

FUSIFORM RUST TRENDS IN EAST TEXAS: 1969 TO 2002

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Abstract—Fusiform rust [*Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *Fusiforme*] infection rates in east Texas increased to nearly 50 percent in slash pine (*Pinus elliottii* Engelm.) and about 15 percent in loblolly pine (*Pinus taeda* L.) plantations during the 18-year period from 1969 to 1987. New data from the East Texas Pine Plantation Research Project showed that fusiform rust infection rates in slash pine peaked in 1987, then decreased to about 15 percent by 2002. For loblolly pine, the rates stabilized around 10 percent after 1987, then decreased to around 5 percent by 2002. The peak infection rates occurred circa 1987 when plantations were 8 to 11 years old. This 32-year continuous record of fusiform rust incidence in east Texas indicates that infection rates are relatively stable (about 10 percent) for loblolly pine and much greater (up to 50 percent) for slash pine.

INTRODUCTION

Fusiform rust is the most important disease affecting the approximately 2.5 million acres (Rosson 1995) of loblolly and slash pine plantations in east Texas (Adams 1989, Pye and others 1995). This disease can impact thinning schedules or rotation ages (Dinus and Schmidt 1977), or both, by reducing stocking levels (Adams and others 1996; Lee and Coble 2002a, 2002b; Nance and others 1981; Shoulders and Nance 1987; Wells and Dinus 1978), which then reduces potential revenues (Bridgwater and Smith 1997, Bridgwater and Smith 2002, Pye and others 1997).

Fusiform rust incidence surveys in east Texas are available from six surveys conducted between 1969 and 1990 (Hunt and Lenhart 1986; Lenhart and others 1988, 1994; Mason and Griffin 1970; Texas Forest Service 1982; Walterscheidt and Van Arsdale 1976). The first three studies presented average rust percentages for independent surveys, whereas the latter three combined the earlier survey data with data from the East Texas Pine Plantation Research Project (Lenhart and others 1985). In the last (sixth) east Texas survey, Lenhart and others (1994) reported that rust incidence in loblolly pine remained stable around 10 percent through 1990, whereas rust incidence in slash pine declined by 7 to 8 percent to 41 percent through 1990.

As of 2002, the ETPPRP consisted of 193 permanent plots located in loblolly and slash pine plantations throughout east Texas. Each plot has been remeasured on a 3-year cycle since 1984. The rust incidence data gathered at each remeasurement should provide forest managers with valuable insight into temporal trends of fusiform rust in east Texas pine plantations.

The purpose of this study is to report fusiform rust incidence trends in east Texas pine plantations for the years 1993, 1996, 1999, and 2002. This report represents the seventh rust survey for east Texas, thereby creating a contiguous 32-year record of fusiform rust incidence from 1969 to 2002.

METHODS

Currently, 132 permanent plots are located in loblolly pine plantations, and 61 plots are located in slash pine plantations throughout east Texas. The ETPPRP study area covers 22 counties across east Texas. Generally, the counties are located within the rectangle from 30 to 35 north latitude and 93 to 96 west longitude. Each plot consists of two subplots: one for model development and one for model evaluation. A subplot is 100 by 100 feet in size, and a 60-foot buffer separates the subplots. All planted pine trees are permanently tagged and numbered. At each remeasurement, each monumented tree was examined for the presence/absence of fusiform rust according to the following guidelines:

- (a) Infected stem: Gall on a stem or a live branch within 12 inches of the stem.
- (b) Infected branch: Gall on a live branch more than 12 inches from the stem.

Subsequent rust analyses were limited to plantations 5 years old or older because field crews could not reliably detect galls on pine trees less than 5 years of age. Stem rust incidence was calculated for each plot as the proportion of living trees with stem galls, irrespective of branch galls.

Rust infection data from the ETPPRP development plots were used for this survey (tables 1 and 2), as well as the 1984, 1987, and 1990 surveys. Two separate datasets for each species were constructed to examine rust incidence trends:

- (a) All plots present in the current measurement cycle were analyzed as one-time observations to examine rust incidence at that moment in time.
- (b) Original plots that remained intact (i.e., not destroyed) since the 1984 measurement cycle were analyzed to examine rust incidence trends for consecutive 3-year periods.

