

Carolinas Climate Connection

Carolinas Integrated Sciences & Assessments

Integrating Climate Science and Resource Management in the Carolinas

Drought is one of the most common natural disasters affecting the United States, influencing everything from ecosystem functions to the economy. The drought of 2012 has been of record proportion, comprising 65% of the continental US and most of the corn and soybean growing region in the Midwest in mid-September. In our first edition of the Carolinas Climate Connection, you will find syntheses from several recent publications with regards to the influence of drought in the southeastern US. Drought is also one of the core focus areas of research and decision-making support for CISA. You can find more about CISA's work on drought on our website, www.cisa.sc.edu.

Regional Drought Research

An Overview of Drought in the Southeast

A synthesis of historic, current and future projections for drought in the region (Konrad et al., 2012)

The Influence of ENSO on Drought in the Southeast

Comparison of precipitation levels with sea surface temperature records helps to determine conditions conducive to periods of drought in the southeastern US (Mo and Schemm, 2008)

Research Links Oyster Health to Drought

Research conducted to analyze the impact of upstream drought and water withdrawals on estuarine oyster populations in the Apalachicola Bay determine a possible salinity level 'tipping point' for oyster mortality (Petes et al., 2012)

The Impact of Drought in Coastal Ecosystems

A synthesis and analysis of peer-reviewed literature examining drought impacts on coastal ecosystems (Gilbert et al., 2012)

New Resources and Tools

Climate Change: Lines of Evidence

The National Academy of Sciences has developed a 7 part video series, which presents information from the definition of climate to attribution of climate changes and future projections. Find more information [here](#).

Regionally Downscaled Climate Data

The Florida Climate Institute has released four new regionally downscaled climate modeling data sets for the Southeast, which can be downloaded from their [website](#).

CISA Updates

NIDIS Carolinas Drought Early Warning Pilot Program

Upcoming Events

SC DNR Climate Connection Workshop Series

Greenville, SC
December 5, 2012

North Carolina GIS Conference

Raleigh, NC
February 7-8, 2013

SC Environmental Conference

Myrtle Beach, SC
March 10-12, 2013

NC Water Resources Research Institute Annual Conference

Raleigh, NC
March 20-21, 2013

NOAA Coastal Services Coastal GeoTools Conference

Myrtle Beach, SC
March 25-28, 2013

Georgia Water Resource Conference

Athens, GA
April 10-11, 2013



USC Department of Geography
Callcott Building
709 Bull Street
Columbia, SC 29208
(803) 777-6875
cisa@sc.edu
www.cisa.sc.edu



UNIVERSITY OF
SOUTH CAROLINA

The University of South Carolina is an equal opportunity institution.

An Overview of Drought in the Southeast

In the Southeast Region Technical Report to the National Climate Assessment, Konrad et al. provide detailed information on historic and current conditions, trends and future projections of climate variables to include temperature, precipitation, and extreme events (e.g. heavy rainfall and floods, droughts, extreme heat and cold, winter storms, and tropical cyclones). The bulleted information below provides a synthesis of the information regarding drought in the Southeast (SE) from the chapter.

- There is no clear historical trend for drought in the Southeast. Climate reconstructions using tree rings reveal significant multidecadal variability in precipitation and soil moisture across the Southeast over the past millennium with no discernible long-term trend.
- Currently, droughts often do not last as long in the Southeast, as compared to the multidecadal droughts in the Western and Central US. The periodic occurrence of tropical cyclones in the late summer and fall have been found to offset drought conditions during these seasonal periods of peak water demand.
- Climate variability, including changes the positioning of the Bermuda High and the strength of ENSO, impact the occurrence and severity of drought in the Southeast.
- Recent droughts in the region, including the 1998-2002 and 2007-2008 droughts, occurred partly in response to an absence of tropical cyclones increased evapotranspiration, and increased water usage.
- The severity of recent droughts across the Southeast raises the possibility of a long-term shift in the precipitation regime.
- Hydrological drought is expected to increase in frequency and intensity across most of the country through the end of the 21st century.
- Across the Southeast, various models project a greater likelihood of drought across the lower Mississippi River Valley and Gulf Coast but fewer droughts across the northern tier of the region, which includes portions of the Carolinas and the mid-Atlantic.
- Uncertainty levels in future projections of drought stem from variations in the projections of future precipitation patterns and evaporation rates in the Southeast, as well as weaknesses in the ability of

models to simulate many of the atmospheric processes that contribute to drought, particularly ENSO.

Read the full Southeast Technical Report [here](#).

