WINDS OF CHANGE: TORNADO AND HURRICANE IMPACTS ON LOUISIANA FORESTS

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Abstract—Severe wind events have devastating impacts on forests throughout the United States. Events such as tornadoes and hurricanes can destroy standing timber, produce stresses that impact wood quality, and leave debris that leads to susceptibility to additional impacts. Data for tornado and hurricane occurrences was obtained and the width of these storms calculated using Geographic Information Systems software. The storm tracks were then used to extract impacted forested pixels in Louisiana to determine the acreage impacted, by forest type, within the State. Approximately 238,000 forested acres have been impacted by tornadoes (~3,000 acres per storm), with EF-2 tornadoes impacting the greatest acreage; hurricanes have impacted the State's forests multiple times, with tropical storm force winds impacting the greatest acreage. These preliminary results will be incorporated with inventory data and damage reports to develop a risk index to forests in Louisiana.

INTRODUCTION

Forests are vitally important to Louisiana's economy, comprising approximately 15 million acres and making a $13 billion impact on the State's economy (Tanger 2018). Extreme wind events, for example, tornadoes and hurricanes, have devastating impacts on forests. These events damage and destroy standing timber, produce stresses that impact wood quality, and leave debris that leads to a greater susceptibility to additional impacts, such as wildfire (Cooke and others 2007). Damage can be influenced by terrain (Cannon and others 2016) and forest type and density relative to wind speeds (Zeng and others 2009, 2010). Damaged and destroyed timber can become a carbon source and affect forest productivity for years (Zeng and others 2009) by reducing timber availability for mills within impacted areas (McConnell and Shmulsky 2009). This loss, in turn, may influence the type of product those mills produce in future if they remain active.

Given the importance of forestry to Louisiana's economy and the varying scale of impacts caused by extreme wind events, an accurate approximation of areal impacts from these storms can be incorporated with damage assessments and volume estimates leading to a relative risk index for various forest types and isolated by area within a State or region. The objectives of this study are to 1) determine the number of tornadoes and hurricanes that have affected Louisiana and 2) quantify the acreage affected by these storms.

MATERIALS AND METHODS

Data were obtained from the National Oceanic and Atmospheric Administration's National Weather Service (https://www.spc.noaa.gov/gis/svrgis/) for all tornadoes occurring between 1950 and 2016. Data for hurricane tracks was obtained from the National Climate Data Center (https://www.ncdc.noaa.gov/ibtracs/index.php?name=ibtracs-data) for all hurricanes in the North Atlantic Basin. Forest cover types were obtained from the Forest Service, U.S. Department of Agriculture (Ruefenacht and others 2008).

Using GIS software, all datasets were extracted using the boundary for the State of Louisiana. To determine the impact of tornadoes and hurricanes on forests in Louisiana, buffers were generated using tornado widths and radii of maximum winds for hurricanes. The tornado and hurricane buffers were used as a mask to extract forested pixels that intersected them. The impacted pixels were then summed by forest type for each wind-speed classification for tornadoes (using the Enhanced Fujita scale) and hurricanes (using the Saffir-Simpson hurricane wind scale).

RESULTS AND DISCUSSION

Forested Area Impacted by Tornadoes

There were 1,900 tornadoes that impacted Louisiana between 1950 and 2016 and affected 238,209 total acres (table 1). Of these tornadoes, approximately 95 percent were EF-0 to EF-2, accounting for 64 percent of the impacted acreage. This was not entirely surprising

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Table 1—Acreage impacted by forest type by EF (Enhanced Fujita scale) classification for each tornado in Louisiana between 1950 and 2016

