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Considering Long Term Drought When Prescribed Burning

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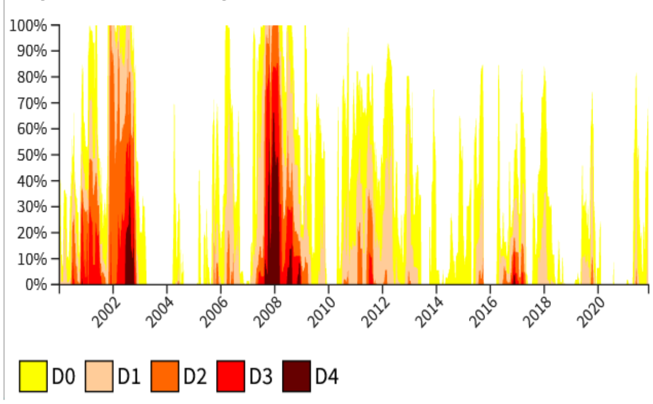
Drought

Periodic drought is common in North Carolina. The graph below (Figure 1) shows drought occurrence from 2000 to 2021 with yellow (D0) indicating abnormally dry and brown (D4) noting exceptional drought. The Y axis indicates the percentage of the state impacted.

Figure 1 -NC Drought 2000 – 2021



Prolonged drought adds stress to trees, weakening the health and resiliency of forested stands. Many management activities also add stress, including but not limited to thinning, prescribed burning, and pine straw raking. Prior events must be considered and current health evaluated before conducting a prescribed burn or implementing any activity that adds additional stress.

Prescribed Burning—Benefit vs. Risk

The NCFS promotes understory burning for the purpose of hazard reduction, aesthetics, wildlife habitat improvement, and for other silvicultural reasons. Burning, while beneficial, contains elements of risk to overstory trees. The art and science of burning requires that burn bosses consider temperature, relative humidity, wind speed, fuel type, fuel load, fuel availability, season, burning history, and firing technique. These parameters control the intensity and duration of heat, which if too intense, can damage valuable overstory trees. Despite responsible planning, unintentional scorching of tree crowns is all too common. Crown scorch (Figure 2) is often a factor in overstory crop tree mortality following prescribed burns.

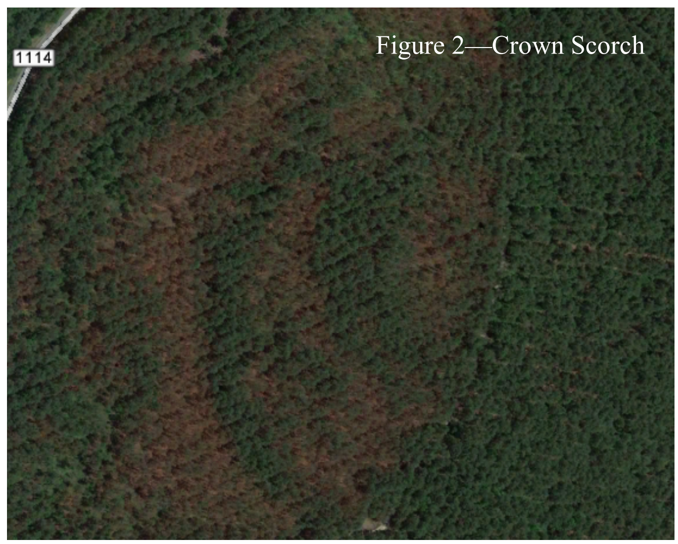


Figure 2—Crown Scorch

The Effects of Drought on Trees

"Water is essential for almost every plant function. When drought stress occurs, the plant reacts in many ways." (Blaedow 2013)

