LONGLEAF PINE REGENERATION FOLLOWING HURRICANE IVAN UTILIZING THE RLGS PLOTS

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Abstract—On September 16, 2004, Hurricane Ivan hit the Alabama coast and severely impacted numerous plots in the U.S. Forest Service's Regional Longleaf Growth Study (RLGS). The Escambia Experimental Forest (EEF) has 201 of the 325 RLGS plots. Nearly one-third of the EEF was impacted. Nine plots with pole-sized trees were entirely lost. Another 54 plots had some type of damage. Following the hurricane, a salvage logging operation was conducted to recover any damaged merchantable timber, which created an opportunity to examine longleaf pine (*Pinus palustris* Mill.) regeneration and its development. Several regeneration-monitoring plots have been installed on the RLGS plots, and an initial inventory of the regeneration has been documented. The location of the monitoring plot, seedling density, and measurements of seedling size have been documented. With this information, longleaf pine regeneration and its development on plots impacted by Hurricane Ivan can be followed.

INTRODUCTION

Natural regeneration of longleaf pine (*Pinus palustris* Mill.) is one of the most important tools natural resource managers have at their disposal to regenerate existing longleaf pine stands in the Southern United States. However, adequate cone crops for natural regeneration typically occur every 5 to 7 years and often longer.

Longleaf pine ecosystems are considered to be in a perilous condition. A report by the U.S. Department of the Interior lists the longleaf pine ecosystem as the second-most threatened ecosystem in the United States (Noss 1989). The original longleaf pine forest was self-perpetuating. It reproduced itself in openings in the overstory where young stands developed. The result was a parklike, uneven-aged forest, composed of many even-aged stands of varying sizes. Wahlenberg (1946) described the original longleaf pine forests as made up mainly of pure, even-aged, irregularly open stands. The even-aged character was the result of relatively infrequent but heavy seedfalls and the ability of reproduction to survive only in openings free of an overstory.

Many of the factors governing the ability of longleaf pine to reproduce are obscure, and the innumerable ecological influences are so interrelated as to make their interpretation difficult. Solutions depend on understanding the prerequisites of the process, the characteristics of seed-bearing trees and longleaf pine seed crops, and the possible causes of failure after seedfall. Predicting seedling performance under varying levels of overstory competition is important for understanding the consequences of silvicultural systems.

One major regeneration problem is irregular seed production. Seed crops considered adequate for regeneration occur at 5- to 7-year intervals, on average, with exceptions. Longleaf pine is generally considered the most intolerant of the southern pines (Baker 1949). It is intolerant of competition from any source especially overstory competition. Survival and growth are closely related to longleaf pine's two unique silvical characteristics—its grass stage and its high resistance to fire. The grass stage usually lasts 4 to 5 years but may range from 2 to 20 years. If competing species are allowed to grow freely, they will completely dominate the site while longleaf seedlings are still in the grass stage. Once this has occurred, a longleaf pine stand can never regain dominance without some type of intervention. Unsatisfactory regeneration in longleaf pine forests may be attributed largely to the lack of management or unwise management. Mismanagement may be the rule rather than the exception, due to ignorance of the unique life history of the species and incomplete knowledge of factors determining the life and death of seedlings.

Research has been conducted on the Escambia Experimental Forest (EEF) since 1947. It is operated by the U.S. Forest Service (Forest Service) in cooperation with the T.R. Miller Mill Company in Brewton, AL. The EEF contains nearly 60 percent of the Regional Longleaf Pine Growth Study (RLGS) plots. From 1964 to 1967, the Forest Service established the RLGS in the Gulf States (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. The RLGS consists of 292 1/5-acre and 13 1/10-acre permanent measurement plots located in central and southern Alabama, southern Mississippi, southwest Georgia, northern Florida, and the sandhills of North Carolina. The plots are inventoried on a 5-year cycle and are thinned at each inventory, as needed, to maintain the assigned density level. Plots cover a range of age classes from 20 to 120 years, five site index classes ranging from 40 to 80 feet at 50 years, and five density classes ranging from 30 to 150 square feet per acre, with a new class recently added of "free to grow" to see what is the maximum density longleaf pine stands can attain prior to extensive mortality setting in. Densities are established and maintained by low thinning. The study accounts for growth change over time by adding a new set of plots in the youngest age class every 10 years. Within this distribution are five time replications of the youngest age class. All five replications are located on

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the EEF. Plots are burned once every 3 years in the dormant season (Kush and others 1987, 1998).

