

TITLE: Post-hurricane Fuel Dynamics and its Implication to Fire Behavior

LOCATION: National Forests in the Southern US

DATE: 2012 New Start

DURATION: Year 3 of 3-year project

FUNDING SOURCE: Fire Plan

PROJECT LEADER: G. Geoff Wang, School of Agricultural, Forest and Environmental Sciences, Clemson University, 864-656-4864, gwang@clemson.edu.

COOPERATORS: Laurie Reid, Forest Health Program Coordinator, SC Forestry Commission

FHP SPONSOR/CONTACT: Dale Starkey, Pineville, LA, (318) 473-7293, dstarkey@fs.fed.us

PROJECT OBJECTIVES: (1) To quantify fuels in stands severely damaged by hurricanes between 1989 and 2008 so that fuel dynamics (i.e., change with time since hurricane) can be characterized and compared with undamaged stands; (2) To assess the impact of post-hurricane mitigation treatments on fuel loading and forest regeneration; (3) To model fire behavior based on measured fuel data using BehavePlus so that the consequences of fuel changes due to natural decomposition and vegetation re-growth or mitigation treatments can be better understood.

JUSTIFICATION:

a. Linkage: Hurricanes are important and recurring natural disturbances along the Atlantic and Gulf coastlines of the US. Historical record indicated that more than 120 hurricanes have made landfall between Texas and Virginia in the past century. Analyses based on FIA data reported significant damage to forests by many major hurricanes. For example, Hurricane Hugo snapped off or uprooted ~70% of the merchantable pine canopy on the 250,000-acre Francis Marion National Forest.

b. Significance: The study covers six national forests from South Carolina west to Texas.

c. Biological impact: Severe damage due to major hurricanes such as Hugo can instantly produce significant mortality of canopy trees. As a result, dead fuel loading increases suddenly and dramatically, creating a serious fire hazard with potentially extreme fire behavior. Over time, this unique fuel complex will also change gradually due to decomposition and vegetation re-growth. However, few studies have quantified fuel characteristics of stands severely damaged by hurricanes, and none has studied the dynamics of this fuel complex. Moreover, how changes in fuels affect fire behavior remains largely unknown. Our project will use a combination of field measurements and modeling to study fuel dynamics and its implication to fire behavior in pine stands damaged by major hurricane events between 1989 and 2008. To reduce economic loss, salvage of downed timber has frequently occurred on hurricane damaged stands. In some cases, mechanical treatments and prescribed burning have also been used to reduce fire hazard. However, the effectiveness of these post-hurricane mitigation treatments in reducing fire hazard, and more importantly, how these treatments affect forest regeneration has not been studied. Our project will sample pine stands subjected to different post-hurricane mitigation treatments, based on which how different treatments affect fuel loading and forest regeneration will be assessed. Understanding fuel dynamics as well as effects of different mitigation treatments on fuel reduction and forest regeneration is essential for managers to make post-hurricane fuel management decisions.

d. Scientific Basis/Feasibility: Forests affected by hurricane have been identified. The methods used in the study are proven in the literature. Our research team has successfully conducted similar projects before, and has extensive experiences in field sampling, data analysis and publication.

e. Priority Issues: the project directly relates to “Fire risk and fuel loading”

DESCRIPTION:

a. Background: Hurricanes and fires are two of the most common disturbances affecting forests in the southern US. Increased hurricane activity has been reported for the past decade, and is believed to persist for several decades to come (Goldenberg et al. 2001). In addition to economic loss, hurricanes greatly increase fire hazard due to accumulation of extremely high fuel loading. Severe damage by hurricanes can produce near 100% mortality of canopy trees over a large area. Snapped off or uprooted trees deposit *in*

