More Variable and Uncertain Water Supply: Global Warming's Wake-Up Call for the Southeastern United States

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Water supply in the Southeast will be more variable and uncertain in the coming decades. The region operated under unusually good water availability conditions for about 40 years prior to significant droughts of the past several years. Droughts were rare and water supply plentiful. But, historic records show that regular droughts are more typical for the Southeast. Now, global warming is expected to bring more uncertainty, potentially causing both more extremely dry periods and more heavy rainfall events. At the same time, warming-induced sea-level rise, along with increased groundwater pumping, will increase the risk of saltwater intrusion into important groundwater aquifers.

Rapidly expanding population and irrigation has increased water demand. The Southeast population has doubled since 1960, and another 23 million more people are expected to call it home by 2030. In fact, 23 of the 100 fastest growing counties nationwide are located in Georgia alone. The rapid development relied on abundant fresh water. Increases in water use have far outpaced population growth: water use for municipalities, irrigation, and power generation has tripled since 1960.

Recent droughts illustrate the Southeast's vulnerability. Crop losses due to the 2007 drought are estimated at more than $1.3 billion from corn, wheat, soybeans, cotton, and hay.[1] Wildfire ravaged 600,000 acres in Georgia and Florida that year. The competition for scarce water has escalated disputes between states.

The astonishing biodiversity of the Southeast is at risk. The Southeast has a wealth of fish, mussels, crayfishes, salamanders, and other freshwater species found nowhere else in the world. More severe droughts in the region combined with increased demand for human uses threaten aquatic fish and wildlife, and the $29 billion outdoor recreation economy they support.

The Southeast should plan for increasing variability in water supply. By making better use of existing water infrastructure and improving water-use efficiency, the water system can be made more reliable and resilient. Risk-based, integrated water management will help meet the multiple demands from communities, agriculture, and industry, while still addressing flood control, reducing energy usage, and protecting clean water, fish, and wildlife.

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CONFRONTING GLOBAL WARMING Report

Increasing Uncertainty of Future Water Supplies

Until the last decade, the Southeast United States enjoyed about 40 years of relatively abundant water supplies, without major widespread drought. Yet, these conditions do not reflect the regular occurrence of periodic droughts evident in historic weather patterns. Now, global warming adds further uncertainty to the future of water in the Southeast, leading to more dry conditions, more heavy rainfall events, and an increasing threat of saltwater intrusion into freshwater systems as sea level rises.

