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Photo Series for Estimating Post-Hurricane Residues and Fire Behavior in Southern Pine

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Abstract

Following Hurricane Hugo, fuels were sampled on nine 2-acre blocks which were then burned during the spring wildfire season. The study was superimposed on dormant-season fire-interval research plots established in 1958 on the Francis Marion National Forest near Charleston, SC. Photographs of preburn fuel loads, fire behavior, and postburn fuel loads were taken to visually depict the fire intensity associated with differing hurricane-generated fuel loads. These photo sequences enable the reader to compare actual fire behavior and consumption with preconceived mental images.

Keywords: South Carolina, fuel consumption.

Introduction

More than 120 hurricanes have made landfall between Texas and Virginia in the last 100 years, nearly all of which could have caused catastrophic damage to forests. But it was not until September 1989, when Hurricane Hugo came ashore over the Francis Marion National Forest in South Carolina, that the awesome ramifications of this potential were fully understood. Hugo created a swath of destruction across South Carolina and into North Carolina before finally dissipating. It snapped off or uprooted about 70 percent of the merchantable pine canopy on the 250,000-acre Francis Marion and produced a dramatic increase in dead-fuel loading. The fire-prone understory flourished in response to increased sunlight and decreased competition for nutrients that resulted from removal of the overstory, further exacerbating the situation.

Fire managers faced formidable challenges. Tractor-plows, the mainstay of fire suppression, became ineffective overnight. Insufficient data existed to adequately predict fuel loading and fire behavior, or to plan for the types and numbers of suppression forces needed. Prescription underburning was the traditional method used to set back the unremitting buildup of hazardous fuel loads. But in the absence of hard data to show that prescribed fires could be used safely in the aftermath of Hugo, the State of South Carolina asked for a 1-year ban on all prescription burns. That winter, the Southern Forest Fire Laboratory proposed a study to quantify the hurricane-generated fuel complex and assess attendant fire behavior during the exclusion period.

Southern Forest Fire Laboratory personnel had installed a long-term prescribed fire study on the Francis Marion in 1958 which would serve as an excellent location for the proposed study. Overstory pines on this 40-acre site were about 65 years old when Hugo struck. Extensive information on fuels and fire behavior is available for the twenty 2-acre plots (five treatments x four replications). Except for the controls, burning had taken place at 1-, 2-, 3-, or 4-year dormant-season intervals. Plots with 1-, 2-, and 3-year roughs had been scheduled for burning during the 1989-90 dormant season. Longleaf pine (*Pinus palustris* Mill.) dominated the overstory on the 6 driest plots, while loblolly pine (*Pinus taeda* L.) dominated the other 11 (3 plots were inactive). Pond pine (*Pinus serotina* Michx.) was a common associate, joined on the unburned plots by midstory hardwoods including red maple (*Acer rubrum* L.), blackgum (*Nyssa sylvatica* Marsh.), and oak (*Quercus* spp.). Common understory species varied by burning regime. They included bluestems (*Andropogon* spp.), switch cane (*Arundinaria gigantea*), sweet pepperbush (*Clethra alnifolia*), myrtles (*Myrica* spp.), gallberry (*Ilex glabra*), lyonias (*Lyonia* spp.), blueberries (*Vaccinium* spp.), and huckleberries (*Gaylussacia* spp.).

Our proposed study was approved by the Francis Marion and agreed to by the State. This plan involved burning the plots as scheduled during the spring wildfire season by using strip headfires to simulate wildfire behavior. The primary objective was to develop a fire behavior photo series under spring wildfire conditions to help fire managers facing similar situations in the future.

With a series of photos, the reader can visually relate given combinations of fuel weight and weather to fire behavior. Guidelines for photographing various levels of natural and postharvest forest residues are available (Fischer 1981, Maxwell and Ward 1980) as well as numerous examples of photo series (such as Lynch and Horton 1983, Maxwell and Ward 1976). Alexander and De Groot (1988) present photos of fire behavior under selected burning

conditions, and Sanders and Van Lear (1988) present preburn and postburn photos that show a range of residue fuel loading/weather combinations. Our publication differs from these in that it combines photographs of preburn and postburn fuel loads with those of fire behavior on the same area. The juxtaposition provides a bridge between prefire and postfire fuel loads and allows readers to compare their preconceived mental images with actual fires. Readers should bear in mind, however, that the photos depict strip headfires which may not have achieved steady state before running into the previous strip.

Methods

Pre-Hugo Fuels

Estimation of pre-hurricane (background) fuels followed our usual procedure for the study area; six quarter-milacre subplots were randomly established on each of the 2-acre treatment plots. All down-and-dead fuels less than 3 inches in diameter were collected, placed in one of seven categories (see fuel weight headings accompanying each set of photographs), ovendried, and weighed. All live vegetation less than 1 inch basal diameter originating in the subplots was clipped, ovendried, and weighed. After the burns, six more quarter-milacre subplots were randomly located on each treatment plot and the fuel sampling procedure repeated.

Hugo-Created Fuels

Foliage and branchwood still attached to tree crowns that fell during Hugo were sampled separately by establishing a 1/8-acre triangular subplot (approximating the field of view of a camera positioned at the triangle apex) on each treatment plot to be burned (Sanders and Van Lear 1987). Downed woody fuels were inventoried by size class along 16 systematically located line-transects in each subplot. Measures of foliage, forest floor depth, maximum fuel depth, and branchwood by size class were recorded both before and after the fires following procedures outlined in Brown (1974).

