CROWN HEALTH OF RESERVE HARDWOOD TREES FOLLOWING REPRODUCTION CUTTING IN THE OUACHITA MOUNTAINS

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Abstract—Monitoring the health of reserve hardwood trees is being performed as part of the Ecosystem Management Research Project on the Ouachita and Ozark National Forests in Arkansas. A suite of crown variables (diameter, live crown ratio, density, dieback, and foliage transparency) was used to detect significant changes in reserve tree health over time. While treatments had some effect on crown variables over time, seasonal climatic conditions (e.g. acute drought) may have had a greater effect. It was generally apparent that for the most intensive treatments, crown variables worsened more over time compared to less intensive treatments. Results will provide information about the success of retaining such trees and provide guidelines for selecting reserve trees in future operational harvests.

INTRODUCTION

An important element of the Ecosystem Management Research Project in the Ouachita Mountains is to investigate whether the shortleaf pine (*Pinus echinata*)-hardwood forest type in the Ouachita and Ozark-St. Francis National Forests can be managed using even-aged and uneven-aged reproduction cutting methods that rely on natural regeneration. A complete description of the project can be found in Baker (1994). In about half of the harvest treatments, overstory and midstory hardwoods are being retained in order to meet ecosystem management objectives such as improved wildlife habitat, greater biodiversity, reduced visual impact of harvesting, and perpetuation of the pine-hardwood forest type.

Retained hardwood trees generally meet the definition of “reserve trees” (Helms 1998) for the even-aged methods, since they are retained after the regeneration period. However, in the uneven-aged methods, retained trees are not truly reserve trees; they are more appropriately considered as a component of the pine-hardwood forest type being studied in this project. Nonetheless, we will use the term “reserve trees” throughout to describe hardwoods retained after reproduction cutting in these treatments.

The health and longevity of reserve trees are important if ecosystem management objectives are to be realized. But little information exists about the health and fate of these trees that might guide the selection of reserve trees in future operational harvests under an ecosystem management regime.

The major concern for the health of reserve hardwoods is oak or hardwood decline (Starkey and others 1989, Wargo and others 1983). Decline can generally be described as a complex disease syndrome resulting from the interaction of a variety of host, site, and stand factors with biotic and abiotic agents and stress factors. It is expressed by a progressive dieback of the crown from the upper and outer portions downward, usually resulting in mortality. Manion (1991) describes decline as “an interaction of interchangeable, specifically ordered abiotic and biotic factors to produce a gradual general deterioration, often ending in death of trees”; decline is depicted as a spiral of (1) one or more predisposing factors, followed by (2) one or more inciting factors, which are then followed by (3) one or more contributing factors. Factors that can be responsible for decline include abiotic, biotic, site/stand or anthropogenic agents (fig. 1).

In oak decline, specific predisposing, inciting and contributing factors interact to affect the incidence and severity of symptoms (fig. 2). In the Eastern United States, decline is attributed to climatic events and site/stand factors, defoliation, drought, frost, root rots and borers (Millers and others 1989, Starkey and others 1989). In the Ouachita Mountains, the factors most likely to be operative are site/stand factors (predisposing), stand disturbance from harvesting, or drought (inciting), and root rot/borers (contributing). Oaks (*Quercus* spp.), hickories (*Carya* spp.), and other hardwoods are susceptible to decline. Oaks in the red oak group are usually more frequently and severely affected than white oaks or hickories. Other hardwoods are less affected.

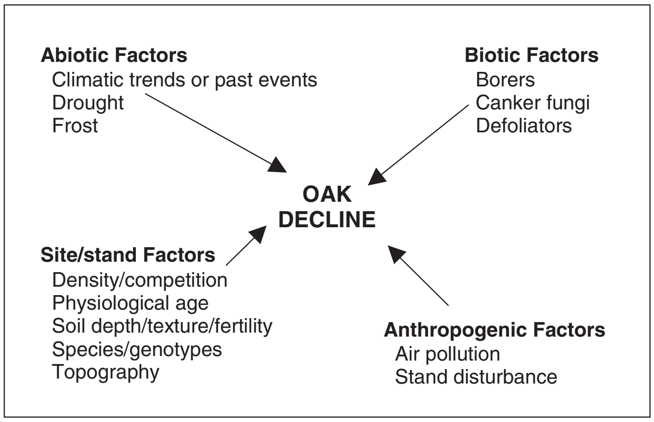

Figure 1—Causal factors of oak decline organized by type.