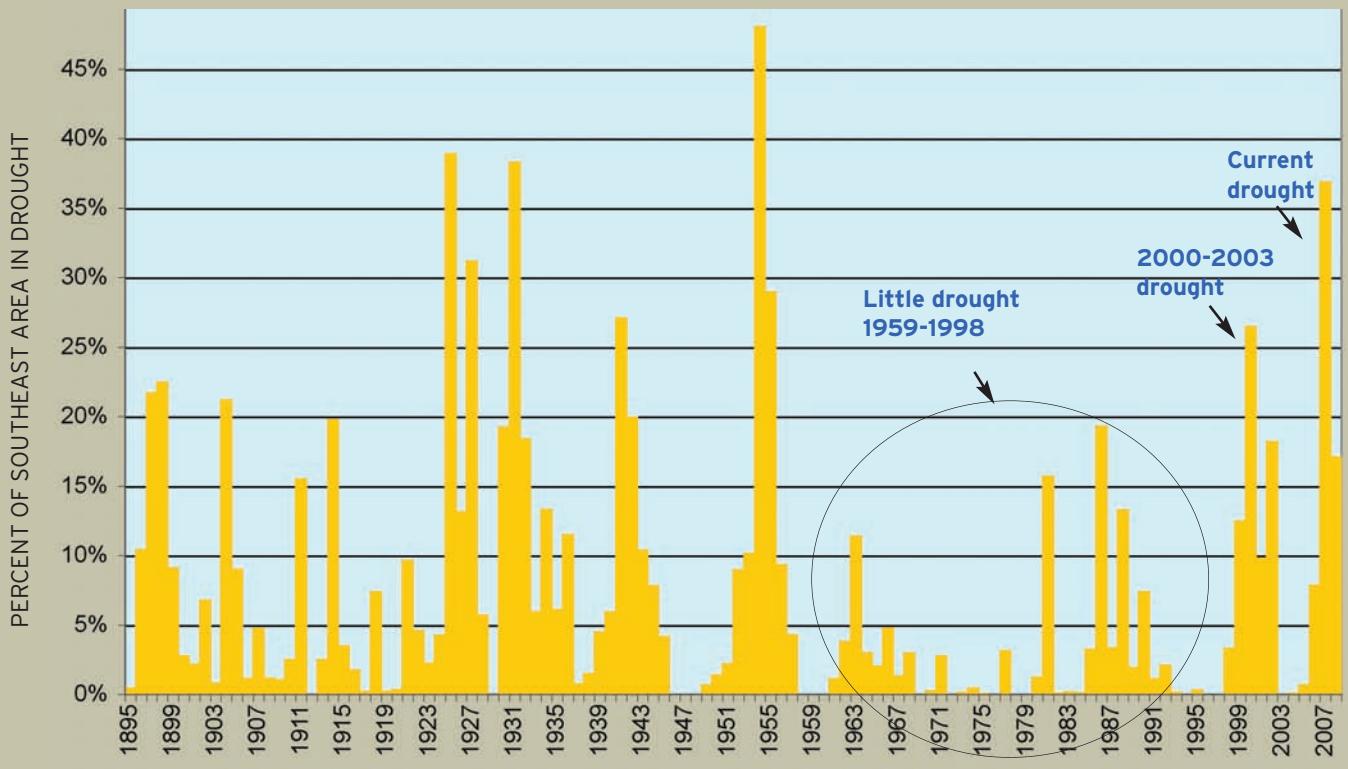
MORE DRY CONDITIONS

The second half of the 20th century was unusually wet in the Southeast United States. From 1959-1998, less than three percent of the area in the Southeast was in extreme and severe drought conditions on average. But, historical records show that drought is a normal feature of the climate in the region (see Figure 1). The two serious droughts of the last decade are more typical of the long-term weather patterns in the Southeast. In fact, tree ring records going back 1000 years show that the region experienced many droughts, some lasting decades.[2] Scientists are not yet certain about the causes of recent variations; however, given the long-term record, it would be imprudent to rely on relatively drought-free conditions continuing.

To make matters worse, global warming is expected to exacerbate future droughts. About two-thirds of climate models indicate that, under warmer conditions, increases in evaporation in the region will outpace increases in precipitation, meaning drier conditions especially during summer when water demand peaks.[3] Much of the United States is experiencing a trend toward longer dry periods punctuated by intense rainfall events.[4] Thus, dry conditions could be a problem even when the region is not in drought.

HEAVIER RAINFALL EVENTS

Seemingly in contradiction to increased drought conditions, global warming will bring more intense rainfall, with greater precipitation for individual storms and the potential for high-volume runoff



Percent of the area in the Southeast part of the United States (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia) in severe and extreme drought as indicated by Palmer Drought Severity Index values less than or equal to -3.[5] Note the period between 1960 and 1999 when the region had little drought compared to other periods over the record.


National Oceanic and Atmospheric Administration (NOAA)

amounts that could overload storm water management systems.[6] The number of days with very heavy rainfall, not including hurricanes, along the Southeast coast increased by 26 percent over the 20th century.[7] If the trend continues, by the end of this century, those heavy rainfall events that now occur in the eastern United States only once every 20 years could occur every eight years.[8] However, while individual precipitation events will be more intense on average, there will be a lower frequency of precipitation events, leaving areas without rainfall for longer periods of time.

With precipitation being the primary source of freshwater in the Southeast, at least some of the surface and groundwater supplies may be replenished during storm events. However, a general trend toward heavier rainfall events with rapid runoff is likely to reduce the region's capacity for recharging groundwater.

