FOREST HEALTH EVALUATION OF OAK MORTALITY AND DECLINE ON THE MARK TWAIN NATIONAL FOREST, 2000

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INTRODUCTION

Widespread and locally severe mortality and decline of scarlet oak, *Quercus coccinea*; and black oak, *Q. velutina* has been occurring on the Mark Twain National Forest for many years. Reports of mortality date back to as early as 1976 (USDA FS MT-1), and continue through the present. Scarlet and black oaks are relatively short-lived species, particularly on upper slopes and broad ridgetops, due in part to the drought susceptibility of these soils. Precipitation deficit exceeded 12 inches below normal in each of the past two years, and consequently, decline and mortality has accelerated in many areas. This stress, coupled with aging stands, renders scarlet and black oak susceptible to insects and pathogens.

More than 16,000 acres of mortality were mapped on the Salem and Potosi Ranger Districts by aerial survey in September of 2000 (USDA FS 2470). Subsequent ground verification showed red oak borer (*Enaphalodes rufulus*) (Donley and Acciavatti) was obviously associated with the damage, along with other secondary agents, including Armillaria root disease (*Armillaria spp.*)(Williams et al.), Hypoxylon canker (*Hypoxylon atropunctatum*)(Lewis), and twolined chestnut borer (*Agrilus bilineatus*)(Haack and Acciavatti).

Personnel from the Mark Twain National Forest and Forest Health Protection (USDA FS, S&PF) were interested in quantifying the severity of the decline and mortality in affected stands, and finding out the role of various pests.

METHODS

Sample stands were surveyed using 5 prism plots (10 BAF) arrayed on a transect through the main part of the stand at a spacing of about 300 feet. Subplot centers were marked to facilitate remeasurement. Plot-level data recorded at each subplot included GPS (global positioning system) location as latitude and longitude (from hand-held units), topographic position, aspect and percent slope (Table 1). For sample trees >5 inches diameter at breast height (d.b.h.), data were collected on species, d.b.h., crown class, crown condition, number of red oak borer attacks, the presence or absence of Hypoxylon canker, and evidence of twolined chestnut borer attacks (Table 1). In addition, 3, 1/100-acre regeneration plots were placed at plot center, 25 feet north, and 25 feet south where advanced reproduction >1 foot tall and < 5 inches d.b.h. was tallied by species.

Table 1.--Plot and tree data collected from sample stands.

VARIABLE	DESCRIPTION
Plot-Level Data	
GPS LOCATION	Latitude/longitude as determined by hand-held global positioning unit.
ASPECT	Down-slope azimuth recorded to nearest degree
PERCENT SLOPE	Average percent slope measured over 50 feet across plot center
Tree-Level Data	
SPECIES	Appropriate species code
D.B.H.	Diameter at breast height to the nearest 2 inches
CROWN CLASS	4=dominant, 3=codominant, 2=intermediate, 1=suppressed
CROWN CONDITION	0=healthy, <5% dieback 1=slight dieback; >5% to <1/3 of crown 2=moderate dieback; 1/3-2/3 of crown 3=severe dieback; >2/3 of crown 4=dead; died this year; fine twigs present, brown leaves may be present, little or no bark sloughing 5=dead; died 2-4 years ago; no fine twigs present, bark sloughing 6=dead; died 4 or more year ago; stubby branches, bark sloughing
ROB	Red oak borer attacks 0=none, 1=1-10, 2=11-20, 3=≥21
HYPOXYLON CANKER	0=None, 1=Present
TLCB	0=None, 1=attacks present