Hurricane damage varied considerably across the study area as it did across the Forest. This variation coupled with fuel differences related to the burning cycle made it advantageous to rank the plots by fuel loading and place them in one of three broad levels: light (12 to 17 tons/acre), moderate (19 to 22 tons/acre), or heavy (29 to 36 tons/acre). Rankings were based on the sum of all layers of the forest floor (litter, fermentation, and humus), all dead materials 3 inches in diameter or smaller, pine cones, and all live vegetation less than 1 inch in basal diameter. Although excluded from this selection process, sound and rotten dead fuels larger than 3 inches in diameter were inventoried; estimated weights can be found in the data given with each photo series. Estimates of postburn weights of these large fuels exceeded preburn estimates on some plots, suggesting that our sampling scheme for this size class did not include enough replicates.

The burns—each involving about 10 people, an engine, and a tractor-plow unit—took place between April 19 and May 3, 1990, as spring greenup signaled the end of the wildfire season. Plots were burned one at a time with mopup fairly complete on one plot before the next was ignited. The procedure we followed on each plot was to blackline the downwind side using a backing fire and then burn the remainder of the plot with strip headfires. Most triangular subplots burned with a single strip. There were no control problems.

Preburn and postburn photos were taken from permanent photo points on each plot as well as from the top of a 9-foot stepladder facing each triangular subplot from its apex. Photographs were taken during each burn to show fire behavior, but none were taken from the ladder, which was removed during the fires.

Results and Discussion

Accompanying the photos are tables that provide stand information, fuel weight by size class, forest floor depth, onsite fire weather observations, rate of spread, fuel consumption, and crown scorch height for the plots. Crown scorch and total tree height of the 10 largest trees were measured on each triangular plot. Leaners were excluded because of the strong possibility that their taproots had snapped during Hugo. Such trees might still have green foliage but may have lost enough needle moisture to produce atypical crown scorch.

An automatic portable weather station was set up onsite to record measurements during the burns, but was removed over weekends. A permanent weather station, located on the Witherbee Ranger District about 10 air miles away, provided precipitation and Keetch-Byram Drought Index (also called the Cumulative Severity Index) values. Data from this station were not archived during the spring of 1990, however, so National Fire Danger Rating System (NFDRS) components and indexes could not be calculated. Fireline intensity ranged from a low of 105 Btu per second per foot without debris to a high of 2,440 Btu per second per foot with debris, but these calculations were not included; to do so would suggest a degree of accuracy not warranted by the wide variability in Hugo-generated debris and resultant fire behavior. However, the tables accompanying the photographs contain all the information needed to calculate the various measures of intensity based on flame length or fuel consumed.

One burned plot (3C) is not included because after the first strip head was ignited, firing was interrupted so that onsite-control forces could respond to an emergency elsewhere on the Forest. The remainder of the plot burned with a low intensity (50 Btu per second per foot) backing fire, excluding it from the study but demonstrating that such fires can safely reduce hazardous fuel complexes without damaging overstory trees.

We did not try to determine if heading fires could accomplish prescribed burning objectives under marginally wet conditions. Nor did we address the other end of the spectrum, where dry conditions would have required different fire suppression tactics and where the overstory would have been severely damaged or destroyed. As it was, surveys showed some mortality occurred in both treated and untreated study area plots during 1990. The strip headfires undoubtedly exacerbated stress to these trees, but the effects of any fire-caused damage could not be reliably separated from the lingering effects of Hugo. The fact that most of the overstory survived the additional stress caused by these fires attests to the resiliency of southern pines.

Summary

Based on our observations of fire behavior and effects during this study, we believe that the immediate and extensive use of prescription fire to reduce fine-fuel loadings would be the most appropriate fire management action in the wake of catastrophes similar to Hugo. The fire season that followed Hugo was not severe due to abnormally wet weather. The usual number of wildfires, most of which are attributed to carelessness, did not materialize; perhaps because of a massive fire prevention campaign conducted by the State of South Carolina (Saveland and Wade 1991). However, the weather could have just as likely been droughty, which when coupled with high winds and a chance ignition could have started a wildfire beyond the capabilities of any suppression force.

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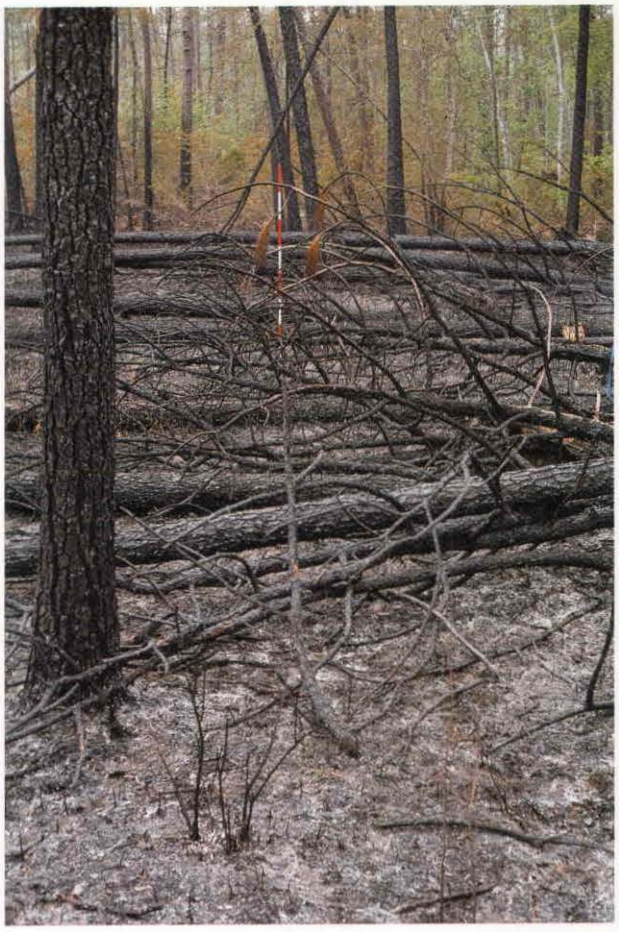