SEA-LEVEL RISE AND SALTWATER INTRUSION

Sea-level rise from the melting of land-based ice around the world and the thermal expansion of oceans will significantly impact coastal communities, habitats, and freshwater availability in the Southeast. Global warming is expected to cause 2.6 to 6.6 feet of sea-level rise by 2100 if recent rapid melting of polar ice caps continues.[9]

As saltwater intrudes into low-lying coastal aquifers, sea-level rise will compromise the primary freshwater as saltwater intrudes into low-lying coastal aquifers, which are the primary freshwater supply for millions of people across the Southeast—especially in Florida.[10] Increased salinity of groundwater is already affecting coastal areas where extensive groundwater pumping combined with reduced groundwater recharge due to drought conditions have lowered the water table. Places where drainage canals have provided an inlet for ocean waters are especially susceptible to increased saltwater intrusion.[11]

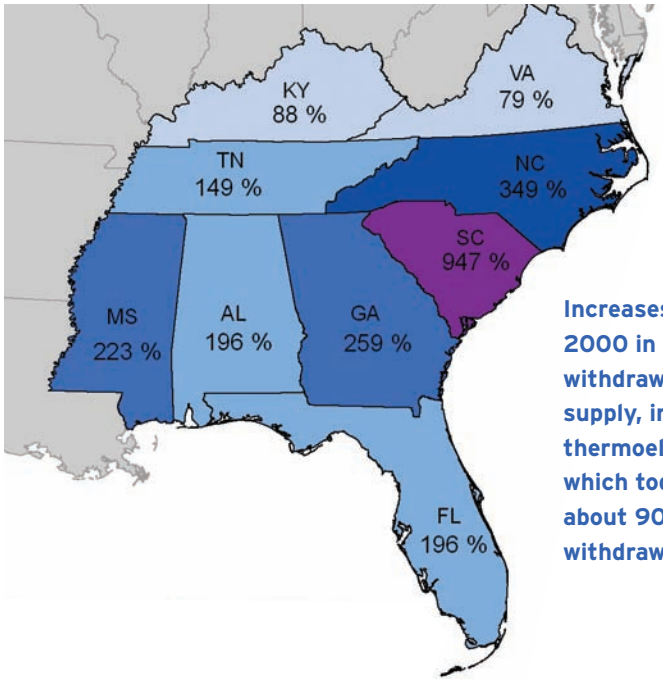
In some areas, as heavier saltwater penetrates farther landward underground, it forces available freshwater closer to the surface, reducing the freshwater volume. This situation can reduce water supply and require installing new, shallower wells or relocating wells further inland.[12] Recent research suggests that the underground saltwater intrusion can extend significantly farther inland than the above ground saltwater inundation, contributing to a greater reduction in available freshwater than had commonly been thought.[13] Sea-level rise is likely to affect freshwater supplies in coastal areas where surface water system intakes are "unprotected" (for example, if they are bounded by dams or dikes) and within tidal reach of an estuary.[14]

Rapid Growth in Population and Water Use

The last 50 years brought an explosion of population and development in the Southeast, bringing with it increasing demand for water. The region had an 89 percent increase in population from 1960 to 2000.[15] The fastest growing state was Florida, where the population more than tripled since 1960. Georgia has had remarkable growth more recently, with 23 of the 100 fastest growing counties nationwide between 2000 and 2007 located in the state.[16] No fewer than 58 of the 100 fastest growing counties in the nation are in the nine states of the Southeast. Rapid regional growth is expected to continue: U.S. Census Bureau projections estimate that the current population of 65 million will increase by nearly 23 million people by 2030.[17]

SOUTHEAST STATES POPULATION (IN MILLIONS)

	1960	2000	% Change 1960-2000	Projections 2030	% Change 2000-2030
Alabama	3.3	4.5	36%	4.9	10%
Florida	5.0	16.0	223%	28.7	79%
Georgia	3.9	8.2	108%	12.0	47%
Kentucky	3.0	4.0	33%	4.6	13%
Mississippi	2.2	2.8	31%	3.1	9%
North Carolina	4.6	8.1	77%	12.2	52%
South Carolina	2.4	4.0	68%	5.1	28%
Tennessee	3.6	5.7	59%	7.4	30%
Virginia	4.0	7.1	78%	9.8	39%
Total	32.0	60.3	89%	87.8	46%



