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Mapping the future of southern pine management in a changing world

Drought and Southern Forests:
The Importance of Forest Health and Resiliency

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Drought has shaped southern forests in the past and will continue to influence health, productivity, and resiliency of forests in the future. However, drought does not impact all forests equally. Some forests resist drought effects and recover quickly. Other forests seem to suffer severely. What causes this phenomenon? This factsheet will define drought and its impacts to individual trees and forests as we explore the reason behind this question.

WHAT IS DROUGHT?

Drought is characterized by a shortage of precipitation over some time period to the extent that it causes impacts to a group, activity, or sector (NDMC, 2013). Drought is actually defined by impacts -- without them, it is just dry weather. Droughts are typically distinguished as having either short-term or long-term impacts, and these have different implications for forests.

Short-term drought occurs for periods of weeks to months in length and mostly affects vegetation. Short-term droughts are common during the growing season and can have a noticeable influence on understory forest vegetation, such as wildflowers, shrubs, and important wildlife browse plants.

Long-term drought occurs for periods of seasons to years in length and directly affects the hydrological cycle. Long-term drought can lag behind short-term drought, and can persist even after the weather event(s) causing the drought have ended and/or returned to a wetter regime. With long-term droughts, streams may stop flowing, groundwater levels may drop below the root zone, and reservoirs and lakes may significantly regress or dry up altogether. Long-term droughts can cause agricultural crop failure, livestock losses, and in the case of forestry, significant loss of growth potential and tree mortality.

WHAT CAUSES DROUGHT?

Droughts -- a natural part of the climate system -- occur due to shifts in the climate pattern that produce extended periods with limited rainfall. The exact trigger that causes drought differs by location. In the South, drought conditions are usually triggered by two meteorological events: 1) the Bermuda High shifting westward during summer, or 2) the La Niña phase of El Niño/ Southern Oscillation (ENSO) developing during the cool season. Droughts that have onset in summer, which tend to have the most visible effect, are often connected with the Bermuda high pressure system. The onset of drought in winter often occurs during La Niña conditions.

THE BERMUDA HIGH PRESSURE SYSTEM (BERMUDA HIGH)

This high pressure system gets its name from the fact that it is centered over the Atlantic Ocean near Bermuda during typical summer conditions (Figure 1a). As a result, the clockwise flow of air around it allows winds from the southwest to bring ample moisture from the Gulf Coast and Atlantic Ocean to the southern US. However, when the Bermuda High moves westward and inland and is positioned over the western Gulf region (Figure 1b), summer drought conditions occur because the clockwise flow of moist winds and tropical storm-related precipitation are both prevented from reaching the southern US. Monitoring the location of the Bermuda High during summer can help forest managers and landowners determine whether to start managing for the risk caused by potential onset of drought conditions.

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Overall, understanding terms and concepts such as high pressure systems and oscillations will provide forest managers and landowners with a better set of tools to use for protecting their forested asset and managing risks.

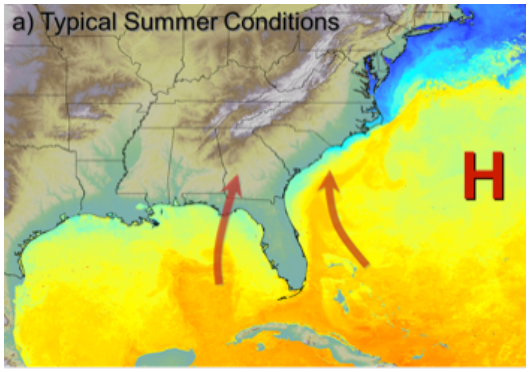

Figure 1a. Bermuda High location during typical summer conditions in the Southeast US.

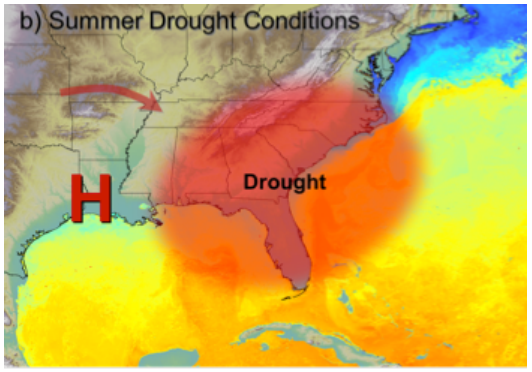

Figure 1b. Bermuda High location during summer drought conditions in the Southeast US.

