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PREDICTING OAK STUMP SPROUTING AND SPROUT DEVELOPMENT IN THE MISSOURI OZARKS

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APPLICATION

Although much of the oak regeneration following harvest cutting results from advance reproduction, oak sprouts originating after cutting from newly cut stumps are also valuable in reproducing oak stands. Thus, prediction of stump sprouting and sprout development is an important part of evaluating the total oak regeneration potential before final harvest cutting in oak-hickory stands (Sander *et al.* 1976).

This report provides a way to estimate the proportion of stumps that will have codominant-or-larger sprouts 5 years after clearcutting. Tables for predicting these proportions were prepared for white oak (*Quercus alba* L.) (table 1), black oak (*Q. velutina* Lam.) (table 2), and for scarlet oak (*Q. coccinea* Muenchh.), post oak, (*Q. stellata* Wang.), and blackjack oak (*Q. marilandica* Muenchh.), (table 3).

The proportions given are for stumps with codominant-or-larger stems (9.6 feet tall or taller) because smaller sprouts are unlikely to contribute significantly to future stand stocking. For black and white oaks, proportions are presented for combinations of parent-tree age and site index for a range of tree diameters (table 1 and 2); for the other species, tree age and site index were not obtainable, so average proportions are presented by tree diameters only (table 3).

HOW TO USE THE TABLES

To calculate the potential for oak stump sprouts before final harvest cutting, you need a sample inventory of diameters of overstory oaks. The inventory routinely used in silvicultural stand examinations to estimate overstory basal area and number of trees per acre will satisfactorily meet this need provided that all oaks 1.6 inches d.b.h. and larger are included in the number of trees per acre (Roach and Gingrich 1968).

Multiply the number of oaks (per unit area) in each diameter or diameter-age class by the appropriate proportion in tables 1, 2, or 3 to get estimates of the number of codominant-or-larger stump sprouts that are likely to be present 5 years after clearcutting.[1]

When you use tables 1 and 2, it will be necessary to determine mean age of oaks from trees selected over the range of diameters present. In true even-aged stands, small diameter trees will be approximately the same age as larger diameter trees. However, if all or most of the smaller diameter oaks are of a different age class, the overstory diameter tally can be divided into two (or more) age classes, and appropriate proportions then applied to the diameter distribution of each age class. For exact determination of proportions for diameter, age, and site values not given in tables 1, 2, or 3, equations for calculating proportions are given in the Documentation section.

[1] *These 5th-year estimates of numbers of stump sprouts per acre can be multiplied by 0.89 to obtain expected 20th-year numbers of sprouts. This number can be compared to the number of stump sprouts required for adequate regeneration given in "A guide for evaluating the adequacy of oak advance reproduction" (Sander* et al. *1976).*

Table 1. – *Proportion of white oak stumps that are expected to produce a codominant-or-larger*[1] *sprout stem 5 years after cutting, by tree diameter, age, and site index*

D.b.h.	Tree age (years)				
	40	60	80	100	120
Inches	- - - -	*Proportion*	- - - - -		
SITE INDEX 50					
2	0.69	0.44	--	--	--
4	.57	.35	0.18	--	--
6	.43	.26	.14	0.07	--
8	.31	.19	.10	.05	0.03
10	.21	.13	.08	.04	.02
12	.15	.10	.06	.04	.02
14	--	.07	.05	.03	.02
16	--	.05	.04	.03	.02
18	--	.04	.03	.02	.02
20	--	--	.02	.02	.02
22	--	--	.02	.02	.02
24	--	--	--	.02	.02
26	--	--	--	--	.02
SITE INDEX 60					
2	0.79	0.58	--	--	--
4	.68	.48	0.28	--	--
6	.54	.37	.22	0.11	--
8	.41	.28	.17	.09	0.05
10	.30	.21	.13	.07	.04
12	.22	.15	.10	.06	.04
14	--	.11	.08	.05	.04
16	--	.08	.06	.05	.03
18	--	.06	.05	.04	.03
20	--	--	.04	.04	.03
22	--	--	.03	.03	.03
24	--	--	--	.03	.03
26	--	--	---	--	.03
SITE INDEX 70					
2	0.88	0.73	--	--	--
4	.79	.63	0.42	--	--
6	.65	.51	.34	0.19	--
8	.52	.40	.27	.16	0.09
10	.41	.31	.21	.13	.08
12	.32	.24	.17	.11	.07
14	--	.18	.14	.10	.07
16	--	.14	.11	.08	.06
18	--	.11	.09	.07	.06
20	--	--	.07	.06	.06
22	--	--	.06	.06	.05
24	--	--	--	.05	.05
26	--	--	--	--	.05

[1]Trees 9.6 feet in height or taller.