ROB = red oak borer; TLCB = twolined chestnut borer

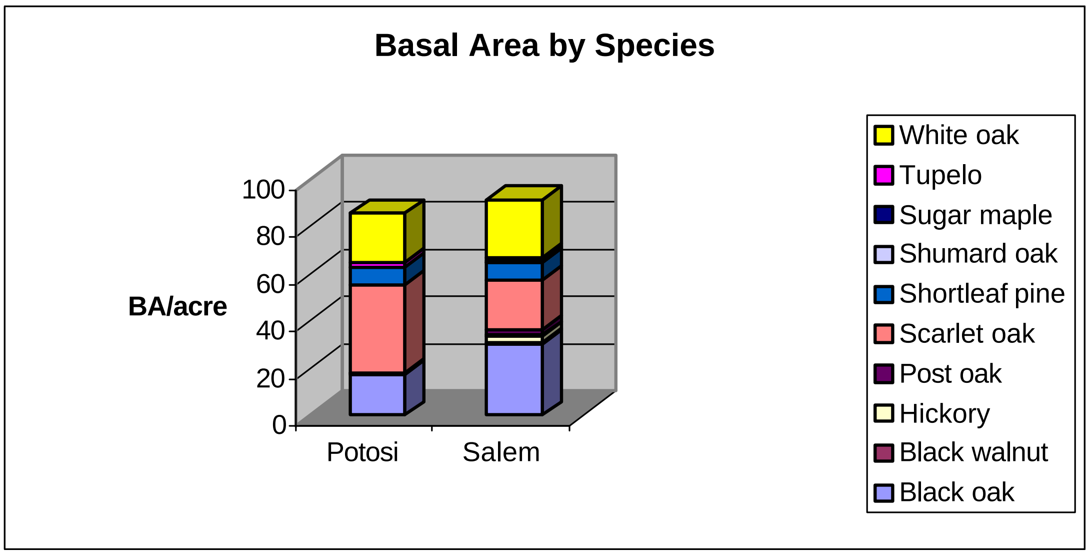
RESULTS

Eleven stands were sampled, 5 on the Potosi and 6 on the Salem Ranger District. This resulted in 55 prism plots (10 BAF) with 488 trees sampled, and 165 regeneration sample points (each .01 acre) yielding 806 countable seedlings and saplings. Stands were dominated by scarlet, black, and white oaks and had a significant component of shortleaf pine. On the Potosi RD, 89 % of the BA was composed of scarlet, black, and white oaks, and they comprised 84% on the Salem RD. Shortleaf pine comprises 8% and 9% of the BA, respectively. Basal area per acre by species on both districts is summarized in Table 2 and Figure 1.

Table 2. BA/acre (ft^2) distribution by species

Species	Potosi BA/acre	Potosi (%)	Salem BA/acre	Salem (%)
Black oak	17	(21)	30	(33)
Black walnut	0	(0)	0.7	(0.7)
Hickory	0.4	(0.5)	3	(3.3)
Post oak	0.4	(0.5)	2	(2)
Scarlet oak	37	(43)	22	(24)
Shortleaf pine	8	(9)	7	(8)
Shumard oak	0	(0)	0.3	(.4)
Sugar maple	0	(0)	0.7	(.7)
Tupelo	2	(2)	1	(1)
White oak	21	(25)	24	(27)
Total	86	(100)	91	(100)