Increases from 1960 to 2000 in daily water withdrawals for public supply, irrigation, and thermoelectric power uses, which together account for about 90% of total water withdrawals.[19]

Ironically, abundant fresh water supply for residences, agriculture, industry, and power generation is a major factor that has contributed to the rapid development in the Southeast.[18] Growth in water use has far outpaced population. In 1960, public water supply used just 447 million gallons a day in the nine-state region. By 2000, it had jumped to 8,529 million gallons a day, a nearly 20-fold increase.[19] Concurrently, water used for irrigation increased 5.6-fold and water used for power generation increased 2.4-fold. Not surprisingly, a recent report concludes that the Southeast has much to gain from improvements in water-use efficiency.[20]

CONTENTION OVER SCARCE WATER SUPPLIES

Water shortages create pressure to transfer water to places where there is high demand, causing both environmental and political problems. The Southeast is already facing the following challenges:

- **Water transfers can transport pollutants, invasive species, pathogens, nutrients, and sediments. They can increase turbidity and temperature in the receiving water body. In June of 2008, EPA finalized a rule exempting such water transfers, which would otherwise be prevented because of environmental impacts, from Clean Water Act permitting requirements. This exemption is currently being challenged in court.**

- **For almost two decades, Georgia, Alabama and Florida have been embroiled in a bitter dispute over rights to the Apalachicola-Chattahoochee-Flint River Basin's water. Georgia wants to retain water in Lake Lanier for use by more than 3 million metro Atlanta residents. But, Alabama wants enough water released into the Chattahoochee River to float barges, cool the Farley nuclear power plant near Dothan, Alabama, and support fisheries. And, Florida wants more water flowing through the Apalachicola River to preserve three federally protected species and the world-famous and economically important oysters in the Apalachicola Bay.**

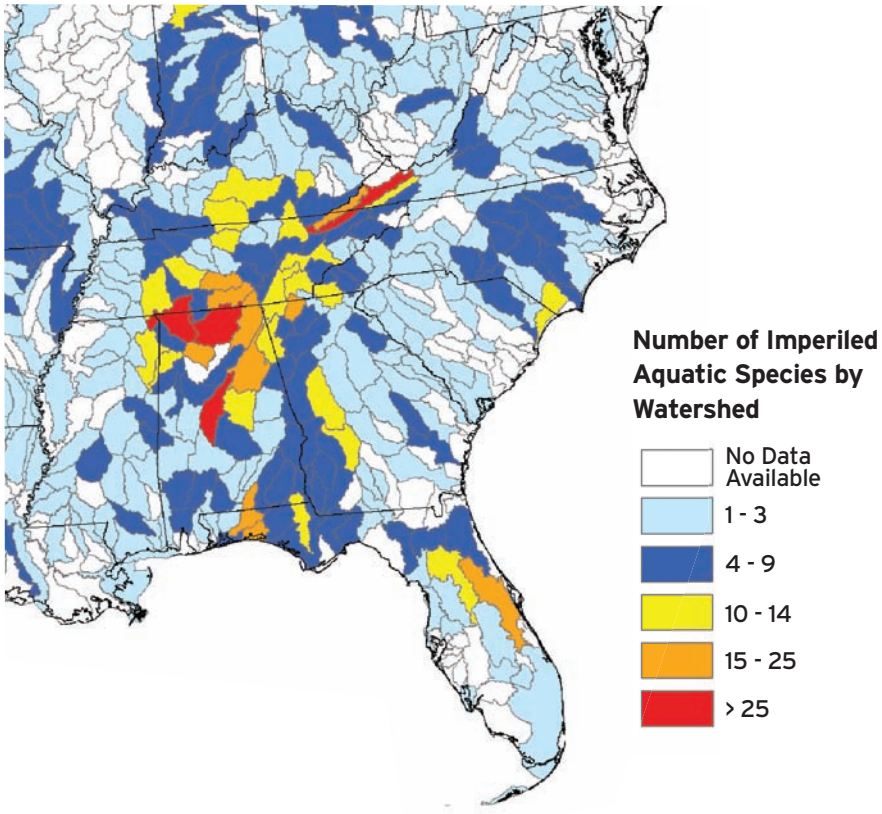
- **In 2007, South Carolina sued North Carolina over water diverted from the Catawba River, which supports a host of power generation facilities, water-based recreation, and a number of factories and plants. The Catawba was recently named one of America's most endangered rivers due to rapid growth, particularly in Charlotte, North Carolina, combined with a lack of long-term water planning in both states.**