Table 2. – *Proportion of black oak stumps that are expected to produce a codominant-or-larger*[1] *sprout stem 5 years after cutting, by tree diameter, age, and site index*

D.b.h.	Tree age (years)					
	40	60	80	100	120	140
Inches	- - - - -	*Proportion*	- - - - - - -			
SITE INDEX 50						
2	0.53	0.52	--	--	--	--
4	.46	.44	0.42	--	--	--
6	.33	.31	.28	0.26	--	--
8	.23	.20	.18	.16	0.14	--
10	.16	.14	.12	.10	.09	--
12	.12	.10	.09	.07	.05	0.04
14	--	.08	.06	.05	.04	.03
16	--	.06	.05	.03	.02	.02
18	--	.05	.04	.03	.02	.01
20	--	--	.03	.02	.01	.01
22	--	--	.02	.01	.01	0
24	--	--	--	.01	.01	0
26	--	--	--	--	0	0
SITE INDEX 60						
2	0.64	0.63	--	--	--	--
4	.57	.54	0.52	--	--	--
6	.41	.38	.36	0.33	--	--
8	.28	.26	.24	.21	0.19	--
10	.21	.18	.16	.14	.12	--
12	.16	.14	.12	.10	.08	0.06
14	--	.11	.09	.07	.05	.04
16	--	.09	.07	.05	.04	.03
18	--	.07	.05	.04	.03	.02
20	--	--	.04	.03	.02	.01
22	--	--	.03	.02	.01	.01
24	--	--	--	.02	.01	.01
26	--	--	--	--	.01	0
SITE INDEX 70						
2	0.76	0.75	--	--	--	--
4	.67	.65	0.63	--	--	--
6	.49	.47	.45	0.42	--	--
8	.34	.32	.30	.28	0.25	--
10	.25	.23	.21	.19	.17	--
12	.20	.18	.16	.13	.11	0.09
14	--	.14	.12	.10	.08	.06
16	--	.11	.09	.07	.06	.04
18	--	.10	.07	.06	.04	.03
20	--	--	.06	.04	.03	.02
22	--	--	.05	.03	.02	.01
24	--	--	--	.03	.02	.01
26	--	--	--	--	.01	.01

[1]Trees 9.6 feet in height or taller.

Table 3. – *Proportion of scarlet, post, and blackjack oaks that are expected to produce a codominant-or-larger*[1] *sprout stem 5 years after cutting, by tree diameter*

D.b.h.	Scarlet oak	Blackjack oak	Post oak
Inches		*Proportion*	
2	--	0.84	0.91
4	0.52	.64	.80
6	.82	.36	.54
8	.85	.20	.32
10	.77	.11	.17
12	.63	.06	.07
14	.28	.03	.02
16	.26	.02	0
18	.14	.01	--
20	.08	0	--
22	.07	0	--

[1]Trees 9.6 feet in height or taller.

DOCUMENTATION

THE BASIC DATA

The 1,546 stumps measured in the study were located in four areas on the Mark Twain National Forest in southern Missouri. Site indices for upland oaks on study areas ranged from 35 to 85, based on Schnur's (1937) curves. Scarlet oaks were restricted to a site index range of 50 to 65 and most post and blackjack oaks were within the range of 35 to 60; about three-fourths of black and white oaks were within the site index range of 50 to 70.

All black and white oaks and approximately two-thirds of the scarlet, post, and blackjack oaks that were sampled were cut trees. Time of cutting ranged from late January through late October, but no trees were cut during August. The remaining one-third of the post, scarlet, and blackjack oaks were standing trees located in portions of two stands completely killed by wildfires in late March and late April 1963. Because burning destroyed the bark on most of the fire-killed trees, the only diameter measurement made on all trees was stump diameter inside bark; measurements were made to the nearest inch (2.5 cm), 6 to 12 inches (15.2 to 30.5 cm) above the ground. For all but blackjack oak, diameters inside bark ranged from 3 inches (7.6 cm) to 30 inches (76.2 cm) or more; the maximum diameter of blackjack oak was 18 inches (45.7 cm) (table 4).