Forest type*	EF-0 (618)	EF-1 (870)	EF-2 (308)	EF-3 (94)	EF-4 (9)	EF-5 (1)	Total
Longleaf pine	0	31	93	0	46	0	170
Slash pine	432	2,564	3,707	649	216	0	7,568
Loblolly pine	4,834	42,641	57,143	50,101	11,506	0	166,224
Shortleaf pine	0	0	46	124	0	0	170
Shortleaf pine/oak	0	31	15	0	0	0	46
Loblolly pine/hardwood	587	3,181	4,386	4,309	680	0	13,143
Slash pine/hardwood	0	15	0	0	0	0	15
Other pine/hardwood	0	0	0	15	0	0	15
Post oak/blackjack oak	0	108	46	62	0	0	216
White oak/red oak/hickory	263	2,471	2,085	1,761	417	0	6,996
Yellow-poplar/white oak	15	0	77	0	0	0	93
Sweetgum/yellow-poplar	15	139	108	741	0	0	1,004
Red maple/oak	0	108	15	0	0	0	124
Mixed upland hardwoods	0	154	62	587	31	0	834
Swamp chestnut oak/cherrybark oak	15	263	124	46	0	0	448
Sweetgum/Nuttall oak/willow oak	417	3,938	7,892	6,564	541	170	19,521
Overcup oak/water hickory	154	1,189	2,255	1,622	185	0	5,405
Baldcypress/water tupelo	77	1,081	2,641	1,390	402	0	5,591
Sweetbay/swamp tupelo/red maple	15	124	124	0	0	0	263
Cottonwood	0	62	62	46	0	0	170
Willow	0	62	31	77	15	0	185
Sycamore/pecan/American elm	0	15	154	108	62	0	340
Sugarberry/hackberry/elm/green ash	510	2,363	4,510	1,637	355	139	9,514
Cherry/ash/yellow-poplar	0	0	93	0	0	0	93
Other exotic hardwoods	0	15	46	0	0	0	62
Total	7,336	60,556	85,715	69,838	14,456	309	238,209

The number of tornadoes in each category are in parentheses.

*Longleaf pine = *Pinus palustris*, slash pine = *P. elliottii*, oak = *Quercus* spp., post oak = *Q. stellata*, blackjack oak = *Q. marilandica*, white oak = *Q. alba*, red oak = *Q. rubra*, hickory = *Carya* spp., yellow-poplar = *Liriodendron tulipifera*, red maple = *Acer rubrum*, swamp chestnut oak = *Q. michauxii*, cherrybark oak = *Q. pagoda*, Nuttall oak = *Q. texana*, willow oak = *Q. phellos*, overcup oak = *Q. lyrata*, water hickory = *Carya aquatica*, sweetbay = *Magnolia virginiana*, swamp tupelo = *Nyssa biflora*, cottonwood = *Populus* spp., willow = *Salix* spp., sycamore = *Platanus* spp., pecan =*Carya illinoinensis*, American elm = *Ulmus americana*, sugarberry = *Celtis laevigata*, hackberry = *Celtis occidentalis*, elm = *Ulmus* spp., green ash = *Fraxinus pennsylvanica*, cherry = *Prunus* spp., ash = *Fraxinus* spp.

as the higher category tornadoes (EF-3 and greater) are typically larger in width and on the ground for greater periods of time. The most acreage impacted by forest type, based on 2008 forest type data, was loblolly pine (*Pinus taeda*), accounting for 70 percent of the affected acreage; loblolly pine accounts for nearly 56 percent of forested acres in Louisiana. However, as a percentage of forest type cover, baldcypress (*Taxodium distichum*)/water tupelo (*Nyssa aquatica*) forest type had 9 percent of its area impacted and shortleaf pine (*Pinus echinata*) saw approximately 6 percent of its area touched by a tornado during the time period covered by the data. The greatest acreage of loblolly pine forest type impacted was impacted by EF-2 and EF-3 tornadoes, likely because these tornadoes were distributed throughout the central to north-central portions of Louisiana (fig. 1).

The tornado dataset dates from 1950. During this time, and through the 1970s, the forest composition in Louisiana looked different that it does presently (Delcourt and others 1981, Murphy 1975). While fewer than half of the tornadoes considered occurred between 1950 and 1980, the bias in reporting and potential errors in estimation of track widths could (and likely does) lead to an underrepresentation of impacts to historical forest cover in the State. For example, 273 tornadoes have impacted the Florida parishes in eastern Louisiana since 1950. There were 101 tornadoes in these parishes between 1950 and 1980, when much of this area was longleaf pine (*Pinus palustris*) (but has since been converted to loblolly pine plantations).

