Incidence of *Heterobasidion annosum* and Other Root-Infecting Fungi in Residual Stumps and Roots in Thinned Slash Pine Plantations in Florida

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ABSTRACT

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Heterobasidion annosum was confirmed to be present in 17 of 30 thinned slash pine (*Pinus elliottii*) plantations in north and north central Florida. Symptoms of possible root disease were detected on only 8% of 1,840 live trees, 14% of 2,204 stumps, and 13% of 811 dead trees examined. Although *H. annosum* was isolated from 47% of root and wood samples with white stringy rot, this symptom was observed in only 0.6, 5, and 4% of the live trees, stumps, and dead trees, respectively. Resin-soaking and/or staining was observed in 6, 2, and 7%, respectively, of the live trees, stumps, and dead trees, and *H. annosum* was isolated from only 10% of root and wood samples exhibiting this symptom. *Inonotus circinatus* was isolated from 9% of root and wood samples displaying resin-soaking and/or staining. Other root and stump infecting fungi detected were *Armillariella tabescens*, *Phaeolus schweinitzii*, *Leptographium procerum*, *Fomitopsis palustris*, *Monascus floridanus*, and a *Ganoderma* sp. *A. tabescens* was a predominant root and stump colonizer in four of the 30 plantations and sometimes occurred in the same roots as *H. annosum*. *H. annosum* was confirmed present in only two of 11 plantations surveyed with the "annosus sampling procedure," whereas the presence of the pathogen was confirmed in six of the same 11 plantations via a 20-unit plantation-row plot method. In one plantation, *H. annosum* was undetected using the annosus sampling procedure, despite the fact that the fungus was isolated, respectively, from 33, 83, and 60% of the live trees, stumps, and dead trees sampled via the plantation-row plot method.

Annosum root rot, caused by *Heterobasidion annosum* (Fr.:Fr.) Bref., is considered one of the most destructive diseases affecting conifers in the north temperate regions of the world. The disease occurs most often in thinned stands where the pathogen can cause direct mortality (7,8,18,29,33), reduced rates of growth (4,16,21), and increased susceptibility to attack by bark beetles (4,5). Although incidence of *H. annosum* in stumps and residual trees in thinned conifer stands has been estimated in several geographical areas of North America (8,17,28,31,33,41), a satisfactory understanding of the overall impact of annosum root rot in managed pine stands in Florida is lacking.

H. annosum has been identified as a cause of reduced growth and mortality in certain thinned and unthinned plantations of slash pines (*Pinus elliottii* Engelm.) in Florida (E. L. Barnard, *unpublished*; G. M. Blakeslee, *personal communication*). In 1978, foresters from the Florida Division of Forestry reported that eight of 64 slash pine plantations, thinned within the previous 10 years, were infected with *H. annosum* (E. L. Barnard, *unpublished*). Trees in an additional 23 of these 64 plantations were reported to be exhibiting symptoms typical of those induced by *H. annosum* (e.g., crown thinning, windthrow, dead or dying trees, resinous or white-stringy rotted roots). While such observations and unconfirmed reports provide a framework for consideration, they fail to provide an assessment of disease impact or risk-hazard rating sufficient for issuing sound and cost-effective recommendations for disease prevention. For example, should foresters and landowners considering thinning stands treat stumps with protective chemicals? If they should, at what cost (7,11,23,25,32,35,39)? To better understand the incidence and severity of annosum root rot in Florida, we conducted a survey of thinned slash pine plantations.

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MATERIALS AND METHODS

Industrial, consulting, and Florida Division of Forestry foresters throughout north and central Florida were provided with data forms and asked for background data on slash pine plantations thinned between 1972 and 1983. From a total of 294 forms returned, 30 plantations (Fig. 1) were selected for field evaluation after consultations with George Ryan, Statistician, Forest Pest Management, Region 8, USDA Forest Service in Atlanta. Selected plantations were stratified so as to evaluate stands thinned 1) between 3 and 8 yr before our survey (i.e., each surveyed plantation was thinned 3–8 yr prior to actual visitation), 2) in calendar years 1976–1983, 3) in all four seasons of the year, and 4) on each of three broadly defined site-soil types (Fig. 2).

Depending on plantation size, 10 or 20 plots (<8 ha = 10 plots, ≥8 ha = 20 plots) were distributed at regular intervals throughout each selected plantation, spaced according to number of rows of trees and distances within rows. Each plot consisted of 20 sampling units in a plantation row, with units identified as live trees, stumps, and dead trees (Fig. 3). Each tree was examined for aboveground indicators of annosum root rot (crown thinning, chlorosis, sporophores, basal resinosis, etc.). Soil at the base of each stump and dead tree was removed, and roots or portions thereof were excavated, dismantled manually with a mattock and axe, and examined for fungal signs, resin-soaking, and wood decay indicative of annosum or other root rot. Additionally, at least two roots from each of four live trees (positions 1, 6, 11, and 16 or the next in linear sequence if necessitated by the presence of stumps or dead trees) were uncovered with a mattock and examined for evidence of root disease, employing a modified version of Alexander and Skelly's "two root method" (3). Efforts were made to examine roots of live trees on sides closest to stumps and dead trees (Fig. 3). Each root was examined for a length of about 0.5–1.5 m. For comparison, we simultaneously employed the "annosus sampling procedure" (ASP) as described by Alexander and Anderson (1,2) in 11 of our 30 survey plantations (ASP plots were located near the center of our 20-unit plantation-row plots). In addition, all units were examined for the presence of stem infections of fusiform rust (caused by *Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusiforme* (Hedgc. & Hunt) Burdsall & G. Snow), pitch canker (caused by *Fusarium subglutinans* (Wollenweb. & Reinking) P. E. Nelson, T. A. Toussoun, & Marasas), and evidence (e.g., pitch tubes, entrance-emergence holes) of infestation by ips engraver beetles (*Ips* spp.).