For all species, measurements were also made of: (1) height of the tallest stem per sprout clump to the nearest foot (30.5 cm) after one, three, and five growing seasons and (2) number of live stems per clump after one, three, and five growing seasons. For black and white oaks additional measurements were made of: (1) tree age at stump height, (2) site index, (3) bark thickness to the nearest 0.1 inch (2.5 mm), (4) the last 10 years' radial growth at stump height to the nearest 0.1 inch, and (5) the week of the year (beginning January 1) trees were cut or killed. For white oak, week of cutting ranged from week 3 (January 15 to 21) to week 43 (October 21 to 27) with 22 percent of trees cut in the dormant season. For black oak, week of cutting ranged from week 10 (March 4 to 10) to week 43, with 45 percent of trees in the dormant season. Ages of black and white oaks ranged from less than 30 years to over 200 years, with most (92 percent) between 40 and 140 years.

GENERAL SPROUTING RELATIONS

The percent of stumps with sprouts at the end of the first growing season ranged from 21 percent for white oak to 66 percent for scarlet oak (table 5). However, among stumps with living sprouts after the first growing season, only 50 percent of black oak and 61 percent of post oak stumps had living sprouts after five growing seasons; survival for the other species ranged from 86 to 89 percent.

Scarlet and white oak sprouts were the tallest after 5 years; the heights of dominant sprouts averaged 14 feet (4.3 m) for both species (table 5). Dominant-sprout

Table 4. – *Distribution of stumps sampled by species and diameter class*

Species	Stump diameter class (inches, inside bark)				
	≤10	11 to 15	16 to 20	21+	Total
	Number of stumps				
White oak	84	89	155	28	356
(Age range-years)	(28-125)	(48-140)	(67-175)	(90-200)	
(Site index range-feet)	(55-70)	(36-75)	(36-75)	(36-75)	
Black oak	31	86	132	45	294
(Age range-years)	(25-75)	(50-130)	(46-163)	(75-225)	
(Site index-feet)	(48-65)	(36-75)	(36-80)	(36-75)	
Scarlet oak	88	96	89	18	291
Post oak	81	87	159	45	372
Blackjack oak	154	65	14	0	233

Table 5. – *Percent of stumps with living sprouts and mean heights of sprouts[1] by species and years after cutting*

Species	Growing seasons after cutting: 1 — Mean height	1 — Stumps with living sprouts	3 — Mean height	3 — Stumps with living sprouts	5 — Mean height	5 — Stumps with living sprouts
	(Feet)	*(Percent)*	*(Feet)*	*(Percent)*	*(Feet)*	*(Percent)*
White oak	2.3	21	7.2	20	13.8	18
Black oak	2.4	30	6.7	19	11.4	15
Scarlet oak	3.8	66	9.5	60	14.0	58
Post oak	2.5	28	6.4	20	10.8	17
Blackjack oak	3.2	46	7.2	43	10.0	41

[1]Means are based on height of dominant stem in each clump.

heights for the other species averaged 10 to 11 feet (3.0 to 3.3 m) tall. For all species, the 5th year height of the dominant sprout was significantly but negatively correlated with stump diameter inside bark (table 6). For black oak, dominant-sprout height at age 5 was significantly—but weakly—correlated with site index ($r = 0.37$, $p < 0.05$).

Number of living stems per clump for all species declined rapidly over the 5-year study period. Average numbers of stems per clump ranged from 7 to 9 at the end of the first growing season for all but scarlet oak, which averaged about 12 stems per clump. However, by the end of the fifth growing season, all species averaged 2 to 3 stems per clump. Although correlations were generally weak, the number of living stems after five growing seasons was significantly and negatively correlated with stump diameter inside bark for all species (table 6). In addition, the number of living stems per clump after 5 years was significantly and positively correlated with the 5th-year height of dominant sprouts for all species; correlation coefficients ranged from 0.28 for scarlet oak to 0.80 for black oak (table 6).

SPROUTING PROBABILITIES

A regression procedure for estimating event probabilities was used to estimate the probability (P_1) that a stump will have at least one live sprout at the end of the first growing season after cutting (or death of the parent tree caused by fire) (Hamilton 1974). For black and white oaks, P_1 was predicted from three factors: (1) stump diameter outside bark, (2) age of parent tree, and (3) site index. After variation attributable to the latter factors were accounted for, other measured factors (bark thickness, 10-year radial growth, and week cut) showed no statistically significant relation to P_1. Final predicting equations were selected from more than 100 equations calculated for each species. The relations between P_1 and the first three factors were the same for both species; P_1 decreased as stump diameter and age increased, and increased as site index increased (figs. 1 and 2). For black oak, values of P_1 for site index 70 ranged from 0.75 for 40-year-old trees 3 inches (7.6 cm) in stump diameter to 0.08 for 120-year-old trees 30 inches (76.2 cm) in diameter; for white oak, P_1 ranged from 0.88 to 0.12 for the same combination of factor values.

