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Hurricane Andrew Damage in Relation to Wood Decay Fungi and Insects in Bottomland Hardwoods of the Atchafalaya Basin, Louisiana

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ABSTRACT

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Hurricane Andrew caused damage to more than 780 sq. km of bottomland hardwood and cypress-tupelo forests in the Atchafalaya Basin of Louisiana in August 1992. Trees in bottomland hardwood sites were examined, in early May 1994, for signs and symptoms of wood decay fungi, and for insect damage, ostensibly present before the hurricane, which may have predisposed trees to windthrow or breaks in the bole or top. Three sites with severe wind damage and three sites with minor wind damage were studied along the path of the hurricane. Surveying for wood decay fungi and insects on trees, and evaluating damage to crowns, stems, and roots was done on 25-m diameter point-sample plots. Evidence of wood decay fungi and insects, or the damage they cause, was rare at all sites, in part because of flooding during the evaluation, so that predisposition to wind damage by these agents was not established. Crown damage rating classes and d.b.h. classes were positively correlated for sites with severe wind damage indicating that larger diameter trees were more susceptible to wind damage than smaller diameter trees. Chinese tallow, swamp cottonwood, pumpkin ash, American sycamore, and swamp dogwood showed greater wind damage on sites with severe wind damage than other species.

ADDITIONAL INDEX WORDS: *Forest pest survey, crown damage rating, wind damage.*

INTRODUCTION

Hurricane Andrew came ashore on the Louisiana coastline and proceeded inland on August 26, 1992. With sustained winds as high as 220 km/hr (STONE *et al.*, 1993), the hurricane caused significant disturbance to more than 450 km^2 of cypress-tupelo swamp and bottomland hardwood forest in the Atchafalaya Basin (DOYLE *et al.*, 1995). The immediate economic impact of the storm on forest resources was estimated to be $38.6 million. Disturbance by the hurricane was wide ranging, affecting terrestrial and aquatic communities, marine and freshwater communities, vertebrate and invertebrate populations (ROMAN *et al.*, 1994), and various forest types (LOOPE *et al.*, 1994; PIMM *et al.*, 1994). The effects of Hurricane Andrew on the general ecology of plant communities and damage to forest resources have been reported for Florida, Louisiana, and Mississippi (KELLY, 1993; SMITH *et al.*, 1994; DOYLE *et al.*, 1995). GUNTENSPERGEN and VAIRIN (1996) provided a general overview of Hurricane Andrew's effects on Louisiana's coastal and forested wetlands, barrier islands, and wildlife.

Damage to bottomland hardwood forests from Hurricane Andrew provided a unique opportunity to evaluate the relationship between wind damage to trees from the hurricane and ostensibly preexisting damage from wood decay fungi and/or wood boring insects. It is possible to estimate the length of time older hardwoods have been affected by wood decay fungi and wood boring insects based on the biology of individual host and parasite species (TAINTER and BAKER, 1996; SOLOMON, 1995; PUTNAM *et al.*, 1960). A loss of structural integrity to roots, stems, or main branches that existed prior to the hurricane would be detectable especially in relation to a wind-induced break. Plots, established by the U.S. National Biological Service (NBS; KEELAND, 1993), were surveyed to accomplish this main objective. In addition, this study provided a check of disease survey data collected by the NBS in their effort to quantify hurricane-related damage in the Atchafalaya Basin (KEELAND, 1993).

MATERIALS AND METHODS

Seventeen plots at six sites (Figure 1) were surveyed by two forest pathologists and a forest entomologist for indicators of wood decay fungi and wood boring insects from May 9 to 12, 1994. The six sites were chosen from among 28 sites previously established by the NBS for documenting the regrowth of vegetation following Hurricane Andrew (KEELAND, 1993). Three sites (S sites), Long Lake (Long), Calp, and

