CHAPTER 11.

Post-Hurricane Fuel Dynamics and Implications for Fire Behavior (Project SO-EM-F-12-01)

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INTRODUCTION

Hurricanes have long been a powerful and recurring disturbance in many coastal forest ecosystems. Intense hurricanes often produce a large amount of dead fuels in their affected forests. How the post-hurricane fuel complex changes with time, due to decomposition and management such as salvage, and its implications for fire behavior remain largely unknown. Therefore, the primary objective of the project was to study post-hurricane fuel dynamics and its effect on fire behavior by conducting field measurements and comparing fire behavior for undamaged stands and hurricane-damaged stands in southern pine forests. In addition, the project also examined the effect of post-hurricane salvage logging and the response of tree regeneration.

METHODS

We investigated four major hurricanes that occurred within the last 25 years, including Hurricanes Hugo (1989), Opal (1995), Katrina (2005), and Ike (2008) (fig. 11.1). We originally attempted to sample only areas without other major disturbances since the studied hurricane, but disturbances from prescribed fire could not be avoided because it is routinely applied to achieve multiple management goals in southern pine forests. As a result, among all sampled stands affected by hurricanes, only eight stands damaged by Hurricane Hugo were not burned after the hurricane, and the rest were periodically burned. To assess the impact of salvage, we also sampled three types of stands in the forests affected by Hurricane Katrina: damaged and salvaged, damaged and unsalvaged, and undamaged stands. Analysis of variance was used to test the differences in fuel loading and tree regeneration between hurricane-damaged and undamaged stands; among stands affected by hurricanes in different years; and among damaged and salvaged, damaged and unsalvaged, and undamaged stands (for Hurricane Katrina only). Based on the post-hurricane fuel dynamics observed in the study, we modeled potential fire behavior using BehavePlus (Andrews 2009).

RESULTS AND DISCUSSION

Fuel Loading and its Dynamics

After a hurricane, fuel accumulates drastically over a short period of time, then drops as time progresses and eventually stabilizes. Post-hurricane fuel loads were significantly elevated in the damaged stands when compared to undamaged stands. Although downed woody debris (all size classes) decreased over time, litter and duff depth remained relatively stable due to prescribed burning. The higher fuel loads in all size classes for Hurricane Hugo, the oldest hurricane investigated in the study, were likely caused by the absence of prescribed burning. Fine fuels (< 7.5 cm in diameter) declined through time, and stabilized after 8 years. Coarse fuels took longer to decompose and their decomposition was greatly facilitated by periodic prescribed burning. Direct consumption

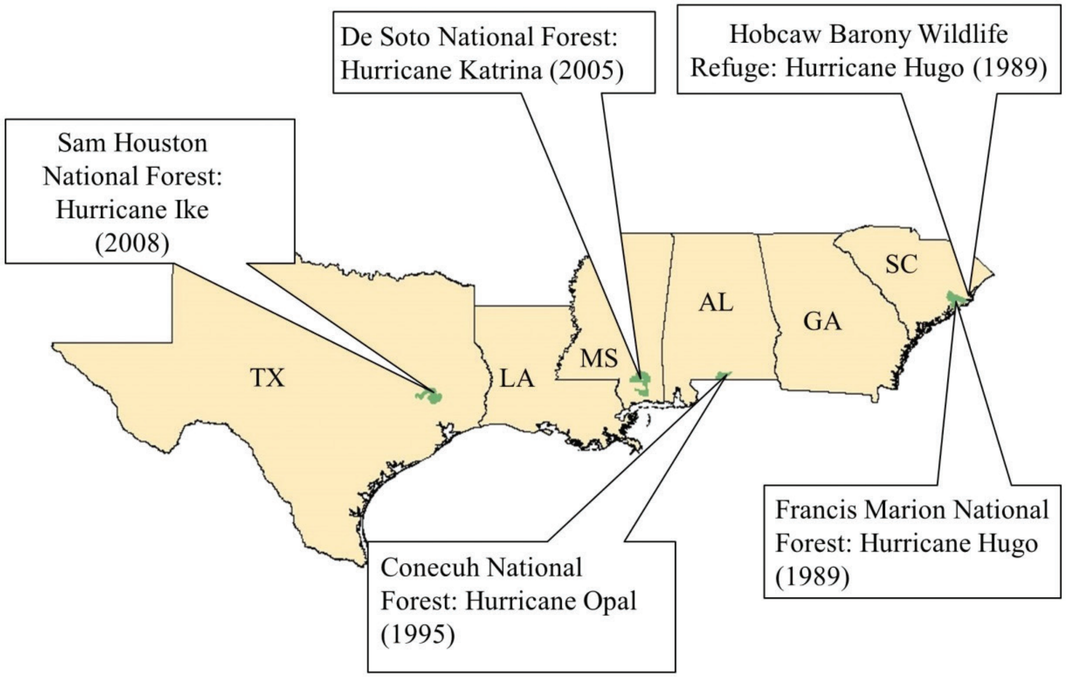

Figure 11.1—Location of study sites where field data were collected (Guan 2014).