Table 6. – *Simple correlation coefficients (r) between selected variables for oak stumps that had living sprouts at the end of the first growing season*

Variable	Dominant sprout height after 5 growing seasons — Oak species: Black	White	Scarlet	Post	Blackjack	Number of living stems per clump after 5 growing seasons — Oak species: Black	White	Scarlet	Post	Blackjack
Stump diameter (inside bark)	[1]-0.55**	-0.46**	-0.18*	-0.70**	-0.34**	-0.64**	-0.23**	-0.47**	-0.38**	-0.23*
Site index	0.37**	ns	(2)	(2)	(2)	0.28**	-0.24*	(2)	(2)	(2)
Dominant-sprout height after 5 growing seasons	--	--	--	--	--	0.80**	0.53**	0.28**	0.66**	0.56**
Number of observations	87	76	192	106	107	87	76	192	106	107

[1]Significance level of r: ** = 0.01; * = 0.05; ns = nonsignificant.
[2]Site index not measured.

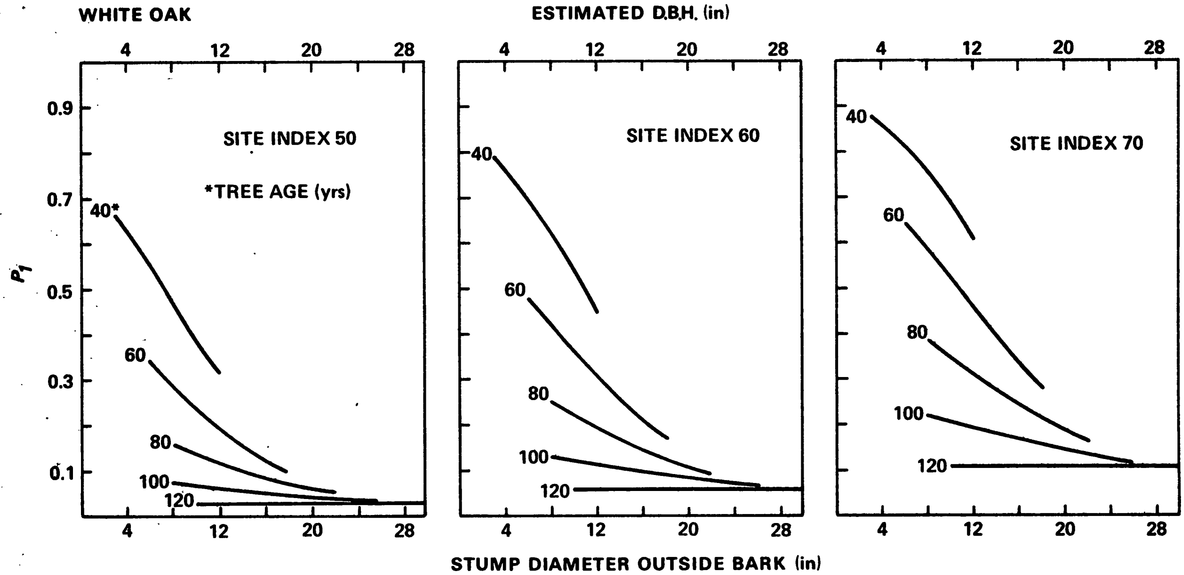

Figure 1. – *Estimated probabilities (P_1) for white oak stumps in relation to tree diameter, age, and site index. (P_1 = probability that a stump will have at least one living sprout at the end of the first growing season after cutting; regression equations and goodness-of-fit statistics are given in table 7. D.b.h. was estimated from stump diameter (outside bark) based on the table for hardwoods from Horn and Keller (1957).)*