Representative samples of root and wood tissues with symptoms of possible root disease were transported on ice to the laboratory. Wood chips were removed aseptically from root and wood samples or removed and surface disinfected (dipped in 95% ethanol and flamed or dipped for 2 min in 0.5% sodium hypochlorite and rinsed in sterile deionized water), placed on malt extract agar and Russell's agar (40), and incubated at room temperature under normal laboratory lighting. Cultures were examined as required over 1–3 wk.

RESULTS

The 30 plantations surveyed represented a total of 456 ha. Sixteen plantations were ≥8 ha and 14 were <8 ha. In all, 460 plots with 9,200 sample units (6,185 live trees, 2,204 stumps, 811 dead trees) were observed, and roots of 1,840 live trees as well as all stumps and dead trees were excavated and examined. Plantations surveyed ranged in age from 17 to 33 yr ($\bar{x} = 23$). Tree mortality within plantations surveyed (i.e., percentage of dead trees, all causes) evident at the time of the survey averaged 11% (range: 2–32%). Fusiform rust was detected in 29 of the 30 plantations at incidence levels (stem infections only) ranging from 1 to 55% ($\bar{x} = 12\%$) on live trees, 1 to 48% ($\bar{x} = 9\%$) on stumps, and 2 to 100% ($\bar{x} = 33\%$) on dead trees. Pitch canker was detected in only two plantations, but it occurred on 29 and 45% of the trees in these plantations. Evidence of ips engraver beetle activity was negligible throughout the survey.

Sporophores of *H. annosum* and other root rot and decay fungi were observed very infrequently during the survey. Sporophores of *H. annosum* were detected on only two, 26, and four live trees, stumps, and dead trees, respectively. Twenty-five of the 26 stumps with sporophores were in one plantation. These stumps represented 26% of the stumps examined in that plantation. Sporophores of *Inonotus circinatus* (Fr.) R. L. Gilbertson, on the other hand, were detected on four live trees, two stumps, and one dead tree, generally in association with basal fusiform rust galls. In one plantation, sporophores detected most frequently were those of *Fomitopsis palustris* (Berk & M. A. Curtis) R. L. Gilbertson & Ryvarden (10 of 114 stumps, largely in association with what we call a "white punky rot") and a *Ganoderma* sp. (16 of 114 stumps).

Symptoms of possible root disease were detected in all 30 plantations. However, symptoms were detected in only 8, 14, and 13% of the live trees, stumps, and dead trees examined. White stringy rot (WSR) symptoms were detected in only 0.6% of the live-tree root systems, 5% of the stumps, and 4% of the dead trees (Table 1). Nearly half of the stumps with WSR occurred in the plantation where 25 of the 95 stumps examined had sporophores of *H. annosum*. However, only three of 80 live-tree root systems and three of 43 dead trees examined in this plantation exhibited either WSR or resin-soaking and/or staining (RSS). Laboratory isolations from five of these six sample units failed to yield *H. annosum*; the pathogen was isolated from one of the three dead trees sampled.

RSS was detected in 6, 2, and 7%, respectively, of the live-tree root systems, stumps, and dead trees (Table 1). However, only 10% of 154 RSS samples isolated on laboratory media yielded *H. annosum*, whereas 47% of 68 WSR samples yielded the pathogen. Twenty-two percent of the RSS samples yielded primarily other fungi upon isolation, a number of which are well-known root pathogens of conifers. *I. circinatus* was

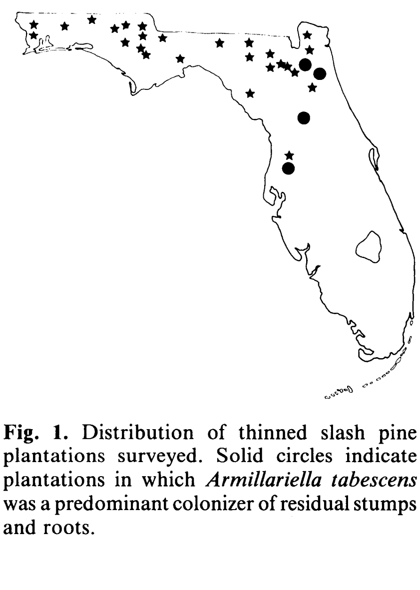

Fig. 1. Distribution of thinned slash pine plantations surveyed. Solid circles indicate plantations in which *Armillariella tabescens* was a predominant colonizer of residual stumps and roots.