EL NIÑO / SOUTHERN OSCILLATION

The El Niño / Southern Oscillation (ENSO) is the change (warming or cooling) of sea surface temperatures (SSTs) in the Pacific Ocean coupled with changes in air pressure. A change in the SSTs by only a degree or two, plus a change in air pressure, causes one of these phases to occur: 1) La Niña - characterized by warmer, drier winters in the Southeast (Figure 2); or 2) El Niño – causing cooler, wetter winters in the Southeast. A third phase, called Neutral, occurs when SSTs are not above or below their normal values, which usually means neither sustained warm and dry nor cold and wet winter conditions in the Southeast. Each phase also ranges in strength from weak to strong.

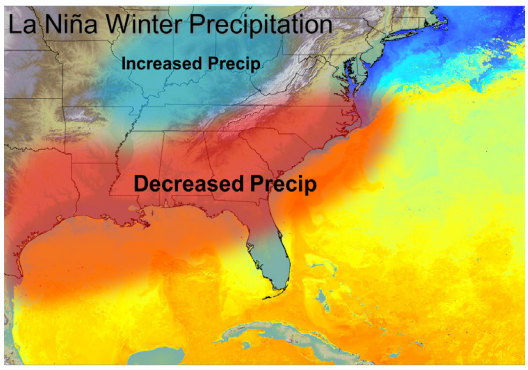

Figure 2. The precipitation pattern during a typical La Niña winter.

Starting around August each year, scientists are able to make forecasts of cool season ENSO conditions with reasonable accuracy. These forecasts can give forest managers and landowners an idea of whether to expect wet or dry conditions during the planting season.

ENSO Phase	Impact to Southeast
El Niño	Wetter winter
Neutral	Average winter
La Niña	Drier winter

HOW DOES DROUGHT IMPACT FORESTS?

Soil moisture is critical to forest growth and health. Trees constantly compete with neighboring vegetation (surrounding trees and understory plants) for soil moisture, nutrients, sunlight and space. During droughts, competition for soil moisture becomes extreme and eventually leads to a moisture deficit within the trees and other plants. Once moisture deficiency occurs, photosynthesis stops and trees reallocate their remaining and stored carbohydrate (energy) resources to defending against further water loss and maintaining only the most basic plant functions.

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Prominent drought effects include:

Loss of newly planted forests: Seedlings and saplings are extremely vulnerable to drought because they have yet to acclimate to the site and develop an extensive root system from which to absorb a majority of their water needs. Most trees get their water and nutrients from within the first 18 to 24 inches of the soil. Only a few tree species (e.g., longleaf pine) have well-developed taproots that extend deep into the soil, and their carbohydrate reserves are small.

Decreased growth and loss of vigor: Trees have existed in the South for a very long time. As a result, they have evolved and developed mechanisms to respond to water deficits caused by droughts. However, these mechanisms lead to cessation of photosynthesis and the production of carbohydrates (energy). At this point, growth stops, vigor is lost, and health declines.

Decreased resistance to insects and disease: Trees produce carbohydrate compounds to defend against insects and diseases. These compounds require a huge amount of energy to develop and move throughout the plant. In times of water deficits, carbohydrates are in short supply, defenses weaken, and trees become more vulnerable to insect and disease pests.

A drought-damaged crop tree. Courtesy of bugwood.org

Enhanced wildfire risk: Dry soils, low humidity, dry plant and litter materials, and high temperatures are prime conditions for wildfire. In addition, many forests have a build-up of excessive and heavy fuel loads resulting from improper management and the absence of frequent, low-intensity fires. Drought conditions increase the risk of these forest fuels igniting and spreading rapidly with increased intensity.