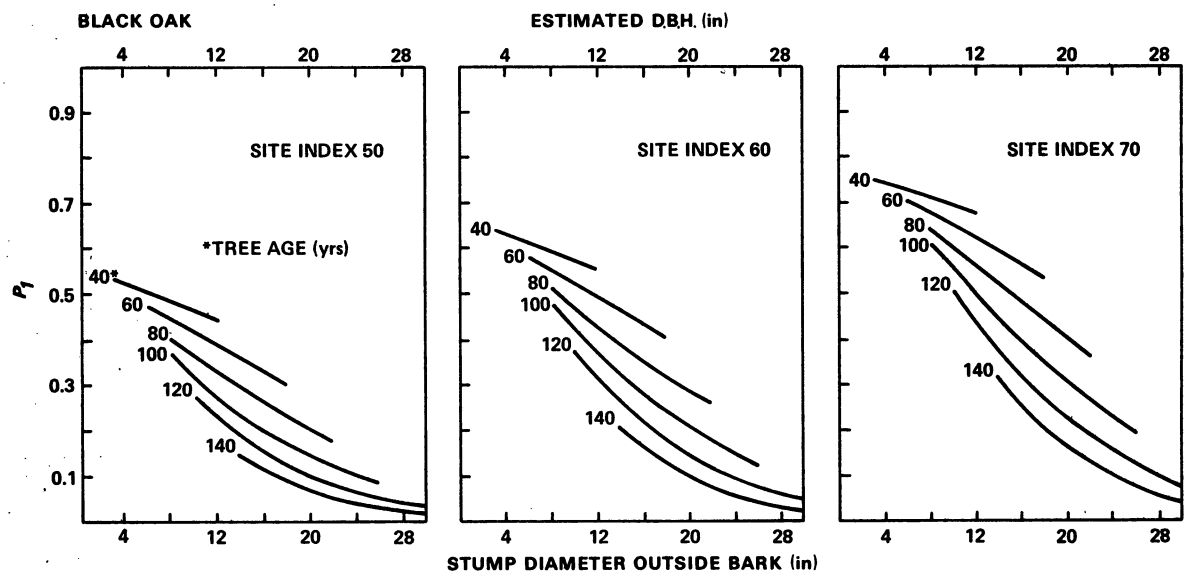

Figure 2. – *Estimated probabilities (P_1) for black oak stumps in relation to tree diameter, age, and site index. (P_1 = probability that a stump will have at least one living sprout at the end of the first growing season after cutting; regression equations and goodness-of-fit statistics are given in table 7. D.b.h. was estimated from stump diameter (outside bark) based on the table for hardwoods from Horn and Keller (1957).)*

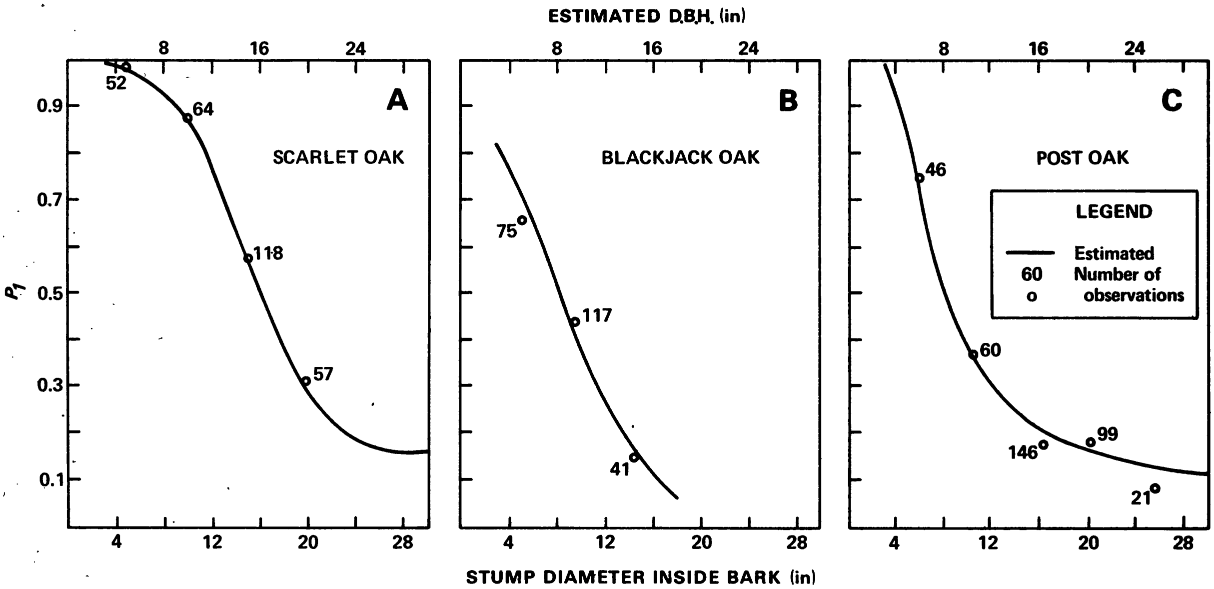

Figure 3. – *Estimated probabilities (P_1) for scarlet, blackjack, and post oak in relation to tree diameter. (P_1 = probability that a stump will have at least one living sprout at the end of the first growing season after cutting; regression equations and goodness-of-fit statistics are given in table 7. Observed values are means for diameter classes that include at least 10 observations per class. D.b.h. was estimated from stump diameter outside bark (d.o.b.) based on the table for hardwoods from Horn and Keller (1957); d.o.b. was estimated by regression of bark-thickness on stump diameter (inside bark) using data for black and white oaks.)*

