WHAT 45 YEARS OF RLGS DATA HAS TO SAY ABOUT LONGLEAF PINE MORTALITY – NOT MUCH

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Abstract--The original longleaf pine (*Pinus palustris* Mill.) forest was self-perpetuating where seedlings always had to be present. It reproduced itself in openings in the overstory where dense young stands developed. These openings would range from a few tenths of an acre to large openings of several thousand acres. Regardless of the event size, longleaf pine was able to regenerate these openings. In 1964, the USDA Forest Service established the Regional Longleaf Pine Growth Study (RLGS) in the Gulf States. The original objective of the study was to obtain a database for the development of growth and yield predictions for naturally regenerated, even-aged longleaf pine stands. The study has been expanded over the decades to examine numerous aspects of longleaf pine stand dynamics. Landowners who have stands of large/old longleaf pine trees have fears they will lose them to some type of mortality before they can harvest them. For over 4 decades, the amount of mortality and its cause have been documented for the trees in the RLGS. One of the major causes of mortality has been suppression that happens among the smallest trees or trees that have been over-topped for several years. At the other end of the tree size class, larger trees are killed by lightning strikes. These events are low level and happen at low frequencies every year. Surprisingly, despite being among the most fire-adapted tree species in nature, fire can kill longleaf pine. So what kills longleaf pine trees and how often does it happen?

INTRODUCTION

Longleaf pine (*Pinus palustris* Mill.) dominated much of the south Atlantic forest in the late 1800s to early 1900s (Ashe 1894, Harper 1928, Mohr 1897, Sargent 1884). This forest was self-perpetuating where seedlings always had to be present. It reproduced itself in openings in the overstory where young stands developed. These openings would have ranged from a few tenths of an acre due to the loss of a single tree to a lightning strike or windfall, a few acres due to insects or a larger-scale wind event, to large openings of several thousands of acres due to tornados or hurricanes. Regardless of the event size, longleaf pine trees were able to regenerate these openings. The result was a park-like, uneven-aged forest, composed of many even-aged stands of varying sizes (Schwarz 1907).

The USDA Forest Service and academia recognized the importance of longleaf pine. Reed (1905) published an inventory of large parcels of forest in central Alabama where he found longleaf pine dominating nearly 80 percent of the area. Schwarz (1907) wrote one of the first books about a U.S. trees species. H. H. Chapman a professor of forestry at Yale University, who spent summers doing research in Mississippi and Louisiana, published several papers between 1907 and the mid-1930s (Chapman 1909, 1912, 1923, 1926, 1932). Research papers discussing longleaf pine regularly appeared in the Journal of Forestry, Ecology, and Ecological Monographs.

The mid-20th century brought about industrial forestry and plantation management. Longleaf pine acreage was decreasing rapidly, and there was very little regard for regeneration. Wahlenberg (1946), in his landmark text, devoted three chapters to the topic of longleaf pine regeneration, nearly one quarter of the book. In his introduction, he stated:

> "Where formerly it had complete possession of the land, it has often failed to reproduce; this failure has resulted in deterioration of land values in many localities."

The two major problems he identified for the frequent failure were: (1) fire, either too frequent and killing recent regeneration or too infrequent and allowing competitors to thrive; and (2) logging practices that left little or nothing on the ground or no seed trees. He summed this up by saying:

> "Mismanagement of longleaf pine has been the rule rather than the exception, due to ignorance of the unique life history and incomplete knowledge of factors

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> determining the life and death of seedlings and hence the succession of forest types."

Despite the renewed interest in longleaf pine, such as the effort of America's Longleaf Initiative (2009), we continue to lose the best-quality longleaf pine stands in structure and ground cover through the loss of natural stands on privately-held lands. Many landowners are fearful of losing their larger, older trees to lightning or some other catastrophic event. We need to maintain what existing stands are left, so it is important we get information to the people who have longleaf pine to educate them on how to maintain it and their options for the future. Do landowners and land managers need to worry about losing their longleaf pine? Some of the answers lie in a long-term study that has been documenting the cause of mortality in naturally regenerated longleaf pine stands across the Gulf Coast states. What kills longleaf pine and how often does it happen? This paper examines nearly 50 years of data to address these questions.