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Table 1—Descriptive statistics for the ETPPRP loblolly pine development plots

Year	Variable	N	Mean	Standard deviation	Standard error	Minimum	Maximum
1984	TPA	78	453.9	141.2	16.0	148.0	849.0
	BA/A		51.3	35.8	4.1	0.0	116.0
	Age		9.2	3.1	0.3	5.0	17.0
	SI		65.3	13.9	1.6	27.0	95.0
1987	TPA	146	465.1	141.8	11.7	105.0	858.0
	BA/A		50.8	41.4	3.4	0.0	173.0
	Age		9.0	3.8	0.3	5.0	19.0
	SI		70.0	14.4	1.2	25.0	115.0
1990	TPA	170	475.9	149.6	11.5	87.0	998.0
	BA/A		68.0	39.1	3.0	4.0	183.0
	Age		10.8	3.8	0.3	5.0	21.0
	SI		69.3	12.5	1.0	35.0	105.0
1993	TPA	161	464.5	146.3	11.5	87.0	928.0
	BA/A		94.2	35.2	2.8	11.0	192.0
	Age		13.5	3.7	0.3	8.0	24.0
	SI		71.8	12.1	1.0	34.0	108.0
1996	TPA	151	448.9	141.8	11.5	87.0	906.0
	BA/A		114.5	34.4	2.8	12.0	189.0
	Age		16.2	3.7	0.3	10.0	27.0
	SI		70.3	10.2	0.8	33.0	92.0
1999	TPA	148	425.9	134.8	11.1	87.0	845.0
	BA/A		128.2	34.7	2.9	13.0	204.0
	Age		19.3	3.7	0.3	14.0	30.0
	SI		70.3	9.6	0.8	30.0	92.0
2002	TPA	132	397.1	130.1	11.3	30.0	780.0
	BA/A		136.8	36.8	3.2	9.0	220.0
	Age		22.3	3.7	0.3	17.0	33.0
	SI		71.9	10.8	0.9	31.0	134.0

ETPPRP = East Texas Pine Plantation Research Project; TPA = trees per acre; BA/A = basal area (ft²) per acre; Age = plantation age; SI = site index (index age = 25 years).

RESULTS

Fusiform rust infection rates for loblolly pine have remained relatively stable around 10 percent since 1969, except in 1987 and 1990 (table 3). In 1987 and 1990, the rates increased slightly to a high of 15 percent. However, the rates decreased since that period to a low of 5 percent in 2002. The observed infection rate range of 5 to 15 percent over the 32-year period is lower than the range of 12 to 19 percent reported by Phelps (1977) for loblolly pine planted along the gulf coast, east of Texas. Lenhart and others (1994) reported that this phenomenon might be attributed to a lower mortality rate of infected east Texas loblolly pine trees coupled with fewer trees becoming infected.

Fusiform rust infection rates for slash pine have gradually decreased from the 40 percent range in 1987 to about 15 percent in 2002 (table 3). The largest drop occurred from 1999 (about 23 percent) to 2002 (about 15 percent). These infection rates more closely resemble the rate of 10 to 41 percent reported for slash pine in other Southern States (Phelps 1977) than those reported for 1987 (Lenhart and others 1988). This decrease is likely attributed to the death of infected trees because there are fewer infected trees in the proportion of total live trees for older plantations. A

drought in the late 1990s may also have contributed to this decrease as infected trees died in response to water stress.

Fusiform rust infection rates remained higher for slash versus loblolly pine for all years. Slash pine trees are more susceptible to fusiform rust than loblolly pine trees and thus are more likely to die (Bridgwater and Smith 2002, Powers 1975). Slash pine not being native to east Texas may also contribute to the rate difference because trees planted outside their natural range are highly susceptible to disease (Little 1971). In any case, the highest infection rates for both species are reported for 1987 and 1990. In these years, plantations were 8 to 11 years old, which corresponds to the period when rust galls are prevalent and easily observed, but rust-induced mortality is minimal (Wells and Dinus 1978); i.e., susceptible young pine trees that are infected have not yet died, so the incidence of infection in the plantation peaks in this age range.

The fusiform rust trends in the original plots should provide deeper insight into how infection changes for specific plot locations. Of the original 78 loblolly and 40 slash pine plots established during the first (1984) measurement cycle in