Table 7. – *Regression coefficients for P_1 equations represented by figures 1, 2, and 3*[1]

Species	B_0	Independent variables[2]						Number of observations
		X_1	X_2	X_3	X_4	X_5	X_6	
Black oak	[3]-0.7853^{ns}					-1.0160×10^{-3}**	4.1528×10^{-4}**	294
White oak	2.2330*	-0.2525**			-0.0511**	2.1145×10^{-3}**	5.1120×10^{-4}*	356
Scarlet oak	6.9053**	-0.5948**	1.0239*					291
Post oak	-2.8058**			22.6839**				372
Blackjack oak	2.3656**	-0.2781**						233

[1]Equations are of the form: $P_1 = \{1 + \exp[-(B_0 + B_1X_1 + \ldots B_nX_n)]\}^{-1}$, where P_1 is the probability that a stump has a living sprout at the end of the first growing season after cutting.

[2]X_1 = Stump diameter (inches) = DIAM (outisde bark for black and white oaks; inside bark for other species); X_2 = $DIAM^2/100$; X_3 = 1/DIAM; X_4 = Age of tree in years at stump height = AGE; X_5 = DIAM x AGE; and X_6 = $(\text{Site index})^2$.

[3]Significance levels are based on "t" tests (H_0 : B = 0) and are: * = 0.05, ** = 0.01, ns = nonsignificant; $p < 0.01$ for all regression F tests. Goodness-of-fit was also tested by chi-square for differences between observed and predicted numbers of stumps with living sprouts among probability intervals of width 0.05; all chi-square values were nonsignificant at the 0.05 level. Goodness-of-fit was based on the above relation because the customary measure, the error mean square, is not appropriate when the dependent variable is dichotomous.

A significantly larger proportion of both black and white oaks cut during the dormant season sprouted than did those cut during the growing season. However, black and white oaks cut during the dormant season had a smaller mean diameter than those cut during the growing season, thus confounding analysis of effects attributable to diameter and week of cutting.

For scarlet, blackjack, and post oak, P_1 was predicted from stump diameter inside bark (fig. 3). For scarlet oak, P_1 declined from 0.99 for 3-inch stumps to 0.15 for 30-inch (76.2 cm) stumps; post oak similarly declined from 0.99 to 0.11 over the same range of stump diameters. For a given diameter, blackjack oak tended to sprout less frequently than either scarlet or post oak, with P_1 ranging from 0.82 for 3-inch (7.6 cm) stumps to 0.07 for 18-inch (45.7 cm) stumps.

Sprouting was significantly greater for fire-killed scarlet, post, and blackjack oaks than for felled live trees (unburned) based on chi-square analyses at the 0.05 level. However, these differences were at least partially related to stump diameters, which on the average were smaller for fire-killed trees than unburned cut trees. When differences due to stump diameter were removed, significant differences in proportion of burned versus unburned stumps that sprouted occurred only in scarlet oak and within the diameter range of 10 to 15 inches (25.4 to 38.1 cm); sprouting was 82 percent for fire-killed trees and 55 percent for unburned cut trees. Thus, there is only slight evidence that burning *per se* increased the proportion of stumps that sprouted.

SPROUT DEVELOPMENT PROBABILITIES

The regression procedure for estimating P_1 was also used to estimate the probability (P_2) that a stump with a living sprout at the end of the first growing season after cutting (or killing of the parent tree by fire) will have a live sprout that is codominant or larger[2] after five growing seasons. P_2 was predictable from stump diameter for all five species (fig. 4). For all but scarlet oak, estimates of P_2 were highest (0.90 or greater) for 3-inch (7.6 cm) stumps, and declined to lower values at larger stump diameters. For scarlet oak, the highest value of P_2 (0.92) was attained at a stump diameter of 9 inches (22.9 cm); P_2 declined as diameter increased or decreased from that size (fig. 4c).

REPLACEMENT PROBABILITIES

Pre-harvest estimation of the potential contribution of stump sprouts to future stand composition and stocking after harvest cutting was facilitated by multiplying P_1 (sprouting) by P_2 (sprout development). Resultant values can be defined as replacement probabilities, i.e., the estimated proportion of trees that will be replaced, 5 years after cutting, by at least one living codominant-or-larger sprout stem. Replacement probabilities (expected proportions) are presented in tables 1, 2, and 3. These values generally parallel trends for P_1, but are adjusted for expected survival and growth of sprouts to age 5.