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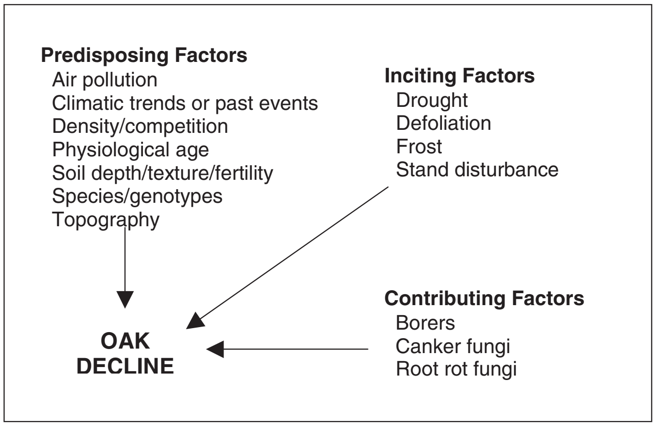

Figure 2—Causal factors of oak decline organized by their function in the decline syndrome.

METHODS

We identified seven treatments in which hardwoods were retained, as follows

(1) UC: unmanaged control treatment

(2) GSPH: group selection treatment, with hardwood retained within groups

(3) STSW: pine-hardwood single-tree selection treatment

(4) STSL: low-impact single-tree selection treatment

(5) SWW: pine-hardwood shelterwood treatment

(6) STPH: pine-hardwood seed tree treatment

(7) CC: clearcutting treatment.

Each treatment was installed in 4 stands and measurements were taken on 12 plots per stand for a total of 336 plots in this study. Details about the treatments and sample plot configuration are presented in Guldin and others (1994).

Prior to the imposition of harvest treatments, three to five of the largest hardwoods nearest plot centers were identified for monitoring at each plot. These constituted the trees most likely to be designated as reserves during marking and harvesting operations. Preference was given to trees already marked as reserves, to oaks, hickories, and finally other hardwoods. Azimuth and distance from plot center were recorded for each tree as well as species and diameter at breast height (d.b.h.). Plots were visited and trees evaluated prior to harvest in 1992, 3 years after harvest in 1996, and 5 years after harvest in 1998.

A suite of crown measurements was utilized to evaluate the condition (i.e. health) of tree crowns at each sampling—a procedure currently being used in the National Forest Health Monitoring Program (U.S. Department of Agriculture, Forest Service 1992). The suite consists of six variables (table 1), each requiring two crew members to estimate. Crown diameter was measured by projecting the crown perimeter onto the ground and measuring with a tape; measurements were taken on N-S and E-W axes. The other five variables were each visually estimated by two observers standing on opposite sides of the tree about one-half to one tree length away such that a clear view of the crown was obtained. Estimates for each variable were made by each crew member individually, and a consensus or average of both is used as the final estimate.

Table 1—Crown health indicators for monitoring reserve hardwood trees

Indicator	Definition and units
Crown diameter	Measured on ground in two directions at 90°; in feet to the nearest foot; average of measurements.
Crown position	Standard forestry definitions; dominant, codominant, intermediate, or suppressed.
Live crown ratio	Ratio (in percent) of live crown length to total tree height; visually estimated in 5-percent increments.
Crown density (DEN)	Estimated percentage of foliage, twigs, branches, and reproductive structures blocking light through the crown; visually estimated in 5-percent increments.
Crown dieback (DBK)	Estimated percentage of recent dieback (fine twigs remaining) in upper and outer portions of the crown compared to entire crown; visually estimated in 5-percent increments.
Foliage transparency (TRN)	Estimated percentage of light being transmitted through the foliated portions of the crown; visually estimated in 5-percent increments.