Plot 3D (heavy plot)

Ignited 1420 on 4/19/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	Dead Branchwood (2)	Dead Branchwood (3)	Cones	Live Fuel (4)	Total
preburn	2.30	5.95	17.24	0.22	3.55	5.52	0.29	1.40	36.47
postburn	0.00	2.62	00.00	0.06	1.46	3.27	0.19	0.25	7.85
consumption	2.30	3.33	17.24	0.16	2.09	2.25	0.10	1.15	28.62
% consumption	68		100	73	59	41	34	82	78

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	45.40	0.89
postburn fuels more than 3 inches diameter	45.76	0.98

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	379	274	10.3	10.2	84	42-100	146	111
hardwood	101	96	1.4	1.5			2	2

Burning Conditions

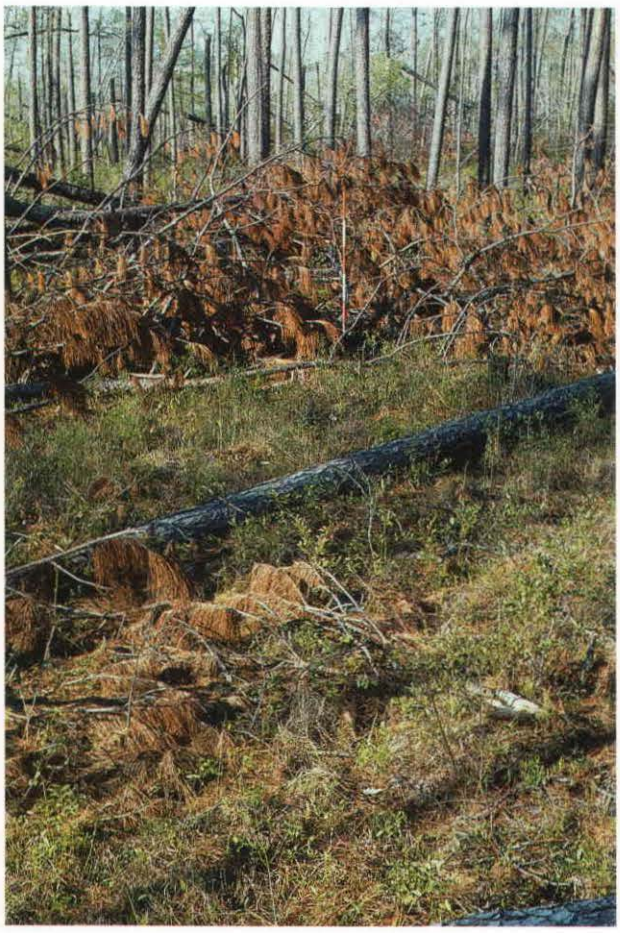
		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		69	
relative humidity (%)		55	
in-stand windspeed at 6 feet (mi/h)	average:	1	
	maximum:	2	
upper litter layer moisture content (%)		14	
debris foliage moisture content (%)		15	
live switch cane moisture content (%)		90	
date and amount of last precipitation (in)			4/14/90 0.40
Keetch-Byram Drought Index (CSI)			137

Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	17	6-33
rate of spread (ft/min)	in debris	23	18-48
flame length (ft)	no debris	3	2- 6
flame length (ft)	in debris	16	3-40

Crown Damage

	Mean	Range
scorch height (ft)	77	42- 97
percent of crown scorched	92	73-100



Plot 2A (heavy plot)

Ignited 1643 on 5/1/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	(2)	(3)	Cones	Live Fuel (4)	Total
preburn	2.96	3.05	11.74	0.30	3.55	6.76	0.21	0.47	29.04
postburn	0.00	1.10	00.00	0.03	0.94	5.52	0.10	0.15	7.81
consumption	2.96	1.95	11.74	0.27	2.61	1.24	0.11	0.32	21.23
% consumption	82		100	90	74	18	52	68	73

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	36.06	0.10
postburn fuels more than 3 inches diameter	30.34	0.10

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	360	187	11.8	11.1	87	68-101	192	88
hardwood	0	0					0	0