On September 16, 2004, Hurricane Ivan hit the Alabama coast and severely impacted numerous plots in the RLGS. Thirteen plots were entirely destroyed, where 9 of those plots had pole-sized trees >40 years old. Another 54 plots had some type of damage. Following the hurricane, a salvage logging operation was conducted to recover any damaged merchantable timber. Kush and Gilbert (2010) documented and evaluated the damage Hurricane Ivan caused on the RLGS plots. The damage done by Hurricane Ivan and the disturbance from the salvage logging operation allowed for an opportunity to examine longleaf pine regeneration and its development as a result of the openings created by the hurricane. The RLGS database contains a history of burn frequency, plot density, and the location of each tree on a plot. Several regeneration monitoring plots have been installed on the RLGS plots.

METHODS

All 13 of the destroyed RLGS plots were visited in the same dormant season. Monitoring plots were installed on these plots to document an initial inventory of the regeneration following the hurricane and salvage logging operation. The location of the monitoring plot, seedling density, and measurements of seedling size have been documented. With this information, longleaf pine regeneration and its development on plots impacted by Hurricane Ivan can be followed.

The RLGS plots are 0.2 acres in size. All trees on the plot with a diameter at breast height (d.b.h.) of 0.6 inches and greater were stem mapped, and the d.b.h. was recorded. To account for smaller regeneration, a regeneration subsample was taken. Four randomly selected subplots, 56 by 56 inches, were installed in each of the destroyed RLGS plots. All longleaf pine seedlings were counted and labeled as grass-stage seedlings, out-of-grass-stage seedlings, or saplings. Grass-stage seedlings were characterized as seedlings that had not initiated height growth. Seedlings out of the grass stage were characterized as having a root-collar diameter ≥1 inch and having initiated height growth. Saplings were characterized as having a d.b.h. <0.6 inches. In an effort to continue monitoring the visual aspects of the plots, photo points were also established at each plot center, and photos were taken facing each cardinal direction (north, east, south, and west).

RESULTS

The destroyed plots covered the range of basal area classes for the RLGS plots from 30 to 120 square feet per acre. Regeneration was found across all basal area classes, but the amounts and sizes varied. One plot was removed due to the amount of damage caused by the salvage logging operation. A plot in the 60-square-feet-per-acre class, which had been damaged by a tornado prior to Hurricane Ivan, originally had 120 square feet per acre. The tornado created openings or gaps for regeneration, which enabled regeneration to become established on the plot. This was the only plot where an overstory tree survived the hurricane and the salvage logging operation but died before this study was installed.

The plots were summarized by the average number of stems per acre by regeneration type. The average number of stems per acre was 1,708 grass seedlings per acre, 375 out-of-grass-stage seedlings per acre, 41saplings per acre, and 152 trees per acre. The plots were also summarized by the size of the trees recorded. Trees were recorded in the 1-, 2-, 3-, 4-, and 6-inch d.b.h. classes. The average number of trees per acre recorded in each d.b.h. class was 67, 30, 7, 1, and 0.4 trees per acre, respectively.

Since basal area provides a measure of density that relates to the amount of sunlight reaching the forest floor, the plots were also summarized by the maintained basal area classes prior to the two disturbances. The average number of grass-stage seedlings per acre recorded in the 30-, 60-, 90-, and 120-square-feet-per-acre basal area classes was 1,800, 2,750, 250, and zero grass-stage seedlings per acre, respectively. The average number of out-of-grass-stage seedlings per acre by basal area class included 200, 750, zero, and 500 seedlings per acre in the 30-, 60-, 90-, and 120-square-feet-per-acre basal area classes, respectively. Saplings were only recorded for one basal area class. The average number of saplings per acre for the 60-square-feet-per-acre basal area class was 125 saplings per acre. Trees were only recorded on the 30- and 60-square-feet-per-acre basal area classes with an average of 152 and 134 trees per acre, respectively.

