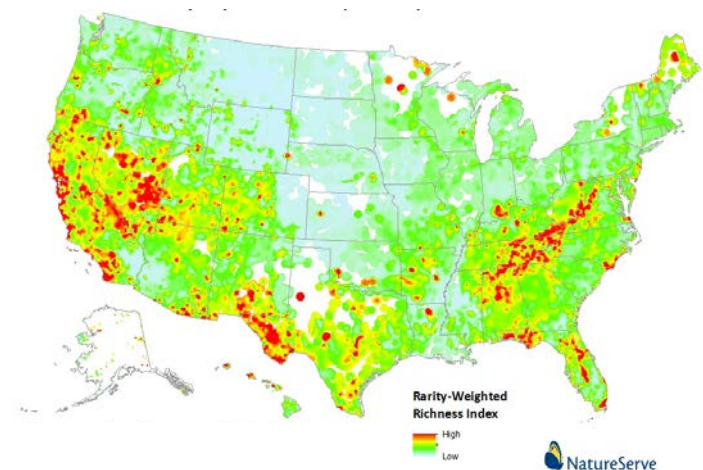
The functioning of healthy natural terrestrial (evapotranspiration) and aquatic (streamflow) ecosystems makes the Southeast sensitive to changes in precipitation. Despite the average abundance in moisture, the region is prone to droughts as deficits in precipitation lead to shortages in freshwater supply. The Southeast has not experienced changes in the amount of average rainfall, but rather changes in the low and high ends of the annual precipitation distribution. The summer months are becoming drier over time, while the fall months are becoming wetter. Streamflow is becoming more variable in many parts of the Southeast and dry years are becoming drier, with droughts more frequent in the record. As climate change influences temperature, precipitation, and circulation patterns within the region, drought conditions are likely to become more prevalent.

Right: Under most flow conditions, stream flows are decreasing in the summer (parameters less than 0) and increasing in the fall (parameters greater than 0). Source: Ford et al. 2011.



Distinct Southeastern landscapes and biodiversity are at risk

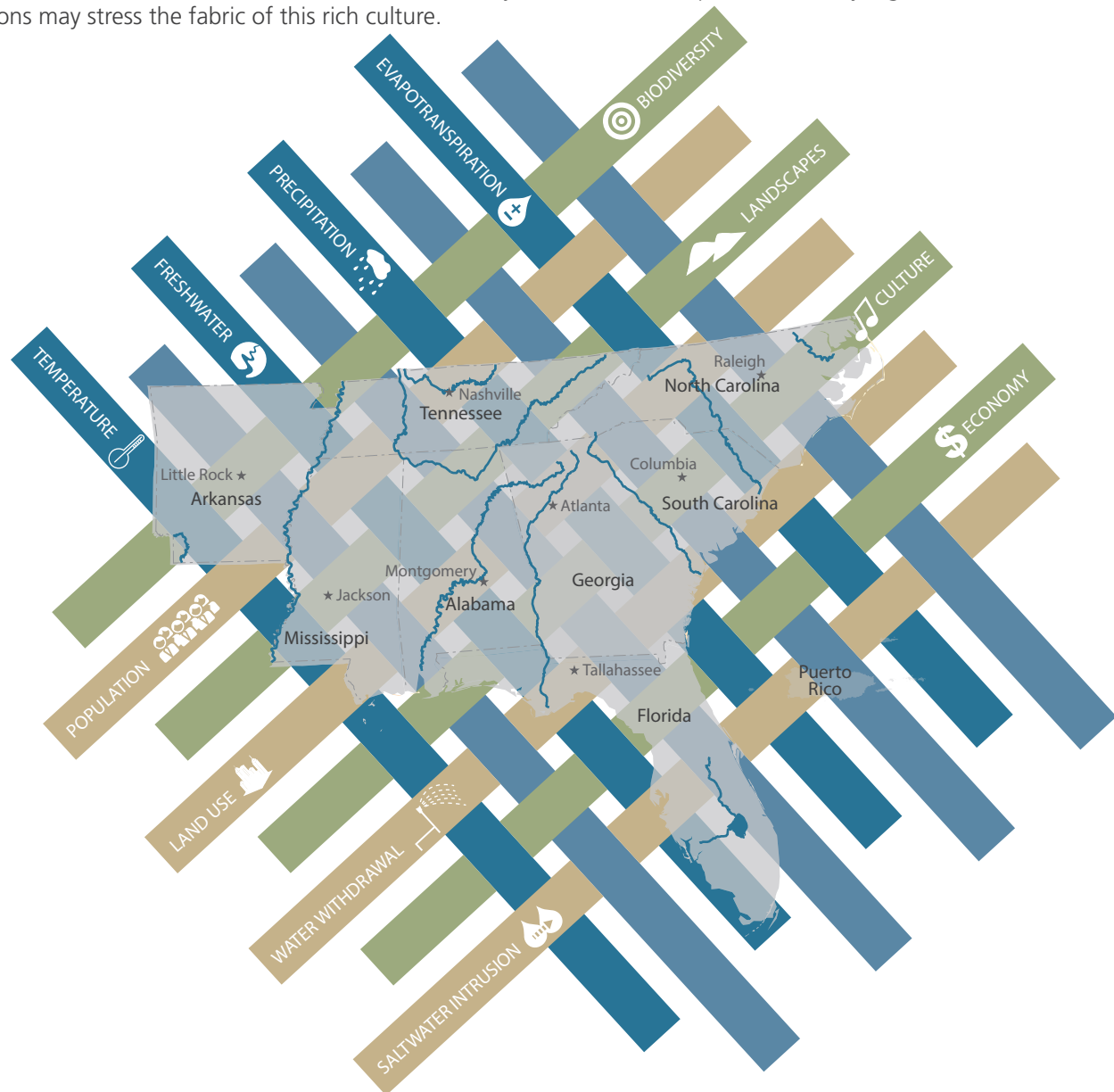
The Southeast U.S. is home to a rich variety of landscapes inhabited by remarkably diverse communities of plants and animals. Forest, wetland, and riverine ecosystems support some of the most biologically diverse temperate ecosystems known. Salamanders, freshwater fishes and mollusks, aquatic insects, crayfishes, fungi, and carnivorous plants all have exceptionally high species diversity in the Southeast, including species found nowhere else in the world. A warm climate coupled with ample rainfall supports high productivity and diversity, but also creates high ecological water demand in the Southeast. Rising temperatures and shifts in the timing and amount of precipitation are expected to lengthen and intensify periods of insufficient water availability. Longer droughts will place novel stresses on natural and human systems, including intermittent streams and wetlands, higher salinity in coastal ecosystems, and increasing tree death and fire. Species unable to adapt to the shifting climate regime will decline, some to extinction.