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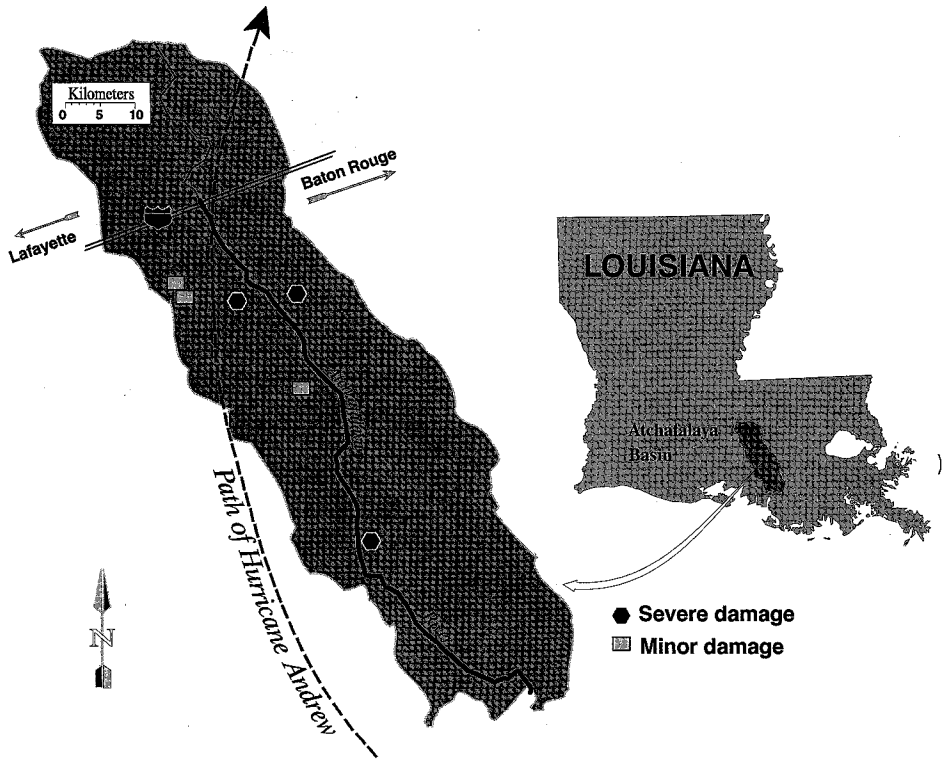

Figure 1. Locations in the Atchafalaya Basin of Louisiana of sites with severe and minor wind damage from Hurricane Andrew on which trees were surveyed to determine whether wind damage was related to prior injury by wood decay fungi and/or wood boring insects.

Camp, were chosen because they incurred severe wind damage to woody vegetation from the hurricane. Three other sites (M sites), Henderson (Hend), Guidry Hunt Club 01 (GHC1), and Dam, were selected because they sustained moderate to minor wind damage to woody vegetation from the hurricane compared with S sites. Severe and minor damage designations were based on the general condition of overstory and understory vegetation shortly after the hurricane. Hend and GHC1 were to the west of Andrew's path while the other sites were to the east. Camp was in the southern part of the Atchafalaya Basin; the other five sites were in the central section of the Basin.

Each site consisted of three 25-m diameter plots, the centers of which were at the points of an equilateral triangle with sides of 80 m. Trees were sampled on 20% of the area of each plot within 1 m of either side of two perpendicular transects, the intersection of which was a plot center. Transects were oriented roughly in east-west and north-south directions. All woody vegetation 0.3 cm in diameter and larger within these 2-m wide strips was recorded and evaluated for damage. Sampling one of the plots at the Dam site was not possible because of high water.

The following information was recorded for each tree sampled: species; diameter at breast height (d.b.h.); crown damage rating; whether the tree was dead or healthy; and whether there were breaks in the top, bole, butt, or roots. Fungi related to damage were identified and the number of fungal fruiting structures was counted. Crown damage was rated from 1 to 5 where: 1 indicated no damage to the crown; 2 indicated 1% to 30% loss in crown mass; 3 indicated 31% to 60% loss in crown mass; 4 indicated 61% to 99% loss in crown mass; and, 5 indicated a break in the stem resulting in the total loss of the crown. The null hypothesis of no difference in crown damage ratings between sites with severe and moderate to minor damage was tested using a non-parametric one-way analysis of variance procedure. Spearman rank correlation coefficients were determined for crown damage ratings and d.b.h.'s for S and M sites.

RESULTS AND DISCUSSION

Three hundred and seven trees representing 23 species (Tables 1 and 2) were surveyed for evidence of wood decay fungi and/or wood boring insects. Of these, 169 trees were in heavily damaged sites, 138 trees were in moderate to minor damaged sites (Table 1), 158 trees were in N–S running transects, and 149 trees were in E–W running transects. Indicators of wood decay fungi or wood boring insects were not observed on most trees (LEININGER *et al.*, 1995). Only 2% of the surveyed trees (4 on M sites, 3 on S sites) had wood decay that appeared to have been present before the hurricane, and this decay did not appear to have influenced stem damage by wind. KEELAND (unpublished data) classified as diseased 10% (54/517) and 1% (5/479) of all surveyed trees on S and M plots, respectively; we judged only 2% and 3% of the trees on S and M plots, respectively, to have had wood decay before