Crown health data were obtained during the leaf-on, summer field season. Field crews were trained at the beginning of the field season to collect crown health data during an all-day session. Classroom training and field practice were followed by field testing and evaluation in order to meet quality assurance goals (U.S. Department of Agriculture, Forest Service 1992). For all visual crown variables, a goal of ±10 percent (i.e., two 5-percent classes, see table 1), 90 percent of the time (when compared to estimates of the trainers) was used. For crown diameter, average diameter was required to be ±10 percent of the trainers result, 90 percent of the time. Catastrophic events (windthrow, logging damage, etc.) occurring to sample trees between visits were identified and these trees removed from the data set used to evaluate the effects of decline.

RESULTS

One thousand and three hardwoods were identified as reserve trees before stand treatments were imposed. Most of these were white oaks (*Q. alba*) (WHO) and post oaks (*Q. stellata)* (PSO); they comprised about 65 percent of the population (fig. 3). Other oaks [black oak (*Q. velutina*) (BLO), southern red oak (*Q. falcate*) (SRO), northern red oak (*Q.*

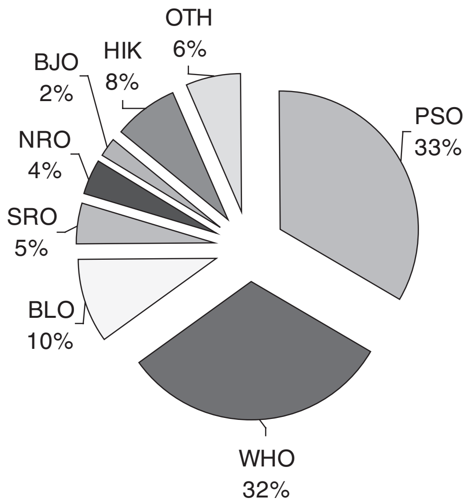

Figure 3—Percent of sample population by species.

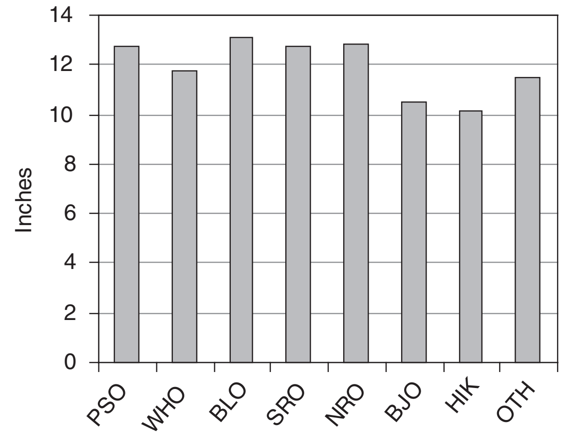

Figure 5—Quadratic mean diameter at breast height for sample population by species.

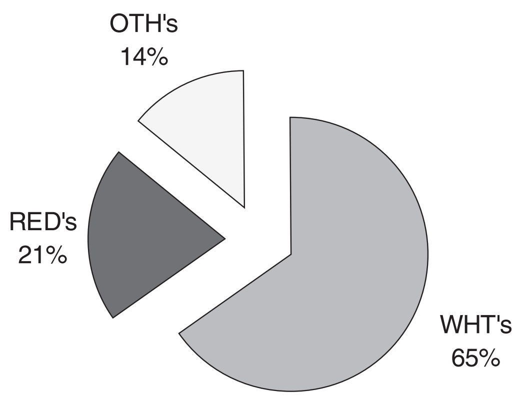

Figure 4—Percent of sample population by species group.

rubra) (NRO), blackjack oak (*Q. marilandica*) (BJO)]; hickories (*C. texana* and *C. tomentosa*) (HIK); and other hardwoods [sweetgum (*Liquidambar stryracifula)*, blackgum (*Nyssa sylvatica*), winged elm (*Ulmus alata*), black cherry (*Prunus serotina),* white ash (*Fraxinus Americana)*, and sassafras (*Sassafras albidum*)] (OTH) made up the remainder. Since most species were present in relatively small numbers, we used species groupings for all data analysis involving species (white oaks, WHTs include PSO and WHO; red oaks, REDs include the other oaks; and other hardwoods, OTHs including hickories and all other species) (fig. 4).