Burning Conditions

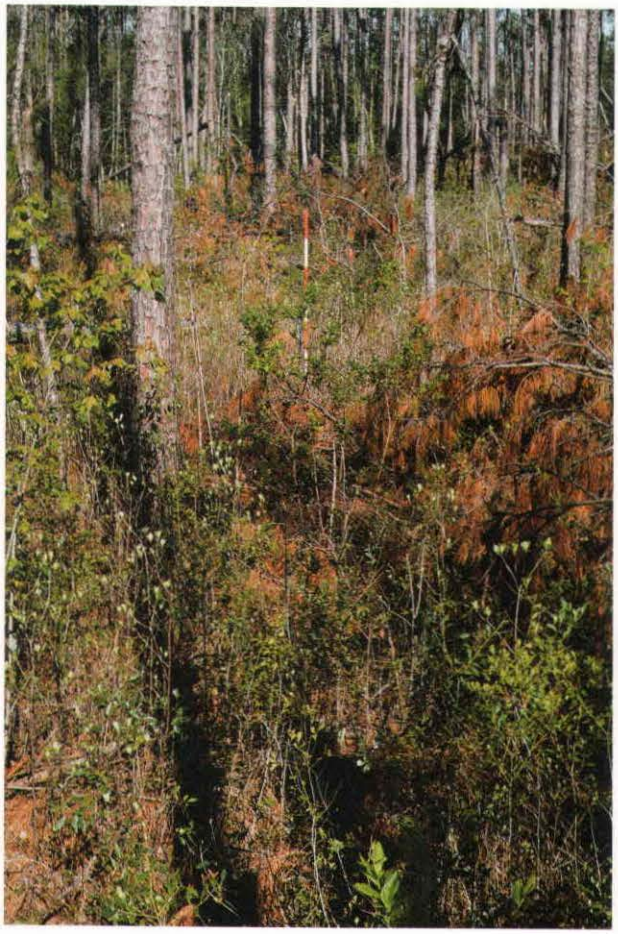
		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		87	
relative humidity (%)		57	
in-stand windspeed at 6 feet (mi/h)	average:	2	
	maximum:	7	
upper litter layer moisture content (%)		11	
debris foliage moisture content (%)		12	
lower litter layer moisture content (%)		18	
live switch cane moisture content (%)		151	
date and amount of last precipitation (in)			4/29/90 0.79
Keetch-Byram Drought Index (CSI)			258

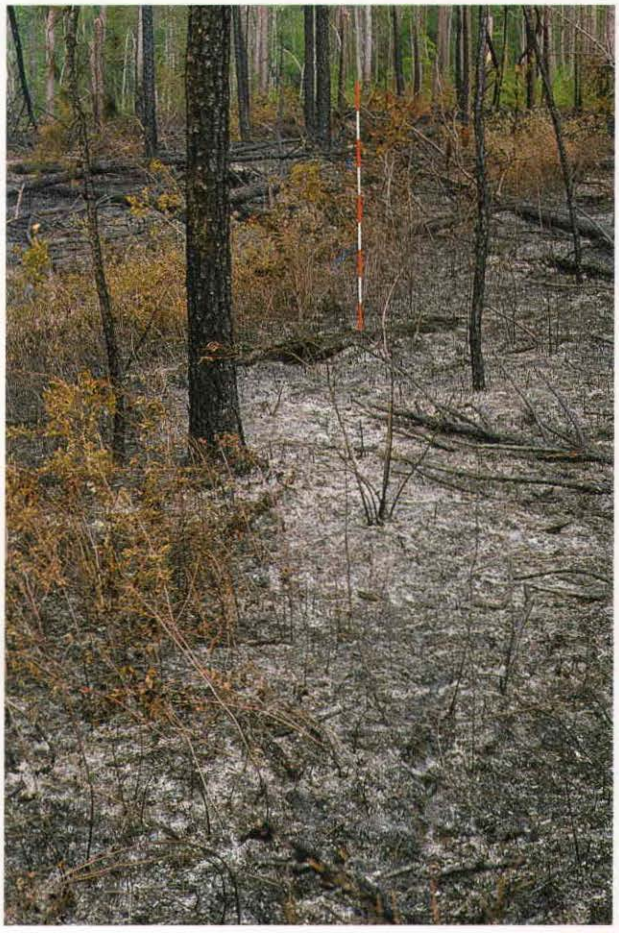
Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	19	14-36
rate of spread (ft/min)	in debris	23	21-90
flame length (ft)	no debris	3	1- 8
flame length (ft)	in debris	16	3-20

Crown Damage

	Mean	Range
scorch height (ft)	75	61-88
percent of crown scorched	87	79-95





Plot 3B (heavy plot)

Ignited 1136 on 5/2/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	Dead Branchwood (2)	Dead Branchwood (3)	Cones	Live Fuel (4)	Total
preburn	1.90	3.90	14.89	0.61	3.47	3.38	0.10	0.72	28.97
postburn	0.00	1.44	00.00	0.08	0.69	1.92	0.03	0.25	4.41
consumption	1.90	2.46	14.89	0.53	2.78	1.46	0.07	0.47	24.56
% consumption	75		100	87	80	43	70	65	85

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	31.60	3.62
postburn fuels more than 3 inches diameter	33.04	2.96

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	307	149	10.7	8.9	81	72-86	141	58
hardwood	5	5	1.6	1.6			1	1