DISCUSSION

Other investigators have previously observed that the proportion of oaks that sprout decreases as the diameter of the parent tree increases; studies have included black, white, and scarlet oaks (Roth and Hepting 1943), blackjack oak (Clark and Liming 1953), northern red oak (*Quercus rubra* L.) (Johnson 1975), and English oak (*Q. pedunculata* (sic *Q. robur* L.)) (Kharitonovich 1937). Clark and Liming (1953) also found that in 1- to 12-inch (2.5 to 30.5 cm) d.b.h. blackjack oak, mortality of sprouts increased as stump diameter increased, thus paralleling estimates of P_2 in the present study. An exception to this pattern was scarlet oak, for which values of P_2 increased with increasing diameter up to 7 inches (17.8 cm) d.b.h. (fig. 4c). The reason for this departure from the apparent norm is not known, but may be related to the unknown age distribution of the scarlet oaks sampled.

Other investigators have also reported a decline in oak stump sprouting as trees age (e.g., Roth and Sleeth 1939, and Rogers and Rogers 1959). However, age-dependent estimates of sprouting capacity have usually been averaged over unspecified variation in parent tree diameter,

[2] *Codominant-or-larger was defined as a stem 9.6 feet (2.9 m) tall or taller, and refers to the position of the dominant sprout (tallest per stump) in the stand as a whole. This minimum height was arbitrarily selected as 80 percent of the unweighted mean height (12 feet (3.7 m)) of 5-year-old dominant sprouts of all five species. On Missouri Ozark oak sites from site index 50 to 70, trees of this minimum height will be in the upper level of tree crowns at age 5.*