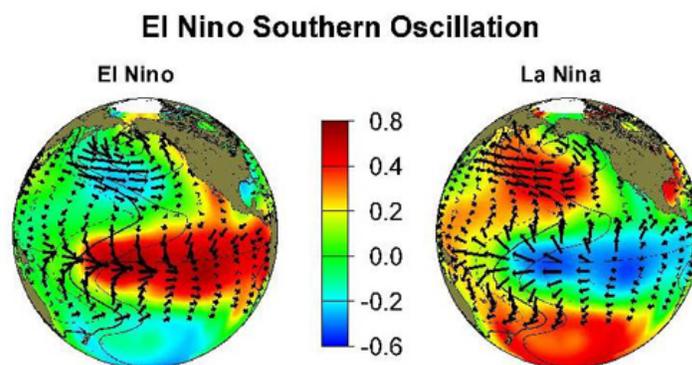
Konrad, C. E. and C.M. Fuhrmann. 2012. 'Climate of the Southeast United States: Past, Present, and Future.' *Southeast Regional Technical Report to the National Climate Assessment*. 9-38.

[Back to Top](#)

The Influence of ENSO on Drought in the Southeast

The El Niño Southern Oscillation (ENSO) influences weather patterns around the globe. Sea surface temperature and atmospheric pressure in the Pacific Ocean, signatures of ENSO, can exacerbate periods of drought or wet. NOAA researchers Chet Ropelewski and Michael Halpert identified the connection between ENSO conditions and precipitation in the Southeast United States. Warm ENSO events (El Niños) during winter typically led to wetter conditions, while the cool ENSO phase (La Niñas) created drier than normal conditions. Recent analysis by Kingtse C. Mo and Jae E. Schemm, researchers at the NOAA NWS Climate Prediction Center in Camp Springs, Maryland, expands on the connection between drought and wet spells in the southeastern United States.

Using data from 1915-2006, the research team identified Southeast droughts and wet spells with the 6 month standard precipitation index (SPI 6). Drought periods were signified by a SPI 6 index of less than -0.8 for 4 consecutive months, while wet spells were identified by the opposite; that is, a SPI 6 index of greater than 0.8 for 4 consecutive months. 19 droughts were identified over the study



Source: Mantua, 2000

period, lasting an average of 7 months. 20 wet spells were identified, lasting an average of 7.8 months.

In order to determine the relationship between drought and/or wet spells with ENSO, composites of sea surface temperature anomalies (SSTAs) were obtained for the winter (December thru March) and summer (June thru September) months corresponding to the identified periods of drought and wet spells. The analysis revealed that the conditions for drought were found to be cold sea surface temperature anomalies in the tropical Pacific in winter and a neutral ENSO summer with warm SSTAs over the West Coast of the US and the North Atlantic. Conversely, wet spells were more likely to occur during a warm ENSO winter or early spring. Therefore, persistence of a particular ENSO phase (warm or cold) reduces the likelihood for drought or wet spells to persist in the Southeast.

This type of research, which correlates climate phenomena with local weather patterns, can contribute to forecasts useful to resource managers. Forecasting drought or wet spells is particularly useful for a number of water resource management practices such as allocating water uptake or discharge levels. Forecast information can also be used to feed into a drought early warning information system to help educate and inform stakeholders who are impacted by decreased precipitation and resultant low flows (e.g. industry and infrastructure) or diminished soil moisture (e.g. agriculture, fire prevention).

Reference: Mo, K.C. and J.E. Schemm. 2008. Relationships between ENSO and drought over the southeastern United States. *Geophysical Research Letters* 35 (15).

DOI: 10.1029/2008GL034656

[Back to Top](#)

Research Links Oyster Health to Drought

During 2007 and 2008 the southeast United States experienced widespread, severe drought in the eastern part of the region, leading to significantly reduced input of freshwater into coastal estuaries along the Gulf Coast. This diminished freshwater input caused by the drought, and exacerbated by upstream water withdrawals, led to an increase in the salinity of coastal estuaries. The researchers in this investigation were working in Florida's Apalachicola Bay. They used a combination of laboratory experiments and field observations to investigate the effects of increased salinity on oysters during prolonged drought conditions, particularly during the summer months.

The investigation found that oyster mortality strongly correlated with an increase in both salinity and seasonal temperature. This was due in large part to disease related impacts of the Dermo parasite (*Perkinsus marinus*), which can be found along the coastline from the Gulf of Mexico to Maine. The mortality rate of oysters was low in cooler temperatures even if the salinity level was high. This was probably because the Dermo parasite is dormant in cold water temperatures. During the summer months, however, parasite proliferation increases not only with an increase in temperature, but salinity as well. This means that oyster mortality is at its highest during high temperature and high salinity. Furthermore, the Dermo parasite is lethal only after the first year of an oyster's life, and with high-salinity also retarding oyster growth many oysters are more likely to die before they are of harvestable size during drought conditions.