Burning Conditions

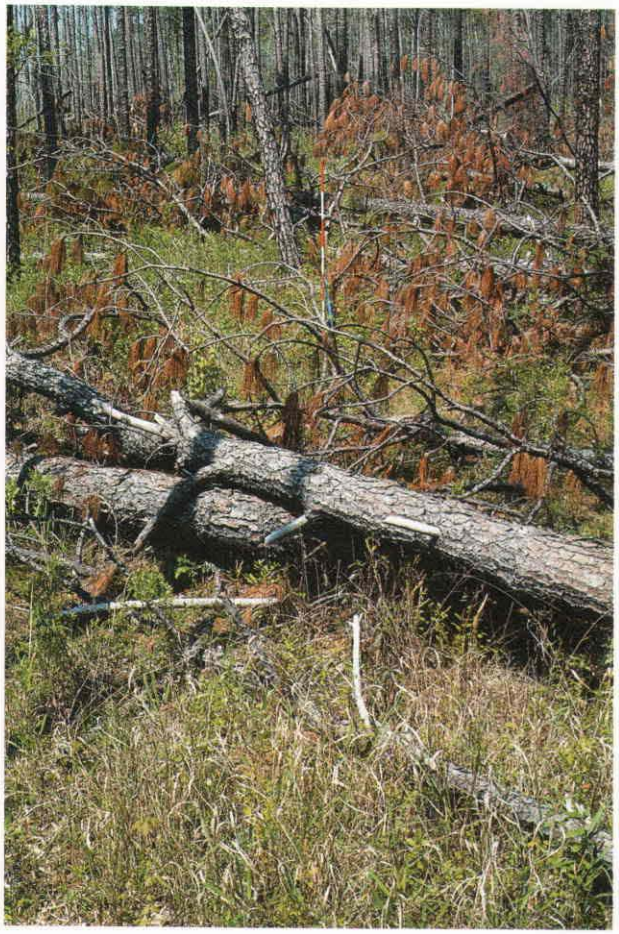
		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		92	
relative humidity (%)		40	
in-stand windspeed at 6 feet (mi/h)	average:	1	
	maximum:	3	
upper litter layer moisture content (%)		12	
debris foliage moisture content (%)		11	
lower litter layer moisture content (%)		20	
live switch cane moisture content (%)		113	
date and amount of last precipitation (in)			4/29/90 0.79
Keetch-Byram Drought Index (CSI)			258

Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	14	-
rate of spread (ft/min)	in debris	25	20-27
flame length (ft)	no debris	3	1- 6
flame length (ft)	in debris	23	15-40

Crown Damage

	Mean	Range
scorch height (ft)	79	72- 85
percent of crown scorched	98	93-100



Plot 2C (medium weight plot)

Ignited 1632 on 4/19/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	(2)	(3)	Cones	Live Fuel (4)	Total
preburn	2.49	1.81	9.08	0.18	3.49	4.28	0.50	0.49	22.32
postburn	0.00	1.32	0.00	0.02	1.46	3.04	0.09	0.25	6.18
consumption	2.49	0.49	9.08	0.16	2.03	1.24	0.41	0.24	16.14
% consumption	69		100	89	58	29	82	49	72

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	56.31	1.80
postburn fuels more than 3 inches diameter	48.28	0.84

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	245	96	12.2	11.2	80	73-89	118	42
hardwood	5	5	6.1	6.1			1	1

Burning Conditions

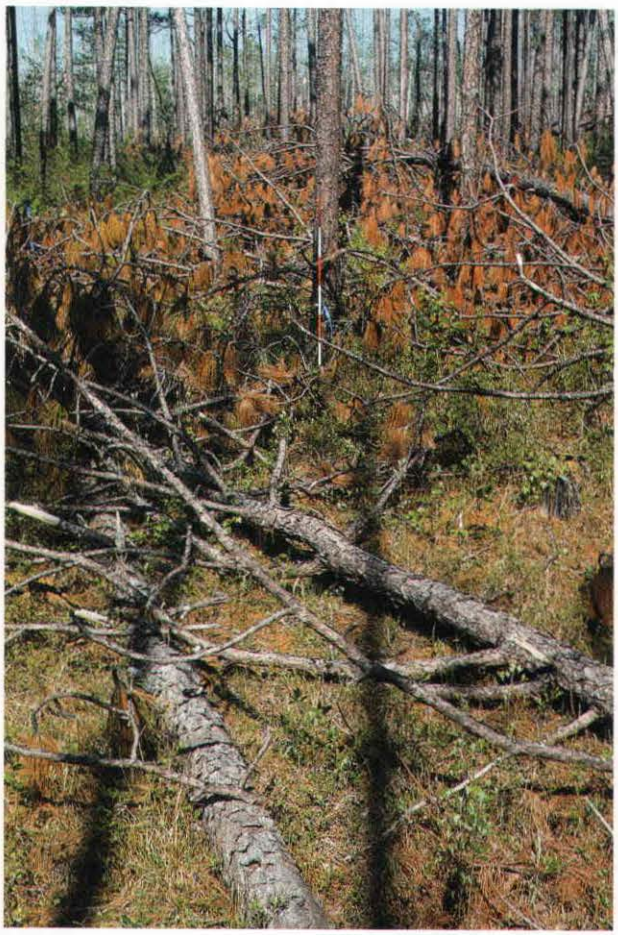
		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		70	
relative humidity (%)		54	
in-stand windspeed at 6 feet (mi/h)	average:	3	
	maximum:	-	
upper litter layer moisture content (%)		12	
debris foliage moisture content (%)		15	
live switch cane moisture content (%)		167	
date and amount of last precipitation (in)			4/14/90 0.40
Keetch-Byram Drought Index (CSI)			137