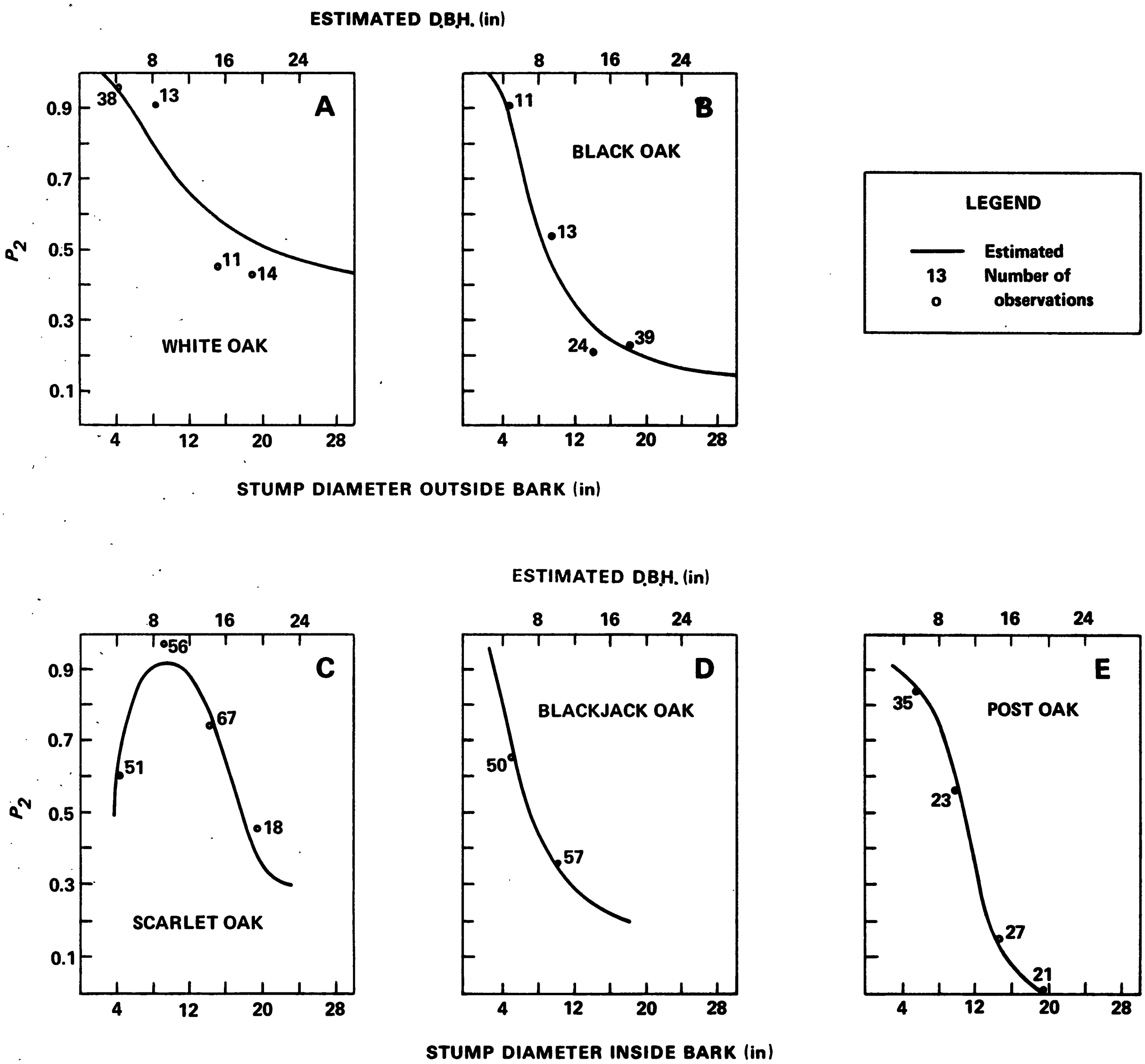

Figure 4. – *Estimated probabilities (P_2) by species in relation to tree diameter. (P_2 = probability that a stump with a living sprout at the end of the first growing season after cutting will have at least one codominant-or-larger sprout five growing seasons after cutting; regression equations and goodness-of-fit statistics are given in table 8. Observed values are means for diameter classes that included at least 10 observations per class.)*

Table 8. – *Regression coefficients for P_2 equations represented by figure 4*[1]

Species	B_0	X_1	X_2	X_3	X_4	Number of observations
		Independent variables[2]				
Black oak	[3]-2.5758**		24.3594**			89
White oak	-0.8478**		18.3965**			76
Scarlet oak	-6.1144**	2.1195**		-0.1611**	0.0034**	192
Post oak	2.4148*			-0.0203**		106
Blackjack oak	-2.3309**		16.1399**			107

[1]Equations are of the form: $P_2 = \{1 + \exp[-(B_0 + B_1X_1 + \ldots B_nX_n)]\}^{-1}$, where P_2 is the probability that a stump with a living sprout at age 1 has a codominant or larger sprout at age 5.

[2]X_1 = Stump diameter (inches) = DIAM (outside bark for black and white oaks, inside bark for other species); X_2 = 1/DIAM; X_3 = $DIAM^2$; X_4 = $DIAM^3$

[3]Significance levels are based on "t" tests (H_0 : B = 0) and are : * = 0.05, ** = 0.01; $p < 0.01$ for all regression F tests. Goodness-of-fit was also tested by chi-square for differences between observed and predicted numbers of stumps with codominant or larger sprouts among probability intervals of width 0.05; all chi-square values were nonsignificant at the 0.05 level. Goodness-of-fit was based on the above relations because the customary measure, the error mean square, is not appropriate when the dependent variable is dichotomous.

or conversely, diameter-dependent estimates have been averaged over unknown variation in tree age (e.g., estimates of P_1 for scarlet, post, and blackjack oaks). In contrast, the estimates of P_1 for black and white oaks differentiate effects of parent tree age and diameter (figs. 1 and 2).

Apparent effects of site quality on oak sprouting are minor in comparison to apparent age and tree diameter effects, based on the regression relations derived for black and white oaks. Site index also explained very little of the variation in height of dominant sprouts of black and white oaks after 5 years of growth. For this reason, definition of codominance was not adjusted for variation in site index in deriving equations for P_1.

Although no statistically significant trends were found for the proportion of oak stumps that sprout in relation to season of cutting, such trends might be expected because of seasonal changes in root carbohydrate reserves that support sprout growth (Kramer and Kozlowski 1960). Consistent with this expectation, Clark and Liming (1953) found that the proportion of blackjack oaks that sprouted in Missouri was lowest in June at about the time of full leaf development; sprouting thereafter gradually increased to a plateau in the dormant season before declining in early spring (April). Assuming that real seasonal differences in sprouting capacity do exist for oaks, estimates of P_1 (figs. 1, 2, and 3) should represent reasonable annual averages for each species because trees were sampled over both dormant and growing seasons.

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1977. Predicting oak stump sprouting and sprout development in the Missouri Ozarks. USDA For. Serv. Res. Pap. NC-149, 11 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

An application section provides tables for easy prediction of the proportion of oak stumps of various species having codominant-or-larger sprouts 5 years after clearcutting. A documentation section gives details of sprout development and equations for estimating sprouting of white, black, scarlet, post, and blackjack oaks.

OXFORD: 181.51:222.2(778). KEY WORDS: regeneration, coppice, black oak, white oak, scarlet oak, post oak, blackjack oak.

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