"Transpiration is the movement of water from the soil through the roots, stem, branches, leaves, and finally lost to the atmosphere. It is driven by negative pressure, like water being sucked through a straw. The loss of water from the leaves creates a suction that pulls water all the way through the tree from the soil. Water travels through elongated cells in the xylem (sapwood) that resemble straws. In hardwoods they are called vessels, in conifers they are called tracheids. The important thing to note is that this long column of water in vessels is under significant tension. If the water potential of the soil (the water available to be moved into the roots) becomes too low and the leaves are losing too much water, the water column can actually break. . . . . The larger the vessels diameter and the longer the water column, the more likely it is to break if soil moisture is inadequate." (Blaedow 2013)

"If the water column in the xylem breaks under this tension, an embolism forms. An embolism is an air bubble in the vessel. Once formed, water can no longer flow upward. This is devastating to the plant. If enough embolisms form in enough of the vessels, the plant will not be able to pull enough water out of the soil to survive. The formation of an embolism is known as "cavitation" or "hydraulic failure." (Blaedow 2013)

Signs of Physiological Drought Stress

- Wilting Foliage
- Wilting Stems
- Leaf Scorch
- Leaf Spotting or Chlorosis
- Early Fall Coloration
- Leaf Senescence
- Bark Cracking
- Stem Bleeding
- Dieback
- Reduced Growth
- Stunting
- Insect Attack
- Disease Spread
- Mortality

Increased Insect and Disease Due to Drought

"Plants under (drought) stress become more suitable as food for herbivorous insects and pathogens resulting in increased incidence and severity of outbreaks"(Blaedow, 2013)

"Drought stressed trees tend to have foliage that is more rich in nitrogen and soluble sugars, callus formation and compartmentalization are weakened, growth is slowed, resin production is reduced, and stressed trees give off many signals that pests can detect such as volatile compounds (e.g. ethanol and α – Pinene), increased foliage reflectivity, increased temperature, and there is even evidence that some insects can detect the sound of cavitation occurring in the xylem. Also, warmer temperatures during the winter allow greater overwintering survival of insects, and perhaps more generations per year allowing larger populations." (Blaedow 2013)

"However, there are other plant responses that would not seem to be good for insects and diseases. Drought stressed trees have increased amounts of toxins, especially in the foliage. Wood moisture can become so low it is not suitable as a food source. Insect predator and parasite populations can also increase drastically with warmer temperatures. Changes in climate may result in insect emergence at the wrong time for specific feeding, or emergence may be spread out over a longer period of time so that mass attacks are not effective. Drought stressed trees have smaller, stunted tissues that are not as good of a food source for many insects." (Blaedow 2013)

In sum foliage feeders, foliage diseases, and pests that require adequate soil moisture, do not benefit from drought conditions in trees, but sap feeders do. Pests like hypoxylon canker, bark beetles, and wood borers, thrive in drought conditions.

Other Stressors In Trees

Drought is not the only stressor for overstory trees. Other known stressors include:

- Overstocked stands are more stressed than properly stocked stands and tend to attract insects.
- Stands in old fields tend to have more *Ips* beetle problems than ones that were established on cutover land.
- Pine stands that have been raked for straw tend to have more *Ips* beetle problems than non-raked stands. Both loblolly and longleaf are affected by this.
- Stands are significantly more stressed if there has been prior crown damage from wind or ice storms.
- Stands established on eroded land are more stressed.
- Stands subjected to excess nutrient from agricultural field runoff, or subjected to overspray of agricultural chemicals, are more stressed.

Fire as a Stressor

Fire is a stress on overstory trees, but fire can range from a 6" backing fire to a raging head fire. Low intensity fire can be a minor stress, while intense fire can be terminal.

The burn boss has to apply burning techniques based on silvicultural knowledge of stand conditions. A healthy stand can easily withstand moderate understory fire, but a stressed stand may suffer from flames of much lower intensity. There are no easy "rules of thumb."

During the summer of 2011, the Ouachita National Forest in Arkansas experienced a severe drought during which the Keetch Byrum Drought Index (Keetch and Byram 1968) was over 700. The High Peak Wildfire burned almost 1500 acres between 29 July and 11 August 2011. The burn site was monitored for damage over the following two years.