These findings have important implications for not only the oyster industry but for water resource management as well. The researchers found that there is a possible



Source: wfsu.org

“tipping point” of salinity that can lead to prolonged effects on oyster colonies. If the timing and quantity of upstream freshwater releases are properly maintained, it is possible that water resource managers can substantially reduce the impact of drought on oysters as well as other estuarine organisms. This would also reduce negative economic impacts to the oyster harvesting industry, an important component of the regional economy around Apalachicola Bay.

Reference: Petes, L.E., A. Brown, C. Knight. 2012. Impacts of upstream drought and water withdrawals on the health and survival of downstream estuarine oyster populations. *Ecology and Evolution*. 2 (7): 1712-1724.

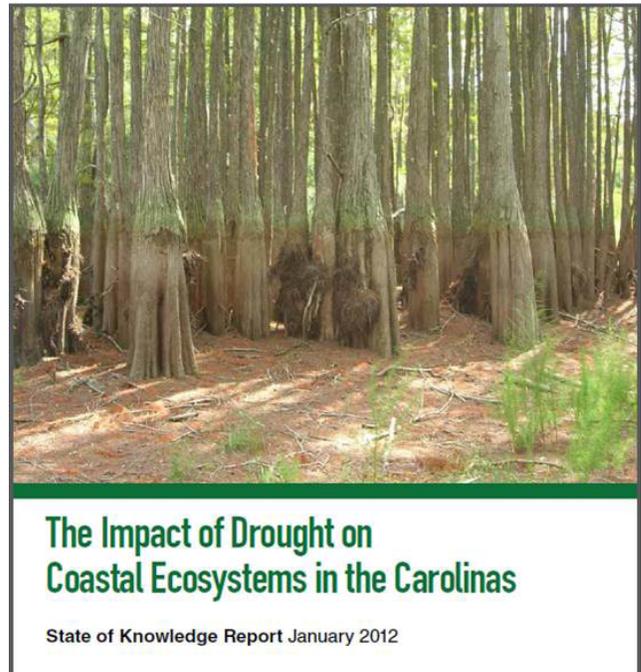
DOI: 10.1002/ece3.291

[Back to Top](#)

The Impact of Drought in Coastal Ecosystems - A State of Knowledge Report

In January 2012, CISA released “The Impact of Drought on Coastal Ecosystems in the Carolinas,” a state of knowledge report. The development of this report was suggested by a group of stakeholders in March 2010 at a workshop hosted by CISA in Georgetown, SC. The group of stakeholders included researchers, resource managers, and education and outreach specialists engaged in coastal resource issues in South Carolina. Participants identified a need for greater availability of appropriate drought data and information to manage coastal resources during drought. The group agreed that one limitation is the lack of overall understanding of how much relevant research had already been done. Participants recommended that a state of knowledge report would be an essential first step to improve understanding and develop an effective means to monitor and forecast drought impacts.

The report provides a synthesis and analysis of peer-reviewed literature examining drought impacts on coastal ecosystems. Literature reviewed for this report indicates that drought is discussed primarily in terms of the hydrology-related impacts that affect coastal ecosystems, such as changes to river discharge, freshwater inflows, water level, and water quality. The severity of these effects depends upon the longevity and recurrence interval of the drought event(s) and may be compounded by other anthropogenic stressors on the system. In addition, some drought-related research considers how sea level interacts with freshwater precipitation and runoff to influence the salinity levels experienced by these systems. The review



indicated that some ecosystems have been better studied and researched than others. For example, the aquatic components of estuaries, including tidal freshwater, have received much more attention than upland systems (e.g. maritime forests) and coastal freshwater wetlands.

The report also identified key literature gaps and research needs, including: examining drought impacts in ecosystems not studied by existing research, implementing long term studies to identify and examine causal relationships, and developing a set of indicators with which to monitor ecological change and impacts. More research and information is needed regarding drought impacts on groundwater resources, the significance of drought during different seasons, the longevity of droughts in relation to long-term impacts and/or length of recovery, and responses to potential future changes in salinity regimes.

A copy of the full report can be found [here](#).

[Back to Top](#)

Reference: Gilbert, S., K. Lackstrom, and D. Tufford. 2012. The Impact of Drought on Coastal Ecosystems in the Carolinas. Research Report: CISA-2012-01. Columbia, SC: Carolinas Integrated Sciences and Assessments.

NIDIS Carolinas Drought Early Warning Pilot Program

CISA has partnered with the National Integrated Drought Information System (NIDIS) to develop and support a drought early warning information pilot program for the coastal regions of the Carolinas. In the Carolinas, drought effects on environmental resources, particularly in coastal areas, are not as well-understood, or as well-integrated into existing drought planning and response processes, as other impacts and resources, such as agriculture and surface water supplies.