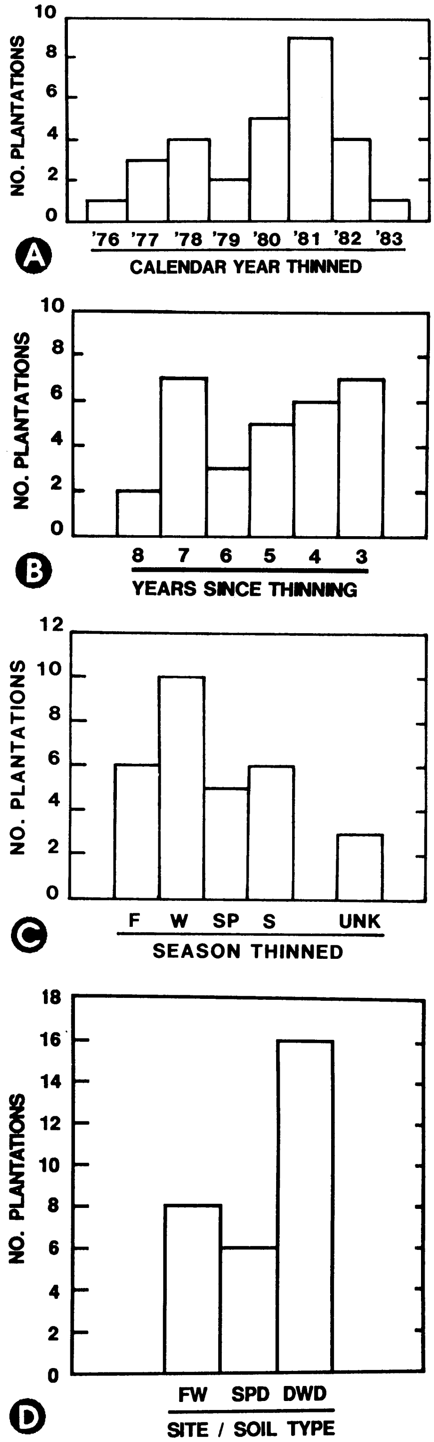

Fig. 2. Stratification of the 30 plantations surveyed with respect to **(A)** calendar year thinned, **(B)** years thinned prior to survey, **(C)** season of thinning (F = fall, W = winter, SP = spring, S = summer, UNK = unknown), and **(D)** general site-soil category (FW = flatwoods; SPD = shallow, poorly drained; DWD = deep, well drained).

isolated from 9% of the RSS samples overall, and in fact was isolated more frequently than *H. annosum* from RSS roots on live trees. *Phaeolus schweinitzii* (Fr.:Fr.) Pat., *Armillariella tabescens* (Scop.) Singer, and/or *Leptographium procerum* (Kendrick) M. J. Wingfield were isolated from 8% of the RSS root and wood samples processed.

In four plantations (Fig. 1), among the predominant symptoms and signs of root disease infection detected in stumps and roots were those produced by *A. tabescens* (Table 2), i.e., a distinct water-soaking of wood tissues associated with the typical subcortical mycelial felts of the fungus (10,34,37). The association of *A. tabescens* was confirmed in all four of these plantations (and at a lower incidence in three other plantations) by isolation. In two of these four plantations (stands 25 and 26), infections by *A. tabescens* were closely associated with infections by *H. annosum*, as indicated by the recovery of the latter in the laboratory from roots displaying water-soaking and subcortical mycelial felts of the former (Table 2).

In the 11 plantations surveyed with both the ASP and our 20-unit plantation-row plot method, an average of 17.1% of the roots examined in each plantation via the ASP were classified as symptomatic of possible root disease. This compares with averages of 8.4, 12.3, and 17.8% of live trees, stumps, and dead trees, respectively, which were classified as symptomatic with our plantation-row plot method (Table 3). With the ASP, *H. annosum* was confirmed to be present in only two of 11 plantations, but with the plantation-row plot method the presence of the fungus was confirmed in six of the same 11 plantations (one plantation by sporophore detection only). In stand 25, we were unable to confirm the presence of *H. annosum* via the ASP (augmented with isolations) despite the fact that 25% of the 87 roots examined via this procedure were classified as symptomatic. Isolations from seven of these symptomatic roots failed to yield *H. annosum*; two of the seven roots yielded *A. tabescens*. In this same stand, symptomatic roots collected via our plantation-row plot method from live trees, stumps, and dead trees, respectively, confirmed *H. annosum* in 33, 83, and 60% of these units upon isolation; *A. tabescens* was isolated from one stump and one dead tree. Overall, a greater variety of root pathogenic fungi were confirmed present in the plantations surveyed via our 20-unit plantation-row plot method (Table 3).