METHODS

In 1964, the Forest Service established the Regional Longleaf Growth Study (RLGS) in the east Gulf Region (Farrar 1978). The original objective of the study was to obtain a database for the development of growth and yield predictions for naturally regenerated, even-aged longleaf pine stands. Plots were installed to cover a range of ages, densities, and site qualities. The study consists of 305 permanent one-tenth and one-fifth acre measurement plots located in central and southern Alabama, southern Mississippi, southwest Georgia, northern Florida, and the sandhills of North Carolina. Plot selection was based upon a rectangular distribution of cells formed by six stand age classes ranging from 20 to 120 years, five site-index classes ranging from 50 to 90 feet at 50 years, and five density classes ranging from 30 to 150 square feet per acre. Several plots have been left unthinned to follow stand development over time.

Within this distribution are five time replications of the youngest age class. All these replications are located on the Escambia Experimental Forest in Brewton, AL. As a part of the RLGS, plots in the youngest age class were first established in 1964, and new sets of plots have been added in this age-class every 10 years. Plots are located to achieve similar initial site qualities and ages and are thinned to their target basal areas.

At the time of establishment, plots are assigned a target basal area class of 30, 60, 90, 120, or 150 square feet per acre. They are left unthinned to grow into that class if they are initially below the target basal area. In subsequent re-measurements, the plot is thinned back to the previously assigned target if the plot basal area has grown 7.5 square feet per acre or more beyond the target basal area. The thinnings are generally of low intensity and from below.

Net (measurement) plots are circular and one-fifth acre (14 net plots are one-tenth acre) in size surrounded by a similar and like-treated ½-chain-wide isolation strip with both surrounded by a ½-chain-wide protective buffer strip that receives extensive management. The measurements are made during the dormant season (October through March), and it takes 3 years to complete a full re-measurement of all plots. Each tree on the net plot with a d.b.h. (diameter at breast height) > 0.5 inches is numbered by progressive azimuth from magnetic north and has its azimuth and distance from plot center recorded. A systematic sub-sample of trees from each 1-inch d.b.h. class has been permanently selected and measured for height to the live-crown base, total height, and, if the tree is dominant or co-dominant, for age from seed.

The RLGS is re-inventoried every 5 years and is now in its 45th year re-measurement. At every re-measurement, each tree has its d.b.h. recorded to the nearest 0.1 inch, and crown class, utility pole class and length determined. Height measurements are made on the selected subsample of trees. In addition to the measurements made on living trees, if a tree dies, the cause of death is recorded. The causes of death are: lightning, insects, disease, wind, fire, suppression, and unknown.

Before getting into the results, a few caveats must be presented. The 5 years between re-measurements can make it difficult at times to determine the exact cause of death. If a tree died due to suppression and the stand was burned twice between the re-measurements, we may not find a "skeleton" despite having the azimuth and distance of the tree from plot center. A second factor is the thinnings conducted to maintain the plots at their assigned basal areas. These thinnings are from below and may remove trees that would have otherwise died due to some other cause. A final factor is the density on many of the RLGS plots. The “average” RLGS plot has 386 trees per acre with a range from 15 to over 1,800 trees per acre. The higher-density plots, which contain over 900 trees per acre, are outside the range of “normal” longleaf pine management.

RESULTS

Overall Mortality

Across the timespan of the RLGS, 1.3 trees per acre per year die. The major cause of death within the RLGS is suppression. Nearly 54 percent of the trees die due to being beneath the overstory canopy. Fire is the second highest cause of death with nearly 19 percent. Wind has killed 13 percent of the trees that have died. The remaining causes are insects, just over 7 percent, unknown with nearly 5 percent, and both disease and lightning causing just over 1 percent.

Suppression

Nearly six trees per acre per year were lost to suppression making it the major cause of mortality in the RLGS. In part, this was due to the density on many plots being well above those of most managed longleaf pine stands. In addition, some of the trees were removed because the plots were thinned when they exceeded their assigned basal area. These thinnings were from below and may have removed trees that ultimately would have died due to suppression. Nearly 90 percent of those trees dying because of suppression occurred on plots < 40 years old or on plots with > 1,200 stems per acre. Older trees on low-density plots did not die of suppression. However, regardless of age or site, suppression was a cause of death on plots with more than 140 square feet per acre of basal area. For the next portion of the paper, suppression was removed from the analyses because of its overwhelming impact.

In addition to the continual loss of trees each year due to suppression, there were waves of mortality about every 30 years where nearly 10 percent of the trees classified as suppressed died. While the density for the plot dropped noticeably, the loss of basal area or volume was minimal. The loss of these trees freed growing space and resources for the remaining trees and increased their growth. The first mortality wave happened when the trees were 30 to 35 years old and waves were seen again at ages 60 to 65 and 90 to 95. The lower the site index the longer it took for the wave of suppression to occur.