The d.b.h. of reserve trees varied little among species, ranging from a quadratic mean d.b.h. of 10.1 to 13.1 inches (fig. 5). Most trees were either codominant or intermediate in crown position with the proportion of each varying by species (fig. 6). Generally, 80 to 90+ percent of sample trees were in these two classes. A few dominant or suppressed crown classes were represented in each species tally.

By the 3- and 5-year measurements a number of trees had been cut, damaged or died (fig. 7). By 1998, 876 trees survived in our sample set. Forty-two trees had been cut by

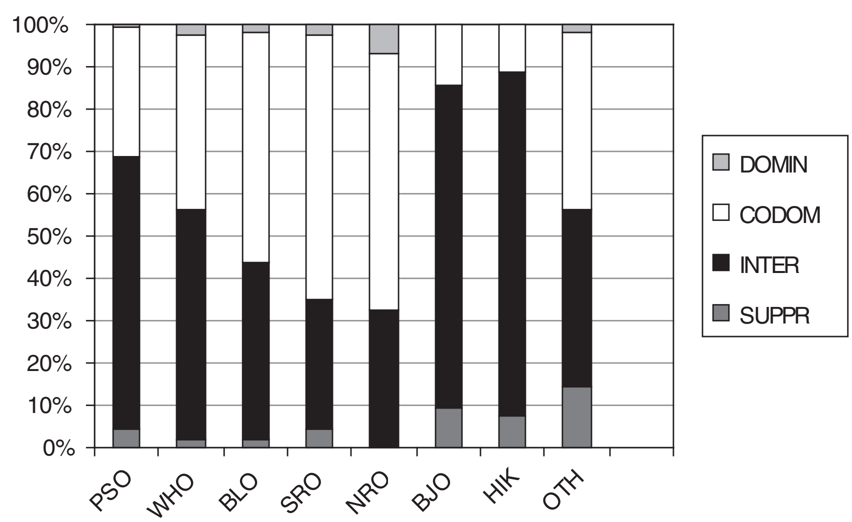

Figure 6—Percent of sample population by crown position and species.

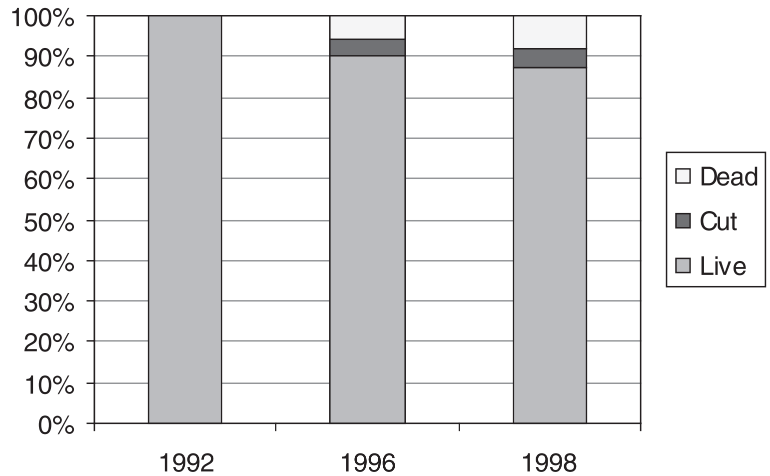

Figure 7—Sample population change due to cutting and mortality.