Overall, the presence of *H. annosum* was confirmed by laboratory culture or the positive identification of sporophores in the field, or both, in 17 of the 30 plantations surveyed. The pathogen was confirmed in six of 10 winter-, three of five spring-, and four of six fall-thinned

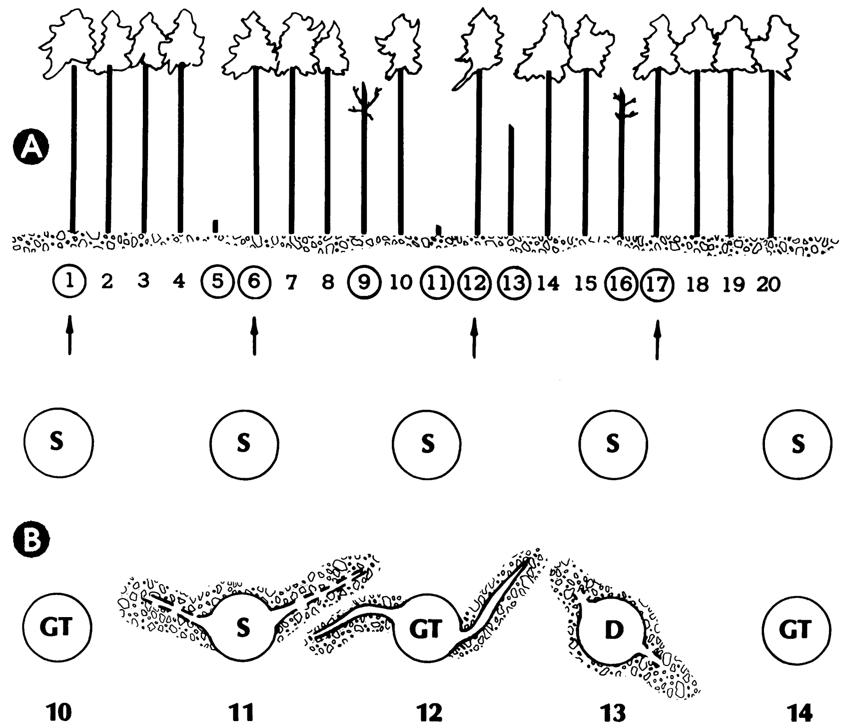

Fig. 3. **(A)** Survey plot schematic (profile) showing 20 sampling units (live trees, stumps, and dead trees) in a linear plantation-row plot. Circled numbers indicate units that had roots excavated and examined. Arrows indicate selection and location of live trees for root excavation and examination. **(B)** Vertical schematic of sampling units 10–14 showing typical pattern of root excavation and examination (stippled areas) (S = stump, D = dead tree, GT = green, live tree).

Table 1. Summary of "root rot" symptoms and signs detected in thinned slash pine plantations in Florida and results of laboratory isolations

Sample units (no.) Symptoms expressed[a]	No. sample units with symptoms		Laboratory isolations: no. units yielding[b]						
	Detected	Sampled	*Ha*	*At*	*Ic*	*Ps*	*Fp*	*Mf*	*Lp*
Live trees (n = 1,840)									
WSR	11	8	5	0	0	0	0	1	0
RSS	117	92	6	1	7	1	1	7	0
WS+*At*	9	4	0	3	0	0	0	0	0
Other	1	1	0	0	1	0	0	0	0
Total	138	105	11	4	8	1	1	8	0
Stumps (n = 2,204)									
WSR	103[c]	34	14	0	0	0	0	0	0
RSS	39	20	3	1	1	0	0	0	0
WS+*At*	64	16	5	5	0	0	0	0	0
Other	96[d]	26	0	0	0	0	8	0	0
Total	302	96	22	6	1	0	8	0	0
Dead trees (n = 811)									
WSR	32	26	13	0	0	0	0	0	0
RSS	53	42	7	2	6	2	0	0	5
WS+*At*	14	8	1	4	0	0	0	1	0
Other	7	4	0	0	0	0	0	0	0
Total	106	80	21	6	6	2	0	1	5
Total (n = 4,855)									
WSR	146	68	32	0	0	0	0	1	0
RSS	209	154	16	4	14	3	1	7	5
WS+*At*	87	28	6	12	0	0	0	1	0
Other	104	31	0	0	1	0	8	0	0
Total	546	281	54	16	15	3	9	9	5

[a] WSR = white stringy rot, RSS = resin-soaked and/or stained, WS+*At* = water-soaked with subcortical mycelial felt of *Armillariella tabescens*. Other = variously defined as brown rot, red-orange discoloration, white pocket rot, yellow-orange stringy rot, and white punky rot.

[b] *Ha* = *Heterobasidion annosum*, *At* = *Armillariella tabescens*, *Ic* = *Inonotus circinatus*, *Ps* = *Phaeolus schweinitzii*, *Fp* = *Fomitopsis palustris*, *Mf* = *Monascus floridanus*, *Lp* = *Leptographium procerum*.

[c] 49 stumps with WSR occurred in one plantation; 25 of these stumps had sporocarps of *H. annosum*.