"Following the High Peak Wildfire, which ignited from a lightning strike during drought conditions, midstory and overstory densities were significantly reduced between preburn and 1 year postburn. Overstory mortality 1 year postburn was higher than typical background mortality (Clark and others 2008, Klos and others 2009), but mortality from 1 to 2 years postburn was not significant. Overstory density in hardwood and pine-oak forests was reduced to 267 and 356 stems/ha, respectively, moving them closer to historical stand structures. At the same time, pine plantations experienced little mortality and retained an overstory density of 933 stems/ ha." (Figure 3) (McDaniel 2016)

This seems to show that, as you would expect, the drought and subsequent fire was harder on natural hardwood and mixed pine-hard wood stands than on managed pine plantations.

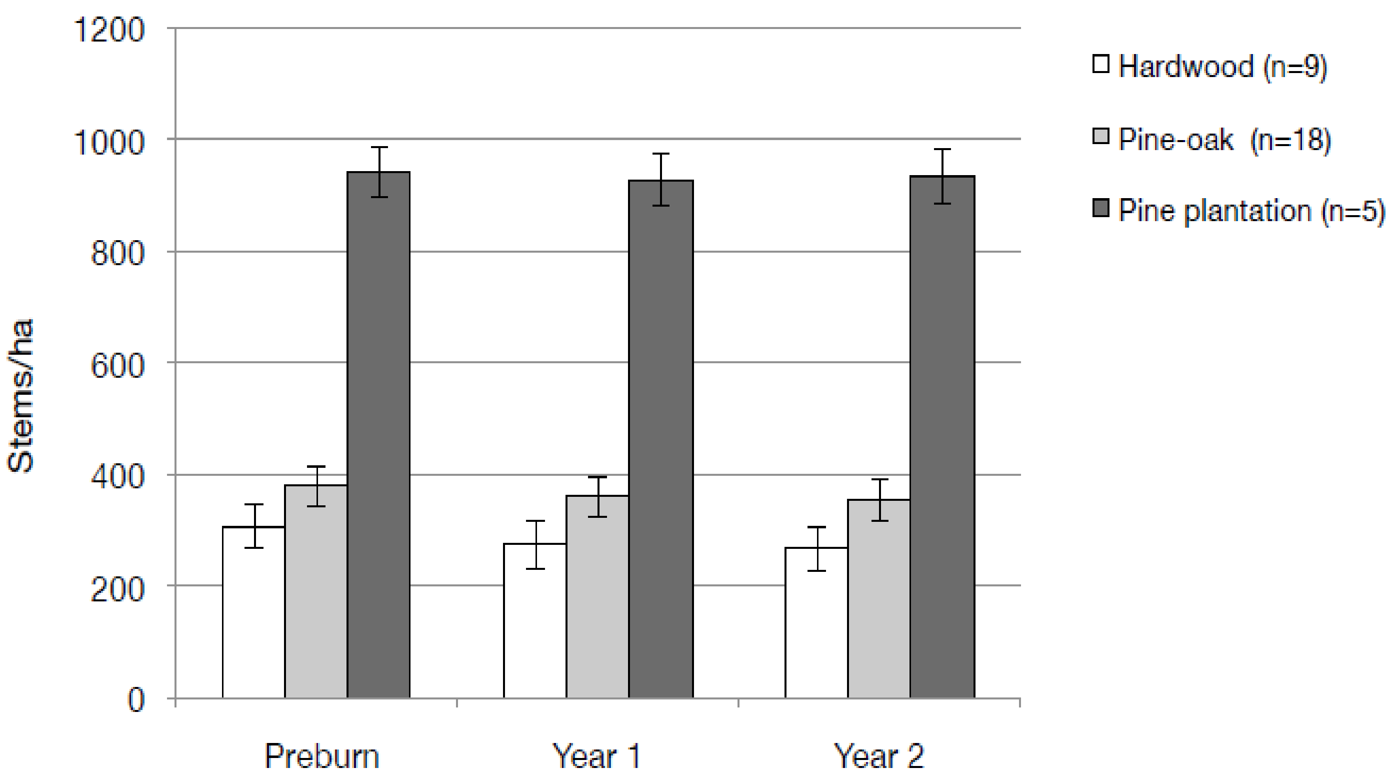
Caution

Without doubt, understory burning of sufficient intensity to top-kill understory plants has the potential to significantly stress trees in the overstory. The burn boss can partially mitigate this risk by choosing to burn the tract under "cooler" conditions . . . but only by accepting less understory control and less fuel reduction.