situ, creating a “jack-strawed” fuel complex. The opened canopy not only allows rapid drying of fuels but also causes an increase in the mid-flame windspeed. These changes are conducive to fires of extreme behavior. As a result, it has been hypothesized that the probability of a major wildfire increases significantly after a severe hurricane (Myers and Van Lear 1998). This hypothesis, also known as hypothesis of hurricane-fire interactions, has not been supported by recent data (i.e., the lack of a major fire outbreak after a recent hurricane strike) likely because of active fire suppression and post-hurricane mitigation efforts. In a recent study, Liu et al. (2007) found that major fires tended to occur within years or a few decades after a catastrophic hurricane based on a 1200-year proxy record of hurricanes and fires, suggesting that the elevated fire hazard after a catastrophic hurricane could last for a few decades. After Hurricane Katrina, several mitigation treatments (including salvage of downed timber (or 1000-hour fuel), mechanical treatments, and prescribed burning) have been applied in the Desoto National Forest (Bryant and Boykins 2007). Surprisingly, characterizing the fuel complex in hurricane damaged stands with or without subsequent mitigation treatments has not been studied, and how post-hurricane fuel complex changes with time, due to decomposition and vegetation re-growth, remains largely unknown. More importantly, we know practically nothing about how different mitigation treatments affect post-hurricane forest regeneration. Although prescribed fire is much more cost-effective in reducing post-hurricane fuel loading (thus the risk of intense and/or severe wildfire), most managers are reluctant to use prescribed fire because of the lack of knowledge of fire behavior. For example, large fuels, such as logs over 10 cm in diameter, can greatly alter fire behavior and smoke production. With detailed fuel data, fire behavior can be modeled under various burning conditions using BehavePlus (Andrews et al. 2003). The result should help managers to make informed decision on prescribed fire.

b. Methods: Our study areas will be national forests located in the southern US, where several major hurricanes have made their landfall between 1989 and 2008. Specifically, we will study Hurricane Hugo (1989) at Francis Marion National Forest, Hurricane Opal (1995) at Conecuh and Taladega National Forests, Hurricane Ivan (2004) at Conecuh National Forest, Hurricane Katrina (2005) at Desoto National Forest, and Hurricane Ike (2008) at Sam Houston National Forest. Together these hurricanes will form a 20-year chronosequence. For each studied hurricane event, 10 upland pine stands that were severely damaged will be identified based on existing records and aerial photos, with assistance of the local Ranger District office. In addition, 10 undamaged pine stands, with similar stand and site conditions as those damaged stands before the hurricane, will also be identified. Brown’s (1974) planar intersect method will be used to tally down woody fuels at four randomly selected points within each stand. Starting from each point, three 50-ft sampling transects will be established. The inner transect will be established in a random direction, and other two transects will be placed at $+22^\circ$ and -23° from the inner transect. Down woody fuels 0.00–0.25 in, 0.25 – 1.0 in, 1.1 – 3.0 in, and over 3 inches in diameter that intersected the sampling plane will be tallied as 1-, 10-, 100-, and 1000-h fuel classes. The 1000- h fuel will be recorded by species (pine or hardwood), diameter, and decaying class. Depths of fuel bed, litter and duff will be measured at three equally spaced points along each transect. Percent cover of herb (forb and grass) and woody species will be estimated in mil-acre plots centered at 0, 9, 18, 27, 36, and 45 ft along the inner transect. Counts of down woody fuel, depths of litter and duff, and covers of herb and woody species will be converted to dry weights using published equations. Fuel loading will be compared among different hurricane years using analysis of variance. Fuels in the hurricane damaged stands will also be compared to undamaged stands using a simple t-test along the chronosequence. Based on measured fuel data, fire behavior under various fire weather and fuel moisture conditions will be modeled using BehavePlus. Fuel and fire behavior data collected by Wade et al. (1993) and Myers (1996) for Hurricane Hugo will be acquired and used to evaluate predictions from BehavePlus. Under each modeled burning condition, changes in fire behavior along the chronosequence will be quantified and compared to undamaged stands.