[d] 66 of these stumps occurred in one plantation; 43 with white punky rot (6/12 isolations = *F. palustris*) and 23 with brown rot (seven isolations, negative). Sporophores of *Ganoderma* sp. and *F. palustris* occurred on 16 and 10 stumps, respectively.

plantations. In only two of the six plantations reportedly thinned during the summer was the presence of the pathogen confirmed. The season of thinning for three of the survey plantations was not identified on plantation data forms (Fig. 2). With respect to site and soil type, the fungus was confirmed in four of eight survey plantations occurring in flatwoods; three of six on shallow, poorly drained sites; and 10 of 16 on deep, well-drained sites.

Table 2. Occurrence of *Armillariella tabescens* in four thinned slash pine plantations in Florida where its predominance was considered noteworthy[a]

Stand no. and county	Sample units (no.)	Root rot symptoms expressed[b]	No. sample units with symptoms: Detected	Sampled	Laboratory isolations: no. units yielding[c]: *Ha*	*At*	*Ps*	*Mf*
9 Pasco	Live trees (80)	RSS	4	4	0	0	0	0
		WS+*At*	3	3	0	3	0	0
	Stumps (61)	WSR	1	1	0	0	0	0
	Dead trees (29)	RSS	2	2	0	0	0	0
		WS+*At*	1	0	...	...	...	...
21 St. Johns	Live trees (80)	RSS	6	4	0	1	1	1
		WS+*At*	5	0	...	...	...	...
	Stumps (72)	RSS	1	1	0	1	0	0
		WS+*At*	12	4	0	2	0	0
	Dead trees (23)	RSS	4	2	0	0	0	0
		WS+*At*	6	3	0	1	0	1
25[d] Marion	Live trees (80)	RSS	13	9	3	0	0	1
	Stumps (119)	RSS	1	1	1	0	0	0
		WS+*At*	16	5	4	1	0	0
	Dead trees (17)	RSS	4	3	2	0	0	0
		WS+*At*	4	2	1	1	0	0
26 Clay	Live trees (80)	RSS	2	2	0	0	0	0
	Stumps (126)	WSR	1	1	1	0	0	0
		RSS	11	1	1	0	0	0
		WS+*At*	35	6	1	1	0	0
		Other	5	0	...	...	...	...

[a] Stand locations shown in Figure 1.
[b] WSR = white stringy rot, RSS = resin-soaked and/or stained, WS+*At* = water-soaked with subcortical mycelial felt of *Armillariella tabescens.*
[c] *Ha* = *Heterobasidion annosum*, *At* = *Armillariella tabescens*, *Ps* = *Phaeolus schweinitzii*, *Mf* = *Monascus floridanus.*
[d] This plantation was the only one of 30 surveyed in which root rot was considered managerially significant. The plantation was clearly "off-site" on a very deep, excessively well-drained sand.

DISCUSSION

Our survey revealed no evidence that *H. annosum* constitutes a general threat to thinned slash pine plantations in Florida. *H. annosum* was isolated from symptomatic root and wood tissues more frequently than any other known or suspected root-pathogenic fungus identified. However, the overall incidence of stumps and roots with symptoms or signs of infections by *H. annosum* was considered inconsequential. Relatively few of the live trees, stumps, and dead trees examined displayed any symptoms of possible root disease, and isolations indicated that only a fraction of these could be justifiably related to *H. annosum* (Tables 1–3). Indeed, other known conifer root pathogens were isolated from RSS roots and wood (the "root disease" symptom most frequently observed, especially in live trees) more frequently than was *H. annosum.* Additionally, at least some (unquantified) of the possible root disease symptoms observed (i.e., RSS) appeared to be a physiological response to mechanical injury (e.g., trauma-induced resinosis) apparently sustained during thinning, and many of the root disease symptoms and signs detected on stumps and dead trees appeared to be a result of post-thinning saprophytic fungus activity only.

In only one of the 30 plantations surveyed was the occurrence of *H. annosum* or root disease considered managerially significant. In stand 25, windthrown trees were observed, symptoms of root disease (i.e., RSS) were detected on 16% of the live trees examined, 6% of the sample

Table 3. Comparative results of two survey methods employed for root disease evaluations in thinned slash pine plantations in Florida