Figure 1. BA/acre (ft^2) distribution by species

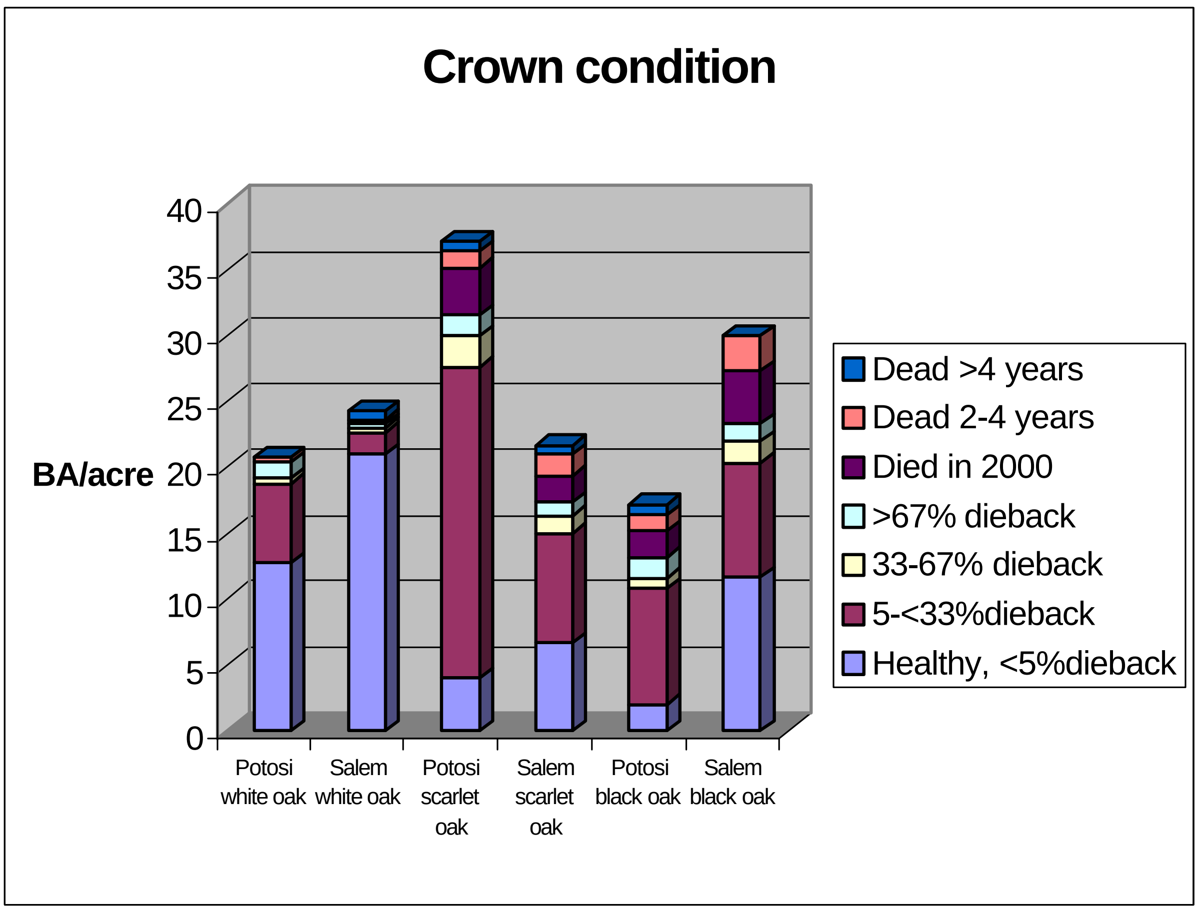


Overall, most non-oak species had healthy crowns or very little dieback. Of the three main oak species, white oaks had the largest percent of healthy crowns, about 61% on the Potosi RD and 88% on the Salem RD. In contrast, only 11% of scarlet, and 12% of black oaks on the Potosi RD were healthy, and 30% of scarlet, and 39% of black oaks on the Salem RD were healthy. On the Potosi RD, 15% and 24% of scarlet and black oaks were dead, and on the Salem RD, 11% of scarlet and 22% of black oaks were dead. Tree crown condition is summarized in Table 3 and Figure 2.

Table 3. BA/acre (ft^2) of oaks by various crown condition classes (% of total)

Crown condition	Potosi white oak	Salem white oak	Potosi scarlet oak	Salem scarlet oak	Potosi black oak	Salem black oak
Healthy, <5% dieback	12.8 (62)	21 (86)	4 (11)	6.7 (31)	2 (12)	11.7 (39)
5-<33% dieback	6 (29)	1.7 (7)	23.6 (63)	8.3 (38)	8.8 (51)	8.7 (29)
33-67% dieback	0.4 (2)	0.3 (1)	2.4 (6)	1.3 (6)	0.8 (5)	1.7 (6)
>67% dieback	1.2 (6)	0.3 (1)	1.6 (4)	1 (5)	1.6 (9)	1.3 (4)
Died in 2000	0	0	3.6 (10)	2 (9)	2 (12)	4 (13)
Dead 2-4 years	0.4 (2)	0.3 (1)	1.2 (3)	1.7 (8)	1.2 (7)	2.7 (9)
Dead >4 years	0	0.7 (3)	0.8 (2)	0.7 (3)	0.8 (5)	0
Total BA	20.8	24.3	37.2	21.7	17.2	30.1

Figure 2. BA/acre (ft^2) of oaks by various crown condition classes



Armillaria root disease was present (mycelial fans in the root collar) in the dead trees and the most severely declining trees examined. Armillaria spp. is ubiquitous in Missouri oak forests, and is often associated with oaks in the later stages of oak decline (Wargo et al.).

Hypoxylon canker and twolined chestnut borer were only found occasionally and did not appear to play a significant role in the decline of oaks on the forest.