Biodiversity hotspots across the United States. The Southeast is home to a variety of landscapes and unique habitat types that allow the region a high number of biological hotspots and rare communities. Source: NatureServe.

Water weaves together Southeastern landscapes and culture

Water weaves together the landscapes and cultures of the Southeast. The abundance of plants, animals, rivers, lakes, and marshes that define the Southeastern landscape are supported by the substantial precipitation that falls in most seasons. This same precipitation supports rich cultural traditions in rural and urban areas and makes both urban and agricultural success possible. While the southeastern United States is relatively water rich in comparison to many regions, more extreme climate conditions may stress the fabric of this rich culture.



Unraveling the changing features of the Southeast United States

-  Increasing temperatures across the region will result in an extended growing season and expansion of habitat.
-  A decrease in summer precipitation and increase in fall precipitation may create a mismatch between summer water demand and availability.
-  Increasing temperatures and changing precipitation patterns will result in increased evapotranspiration during warmer months, causing a greater ecological demand for water.
-  Growing communities place increased demands on inland water resources that feed both riverine and coastal ecosystems. More frequent droughts may lead to further reductions in the natural resources these systems provide.
-  As the population of the Southeastern United States continues to grow, there is an increasing need to balance human and ecological needs of water.
-  Increases in impervious surfaces and soil compaction in urban areas increase run-off and reduce soil infiltration resulting in changes in soil hydrology and water availability.
-  Groundwater withdrawals for domestic, agriculture, and industrial uses depletes underground aquifers.
-  Diminished freshwater flows can result in saltwater intrusion in the coastal regions of the Southeast.
-  Seasonal shifts can result in a mismatch in plant and animal life histories. Changes in growing season length can lead to changes in plant species ranges and phenology, and influence migratory bird species and habitat.
-  Changes in weather patterns and drought can lead to increased extreme weather events, including higher frequency and larger forest fires. This can contribute to the success of forest pest species.
-  More frequent and severe droughts may disrupt natural and human systems that define the distinct culture of the Southeast.
-  Ecological and economic impacts of climate change and drought will have major impacts on agriculture, energy, and tourism.

Working together to manage multiple uses of water

Without enough water at the right place at the right time, the features that make the Southeast a special place to live—thriving agriculture, cities, and economic opportunities; clean water; diverse human communities; and diversity in recreational opportunities and in the plants and animals that define the Southeast's landscape—may be threatened. Because of soil and geology conditions in the Southeast, our soils don't hold much water. Even a few weeks without rainfall can cause drought that quickly affects the well-being of both natural and human communities. Droughts have historically occurred within the Southeast U.S. In the past 15 years, the Southeast has suffered three record-breaking droughts with the most recent (2016) producing wildfire and smoke that drew the nation's attention.

As part of our mission to develop and deliver actionable science to natural resource managers, the Southeast Climate Science Center is incorporating ecological drought science needs into its science agenda. While we can't prevent the droughts of the future, we can work with managers to co-develop science needed to minimize drought impacts to the landscapes and cultures that define our region.

– **Jerry McMahon, Director, Southeast Climate Science Center**

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Participants at the Southeast Climate Science Center workshop held in Raleigh, North Carolina in November 2016.

For more information regarding ongoing research and activities at the Southeast Climate Science Center, visit globalchange.ncsu.edu/secsc/

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