Table 1. *Mean crown damage ratings, mean d.b.h.'s, and sample sizes of all trees measured on six plots in the Atchafalaya Basin, La. following damage from Hurricane Andrew.*

Plot	Wind Damage Classification	Crown Damage Rating ± SE	D.B.H. ± SE (cm)	n
CALP	Severe	1.2 ± 0.1	14.0 ± 1.6	42
CAMP	Severe	2.6 ± 0.1	9.2 ± 0.7	82
LONG	Severe	2.6 ± 0.2	19.6 ± 1.6	45
DAM	Minor	1.4 ± 0.1	9.7 ± 1.2	42
GHC1	Minor	1.0 ± 0.0	15.8 ± 1.7	47
HEND	Minor	1.0 ± 0.4	20.3 ± 3.1	49
Overall Mean	Severe	2.3 ± 0.1***	13.2 ± 0.7	169
Overall Mean	Minor	1.2 ± 0.0	15.5 ± 1.3	138

***Indicates significant difference between severe and minor plots at P = 0.0001 level, F = 21.7

the hurricane. Most of the trees (52/54) recorded by KEELAND (unpublished data) as diseased were on the Camp site. This discrepancy in results for the S sites is due in part to the fact that many plots were under 0.3 to 1 m of water when we visited them, a factor that confounded our ability to evaluate fully the occurrence of wood decay and wood boring insects on woody debris. The only identifiable wood decay fungus was *Ganoderma applanatum* (Pers.) Pat. on a 44.5 cm windthrown *Carya aquatica* on M-site GHC1, and it was unclear whether the fungus was present before the hurricane.

Fifty percent of the trees on S sites had damaged crowns (*i.e.*, a crown rating > 1) whereas only 7% of trees on M sites had crown damage (Figure 2). Mean crown damage rating (Table 1) was greater (P = 0.0001) for S sites (2.3) than for M sites (1.2). Furthermore, 70 percent (16/23) of the dead trees surveyed on all plots were on S sites. These statistics provide an indication of the difference in wind damage to trees on S and M sites.

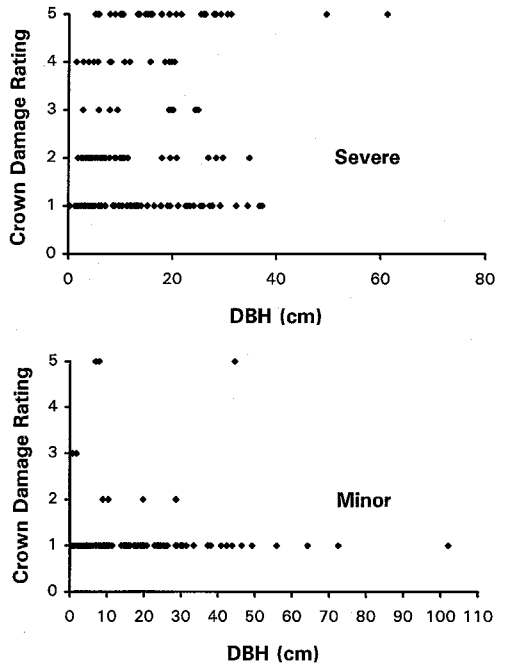

Figure 2. The relationship between crown damage rating and d.b.h. of all trees on the three sites with severe and three sites with minor wind damage from Hurricane Andrew in the Atchafalaya Basin of Louisiana.

Some species were more prone to wind damage than others

Table 2. *Mean crown damage ratings, mean d.b.h., and sample sizes of all trees measured on the three sites with severe and three sites with minor wind damage from Hurricane Andrew in the Atchafalaya Basin of Louisiana.*