Red oak borer was clearly the most significant pest agent associated with dead and declining oaks. Only black and scarlet oaks were attacked by the red oak borer. Oaks on the Potosi RD were the most severely attacked with 98% of both black and scarlet oak BA/acre having symptoms of attack. On the Salem RD attacks by red oak borer ranged from 66% of black oak to 71% of scarlet oak BA/acre. The number of red oak borer attacks affecting BA/acre on each district is summarized in Table 3 and Figures 3-6.

Table 3. BA/acre (ft^2) of oaks attacked by red oak borer (ROB) in 4 classes

	Black oak				**Scarlet oak**			
	0 ROB attacks	1-10	11-20	≥21	0 ROB attacks	1-10	11-20	≥21
Potosi BA/ac	0.4	7.6	2.4	6.8	0.8	13.2	7.2	16
Salem BA/ac	10.3	13.3	5.3	1	6.3	7.7	2.7	5

Figure 3. ROB in black oak on the Potosi RD

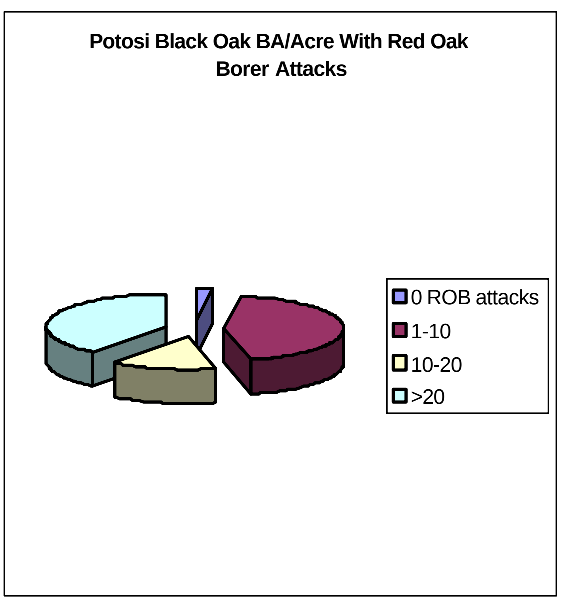


Figure 4. ROB in scarlet oak on the Potosi RD