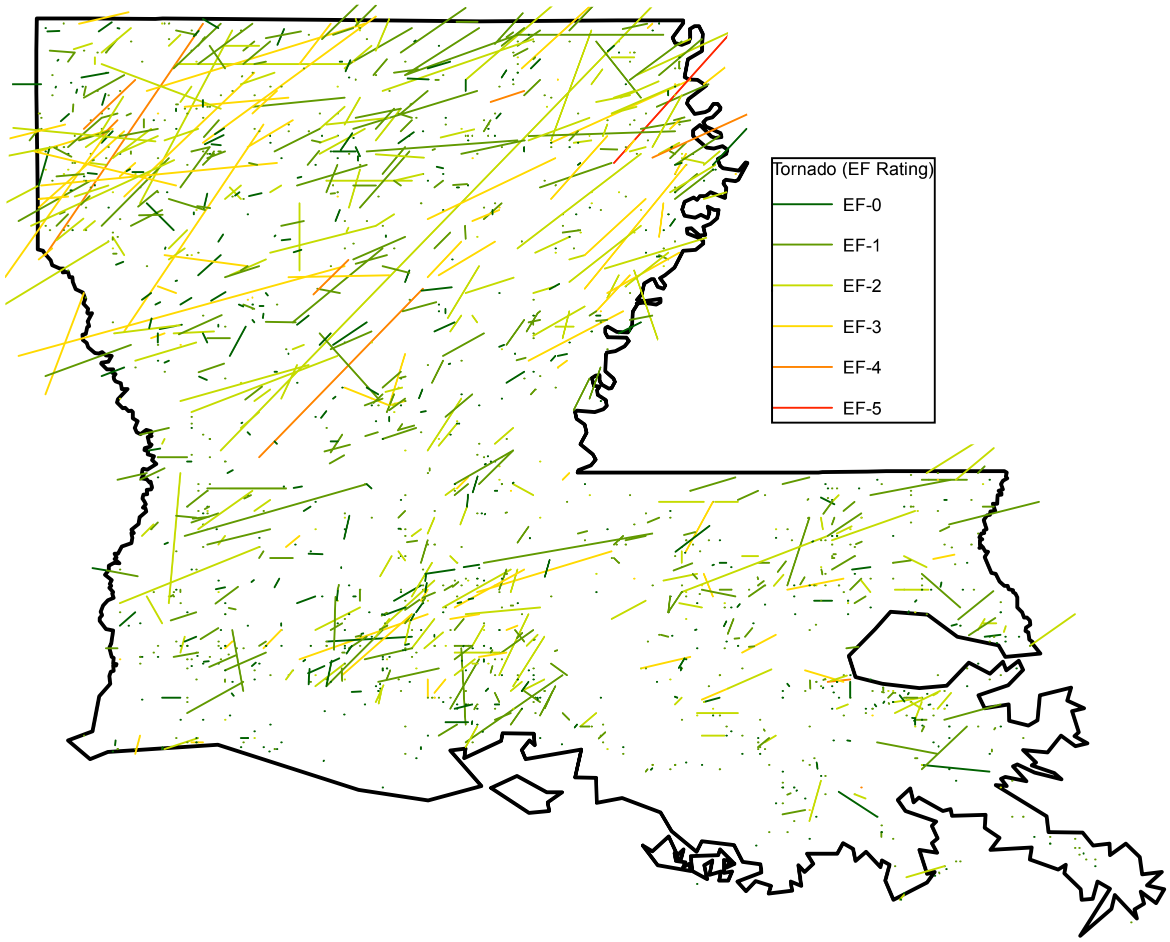

Figure 1—Tornadoes impacting Louisiana, 1950-2016.

Forested Area Impacted by Hurricanes

Analysis of the impacts of hurricanes on forests was limited by data availability. Of the 147 hurricanes impacting the State between 1854 and 2012 (fig. 2), only 13 storms (all making landfall between 2002 and 2012) had reliable data for radius of maximum winds with which buffers could be created. Of the storms used in assessing impacted acreage, it was determined that (in terms of total acreage impacted), loblolly pine was the most affected forest type with approximately 2.9 million acres affected (table 2). It is important to note that, as a percentage of forest impacted, some forest types were repeatedly impacted—most notably baldcypress/water tupelo, commonly found in coastal/wetland areas. Sweetgum (*Liquidambar styraciflua*) forests were also impacted (greater than 750,000 acres total), likely because of where they are located in the southern part of the State.

Most areas/forest types were impacted more than once in the analysis but they were still counted cumulatively to indicate how often the forest areas are impacted. As a total, roughly one-half of Louisiana forests were affected by the 13 storms that had wind radii reported in the data set. It is important to distinguish between impact and damage as this study only quantifies acreage impacted and is not an indication of damage. Coastal forests in Louisiana are dominated by wetland species, with baldcypress and water tupelo dominant and among the 10 most common species in the State (Oswalt 2016). However, baldcypress and water tupelo saw little damage from Hurricane Katrina (Middleton 2009) while pine and sweetgum were damaged (Oswalt and others 2008). It will be useful in subsequent research to determine areas that have been repeatedly impacted by this type of system. Determination of probabilistic damage of species classes within forest types will drive future research efforts to build a stand-level damage model for forests throughout the region.