Table 2—Descriptive statistics for the ETPPRP slash pine development plots

Year	Variable	N	Mean	Standard deviation	Standard error	Minimum	Maximum
1984	TPA	40	356.5	147.0	23.3	135.0	1002.0
	BA/A		35.6	29.2	4.6	0.0	107.0
	Age		8.6	3.0	0.5	5.0	16.0
	SI		72.6	15.1	2.4	30.0	108.0
1987	TPA	73	413.1	177.3	20.8	113.0	989.0
	BA/A		36.9	28.3	3.3	0.0	129.0
	Age		8.7	3.7	0.4	5.0	18.0
	SI		74.2	15.6	1.8	15.0	110.0
1990	TPA	76	388.3	176.4	20.2	113.0	923.0
	BA/A		53.5	28.0	3.2	1.0	140.0
	Age		11.0	3.8	0.4	6.0	21.0
	SI		74.9	12.6	1.4	22.0	96.0
1993	TPA	66	377.1	173.6	21.4	91.0	897.0
	BA/A		69.8	29.0	3.6	7.0	166.0
	Age		13.3	3.2	0.4	9.0	24.0
	SI		75.5	10.6	1.3	37.0	93.0
1996	TPA	65	346.3	160.3	19.9	78.0	758.0
	BA/A		84.4	31.3	3.9	16.0	133.0
	Age		16.2	3.1	0.4	12.0	26.0
	SI		75.4	10.0	1.2	37.0	94.0
1999	TPA	65	313.1	153.3	19.0	70.0	693.0
	BA/A		92.5	35.2	4.4	24.0	155.0
	Age		19.3	3.1	0.4	15.0	29.0
	SI		75.0	9.4	1.2	39.0	99.0
2002	TPA	61	286.7	151.0	19.3	61.0	662.0
	BA/A		98.8	39.3	5.0	24.0	168.0
	Age		22.2	3.0	0.4	18.0	33.0
	SI		73.8	8.4	1.1	41.0	91.0

ETPPRP = East Texas Pine Plantation Research Project; TPA = trees per acre; BA/A = basal area (ft²) per acre; Age = plantation age; SI = site index (index age = 25 years).

Table 3—Average fusiform rust incidence (expressed as a percentage) in loblolly and slash pine plantations greater than 5 years old by survey year and geographic location in Texas

Species/ Location of rust galls	Survey year									
	1969	1976	1980	1984	1987	1990	1993	1996	1999	2002
East Texas^a										
Slash										
Stem only	8	—	—	35	41	33	26	27	22	14
Stem + branches ^c	—	30	—	45	44	37	29	34	24	16
Loblolly										
Stem only	6	—	—	8	11	10	7	9	8	5
Stem + branches	—	9	—	11	15	14	8	11	10	5
Southeastern Texas^b										
Slash										
Stem only	19	—	32	39	41	32	27	28	23	15
Stem + branches	—	43	55	47	44	36	30	36	25	17
Loblolly										
Stem only	—	—	8	10	13	11	9	9	9	6
Stem + branches	—	6	18	14	16	15	10	13	11	6

^aIncludes counties in southeastern Texas.

^bIncludes all counties located south of Cherokee, Angelina, San Augustine, and Sabine counties.

^cMay or may not also have rust-infected branches located greater than 12 inches from stem.

plantations greater than 5 years old, 43 loblolly and 20 slash pine plots remained in 2002. Fusiform rust infection trends for these “survivor” plots (table 4) did not substantially differ from those for all plots (table 3). The only exception might be for slash pine in 1999 and 2002. However, we believe the difference is attributable to sampling variation rather than an actual trend. This differs from the explanation of Lenhart and others (1994), who believed the difference was attributed to impact of younger slash pine plots with lower rust incidence on the average rate values calculated from all plots present in the measurement cycle.

CONCLUSIONS AND RECOMMENDATIONS

The 32-year continuous record of fusiform rust incidence in east Texas reported here indicates that infection rates are relatively stable (about 10 percent) for loblolly pine but much greater (up to 50 percent) for slash pine. The greatest period of infection incidence occurs when plantations are 8 to 11 years of age. If forest managers desire to produce sawtimber/plywood grade timber from their plantations, they should consider planting loblolly over slash pine or choose proven, rust-resistant slash pine planting stock. For existing slash pine plantations, forest managers should consider intensive silvicultural methods to reduce the impact of fusiform rust on wood quality. For short-rotation pulpwood plantations, the faster growth of slash pine may outweigh its high rust susceptibility. However, managers should realize slash pine is not native to east Texas and therefore expect high infection rates in

slash pine plantations, unless proven rust-resistant slash pine planting stock is used.

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Table 4— Average fusiform rust incidence (expressed as a percentage) for original loblolly and slash pine plots established during the 1984 measurement cycle in plantations greater than 5 years old in East Texas

Species/ Location of rust galls	Survey year						
	1984	1987	1990	1993	1996	1999	2002
East Texas^a							
Slash							
Stem only	35	43	33	26	22	16	9
Stem + branches ^c	45	48	38	28	24	18	10
Loblolly							
Stem only	8	12	12	8	10	10	6
Stem + branches	11	17	18	9	12	11	6
Southeastern Texas^b							
Slash							
Stem only	39	44	32	25	22	17	10
Stem + branches	47	48	37	27	25	19	11
Loblolly							
Stem only	10	14	13	9	10	11	7
Stem + branches	14	19	19	10	12	12	7

Note: In 2002, 41 loblolly plots and 20 slash plots remained of the original 78 and 40, respectively.

^aIncludes counties in southeastern Texas.

^bIncludes all counties located south of Cherokee, Angelina, San Augustine, and Sabine counties.

^cMay or may not also have rust-infected branches located greater than 12 inches from stem.

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