

IMPACT OF HURRICANE IVAN ON THE REGIONAL LONGLEAF PINE GROWTH STUDY: IS THERE A RELATION TO SITE OR STAND CONDITIONS?

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Abstract—The US Forest Service Regional Longleaf Pine Growth Study (RLGS) began its eighth re-measurement (40th year) during 2004 autumn. The study has 305 plots of which 171 plots are located on the Escambia Experimental Forest (EEF) in Brewton AL. EEF is operated by the U.S. Forest Service in cooperation with the T.R. Miller Mill Company. The RLGS has plots distributed across a range of age, site and density (basal area) classes. On September 16, 2004 Hurricane Ivan hit the Alabama coast and severely impacted numerous RLGS plots. Nearly 1/3 of the EEF was impacted. Thirteen plots, which had pole-size trees, were entirely lost. Another 125 plots experienced some type of mortality. The greatest damage was on plots with the lowest density or located near openings. Nearly 30 percent of trees greater than 80 years old had their tops snapped off. There was little relation between these site conditions and impacts from the hurricane.

INTRODUCTION

Numerous climate models are predicting global warming which will lead to more frequent and intense hurricanes for the Southeastern United States. These scenarios have serious implications for forest management. Several research papers have discussed the impacts of hurricanes to forested stands, including a compilation about the impacts from Hurricane Hugo (Haymond and Harms 1996).

In the very early morning of September 16, 2004, Hurricane Ivan came ashore near Orange Beach, AL, southeast of Mobile, AL with winds in excess of 120 miles per hour. It maintained hurricane force winds for the next several hours as it traveled through west-central Alabama. At 4:00 a.m. on the morning of the 16th, the eye wall of the hurricane was approximately 15 miles to the west of Brewton, AL, location of the Escambia Experimental Forest (EEF). Winds at a National Weather Service station located in Brewton had measured wind speeds of 120 miles per hour as the hurricane and associated winds passed through.

The EEF has been conducting longleaf pine (*Pinus palustris* Mill.) research since 1947 (Boyer and others 1997). It is operated by the US 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, Dr. Robert M. Farrar Jr., with the U.S. 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 AL, southern MS, southwest GA, northern FL, and the sandhills of NC. 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 the EEF. The project will complete its eighth re-measurement (40-year measurement) in spring 2007 (Kush and others 1987, 1998).

Work had begun on the eighth re-measurement of the RLGS when Hurricane Ivan struck. Nearly 60 percent (171 plots) of these plots are located on the EEF. Damage to the forest was extensive and within days T.R. Miller Mill Company began to salvage snapped, downed, and leaning trees. In the midst of the salvage operation, a visit was made to each RLGS plot to record the fate of each tree. These data will be summarized based on stand and site conditions.

METHODS

Notes were made for each tree on every RLGS plot. The tree was noted as alive or dead, if dead, was it due to being snapped off or was it tipped up. If it was snapped off, the height of breakage was estimated. If the tree was alive, notes were made to whether there was no apparent damage or if it was leaning or if it had a broken top. In addition, the trees were separated out by those that were of merchantable size, diameter at breast height (d.b.h.) greater than 7.0 inches, because these trees were the focus of the salvage operation.

The tree mortality and damage data were examined based on stand conditions. The RLGS plots on the EEF cover a range of six 20-year age classes from 20 to 120 years, three 10-foot site-index classes, ranging from 60 to 80 feet at 50 years, and five 30-square feet per acre density classes, ranging from 30 to 150 square feet per acre. In addition, soil type, plot aspect and percent slope were used to examine these data. Excellent information is available about the soils because the EEF was extensively mapped in the 1970s to aid Forest Service research. The RLGS plots are found on 10 different soil series.

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The predominant soil series are Troup (41 percent), Benndale (19 percent), Wagram (13 percent), and Esto (12 percent).

RESULTS AND DISCUSSION

Stand Conditions

Merchantable trees—It is estimated nearly 1/3 of the EEF was severely impacted by Hurricane Ivan. Thirteen RLGS plots were destroyed and 125 plots (73 percent) experienced some form of mortality. Only 26 (15 percent) plots had no visible impact. The thirteen destroyed plots contained all merchantable trees. In addition, 16 plots lost more than 50 percent of their basal area on plots with only merchantable trees. Only 15 plots of the 92 plots with merchantable trees had no visible impact.

Table 1 presents data collected on the RLGS trees impacted by Hurricane Ivan. The major cause of mortality among merchantable trees was caused by the top snapping off. The cause of mortality among merchantable trees was snapping off (9 percent) and another 4 percent were tipped up (blowdowns). Among the trees which snapped off, nearly 90 percent of the breakage occurred between 15-20 feet above the ground and not at the crown like might be thought.