Water Shortages Threaten Prized Freshwater Habitats

The Southeast hosts an impressive array of ecosystems, from the richly productive wetlands along the Gulf Coast, and majestic longleaf pine forests of the coastal plains, to the rhododendron-covered slopes of the southern Appalachians. Yet, most remarkable are the region's freshwater habitats, and the largely unseen aquatic life they support, such as prized freshwater sturgeon and mussels. The region's diversity of freshwater fishes is legendary. A single river in Tennessee, for example, harbors more species of fish than are found in all of Europe! The Southeast is also the global center of diversity for freshwater mussels, crayfish, and salamanders.[21]

Alterations of the Southeast's rivers and streams by damming, channelization, pollution, and water withdrawal have already put these freshwater creatures in grave danger.[22] The Southeast is home to about 70 percent of the nation's vulnerable and imperiled fish and mussel species, primarily in the Tennessee-Cumberland River basins and the Mobile River basin.[23] Many of these at-risk species are found nowhere else in the world. Climate change—and the increasingly extreme weather patterns it brings—now poses a new set of threats to already beleaguered aquatic habitats and the $29 billion outdoor recreation economy they support.[24]

The increasing intensity of droughts is particularly problematic for aquatic species, especially when the competition for water from people can further deplete lakes, reservoirs, and rivers. Even where water is still available during a severe drought, its infrequent replenishment and declining volume decreases water quality while forcing remaining fish populations into shrinking habitats. Smaller bodies of water heat up more rapidly, which in turn decreases the amount of dissolved oxygen the water can hold, stressing aquatic life even further. Although many species can recover from drought when water becomes more plentiful, severe droughts can reduce populations to such low levels that it can take much longer for them to fully recover when water abundance increases than it would following less severe droughts.



The river systems of the Southeast have unusually high biodiversity, with many species already at risk. Map courtesy of NatureServe. Data Source: NatureServe and its natural heritage member programs, 2008.

Freshwater, Forests, and Fire


USDA Forest Service, Bugwood.org

Forested lands covering more than 50 percent of the Southeast United States help clean and naturally regulate freshwater supply. However, as the human population continues to expand in the region, as many as 12 million acres of forested land could be lost to urban development by 2020.[25] With smaller and more fragmented forests, these valuable ecosystem services will be diminished just when the region needs them most. As global warming brings more heavy rainfall events separated by longer dry periods, forests will be critical for slowing stormwater runoff and helping to recharge ground water.

Unfortunately, the increased temperatures, droughts, floods, and storms expected because of global warming could also take a toll on forests.[26] When stressed by water scarcity, trees and other plants are more susceptible to diseases and infestations. For example, pines are most vulnerable to attack by southern pine beetles, the most destructive insect pest of pines in the Southeast, when stressed by drought, flooding or storm damage.[27]

Drought conditions also make southeastern forests more susceptible to wildfires. Most southeastern terrestrial ecosystems evolved in and are highly adapted to frequent small fires. But, severe drought could cause catastrophic fires that are much larger and more intense. Such catastrophic fires put communities at risk, can decimate even fire-adapted species such as longleaf pines, and can deplete soil nutrients if topsoil layers are actually burned. In 2007, drought-fueled fires burnt about 600,000 acres in Georgia and Florida, the largest fires in the history of either state.[28]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LESSONS FROM THE WEST

The Southeast has the opportunity to transform water use by putting in place management strategies that accommodate the projected regional growth and increasing climate variability. In developing such a system, the experiences in Western states, where water rights and shortages have been a major issue for decades, can help the Southeast avoid pitfalls. Some key lessons from the West include:

Accommodate all water uses. The Colorado River is the lifeblood of the West, now providing water to seven U.S. states and Mexico, 25 million people, and 3.5 million acres of farmland. Yet a few important things were missed when access to its water was first divvied up: Mexico originally was not granted rights to water; insufficient water was allocated to reach the Sea of Cortez, where the Colorado River Delta once supported a significant fishery; and water quality was not considered.