Tree Species	Damage Rating ± SE		D.B.H. (cm) ± SE		n	
	Severe	Minor	Severe	Minor	Severe	Minor
Sapium sebiferum (L.) Roxb.	3.4 ± 0.3	—	11.5 ± 1.2	—	21	0
Populus heterophylla L.	3.0 ± 2.0	1.0	14.4 ± 7.2	102.1	20	1
Fraxinus profunda (Bush) Bush	3.1 ± 0.4	1.1 ± 0.1	15.9 ± 1.6	19.2 ± 1.6	14	31
Cornus foemina Mill.	2.1 ± 0.2	1.0 ± 0.0	6.6 ± 0.5	1.9 ± 0.4	45	5
Platanus occidentalis L.	2.1 ± 0.4	—	20.4 ± 1.9	—	18	0
Planera aquatica Gmelin	2.0 ± 0.7	1.3 ± 0.2	13.1 ± 4.7	12.5 ± 1.8	8	24
Ilex decidua Walter	2.0	1.0 ± 0.0	6.4	6.8 ± 0.9	1	8
Quercus laurifolia Michx.	1.7 ± 0.3	1.0 ± 0.0	3.7 ± 1.4	3.7 ± 1.4	3	4
Taxodium distichum (L.) Rich.	1.5 ± 0.3	1.0 ± 0.0	22.8 ± 2.5	31.8 ± 4.8	13	8
Salix nigra Marsh.	1.5 ± 0.5	1.2 ± 0.2	23.8 ± 4.7	42.1 ± 10.1	2	6
Acer negundo L.	1.3 ± 0.3	1.0 ± 0.0	8.1 ± 1.4	3.6 ± 0.5	14	13
Acer rubrum L.	1.0	1.0 ± 0.0	7.2 ± 1.6	9.6 ± 3.4	8	7
Cornus drummondii C.A. Mey.	1.0	—	1.3	—	1	0
Forestiera acuminata (Michx.) Poir.	1.0	1.5 ± 0.3	8.1 ± 3.2	8.1 ± 3.2	1	6
Carya aquatica (Michx.) Nutt.	—	5.0	—	44.5	0	1
Quercus nuttallii E.J. Palmer	—	3.0 ± 2.0	—	5.1 ± 1.8	0	2
Cephalanthus occidentalis L.	—	1.0 ± 0.0	—	24.5	0	3
Crataegus spp. L.	—	1.0 ± 0.0	—	8.7 ± 1.0	0	9
Fraxinus pennsylvanica Marsh.	—	1.0	—	55.9	0	1
Quercus nigra L.	—	1.0	—	9.1	0	1
Quercus shumardii Buckley	—	1.0 ± 0.0	—	13.5 ± 2.1	0	2
Liquidambar styraciflua L.	—	1.0 ± 0.0	—	14.1	0	2
Morus rubra L.	—	1.0 ± 0.0	—	6.6 ± 1.2	0	4

(Table 2), a phenomenon noted previously (DOYLE *et al.*, 1995; FRANCIS and GILLESPIE, 1993; GRESHAM *et al.*, 1991). On S sites, *Sapium sebiferum*, *Populus heterophylla*, *Fraxinus profunda*, *Cornus foemina*, *Platanus occidentalis*, *Planera aquatica*, and *Ilex decidua* each had average crown damage ratings of 2.0 or greater (Table 2). The high average crown ratings for *Carya aquatica* and *Quercus nuttallii* on M sites can be discounted due to small sample sizes. These results were similar to those of DOYLE *et al.* (1995) who found that canopy trees *P. heterophylla*, *S. sebiferum*, and *P. occidentalis*, along with the subcanopy species *C. foemina*, to name a few, sustained the greatest proportion of stem damage from Hurricane Andrew. These same four species made up 34% of the trees in the whole study, and they made up 62% of the trees sampled on S sites, a fact which contributed to the difference in mean crown ratings between S and M sites.

Average d.b.h. of all trees on S sites was slightly smaller than average d.b.h. of all trees on M sites (Table 1). Nonetheless, a Spearman rank correlation coefficient of 0.221 ($P = 0.004$) indicated a correlation between diameter classes and crown damage rating classes for S sites. Damage rating classes and diameter classes were not correlated ($P = 0.84$) for M sites. Crown damage rating classes and d.b.h. for S and M sites listed by species in Table 2 suggest that differences in crown damage between S and M sites (Table 1; Figure 2) were due to a combination of species composition and d.b.h.

CONCLUSIONS

The lack of indicators of wood decay fungi and wood boring insects in the plots surveyed precluded establishing that preexisting damage from those agents predisposed trees to damage by Hurricane Andrew. It appeared that wind was the dominant force that damaged trees on both S and M sites. However, there was more damage to tree crowns on S sites than on M sites ($P = 0.0001$), and there were more dead trees on S sites than on M sites indicating the relative force of the wind at each type of site. Spearman rank correlation coefficients indicated that larger diameter trees on S sites were more prone to crown damage by wind than those with smaller diameters, and that tree diameters were not correlated to crown damage ratings on M sites. PUTZ and SHARITZ (1991) found that trees with diameters greater than 20 cm were more likely to be damaged seriously by Hurricane Hugo if they had severe mechanical damage in boles and crowns prior to the hurricane. They speculated that prior mechanical injury may have affected the incidence and severity of heart rot fungi in trees thereby contributing to their susceptibility to hurricane wind damage. In the current study, wood decay fungi that might predispose trees to wind damage were rare. Larger diameter trees on S sites had more damage to crowns because they presumably had larger crowns to be impacted by hurricane winds.

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