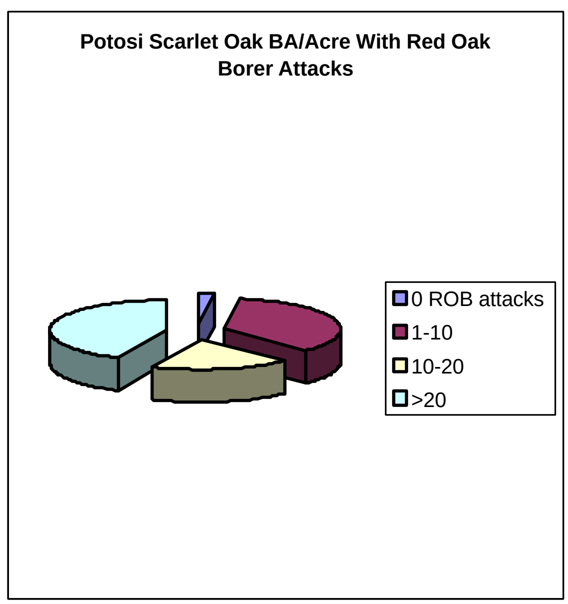


Figure 5. ROB in black oak on the Salem RD

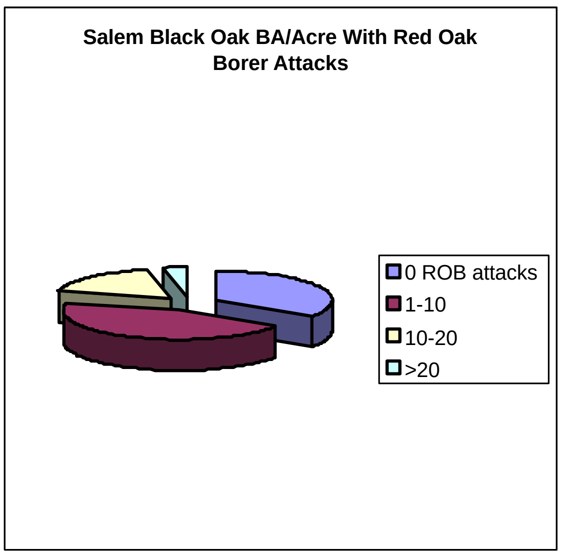
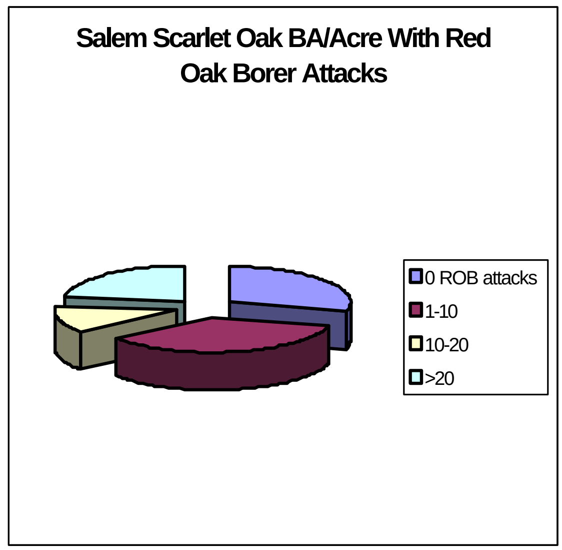


Figure 6. ROB in scarlet oak on the Salem RD



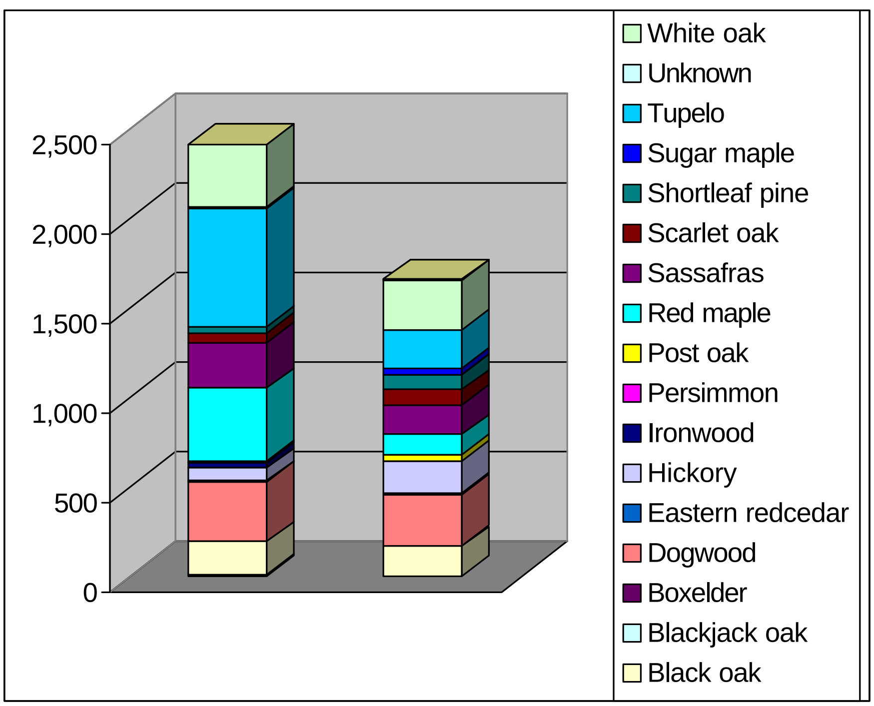
REGENERATION

The status of advance regeneration will dictate which management options are viable. In total, there is an adequate amount of advanced regeneration to insure a replacement stand should the predominant overstory continue to decline, as seems inevitable. There are an average of between 1,661 and 2,420 seedlings and saplings per acre over both districts. The numbers range from 163-185 per acre for black oak, and 51-86 per acre for scarlet oak. There are an average of 279-353 white oaks per acre, and 35-83 shortleaf pine per acre. The summary of regeneration is presented in table 4 and figure 7.