Plan for drought. The water allocations for the Colorado River were based on best-case flow scenarios, yet drought is common in the West. After a series of droughts, Boulder, Colorado adopted a drought management plan that uses risk assessment. Just as flood management uses recurrence intervals, Boulder, and cities using similar approaches, plan for droughts of different severity — the 20, 100 or 1000 year drought — with increasingly stringent responses.

Integrate surface and groundwater planning. The law in many Western states treats ground water and surface water as independent, even though the two systems are physically connected. During drought, when groundwater is most valuable, it may not be there when you needed it.

Plan for change. Western states long ago allowed the region's water to be claimed, mostly for irrigated agriculture, and created legal systems that made changing water uses very difficult. Now that growing cities are demanding more water and that we recognize the water requirements for fish and wildlife, the legal system makes accommodating changes difficult.

Managing Water Supply in A More Variable Climate

The Southeast must plan for increasing variability in water supply in the face of growing demand. This means shifting from an assumption of plentiful water, with occasional emergency events of too little or too much, to a modern management strategy that better plans for more extreme weather events and results in more sustainable water use. Fortunately, more strategic water management approaches have important co-benefits. Because heating, treating, and moving water is energy intensive, reducing water use lowers electricity use, in turn reducing the global warming pollution that contributes to a more variable climate. Likewise, healthy forests and wetlands naturally regulate and cleanse water, are important fish and wildlife habitat, and sequester carbon that would otherwise contribute to global warming.

Important steps to meet these goals include:

Reduce global warming pollution. To prevent the worst impacts of climate change and limit the impacts on communities and wildlife, we must reduce global warming pollution. The National Wildlife Federation recommends that policy makers, industry, and individuals take steps to reduce global warming pollution from today's levels by at least 2 percent per year, and by at least 20 percent by 2020. Science tells us that this is the only way to hold global warming to no more than 2 degrees Fahrenheit in this century.[29] This target is achievable with technologies either available or under development, but we need to start taking action now.

Improve water-use efficiency and conservation. Reducing overall demand is the surest way of avoiding problems with drought. Furthermore, linking water use and energy use will be an important component of any strategy to reduce global warming pollution. For most municipalities, the water and wastewater system is the largest single energy consumer. At the same time, about 65 percent of the water withdrawn from streams in the Southeast is used to produce electricity, mostly to cool coal and nuclear plants.[30] Cities in the Southeast could achieve water-use reductions of 20 to 40 percent by implementing several proven strategies, such as stopping leaks, modifying water pricing, and modifying landscaping practices.[31] Water planners should include municipal and industrial conservation and efficiency programs as part of the base assumption when forecasting demand and evaluating supply, and then implement those programs.

Use risk-based, integrated water management strategies. Risk-based systems can help prepare for increasing population in the Southeast, more competition for water resources, and a more variable water supply. For example, a portfolio of water supplies from different sources is more reliable and resilient than dependence on a single source. Integrated planning helps to make the best use of existing reservoirs and infrastructure, often resolving many problems at once. For instance, allowing rivers to spill into floodplains maximizes groundwater recharge and the natural water filtration provided by wetlands, while providing habitat benefits and reducing flood potential.

Consider sea-level rise in managing coastal freshwater resources. Water managers need to develop strategies to address saltwater intrusion and inundation. For example, surface water managers in coastal areas could consider operating their plants only at low tide or moving some freshwater intakes to higher ground. Projected sea-level rise should be a major consideration in the citing and design of future coastal freshwater systems.

Maintain and restore natural forest and wetland systems. Healthy forests and wetlands absorb flood waters, provide efficient water storage, and are critical for water purification and groundwater recharge, while also providing important fish and wildlife habitat. As global warming leads to more evaporation from reservoirs and lakes, natural storage in ground water aquifers will become an increasingly attractive alternative. These ecosystems can also sequester carbon that would otherwise contribute to global warming. Thus efforts to conserve these natural lands would provide multiple benefits to the Southeast.

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