It bears repeating that, particularly for the estimated areas impacted by tornadoes, the data used is for current forest cover types (Ruefenacht and others 2008). While this will lead to an underestimation of impact on historic forest types by tornadoes, it does provide a preliminary estimate of area impacted by tornado magnitude. The hurricane impacts are closer to true estimate of cover type during the time of impact of

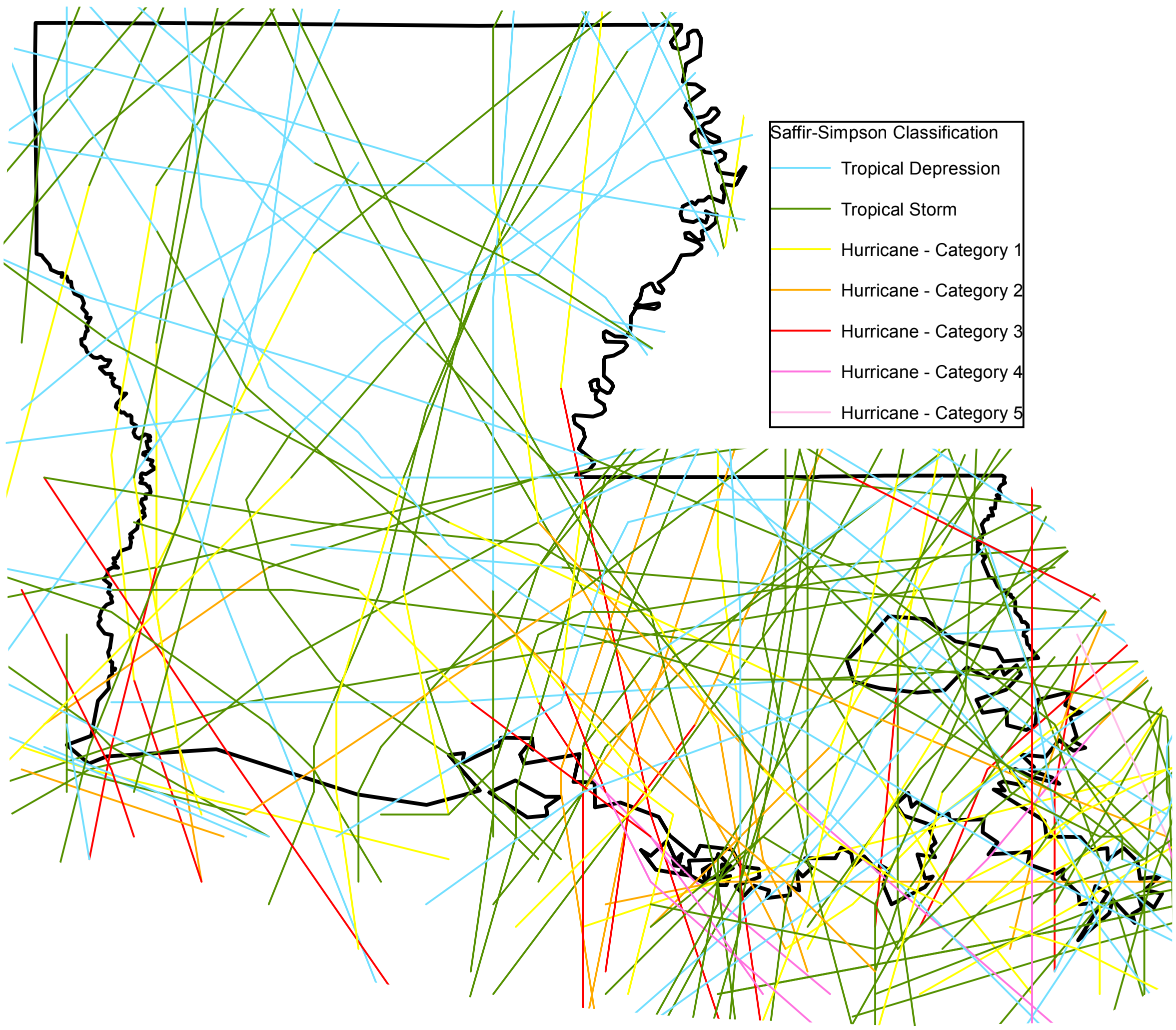

Figure 2—Land-falling tropical hurricanes impacting Louisiana, 1854-2012; this study only considered storms from 2002-2012 with complete track length and width attributes.

each storm, but there were only 13 storms for which consistent track data was available. Future work could build on such estimates, elucidate historic impacts of types, combine with inventory data, and attempt to estimate potential biomass losses of historic storms.