Lightning

The cause of tree death feared by many landowners, lightning, resulted in mortality of < one tree per acre per year. However, those trees hit by lightning were large, with over 95 percent of them classified as dominant trees on the plot; in other words, they served as lightning rods. Nearly 82 percent of this mortality happened on plots with < 60 square feet per acre of basal area (or 45 trees per acre).

Insects

Insects killed a little more than one tree per acre per year. Nearly 95 percent of the deaths due to insects were related to a lightning strike. Frequently, *Ips* beetles were attracted to the stressed tree, and the tree died due to the insect activity. In addition to the lightning-struck tree dying, a few trees around it that may have been connected through their roots were attacked by the beetles and died.

Wind

Mortality due to wind was very episodic and quite often is large-scale event. A little more than 1.5 trees per acre per year were lost to wind damage. Kush and Gilbert (2010) provided a description of the mortality to wind in their examination of the RLGS data after Hurricane Ivan. Trees growing in open conditions, adjacent to roads and fields, or recently released from a thinning operation were more susceptible to blow-down or breakage than were trees in denser stands.

Fire

Yes, fire killed longleaf pine and did so at a rate of nearly three trees per acre per year. The RLGS plots were supposed to be prescribe-burned every 3 years with cool season (winter) burns. Every now and then weather conditions (especially wind direction) changed, and fires became hotter than intended. There was no fire-related mortality on plots with a basal area < 45 square feet per acre.

Disease

The loss due to disease is very small, < one tree per acre per year. It is very similar to the mortality due to insects because like most trees that have been listed as dying due to disease, the tree had fusiform rust, and it snapped off at the cankered location.

Unknown
With 5 years between re-measurements, it was occasionally difficult to determine the cause of death. It appeared as if much of this mortality would have been due to suppression since quite often the tree could not be found.

Age Class Mortality
The RLGS data set was separated into 40-year age groupings to examine tree mortality. For trees < 40 years old, fire and wind were the major reasons for mortality. Lightning mortality increased with tree age. Insect mortality was higher in the younger age classes due to its relationship with fire mortality.

Density Class Mortality
Density was examined by separating the RLGS into basal area classes of < 45, 45 to 90, and > 90 square feet per acre. The major cause of mortality on the lower-density plots was due to wind, secondly to lightning. At the higher density level, fire was the major cause of mortality due to higher fuel loading.

Ten-year Periods and Mortality
The RLGS was broken into 10-year periods, 1964-1973, 1973-1983, 1994-2003, and 2004-present to see if there were any trends in mortality. There was no trend with lightning; in fact, mortality has dropped very slightly over time. Insect mortality was related to stressor events of wind and fire. Wind mortality was episodic and occurred with Hurricanes Fredrick, Opal, and Ivan. Trees dying from fire were found on young plots, < 30 year old, that burned hotter than intended.

DISCUSSION and CONCLUSION

A very high percentage of the mortality occurring on the RLGS plots over the past 45 years was related to some type of episodic event. There is nothing that can be done to prevent mortality from hurricanes and tornados. At best, from a management perspective, stands should not be opened up dramatically. The sudden release from surrounding and supporting trees leave the trees more susceptible to loss from a wind event. Losses from fire can be prevented or minimized by understanding fuel and day-of-burn conditions.

Lightning was not striking all of the trees older than 80-years old. In fact, the loss due to lightning strikes decreased over time since the mid-1960s. Landowners need not fear the loss of these valuable trees.

The one area where landowners and land managers can control mortality in longleaf pine stand is to minimize the loss due to suppression. Longleaf pine stands are very well-suited to frequent thinning as reported by Lauer and Kush (2011). These frequent thinnings can remove the potential suppression mortality before it happens by being pro-active instead of reactive. Nature managed longleaf pine by taking out a tree or two on a yearly basis to create openings that were then filled with regeneration. Why do we not manage longleaf the way nature did?

While much research focus shifted to loblolly and slash pine, this study survived despite threats from conversion, lack of funding, and natural catastrophic events such as tornados and hurricanes. Over the past nearly 50 years, the RLGS has provided much information for landowners and land managers. The RLGS is and has been an incredible resource and an underutilized wealth of information and knowledge about longleaf pine ecology and management. While not perfect, and no study is, the RLGS has data that cannot be found in any other study due to the combination of different age, site, and density classes. Hopefully, the RLGS will continue another 50 years, and it still will be just a small portion in the lifespan of one of these trees.

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