	Annosus sampling procedure[a]					20-Unit plantation-row plot method											
						No. units examined			Units symptomatic[b] (%)			No. units plated			Recovery[c]		
Stand	No. plots	No. roots examined	Roots symptomatic[b] (%)	No. roots plated	Recovery[c]	Live trees	Stumps	Dead trees	Live trees	Stumps	Dead trees	Live trees	Stumps	Dead trees	Live trees	Stumps	Dead trees
4	20	112	42	15	2*Ha*	80	95	43	4	58	7	2	14	3	0	7*Ha*	1*Ha*, 1*Lp*
6	20	103	13	4	3*Ha*	80	105	47	6	7	32	5	2	10	2*Ha*	1*Ha*	3*Ha*, 1*Lp*
7	20	140	4	2	0	80	1	103	9	0	9	5	...	9	1*Ic*	...	1*Ps*
9	20	154	23[d]	9	0	80	61	29	9	2	10	7	1	2	3*At*	0	0
10	20	101	13	7	0	80	205	6	8	10	33	6	3	2	0	0	0
11	10	67	4	1	0	40	82	27	15	11	4	3	4	0	2*Ha*	2*Ha*	...
12	20	195	19[e]	6	0	80	0	0	5	...	...	4	...	...	1*At*	...	...
15	20	198	18	8	0	80	105	9	4	15	11	2	7	0	0	2*Ha*, 2*Fp*	...
21	20	155	5[f]	0	...	80	72	23	14	18	43	4	5	5	2*Mf*, 1*At*, 1*Ps*	3*At*	1*At*, 1*Mf*
24	10	107	22	2	1*Ic*	40	80	7	2	0	0	1	...	...	0	...	...
25	20	87	25[g]	7	2*At*	80	119	17	16	14	47	9	6	5	3*Ha*, 1*Mf*	5*Ha*, 1*At*	3*Ha*, 1*At*
Sums	200	1,419	...	61	...	800	925	311	...	...	...	48	42	36	...	...	...
Means	...	...	17.1	...	...	...	...	...	8.4	12.3	17.8	...	...	...	...	...	...

[a] Alexander (1), Alexander and Anderson (2).
[b] Symptomatic = resin-soaked or stained, necrotic and/or decayed.
[c] Recovery = no. of roots or units, respectively, yielding fungus indicated. *Ha* = *Heterobasidion annosum*, *Ic* = *Inonotus circinatus*, *At* = *Armillariella tabescens*, *Lp* = *Leptographium procerum*, *Ps* = *Phaeolus schweinitzii*, *Fp* = *Fomitopsis palustris*, *Mf* = *Monascus floridanus.*
[d,e,f,g] Respectively, 4, 2, 1, and 4 roots with subcortical mycelial felts of *Armillariella tabescens.*

units in our survey plots were dead trees, and *H. annosum* was isolated from root tissues more frequently than any other organism (Table 2). Indeed, *H. annosum* was isolated from roots exhibiting water-soaking and mycelial felts of *A. tabescens* more frequently than was *A. tabescens.* The precise roles of *H. annosum* and *A. tabescens* in the root disease epidemiology of this stand are unclear, however, due to the coincident occurrence of the pathogens and the fact that the site was clearly not well suited for slash pine. The site was characterized as a very deep, well-drained, sandy soil (Candler Sand of the Candler-Apopka Association).

The one plantation (stand 4, Nassau County) in which we observed abundant sporophores of *H. annosum* was located on a flatwoods site, a site not considered a high hazard for annosum root rot (22,26,30). Webb et al (41) reported similar observations on a clearcut site in north Florida. In subsequent investigations, Webb et al (41) were unable to relate incidental mortality of slash pine seedlings growing among infected stumps to infections by *H. annosum.* Their assessment of seedling mortality may have been premature, however, as it was performed only 18 months after planting (insufficient time for stump infection, colonization, and progression into seedling roots). Periodic spot checks over several years following our survey failed to provide any evidence of root disease or infection center development in our Nassau County stand, despite the prevalence of stump infection observed during the survey. In this case, it appears that site factors (26,27) are effectively checking the pathogenic activity of *H. annosum.*

Relatively few and variable numbers of plantations were evaluated on each of the three broadly defined site-soil types (Fig. 2D), and the seasons in which plantations were reportedly thinned could not be verified. Indeed, our survey was not specifically designed to provide a statistically reliable assessment of the occurrence of *H. annosum* in relation to site-soil types, season of thinning, or interactions thereof. Nonetheless, our results with respect to these factors are generally compatible with the known biology of the pathogen (19,22,26,38).

In general, our data show a potpourri of decay fungi, pathogenic fungi, and other fungi colonizing residual stumps and tree roots in the thinned slash pine plantations surveyed. None of the fungi recorded occurred at particularly high or alarming levels, and overall, stump and root colonization did not appear to be the restrictive domain of any particular organism. The occurrence of *I. circinatus* was often, though not always, related to basal galls caused by *C. q.* f. sp. *fusiforme* (13–15,36). *I. circinatus* is known to be a significant contributor to Florida's sand pine root disease scenario (10). The relatively infrequent occurrences of *P. schweinitzii, L. procerum,* and *Monascus floridanus* E. Barnard & P. Cannon were of interest and not unexpected. Blakeslee and Oak (12) reported *P. schweinitzii* causing root rot centers in 10- to 22-year-old plantations of slash pine in north-central Florida. Barnard et al (10) reported *L. procerum* as a component of sand pine root disease in Florida, and this organism was previously isolated from resin-soaked slash pine roots in Florida, often in association with apparent insect feeding wounds (E. L. Barnard, *unpublished*). Barnard and Cannon (9) described *M. floridanus* as a frequent inhabitant of resin-soaked pine roots in Florida. The role of this organism, however, remains unknown. The occurrence of *F. palustris* was no surprise, because this organism is a common colonizer of pine stumps in the southeastern United States (6,24). The surprisingly high incidence of a *Ganoderma* sp. on stumps in one plantation was, however, quite unexpected, although *Ganoderma* spp. have been reported previously on pines in Florida (6). Perhaps most interesting was the relative abundance of *A. tabescens* encountered during our survey (Fig. 1, Tables 1 and 2). This fungus is a well-known root disease pathogen affecting a wide variety of woody species, including pines, in Florida (6,10,34,37), but to our knowledge, documentation of this level of occurrence in thinned slash pine stands is unprecedented.