Plots were also summarized by the remaining basal area following the hurricane and the salvage logging operation to determine if openings caused by the disturbances seemed to influence regeneration more than the previously maintained basal area classes. The residual basal areas were classified into five classes including zero, 10, 20, 30, and 40 square feet per acre. The average number of grass-stage seedlings per acre was 2,000, zero, 2,000, 3,334, and 500 for each basal area class, respectively. The average number of out-of-grass-stage seedlings per acre was 1,000, 167, 333, 333, and zero for the zero-, 10-, 20-, 30-, and 40-square-feet-per-acre basal area classes, respectively. Saplings were only recorded in the zero-square-feet-per-acre class with an average of 250 saplings per acre. The average number of trees per acre was 405, 32, 75, 55, and zero for the zero-, 10-, 20-, 30-, and 40-square-feet-per-acre basal area classes, respectively.

DISCUSSION

The amount of and type of regeneration varied across the maintained basal area classes and basal area per acre following the hurricane and the salvage logging operation. The RLGS does not account for regeneration. The plots undergo numerous disturbances like harvest operations to maintain basal area classes, natural mortality, weather damage, and prescribed fires. Therefore, it is not possible to determine exactly how old the regeneration is or how many cohorts exist on each plot. However, the basal area classes maintained in the RLGS provided an interesting way to look at regeneration following the disturbances. These findings show that, on average, grass-stage seedlings were the most abundant type of observed regeneration followed by out-of-grass-stage seedlings, trees, and then saplings. The saplings and trees, which only existed in the understory and midstory of the 30- and 60-square-feet-per-acre plots, had to be present before the hurricane. These densities and regular prescribed fire provided enough sunlight and bare mineral soil for seed to establish and grow. The high densities of 90 and 120 square feet per acre did not contain the large types of regeneration, but they did contain grass-stage and out-of-grass-stage seedlings. The majority of the out-of-grass-stage seedlings were likely grass-stage seedlings before the hurricane and were released after the overstory was damaged or removed by the two disturbances. Looking at the residual basal area classes following the disturbances does show that grass-stage seedlings were present across all of the residual basal area classes except the 10-square-feet-per-acre class. However, there is not a clear pattern showing the plots with no- or low-residual basal areas having the largest amounts of grass-stage seedlings. It is likely that many of the grass-stage seedlings were also present before the disturbances. The amounts and types of regeneration did not consistently show that as the basal area increased, the size and abundance of regeneration decreased or that the inverse is true. This is potentially due to the disturbances that have affected the plots like the 60-square-feet-per-acre plot that had earlier been affected by a tornado. These disturbances change the spatial distribution of the plots creating gaps from trees being removed or fire not carrying evenly across the plot. A more intense spatial analysis including trees surrounding the plots is needed to determine what is driving regeneration patterns.

CONCLUSIONS

The relationship between target basal area classes in combination with residual basal areas following the disturbances seem to be influential to the patterns of regeneration on the plots, but a more complex spatial dynamic exists. Regeneration was not seen in areas with thick patches of inkberry (*Ilex glabra* L.) and/or hardwood regeneration which suggests that gaps have been opened from other disturbances like prescribed fire, natural tree mortality, and harvest operations to maintain basal area classes. This also suggests the potential need to switch to growing season fires which can help control competing vegetation. Monitoring the plots will allow the opportunity to follow the progress of natural regeneration in the destroyed RLGS plots over time. The character of the ecosystem is best maintained with natural regeneration, using the processes that have long maintained longleaf ecosystems over the millennia. No phase of longleaf pine management presents more complex and critical problems than does its reproduction.

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