Table 4. Number of seedlings and saplings per acre

	Potosi	Salem
Am. Hornbeam	3	0
Black cherry	5	4
Black oak	185	163
Blackjack oak	0	1
Boxelder	0	1
Dogwood	339	286
Eastern redcedar	3	11
Hickory	72	178
Ironwood	28	0
Persimmon	0	1
Post oak	11	38
Red maple	407	110
Sassafras	259	164
Scarlet oak	51	86
Shortleaf pine	35	83
Sugar maple	3	38
Tupelo	664	217
Unknown	4	0
White oak	353	279
Willow oak	0	1
Grand Total	2,420	1,661

Figure 7. Status of regeneration, seedlings and saplings per acre



CONCLUSIONS

It is clear that large numbers of oaks are dying over thousands of acres on the Mark Twain National Forest, especially the Potosi and Salem Ranger Districts. The decline and mortality is affecting black and scarlet oak in particular.

Oak decline is a model that best describes this phenomenon. Decline is a syndrome caused by predisposing, initiating, and contributing factors which together result in decline and mortality of oaks, particularly red oaks. This phenomenon has been studied and described in the past in many upland hardwood areas of the eastern U.S. (Wargo et al.). It is a natural and recurring phenomenon involving a complex set of circumstances, none of which can be addressed alone to stop tree decline to any great extent. In the current episode, the last several years of drought is the inciting (and primary) factor responsible for the problem. Predisposing factors such as high proportions of red oak in stands, advanced age, ridge and upper slope topographic positions, shallow, rocky soils and other factors have set the stage for decline. Contributing factors are the red oak borer and other organisms like Armillaria root rot. Increasing numbers of dead and dying trees invigorates populations of Armillaria root rot, placing residual trees at increased risk of attack. Trees attacked by ROB serve as brood trees, increasing their numbers, and putting even more pressure on the remaining susceptible host trees (Donley and Acciavatti).

Even though there is adequate advance regeneration to insure a replacement stand, the mix of species might not be ideal. Black and scarlet oak in the overstory are declining, but there are adequate numbers of both species present in the understory to obtain representation in any future stand. The preferred white oak and shortleaf pine regeneration will need to be released to insure the survival and increased representation of these species in the future overstory.

RECOMMENDATIONS

Since no direct treatments are available for the remediation of decline, silvicultural and other management activities must be used to mitigate effects over relatively long periods of time. Depending on the management objectives for areas or stands, several short- and long-term treatment or management options can be identified.

Short-Term Options

Areas with concentrated mortality and decline can be identified from ground and aerial sketch-map surveys. Depending on the amount and distribution of mortality and decline in the stand, any of the following actions, alone or in combination may be useful:

1. *Salvage cutting of dead/declining red oaks, then other oaks, including removal of red oak borer brood trees* -- to capture usable, high-value oak volume, reduce red oak borer populations (Donley and Acciavatti), and eliminate hazards to the public along well-traveled roads, trails or in recreation areas,

2. *Mid-story removal of less desirable, more shade-tolerant species* -- to encourage development of advance oak reproduction, and encourage reproduction of shortleaf pine,
3. *Regenerate by group selection harvest* -- to capture oak regeneration potential, and encourage reproduction of shortleaf pine which may exist in areas of heavy mortality/decline,
4. *Patch or stand clearcut regeneration* – to capture oak regeneration potential, and encourage reproduction of shortleaf pine, which may exist in larger areas of heavy mortality/decline.
5. *Prescribed burning* – to encourage development of oak advance reproduction, and encourage reproduction of shortleaf pine, and reduce stocking of less desirable, more shade-tolerant species.

Long-Term Options

For areas with less severe mortality/decline, and areas that may be vulnerable to decline, the following options may be useful.

1. *Hazard-rating systems* (Oak et al.) may be useful in identifying stands vulnerable to decline, that would be candidates for silvicultural treatments to reduce their vulnerability,
2. *Silvicultural treatments* such as mid-story removal, light thinnings (from below), or even prescribed burning could be used to develop oak advance reproduction, encourage reproduction of shortleaf pine, reduce stocking of less desirable, more shade-tolerant species, reduce the stocking of more susceptible species (like scarlet and black oaks) in favor of quality stems of other less susceptible, but acceptable species like white oaks, shortleaf pine, hickory, etc.,
3. *Regenerate vulnerable stands* with acceptable advance oak reproduction and shortleaf pine, using group selection, patch or stand clearcutting with the aim of reducing the inventory of highly-susceptible stands.

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