The variety of fungi we isolated so readily and frequently from RSS root and wood tissues, like that encountered in a previous Florida root disease survey (10), emphasizes the need for caution when attempting to diagnose root disease on the basis of symptoms. Clearly, reliance on RSS alone as a definitive indicator of infection by *H. annosum* (4,5,16,17) would have grossly overestimated the occurrence and importance of this pathogen in thinned slash pine stands in Florida. Similarly, had we relied strictly upon the visual detection of water-soaking and associated mycelial felts as exclusively definitive for *A. tabescens,* we would have completely overlooked the involvement of *H. annosum* in at least one plantation (Table 2).

Our data clearly document the colonization of residual stumps and roots in thinned slash pine plantations in Florida by a variety of decay fungi and other fungi. We do not consider this particularly novel, and certainly the phenomenon is not without precedent. Filip (20) recently reviewed findings in the Oregon-Washington area in which colonization of stumps and roots in thinned conifer stands by several decay and/or root disease fungi, including *H. annosum* and *Armillaria ostoyae* (Romagnesi) Herink (presumably a close relative of *A. tabescens*) is apparently not uncommon. These types of studies illustrate the complexity of stump and root decay ecology and emphasize the need for recognizing fungi other than *H. annosum* as key players in post-thinning stump and root colonization and possible root disease.

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LITERATURE CITED

1. Alexander, S. A. 1989. Annosus root disease hazard rating, detection, and management strategies in the southeastern United States. Pages 111-116 in: Proceedings of the Symposium on Research and Management of Annosus Root Disease (*Heterobasidion annosum*) in Western North America. W. J. Otrosina and R. F. Scharpf, Tech. Co-ords. U.S. For. Serv. Gen. Tech. Rep. PSW (Pac. Southwest For. Range Exp. Stn.) PSW-116.
2. Alexander, S. A., and Anderson, R. L. 1985. How to identify and control annosus root rot in the south. U.S. For. Serv. For. Bull. (Southern Region) R8-FB/P-19.
3. Alexander, S. A., and Skelly, J. M. 1974. A comparison of isolation methods for determining the incidence of *Fomes annosus* in living loblolly pine. Eur. J. For. Pathol. 4:33-38.
4. Alexander, S. A., Skelly, J. M., and Webb, R. S. 1981. Effects of *Heterobasidion annosum* on radial growth in southern pine beetle-infested loblolly pine. Phytopathology 71:479-481.
5. Alexander, S. A., Skelly, J. M., Webb, R. S., Bardinelli, T. R., and Bradford, B. 1980. Association of *Heterobasidion annosum* and the southern pine beetle on loblolly pine. Phytopathology 70:510-513.
6. Alfieri, S. A., Jr., Langdon, K. R., Wehlburg, C., and Kimbrough, J. W. 1984. Index of plant disease in Florida. Div. Plant Ind., Fla. Dep. Agric. Consumer Serv. Bull. 11. 389 pp.
7. Anderson, R. L., and Mistretta, P. A. 1982. Management strategies for reducing losses caused by fusiform rust, annosus root rot, and littleleaf disease. U.S. For. Serv. Coop. State Res. Serv. Agric. Handb. 597. 30 pp.
8. Appelgate, H. W. 1971. Annosus root rot mortality in once-thinned loblolly pine plantations in Tennessee. Plant Dis. Rep. 55:625-627.
9. Barnard, E. L., and Cannon, P. F. 1987. A new species of *Monascus* from pine tissues in Florida. Mycologia 79:479-484.
10. Barnard, E. L., Blakeslee, G. M., English, J. T., Oak, S. W., and Anderson, R. L. 1985. Pathogenic fungi associated with sand pine root disease in Florida. Plant Dis. 69:196-199.
11. Berry, F. H. 1965. Treat stumps to prevent *Fomes annosus* in shortleaf pine plantations. U.S. For. Serv. Res. Note CS-34. 4 pp.
12. Blakeslee, G. M., and Oak, S. W. 1980. Residual naval stores stumps as reservoirs of inoculum for infection of slash pines by *Phaeolus schweinitzii.* Plant Dis. 64:167.
13. Boyce, J. S., Jr. 1963. Red root and butt rot in a Georgia slash pine plantation. Plant Dis. Rep. 47:572-573.
14. Boyce, J. S., Jr. 1965. *Polyporus tomentosus* in pine plantations at Athens, Georgia. Plant Dis. Rep. 49:322.
15. Boyce, J. S., Jr. 1967. Red root and butt rot in planted slash pines. J. For. 65:493-494.
16. Bradford, B., Alexander, S. A., and Skelly, J. M. 1978. Determination of growth loss of *Pinus taeda* L. caused by *Heterobasidion annosum* (Fr.) Bref. Eur. J. For. Pathol. 8:129-134.
17. Bradford, B., Skelly, J. M., and Alexander, S. A. 1978. Incidence and severity of annosus root rot in loblolly pine plantations in Virginia. Eur. J. For. Pathol. 8:135-145.
18. Driver, C. H., and Dell, T. R. 1961. *Fomes annosus* root rot in slash pine plantations of the eastern Gulf Coast States. Plant Dis. Rep.