At the Desoto National Forest, 40 hurricane damaged pine stands, 10 each subjected to salvage, mechanical treatment, prescribed burning, or no treatment, will be sampled to measure fuel loading and forest regeneration. Fuel measurements will be conducted using the same method described above. Small (<1 ft tall) and large (> 1 ft tall but diameter at breast height (DBH) < 1 in) seedlings will be tallied by species on each mil-acre plot. DBH of saplings/trees (DBH > 1.0 in) will be measured by species on a 0.1 acre plot centered on each fuel sampling point. A small subset of tree regeneration over the entire size

range will be sampled, destructively or by tree core, to determine age and annual diameter growth. Fuel and tree regeneration data will be compared across treatments using one-way analysis of variance.

c. Products: A poster will be presented at FHM workshop, a MS thesis and a final report will be produced, and two manuscripts will be submitted for publication in refereed journals.

e. Progress/Accomplishments: Since starting in September 2012 when funding was received by Clemson University, we have made significant progresses. Currently, we have assigned a lab technician and a graduate student (Mr. Shanyue Guan) working on the project. Up to now, we have searched and acquired available data on past hurricanes, and finished field sampling of hurricane Hugo in Hobcaw Barony and Francis Marion National Forest with 12 plots (23 sampling points) for damaged stands and 12 plots (18 sampling points) for undamaged stands. We have also started to sample Conecuh National Forest for Hurricane Opal. So far, we have sampled 10 plots (20 sampling points) for damaged stands and 10 plots (20 sampling points) for undamaged stands. Additionally, we have also discussed with Dr. Tara Keyser, a research forester with USFS SRS, about collaborating on a long-term study on the decomposition of down logs originated from hurricane Opal. With a project ending date of August 2015, we should accomplish the work originally proposed. The original schedule of activities is: **Year 1:** Search and acquire available data; identify sample stands; collect data in the national forests affected by Hurricanes Hugo, Opal and Ivan. **Year 2:** Start modeling work using data collect in year 1, test model predictions using published prescribed fire data after hurricane Hugo, collect data in the national forests affected by hurricanes Katrina and Ike. **Year 3:** Complete modeling work; analyze data; prepare poster, final report, and two manuscripts. Activities proposed for Year 1 is largely accomplished, with some unfinished field sampling being conducted right now. Activities in year 2 are just underway.

Costs: (*Please transfer the requested funds to SC Forestry Commission.

	Item	*Requested FHM EM Funding	Other-Source Funding	Source
Year 3				
Administration	Salary	\$27,260		
	Overhead	\$0		
	Travel	\$3,500		
Procurements	Supplies	\$1,000		
	Total	\$31,760		

f. Literature Cited:

Andrews, P.L. et al. 2003. BehavePlus fire modeling system Version 2.0: User’s Guide. Gen. Tech. Rep. RMRS-GTR-106WWW. Ogden, UT: USFS, Rocky Mountain Research Station. 132p.

Brown J.K., 1974. Handbook for inventorying downed woody material. USDA For. Serv. Gen. Tech. Rep. INT-16.

Bryant, D. and J. Boykin. 2007. Fuels Management on the National Forests in Mississippi after Hurricane Katrina. Proceedings RMRS-P-46CD. Fort Collins, CO: USFS, Rocky Mountain Research Station. pp.287-292.

Goldenberg, S.B. et al. 2001. The recent increase in Atlantic hurricane activity: Causes and implications. Science 293: 474-479.

Liu, K.-b., et al. 2008. A 1200-year proxy record of hurricane and fire from the Gulf of Mexico coast: Testing the hypothesis of hurricane-fire interactions. Quat. Res. 69: 29-41.

Myers, R.K. and D.H.Van Lear. 1998. Hurricane-fire interactions in coastal forests of the South: a review and hypothesis. Forest Ecology and Management. 103: 265-276.

Myers, R.K. 1996. Coastal plain forest community response to hurricane –fire interactions. Ph.D. dissertation. Clemson University, Clemson, SC. 238p.

Wade, D.D. et al. 1993. Photo series for estimating post-hurricane residues and fire behavior in southern pine. Gen. Tech. Rep. SE-82. Asheville, NC: USFS, Southeastern Research Station. 19p.