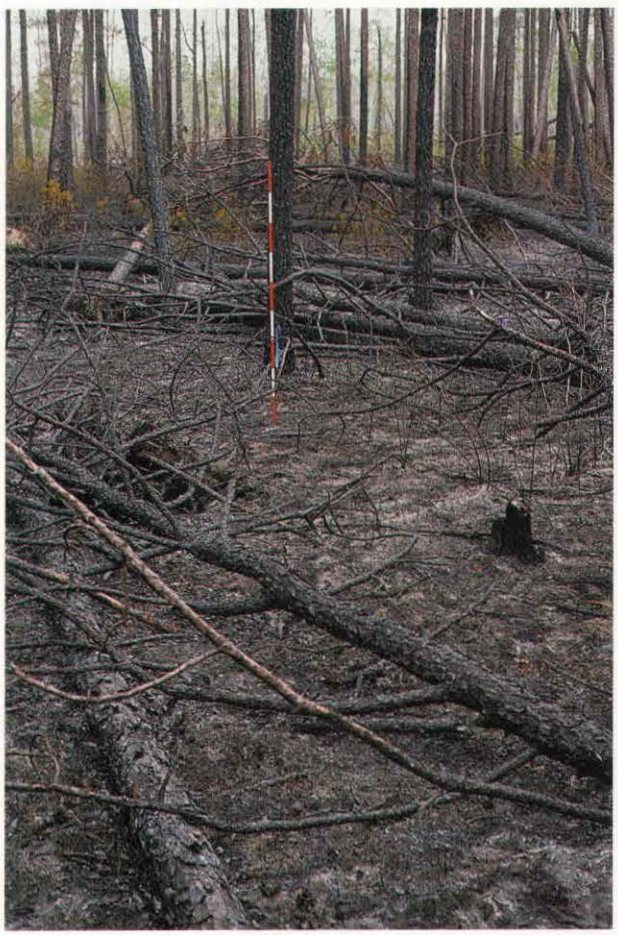
Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	47	9-17
rate of spread (ft/min)	in debris	18	12-24
flame length (ft)	no debris	2	0.5- 3
flame length (ft)	in debris	17	3-30

Crown Damage

	Mean	Range
scorch height (ft)	none	
percent of crown scorched		





Plot 2D (medium weight plot)

Ignited 1030 on 4/19/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	(2)	(3)	Cones	Live Fuel (4)	Total
preburn	2.91	4.27	3.10	0.08	1.84	5.52	0.34	0.93	18.99
postburn	0.00	1.48	0.00	0.02	1.90	3.90	0.08	0.12	7.50
consumption	2.91	2.79	3.10	0.06	(0.06)	1.62	0.26	0.81	11.49
% consumption	79		100	75	0	29	76	87	61

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	50.71	0.38
postburn fuels more than 3 inches diameter	46.20	0.90

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	336	240	11.1	11.1	78	62-95	178	134
hardwood	10	0	4.0	0			1	0

Burning Conditions

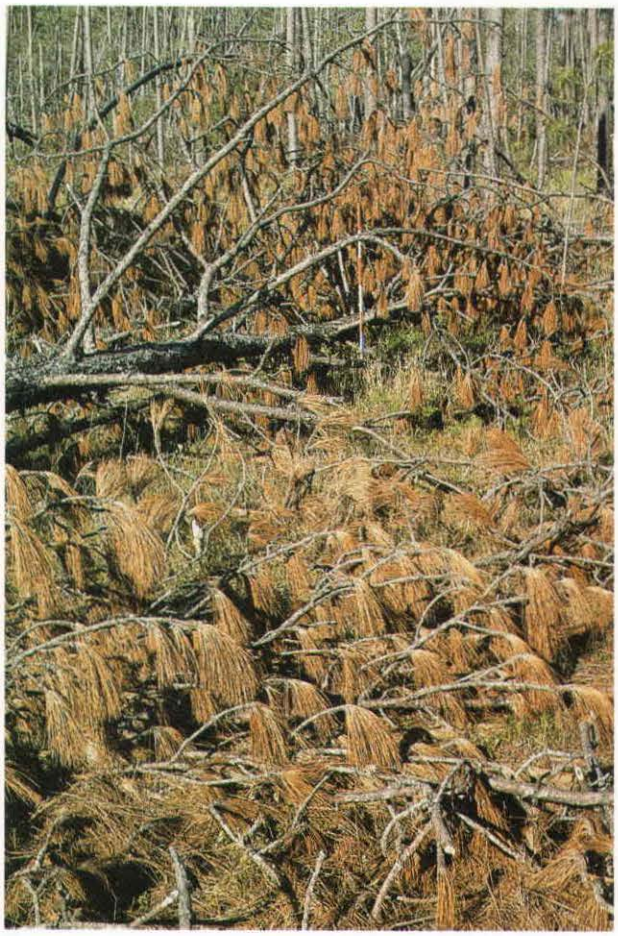
		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		63	
relative humidity (%)		63	
in-stand windspeed at 6 feet (mi/h)	average:	3	
	maximum:	-	
upper litter layer moisture content (%)		15	
debris foliage moisture content (%)		13	
cured grass moisture content (%)		20	
date and amount of last precipitation (in)			4/14/90 0.40
Keetch-Byram Drought Index (CSI)			137