45:38-40.
19. Driver, C. H., and Ginns, J. H., Jr. 1969. Ecology of slash pine stumps: Fungal colonization and infection by *Fomes annosus*. For. Sci. 15:2-10.
20. Filip, G. N. 1988. Incidence and biology of root and stem decay fungi in thinned conifer stands, Oregon and Washington, USA. Pages 267-273 in: Proc. Int. Conf. Root and Butt Rots, 7th. D. J. Morrison, ed. International Union of Forest Research Organizations, Working Party S2.06.01, Vernon and Victoria, B.C., 9-16 Aug. 1988.
21. Froelich, R. C., Cowling, E. B., Collicott, L. V., and Dell, T. R. 1977. *Fomes annosus* reduces height and diameter growth of a planted slash pine. For. Sci. 23:299-306.
22. Froelich, R. C., Dell, T. R., and Walkinshaw, C. H. 1966. Soil factors associated with *Fomes annosus* in the Gulf States. For. Sci. 12:356-361.
23. Froelich, R. C., Kuhlman, E. G., Hodges, C.S., Weiss, M. J., and Nichols, J. D. 1977. *Fomes annosus* in the South. Guidelines for prevention. U.S. For. Serv. Southeast. For. Exp. Stn. and Southeast. Area State Priv. For. 4. 17 pp.
24. Gilbertson, R. L., and Ryvarden, L. 1986. North American Polypores. Vol. 1. Fungiflora A/S. Oslo, Norway. 433 pp.
25. Hodges, C. S., Jr. 1974. Cost of treating stumps to prevent infection by *Fomes annosus*. J. For. 72:402-404.
26. Kuhlman, E. G. 1974. Variation in infection of loblolly pine roots on high and low hazard sites in the southeastern United States. Pages 179-183 in: Proc. Int. Conf. on *Fomes annosus*, 4th. U.S. Dep. Agric., Washington, DC.
27. Kuhlman, E. G. 1980. Influence of moisture on rate of decay of loblolly pine root wood by *Heterobasidion annosum*. Can. J. Bot. 58:36-39.
28. Mason, G. N. 1969. An evaluation of the incidence of *Fomes annosus* in east Texas. Plant Dis. Rep. 53:936-939.
29. Morris, C. L. 1970. Volume losses from *Fomes annosus* in loblolly pine in Virginia. J. For. 68:283-294.
30. Morris, C. L., and Frazier, D. H. 1966. Development of a hazard rating for *Fomes annosus* in Virginia. Plant Dis. Rep. 50:510-511.
31. Morrison, D. J., Larock, M. D., and Waters, A. J. 1986. Stump infection by *Fomes annosus* in spaced stands in the Prince Rupert Forest Region of British Columbia. Can. For. Serv. Pac. For. Ctr. Inf. Rep. BC-X-285. 12 pp.
32. Myren, D. J. 1981. Use of borax and sodium nitrite in an operational thinning of red pine in Ontario to prevent stump infection by *Fomes annosus*. For. Chron. 57:284-285.
33. Powers, H. R., Jr., and Verrall, A. F. 1962. A closer look at *Fomes annosus*. For. Farmer 21(13):8-9, 16-17.
34. Rhoads, A. S. 1950. Clitocybe root rot of woody plants in the southeastern United States. U.S. Dep. Agric. Circ. 853. 25 pp.
35. Robbins, K. 1984. Annosus root rot in eastern conifers. U.S. For. Serv. For. Insect Dis. Leafl. 76. 10 pp.
36. Ross, E. W. 1966. Incidence of *Polyporus tomentosus* in slash pine plantations in the southeastern United States. Plant Dis. Rep. 50:527.
37. Ross, E. W. 1970. Sand pine root rot pathogen: *Clitocybe tabescens*. J. For. 68:156-158.
38. Ross, E. W. 1973. *Fomes annosus* in the southeastern United States. Relation of environmental and biotic factors to stump colonization and losses in the residual stand. U.S. For. Serv. Tech. Bull. 1459. 26 pp.
39. Ross, E. W., and Hodges, C. S., Jr. 1981. Control of *Heterobasidion annosum* colonization in mechanically sheared slash pine stumps treated with *Peniophora gigantea*. U.S. For. Serv. Southeast. For. Exp. Stn. Res. Pap. SE-229. 3 pp.
40. Russell, P. 1956. A selective medium for the isolation of basidiomycetes. Nature 177:1038-1039.
41. Webb, R. S., Hollis, C. A., and Swindel, B. F. 1982. Incidence of *Heterobasidion annosum* basidiocarps on two low-hazard Florida soils after clearcutting and site preparation. South. J. Appl. For. 6:39-41.