Impacts to wildlife: By affecting water availability and overall forest health, drought also influences wildlife. Drought indirectly limits the amount of browse, and hard and soft mast available for deer and other wildlife. Drought directly limits available water supplies such as creeks, ponds, and other sources. Lower production rates, outmigration, and even mortality are usually common in areas of extreme drought.

These drought effects can have huge negative economic, social, and environmental consequences. These impacts result in the potential for economic loss to the private landowner due to wildfire, lost productivity, and growth. Also, society and the regional economy can suffer indirectly due to decreased stumpage and forest product revenues, fewer recreational activities, and other losses.

WHAT CAN BE DONE ABOUT DROUGHT?

Maintaining forests in good health and vigor prior to drought will enable crop trees to resist water deficits. Appropriately stocked forests are best equipped to endure and recover from drought. Landowners can drought-proof their forests by favoring resilient management practices that reduce competition for water during dry spells and prolonged drought. Here are some tips for managing the forest:

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Being aware of La Niña and Bermuda High conditions -- which can help identify the onset of drought -- will allow forest managers and landowners to anticipate changes in a stand's condition.

- Forests often need management to enhance health and vigor. Proper silvicultural treatments can build carbohydrate reserves and enhance resistance to drought and other stressors.
- Monitor drought-sensitive areas (typically overstocked stands found on sandy soils and shallow, rocky, ridge-top soils) by looking for signs of drought stress, e.g., yellow or reddish needles, or early needle fall.
- Properly time your thinning, mechanical and chemical competition control, nutrient additions, and prescribed fire to promote forest health and resiliency.
- Prioritize areas to manage based on forest health and other management needs.
- Be proactive. Take action before drought stress risks loss of the entire forest.

For more details on how management practices help increase resiliency, especially during drought conditions, please visit PINEMAP.ORG.

FOR MORE INFORMATION...

Local climatologists are an excellent source of information about drought and other weather and climate-related data. They also may have access to tools to help understand past, present, and future climate trends. Local climatologists are often located within university departments or are housed at a state climate office (see table to the right), and each provides different services and resources, including:

- Historical weather and climate data
- State-specific drought monitoring information
- Maps of lawn-and-garden moisture index data
- Reference evapotranspiration estimates
- Maps of topsoil moisture conditions
- Graphs with the likelihood of big rain events

For more tools and resources, please visit these state-specific webpages:

State	Website
TX	http://climatexas.tamu.edu
LA	http://www.losc.lsu.edu
MS	http://geosciences.msstate.edu/statecli-matologist.htm
AL	http://nsstc.uah.edu/aosc
FL	http://climatecenter.fsu.edu
GA	http://extension.uga.edu/about/staff/index.cfm?pk_id=6711
SC	http://www.dnr.sc.gov/climate/sco
NC	http://www.nc-climate.ncsu.edu
VA	http://climate.virginia.edu

CONCLUSIONS

Drought has an impact on forest health and productivity in the southern US. Foresters and landowners can minimize risk and damage to their forested asset by incorporating sound management practices in a timely fashion. Good forest management can not only make stands more resilient to drought, but also improve growth rates and wildlife habitat.

To learn more about drought and to access useful drought indices and related resources, please visit the U.S. Drought Portal at:

http://drought.gov/drought/content/products/current-drought-and-monitoring

1. Click on the **Soil Moisture** and/or the **Standardized Precipitation Index (SPI)** to assess drought conditions for those critical times that forest management practices are being conducted, such as the planting season.
2. Click on the **Palmer Drought Severity Index** to assess long-term drought conditions.
3. Visit **Drought Termination and Amelioration** for information on how much precipitation is needed to end a drought:

http://www.ncdc.noaa.gov/temp-and-precip/drought/recovery.php

REFERENCES

Fekedulegn, D., R.R. Hicks Jr., and J.J. Colbert, 2003: Influence of topographic aspect, precipitation and drought on radial growth of four major tree species in an Appalachian watershed. Forest Ecology and Management 177, 409-425.

National Drought Mitigation Center (NDMC), 2013: What is Drought? Available at http://drought.unl.edu/droughtBasics/WhatisDrought.aspx

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