of coarse fuels by fire is also possible depending on fuel moisture. It was estimated that the heavy fuel loading produced by hurricanes will require several decades to decompose without the addition of fire. With prescribed fire, heavy fuel loads will be consumed and decomposed within 18 years except for 1,000-hour fuels. Salvaging downed trees greatly reduced the fuel load and affected fuel dynamics. In salvaged stands, 1-hour (< 0.64 cm in diameter), 10-hour (0.64 to 2.54 cm in diameter), and 1000-hour (> 7.62 cm in diameter) fuel loads were significantly lower than those in unsalvaged stands. Even though prescribed fire consumed most of the fine fuels, additions from coarse woody debris decomposition likely act as a source of fine fuels. There was no difference in 100-hour (2.54 to 7.62 cm in diameter) fuels, which may be the result of periodic prescribed burning reducing fuel size.

Post-Hurricane Forest Regeneration

Intense hurricanes destroyed many trees in the forest canopy, and the resulting canopy gaps promoted forest regeneration. However, periodic prescribed fires after hurricane disturbance significantly suppressed the regeneration of those tree species susceptible to fire. For stands that were subjected to periodic prescribed burning, there were no significant differences in the density of small seedlings between damaged and control stands. Significant differences in large seedlings were observed between damaged and control stands for Hurricanes Ike and Katrina but not for Hurricane Opal. Given its fire adaptation, it was not surprising that significantly more longleaf pine regeneration was found in stands damaged by Hurricane Katrina. With the absence of prescribed fire after Hurricane Hugo, more tree regeneration was observed in damaged stands which led to elevated loblolly pine recruitment. Salvage in hurricane-damaged longleaf pine stands greatly reduced fuel loads and thus fire hazard, but did not impact the regeneration of longleaf pine.

Post-Hurricane Fire Behavior

Due to periodic prescribed fires, modeled fire intensities were mild regardless of the hurricane studied. Predicted fire behavior did not differ between damaged and control stands for Hurricanes Opal and Katrina, but it did for Hurricanes Ike and Hugo, where damaged stands had a higher rate of spread and a longer flame length than control stands. Lack of prescribed burning (Hurricane Hugo) and being the most recent disturbance (Hurricane Ike) were likely the causes of the observed differences in predicted fire behavior between damaged and undamaged stands. To evaluate our predictions from BehavePlus, fire behavior data from prescribed fires conducted after Hurricane Hugo were acquired. With comparable fuel loads, we found that the modeled fire behaviors were similar to those observed. Although we could not test the modeled fire behaviors for other hurricanes due to a lack of data, the low fire intensity that resulted from our modeling would be expected given that those stands were subjected to periodic prescribed burning. Our modeling study also suggested that, if some variables required in the model were not available from measurements, the fire model Southern Rough (Anderson 1982) could be appropriately applied to predict the fire behavior in most coastal pine stands, and especially in well-managed longleaf pine stands.

Effect of Mitigation Treatments

Mitigation treatments after a hurricane, such as salvaging and prescribing fire, reduce fuel load and thus fire hazard. Because of significantly lower 1-hour and 10-hour fuel loads, fires in salvaged stands were not predicted to be as intense as those in unsalvaged stands. However, fires in unsalvaged stands were also predicted as low intensity, probably due to periodic prescribed burning. Therefore, with periodic prescribed burning, salvaging hurricane-damaged stands may not be necessary for the purpose of reducing fire hazard. However, our data did not allow us to evaluate the immediate impact of salvage on fire hazard. Unlike other studies which found that mitigation impacted the regeneration of local climax species, mitigation treatments in our study did not compromise the regeneration of desired canopy species. In fact, we found more longleaf pine seedlings in salvaged stands than in unsalvaged stands. It is possible that there were enough longleaf pine seed trees left after the hurricane, and salvaging increased seed germination and establishment.

CONCLUSIONS

Our results indicated that the elevated fuel loadings from hurricane damage diminished gradually over time, and mitigation measures such as salvage operations, especially when combined with prescribed fire, greatly reduced the potential fire hazard while promoting the regeneration of longleaf pine. Therefore, salvage in combination with prescribed burning can be used as an effective strategy to restore longleaf pine forest after a hurricane while reducing fire risk at the same time.

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