Before burning, the burn boss must do a complete size-up and determine if the stand is healthy enough to endure a moderate understory burn. This size-up should consider all stressors and all risks.

<u>Long-term drought adds one more risk factor to these burns.</u>

Figure 3— Midstory stem density by community type from preburn to 2 years postburn on plots on the High Peak Wildfire in Arkansas, 2011-2013 (McDaniel, 2016)



Two Case Studies from the NCFS Forest Health Branch

Case Study #1

In May of 2015 NCFS Forest Health staff were called by a consultant in Moore County. A late winter/ spring prescribed burn had recently been conducted that became a very hot head-fire in a mature, **well managed (BA =~40-50 sqft/ac)** and **frequently burned long-leaf stand.** The consultant was concerned that the hot fire had created "beetle bait" and neighboring *Ips* beetle populations would attack the stressed trees. This stand had a few trees attacked by *Ips* beetle over the years, but it was not a problem on this property—however, post drought *Ips* beetle outbreaks were abundant in the area. In the hot spots, understory longleaf pines were killed, some totally consumed. Mature trees were singed to the top. Buds were breaking on the mature trees and the new candles looked healthy. Immature longleaf were also recovering where the fire was not as hot. There was no indication of *Ips* beetle presence on the property. However, 19 trees (mostly red cockaded woodpecker den trees and trees previously cat-faced for turpentine production) were attacked by black turpentine beetle. Sap-flow in the larger trees was healthy as indicated by typical pitch tubes (Figure 4). The consultant was advised to wait and not conduct any additional treatments. The Forest Health staff assessed that *Ips* beetle wasn't likely to be a problem. As of February 2017 this assessment has been correct and very few mature trees have been lost.

Case Study #2

In the winter of 2015/2016, NCFS Forest Health staff were alerted to an *Ips* beetle outbreak at BLSF in a longleaf stand. The 56-year old stand had been thinned in 2012 (at the end of the drought) and burned in the fall 2015 (flame lengths were reported to be very low as the fire backed through the stand). **NOTE: the pre-thinned BA for this stand was 220 sqft/ac and the stand was thinned down to 90.**

Upon visiting the site, almost half of the standing trees were dead. Many of the remaining live trees were infested with *Ips* and/or ambrosia beetles. Pitch tubes (Figure 4) were lacking or very small, an indicator of heavy stress. The fire was blamed, but the situation was nuanced. Another nearby stand that had been thinned about the same time, and was burned in 2010 and 2014, had similar mortality. Both stands (totaling 54 acres) were salvaged."

Figure 4—Pitch tubes as seen in photo may not be as visible during times of drought due to reduced resin flow.

Figure 5—Crown Scorch

Conclusion of NC Case Studies

Why did the stand in Case Study #1 recover, but the Case Study #2 sites suffered catastrophic Ips beetle attack? Was it stress caused by the initial stocking? Short-term shock from thinning? Burning? Prolonged drought? Age? Likely, the answer is the combination of all of these stresses. This is known as cumulative stress—no single factor leading to mortality held the 'smoking gun', but all were contributors.

Considerations Following Drought

Evaluate the health and vigor of the stand. Go lightly (if at all) on the management (thinning and burning) during and directly after a heavy drought for stressed, unmanaged, poorly managed or overmature stands. Even in well managed stands, be cautious with management practices that cause short-term stress during, or immediately following prolonged drought. Healthy stands can withstand stress conditions better than stands that are already stressed. It's hard to make a blanket statement about management during stressful conditions because there are many factors involved.

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