CONCLUSIONS

This initial assessment provides information that will be used in subsequent analyses. If reliable damage assessment data can be found it could be leveraged with remotely sensed data to develop a risk-rating of probabilistic damage by forest type. This methodology could then be applied to a broader area—regionally or nationally—and utilized to assess annual damage risk from tornadoes and land-falling tropical systems.

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Table 2—Acreage impacted by forest type by Saffir-Simpson hurricane wind scale for 13 hurricanes in Louisiana between 2002 and 2012

Forest type	Tropical depression	Tropical storm	Category 1	Category 2	Category 3	Category 4	Total
Longleaf pine	2,286	9,759	672	185	463	0	13,365
Slash pine	43,246	269,958	69,406	54,981	22,571	0	460,163
Loblolly pine	394,735	2,312,758	63,799	124,495	20,178	0	2,915,964
Shortleaf pine	49	537	3	0	0	0	589
Sand pine	12	16	0	0	0	0	28
Eastern redcedar	3	6	0	0	0	0	9
Longleaf pine/oak	83	95	0	0	0	0	179
Shortleaf pine/oak	6	222	0	0	0	0	228
Loblolly pine/hardwood	62,308	290,048	22,031	52,626	1,274	0	428,286
Slash pine/hardwood	442	458	10	0	77	0	987
Other pine/hardwood	723	1,209	0	0	15	0	1,948
Post oak/blackjack oak	6	547	0	0	0	0	553
White oak/red oak/hickory	44,680	117,840	867	3,660	100	0	167,148
Yellow-poplar/white oak	49	1,650	566	154	39	0	2,459
Sweetgum/yellow-poplar	9,195	17,708	39	981	0	0	27,923
Chestnut oak/black oak/scarlet oak	0	39	0	0	0	0	39
Red maple/oak	544	1,498	368	178	46	0	2,634
Mixed upland hardwoods	34,354	51,191	407	2,394	15	0	88,361
Swamp chestnut oak/cherrybark oak	10,508	19,182	528	1,290	2,440	0	33,947
Sweetgum/Nuttall oak/willow oak	222,873	430,704	10,777	99,244	14,000	232	777,830
Overcup oak/water hickory	37,532	135,608	1,109	28,873	239	0	203,362
Baldcypress/water tupelo	477,293	578,057	128,502	329,267	14,355	541	1,528,016
Sweetbay/swamp tupelo/red maple	23,997	29,508	927	749	12,988	15	68,184
River birch/sycamore	99	223	15	0	0	0	337
Cottonwood	1,319	5,286	0	1,699	8	0	8,312
Willow	23,855	27,725	2,528	22,131	162	31	76,432
Sycamore/pecan/American elm	32,192	38,548	69	37,313	0	0	108,122
Sugarberry/hackberry/elm/green ash	163,228	279,195	7,578	98,726	1,900	77	550,704
Red maple/lowland	65	110	51	0	0	0	227
Cottonwood/willow	3,351	3,833	28	4,270	0	0	11,483
Cherry/ash/yellow-poplar	1,313	1,909	0	0	0	0	3,222
Other exotic hardwoods	1,375	1,729	36	263	8	0	3,409
Total	1,591,721	4,627,158	310,318	863,478	90,881	896	7,484,450

Slash pine = *P. elliottii*, loblolly pine = *P. taeda*, shortleaf pine = *P. echinata*, sand pine = *P. clausa*, eastern redcedar = *Juniperus virginiana*, post oak = *Quercus stellata*, blackjack oak = *Q. marilandica*, white oak = *Q. alba*, red oak = *Q. rubra*, hickory = *Carya* spp., yellow-poplar = *Liriodendron tulipifera*, sweetgum = *Liquidambar styraciflua*, chestnut oak = *Q. montana*, black oak = *Q. velutina*, scarlet oak = *Q. coccinea*, red maple = *Acer rubrum*, swamp chestnut oak = *Q. michauxii*, cherrybark oak = *Q. pagoda*, Nuttall oak = *Q. texana*, willow oak = *Q. phellos*, overcup oak = *Q. lyrata*, water hickory = *Carya aquatica*, baldcypress = *Taxodium distichum*, water tupelo = *Nyssa aquatica*, sweetbay = *Magnolia virginiana*, swamp tupelo = *Nyssa biflora*, river birch = *Betula nigra*, sycamore = *Platanus* spp., cottonwood = *Populus* spp., willow = *Salix* spp., pecan = *Carya illinoinensis*, American elm = *Ulmus americana*, sugarberry = *Celtis laevigata*, hackberry = *Celtis occidentalis*, elm = *Ulmus* spp., green ash = *Fraxinus pennsylvanica*, cherry = *Prunus* spp., ash = *Fraxinus* spp.

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