Key concerns related to drought and coastal ecosystems focus on impacts to water quality and quantity, habitats, species, and estuarine processes. Drought contributes to increased salinity and saltwater intrusion, reduced flushing and assimilation of pollutants, and overall water quality changes. Ecosystem impact concerns center on habitat loss or conversion and consequent effects on recruitment, distribution and migration patterns as well as on primary and secondary production. Saltwater intrusion, low stream flows, and low water levels contribute to impacts and are attributed to both drought and human actions, such as changes in dam releases due to drought.

A scoping workshop was held in Wilmington, NC on July 31 – August 1, 2012, in order to generate potential pilot project ideas for the NIDIS Carolinas regional drought early warning system (RDEWS). Stakeholders from federal and state agencies, NGOs, academia, and the private sector came together to identify important issues of concern for the coastal region and to establish and refine priorities for pilot projects.

Pilot ideas were generated out of small group discussions centered on topics of importance regarding Carolina coastal ecosystems. Some of these topics included public health risks, impacts and management strategies for coastal lands, water and drought management, and drought early warning metrics and tools.

Stakeholders at the Wilmington workshop used a series of selection criteria and metrics for success in choosing priority projects. These included the potential to build partnerships, projects with a regional focus, projects which could use and benefit from existing resources, and projects with an ability to be transferred to other areas where such programs are needed. Each project will be geared towards addressing the needs of stakeholders in the coastal ecosystems of the Carolinas, with the intent that they could be replicated in other coastal areas throughout the US.

Four pilot projects were selected by workshop participants to move forward and steering committees for each pilot were formed. The projects include evaluation of drought indicators and indices, a seafood safety forecast, a drought forecasting communications program, and a project to improve drought impacts reporting. More information about the background and goals of each project can be found on the [next page](#). Currently, steering committees are working to refine the project plans and engage potential stakeholders.

NIDIS Workshop Participants



Click [here](#) for more information on the NIDIS Carolinas pilot projects, to include presentations from the Wilmington scoping workshop and a copy of the full workshop report.

[Back to Top](#)

About CISA

The Carolinas Integrated Sciences & Assessments is 1 of 11 NOAA-funded [Regional Integrated Sciences & Assessments](#). CISA works with a variety of stakeholders across North and South Carolina to incorporate climate information into water and coastal management and related decision-making processes. For more information, visit our website at www.cisa.sc.edu.

NIDIS Carolinas Drought Early Warning Pilot Projects		
Title	Background Information	Goals
Evaluation of Drought Indicators and Indices	Many of the commonly used drought indices were not developed with the unique characteristics of coastal ecosystems in mind. Predicting the onset, intensification and recovery of a drought could be improved with more knowledge of drought indicators and indices in coastal ecosystems. The goals developed by workshop participants for this particular pilot project will be to:	<ul style="list-style-type: none"> • Determine which current drought indicators and indices are appropriate for assessing drought in coastal ecosystems • Investigate the benefits and feasibility of creating a drought index based on real-time salinity data
Seafood Safety Forecast	During drought, freshwater flows are reduced and water temperatures rise. Impacts of these changes include increases in concentrations of pollutants, increases in salinity, changes in pH, increases in harmful algal blooms (HABs), increases in shellfish predator populations, increases in Vibrio bacteria and Cyanobacteria. All of these changes, and others not listed here, can have harmful effects on seafood. The Seafood Safety Forecast pilot project would aim to :	<ul style="list-style-type: none"> • Provide an early warning system for commercial, recreational and subsistence fishermen who harvest drought-sensitive seafood in both fresh and salt waters in the coastal regions of the Carolinas
Drought Forecasting Communications	Numerous drought, hydrometeorological and climate products are available to stakeholders in the Carolinas. However, stakeholders may not be aware of all products which are available, may not have the products they need to make decisions (i.e. the regional or temporal scale may not be adequate), or may not know the best way to tailor the products to their region or situation. This pilot project idea was designed by workshop participants to:	<ul style="list-style-type: none"> • Introduce stakeholders to current products used for drought forecasting • Determine what additional drought forecasting products stakeholders need and what time scales are of most interest to them • Determine the best way to deal with uncertainty resulting from forecast data, including how uncertainty is conveyed to stakeholders • Determine the best ways to relay information about drought forecast tools
Drought Impacts Reporting	Participants identified many possible benefits of improving drought impact reporting to include improving drought monitoring, building stakeholder awareness and engagement, building linkages between drought indicators and impacts, and addressing the need to improve understanding of the economic benefits of preparedness activities related to the NIDIS pilot, and mitigation and planning strategies. The overarching goals suggested by participants for this project will be to:	<ul style="list-style-type: none"> • Assess ways in which drought impacts might be monitored through stakeholder engagement and citizen science • Investigate ways to improve the communication of coastal ecosystem drought impacts

Find more information about each of the pilot projects [here](#).

[Back to Top](#)