Table 2—Causes of mortality

Year	Herbicide	Logging	Lightning	Windthrow	I/D/Unknown	Total
1996	1	12	0	2	44	59
1998	0	0	1	1	20	22
Total	1	12	1	3	64	81

1996 and another 4 trees by 1998, either in the initial harvest or subsequent site—preparation treatments. Removing these from consideration, a total of 81 trees died over the 5 years out of 957 trees—a very acceptable survival rate of 91.5 percent. Of the trees that died, a few were attributed to logging, lightning or windthrow, but most were from unknown causes (which could be decline-related) (table 2). If all of the 64 trees which died from unknown causes are attributed to decline, then the mortality rate due to decline after 5 years is 6.7 percent.

Previous experience and research suggests that decline is closely related to inciting events like severe drought (Starkey and others 1989, Wargo and others 1983). Thus, drought can have an effect on reserve tree health in spite of cutting practices imposed. To evaluate this phenomenon we examined the crown variables of trees in the uncut control treatment. Climatic conditions over the 1992-98 period caused a rather large increase in dieback, a decrease in density, and an increase in transparency—all indicative of worsening crown health (fig. 8). The trend is most apparent from 1996-

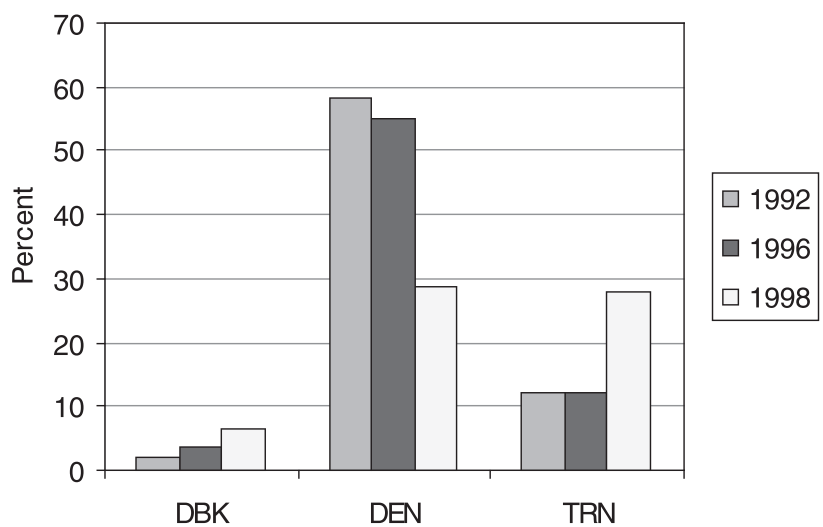

Figure 8—Mean crown variables by year for the uncut control treatment.

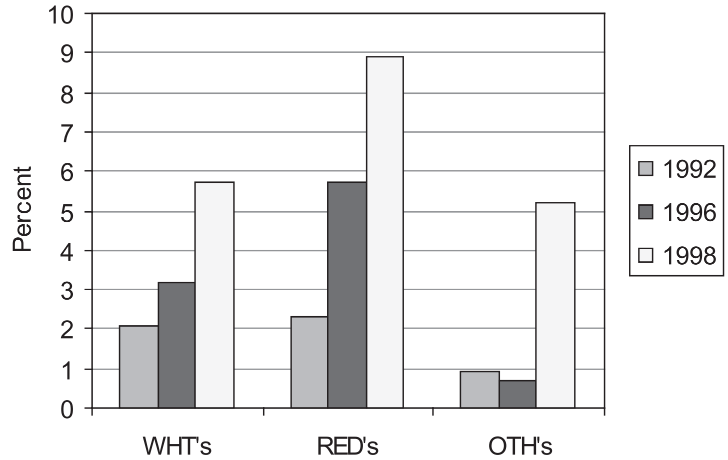

Figure 9—Mean dieback in the uncut control treatment for species groups by year.

98, reflecting the acute drought conditions which prevailed in central and northern Arkansas in the past few years, particularly 1995, 1996, and 1998.

Past experience and research (Starkey and others 1989, Wargo and others 1983) shows that trees in the red oak group are more often and severely affected by decline than trees in the white oak group or other species of hardwoods. This too is evident in the uncut control treatments by examining the crown variables for the species groups. Red oak dieback started out little different from white oaks in 1992, but increased much more in 1996 and 1998 (fig. 9).