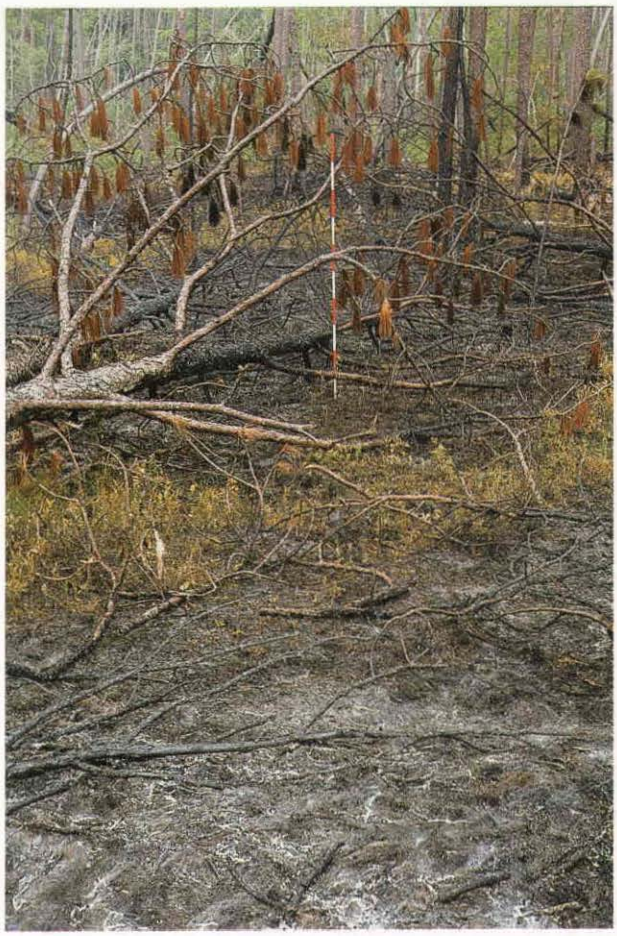
Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	6	5- 8
rate of spread (ft/min)	in debris	27	16-40
flame length (ft)	no debris	2	0.5- 5
flame length (ft)	in debris	14	10-20

Crown Damage

	Mean	Range
scorch height (ft)	66	53- 79
percent of crown scorched	66	73-100





Plot 1A (light plot)

Ignited 1457 on 5/2/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	(2)	(3)	Cones	Live Fuel (4)	Total
preburn	1.70	1.27	6.71	0.17	2.17	4.84	0.09	0.44	17.39
postburn	0.00	1.10	0.00	0.07	1.96	4.51	0.04	0.10	7.78
consumption	1.70	0.17	6.71	0.10	0.21	0.33	0.05	0.34	9.61
% consumption	63		100	59	10	07	56	77	55

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	14.18	0.99
postburn fuels more than 3 inches diameter	11.95	1.07

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	259	149	11.2	10.6	56	29-80	154	82
hardwood	0	0					0	0

Burning Conditions

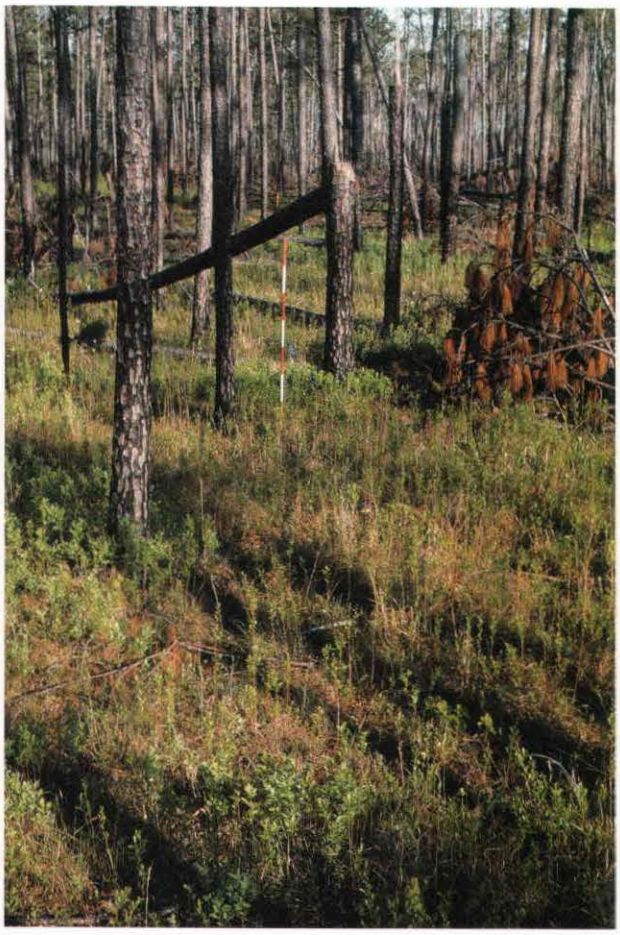
		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		86	
relative humidity (%)		63	
in-stand windspeed at 6 feet (mi/h)	average:	1	
	maximum:	3	
upper litter layer moisture content (%)		14	
debris foliage moisture content (%)		15	
live switch cane moisture content (%)		126	
date and amount of last precipitation (in)			4/29/90 0.79
Keetch-Byram Drought Index (CSI)			258

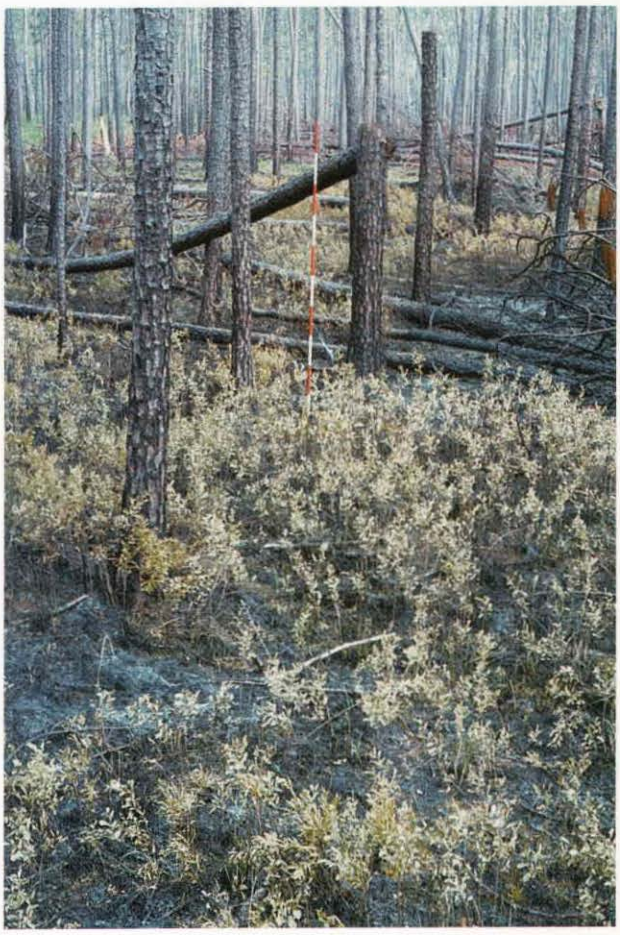
Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	9	9-10
rate of spread (ft/min)	in debris	10	-
flame length (ft)	no debris	2	0.5- 3
flame length (ft)	in debris	18	-