The greatest loss of merchantable trees occurred on plots with the lowest basal areas (table 2). The more open plots and heavier crowns may have been the reason for the higher incidence of snapping off on the 30, 60 and 90 square feet per acre plots compared to the 120 and 150 square feet per

acre plots. As could be expected, the highest rate of tip-ups occurred on the lowest basal area plots and decreased with increasing density. The higher rate of broken tops on the 150 square feet per acre plots may have been due to the crowns of trees hitting each other.

More than 1/4 of all merchantable trees 80 years and older were snapped off on the RLGS plots as a result of Hurricane Ivan (table 3). The obvious explanation is these are the larger trees and in more open conditions making them the most vulnerable to the winds. Very little mortality occurred to those trees 40-years-old and younger.

There were no apparent relations between site index and impacts from the hurricane (table 4). Nearly 70 percent of the RLGS plots on the EEF occur on plots with an average site index in the 70-foot class. All plots over 80 years old are site index 70 which explains the higher rates of snapping on those plots compared to the site index 60 and 80 plots.

Non-merchantable trees—Very little damage occurred to the non-merchantable trees, those trees less than 7.0 inches d.b.h. On the youngest plots, age class 20, there is very little mortality. Broken tops were the major problem as nearly five percent of these trees experienced broken tops. The most impact came from trees that are now leaning and their fate is unknown. Over two percent of the trees in the 20-year age class are leaning, but on a few plots, more than 20 percent of the trees experienced severe enough lean that they probably

Table 1—Percent of all trees and merchantable (d.b.h. > 7.0 inches) trees sampled by the RLGS on the EEF impacted by Hurricane Ivan

Tree class	Snapped	Tip-up	Broken	
			Top	Leaning
	----- percent -----			
All Trees	4.3	1.1	4.9	2.2
Merchantable trees	8.9	3.9	5.4	1.7

Table 2—Percent of RLGS merchantable trees on the EEF impacted by Hurricane Ivan by basal area class

Basal area class (square feet/acre)	Snapped	Tip-up	Broken	
			top	Leaning
	----- percent -----			
30	12.9	7.2	0.0	3.2
60	11.9	5.4	0.8	0.6
90	14.3	5.2	4.7	1.2
120	5.9	3.2	4.7	2.1
150	6.2	1.7	13.9	1.7

Table 3—Percent of RLGS merchantable trees on the EEF impacted by Hurricane Ivan by age class

Age class (years)	Snapped	Tip-up	Broken	
			Top	Leaning
	----- percent -----			
40	0.8	0.0	6.3	0.5
60	7.6	4.8	6.1	2.8
80	29.9	7.3	8.8	1.5
100	25.6	10.4	1.8	2.1

Table 4—Percent of RLGS merchantable trees on the EEF impacted by Hurricane Ivan by site index class

Site index class (feet at base-age 50)	Snapped	Tip-up	Broken	
			top	Leaning
	----- percent -----			
60	8.3	2.5	7.4	0.0
70	13.6	4.4	5.4	1.1
80	6.4	3.7	5.2	2.1

will not recover. In all cases, the trees were leaning in a southeast-to-northwest direction.

Site Conditions

Percent slope was not a factor in the impacts from Hurricane Ivan to the EEF RLGS plots. Most of the EEF is relatively flat with slopes of zero to three percent for most of the forest. There appears to be a role with aspect as 7 of the 13 plots destroyed had an aspect classified as south-to-west. In addition, plots with a southwesterly aspect accounted for 20 percent of trees lost.

Among the major soil series, every plot on the Esto series experienced some type of mortality and 18 percent of the plots lost more than 50 percent of their basal area. The Esto soil series have the shallowest soils of the major soils series on the EEF. The Benndale and Wagram soil series were similar in the impacts from Hurricane Ivan. Nearly 94 percent of the plots experienced some type of mortality and approximately one-third of the plots lost more than 50 percent of their basal area. The Troup soil series, with the deepest A-horizon, experienced the least amount of loss. Only 50 percent of the plots had mortality with only 8 percent of the plots losing more than 50 percent of their basal area.

CONCLUSIONS

Hurricanes are chaotic events! There are no definitive findings about the impacts of Hurricane Ivan to the RLGS plots located on the EEF. It can be noted that 11 of the 13 plots destroyed were open to their east side. Nine of these 13 plots were adjacent to a woods road. These two findings indicated the plots more protected with other trees around them did better than those in an opening or with a lower basal area. The major management implication is to keep a higher density out there to protect stands. Unless there is

longleaf regeneration on the ground, once the overstory is lost, there is no hope of returning the site in longleaf unless the trees are planted.

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