Despite the effects of climate, treatment effects are somewhat apparent on reserve tree dieback for all tree species (fig. 10). Dieback increased the greatest amount in 1996 and 1998 in the even-aged treatments—the shelterwood, seed tree, and clearcut—with the greatest increase in the clearcut.

Red oaks began with a little higher dieback levels in 1992 and also seemed to experience higher dieback by 1998, even in the uneven-aged treatments and the uncut control (fig. 11). This again is probably a response to the acute drought conditions that occurred after the treatments were imposed. Nonetheless, 1996 and 1998 dieback was highest in the more intensive treatments.

DISCUSSION

Reserve trees were affected by both climatic variation and by the cutting treatments applied. The largest effect appears to be due to short-term climatic variation, specifically, drought over the measurement period. Survival of reserve trees to date is 91.5 percent, greater than we expected. Although dieback increased over the measurement period, surviving trees had mean dieback levels that are not excessively high (generally < 15 percent) and may not lead to further mortality. We have found in other studies that for oaks, dieback does not generally indicate a high risk for mortality unless it is one-third of the crown or more (Steven W. Oak, Dale A. Starkey [and others]. Unpublished data on file. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Region, Forest Health Protection).

To date, these results suggest that reserve hardwood trees selected from the larger diameter and higher crown classes

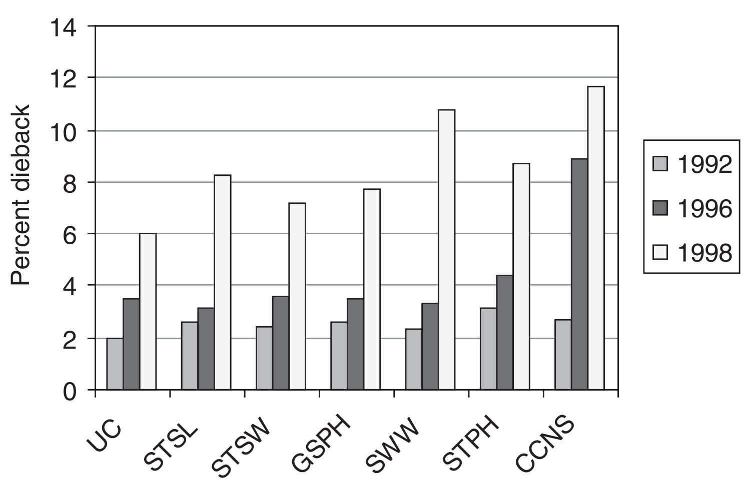

Figure 10—Dieback by treatment and year for all species.

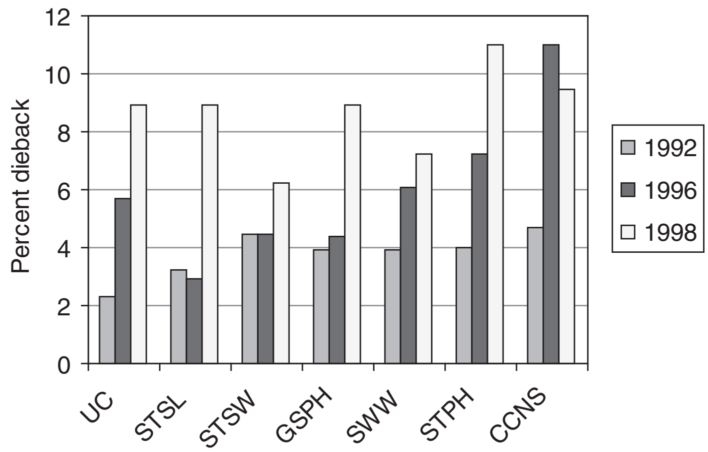

Figure 11—Dieback for red oaks by treatment and year.

can be any species desirable in meeting management objectives. Further, survival and health of reserve trees in this study suggests that reserve tree selection need not be a complicated task, and acceptable results may obtain from simply selecting the largest trees of desired species in numbers that meet the objectives of management.

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