Crown Damage

	Mean	Range
scorch height (ft)	47	29- 61
percent of crown scorched	89	69-100





Plot 1C (light plot)

Ignited 1355 on 5/3/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	(2)	(3)	Cones	Live Fuel (4)	Total
preburn	1.67	2.05	5.38	0.12	1.86	2.82	0.15	0.57	14.62
postburn	0.00	1.15	0.00	0.07	1.57	1.88	0.26	0.27	5.20
consumption	1.67	0.90	5.38	0.05	0.29	0.94	(0.11)	0.30	9.42
% consumption	96		100	42	16	33	0	53	64

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	20.63	0.95
postburn fuels more than 3 inches diameter	18.20	0.86

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	254	192	11.3	10.9	64	40-78	254	192
hardwood	19	19	8.8	8.8			19	19

Burning Conditions

		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		86	
relative humidity (%)		57	
in-stand windspeed at 6 feet (mi/h)	average:	0.5	
	maximum:	0.5	
upper litter layer moisture content (%)		15	
debris foliage moisture content (%)		17	
live switch cane moisture content (%)		129	
date and amount of last precipitation (in)			4/29/90 0.79
Keetch-Byram Drought Index (CSI)			274

Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	2	2-3
rate of spread (ft/min)	in debris	2	-
flame length (ft)	no debris	0.75	0.5-2
flame length (ft)	in debris	0.75	0.5-1.5

Crown Damage

	Mean	Range
scorch height (ft)	50	34-73
percent of crown scorched	91	85-94

Plot 1D (heavy plot)

Ignited 1235 on 4/19/90

Fuel Weight (tons/acre)

	Litter	Duff	Foliage	Dead Branchwood (1)	(2)	(3)	Cones	Live Fuel (4)	Total
preburn	2.62	2.38	0.30	0.05	1.24	4.60	0.40	0.46	12.05
postburn	0.00	2.22	0.00	0.05	1.89	3.76	0.22	0.12	8.26
consumption	2.62	0.16	0.30	0.00	(0.65)	0.84	0.18	0.34	3.79
% consumption	56		100	0	0	18	45	74	31

(1) 0.01–0.25 inch diameter
(2) 0.26–1.00 inch diameter
(3) 1.01–3.00 inches diameter
(4) under 1 inch basal diameter

	Sound	Rotten
preburn fuels more than 3 inches diameter	7.62	0.11
postburn fuels more than 3 inches diameter	8.20	0.00

Stand Conditions

(trees larger than 0.5 inch diameter breast height)

	Stems/acre		Mean d.b.h. (in)		Height (ft)		Basal Area (ft^2/ac)	
	Pre-Hugo	Post-Hugo	Pre-Hugo	Post-Hugo	Mean	Range	Pre-Hugo	Post-Hugo
pine	442	370	11.6	11.7	73	38-85	242	206
hardwood	0	0					0	0

Burning Conditions

		Onsite	NFDRS (Witherbee RS)
dry-bulb temperature (°F)		70	
relative humidity (%)		55	
in-stand windspeed at 6 feet (mi/h)	average:	3	
	maximum:	8	
upper litter layer moisture content (%)		13	
debris foliage moisture content (%)		14	
live switch cane moisture content (%)		159	
date and amount of last precipitation (in)			4/14/90 0.40
Keetch-Byram Drought Index (CSI)			137

Fire Behavior

		Mean	Range
rate of spread (ft/min)	no debris	7	6- 8
rate of spread (ft/min)	in debris	15	12-18
flame length (ft)	no debris	2	0.5- 3.5
flame length (ft)	in debris	21	6-30

Crown Damage

	Mean	Range
scorch height (ft)	none	
percent of crown scorched		

The Forest Service, U.S. Department of Agriculture, is dedicated to the principal of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

Wade, Dale D.; Forbus, James K.; Saveland, James M. 1993. Photo series for estimating post-hurricane residues and fire behavior in southern pine. Gen. Tech. Rep. SE-82. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 19 pp.

Following Hurricane Hugo, fuels were sampled on nine 2-acre blocks which were then burned during the spring wildfire season. The study was superimposed on dormant-season fire-interval research plots established in 1958 on the Francis Marion National Forest near Charleston, SC. Photographs of preburn fuel loads, fire behavior, and postburn fuel loads were taken to visually depict the fire intensity associated with differing hurricane-generated fuel loads. These photo sequences enable the reader to compare actual fire behavior and consumption with preconceived mental images.

Keywords: South Carolina, fuel consumption.

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