Deer Browse Response to Pine-Hardwood Thinning Regimes in Southeastern Arkansas

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ABSTRACT. *Understanding relationships between stand thinning and browse production allows land managers to encourage both white-tailed deer* (Odocoileus virginianus) *browse production and timber production. In our study, browse biomass was determined before thinning and two and four growing seasons after thinning a 35 yr old natural loblolly pine–hardwood stand (initially 27 m^2/ha of pine and 8 m^2/ha of hardwood basal area). Combinations of 3 loblolly pine (15, 18, and 21 m^2/ha) and 3 hardwood (0, 3.5, and 7 m^2/ha) basal areas were replicated 3 times, resulting in a total of 27 0.08 ha plots. Understory biomass was determined for 14 browse species on 25 understory plots systematically located within each plot. Browse production following thinning was dominated by grape* (Vitis *spp.), blackberry* (Rubus *spp.), Japanese honeysuckle* (Lonicera japonica), *and greenbrier* (Smilax *spp.). Most deer browse species responded negatively to retained pine and/or hardwood basal areas, with hardwoods having the greater impact. Thinning improved overall browse biomass availability for deer, but responses varied by individual species. South. J. Appl. For. 23(1):16–20.*

Forest management that retains a hardwood component in pine–hardwood stands to increase habitat diversity and aesthetic quality can negatively affect white-tailed deer (*Odocoileus virginianus*) browse production. In unmanaged pine-hardwood stands, the habitat carrying capacity for deer is relatively low due to the negative effects of shading on browse production and low potential of hardwoods for mast crops Silvicultural practices and ecological succession largely determine deer browse production in naturally regenerated pine stands retaining hardwoods Intensive control of the overstory pine basal area is often required to moderate the negative effects of hardwood shading. Hardwoods tend to form dense midstory canopies which inhibit understory browse production. Thinning to remove midstory hardwoods and to reduce stand density is commonly employed as a means of stimulating browse production (Blair and Feduccia 1977). However, because of the potential to increase mast production and habitat diversity, total removal of hardwoods from pine-hardwood stands is not recommended (Hassinger and Smith 1979, Decker et al. 1983).

Understanding the relationships between stand density and browse production provides land managers with a tool for prescribing thinning to encourage both deer browse and timber production Halls and Schuster (1965) suggest thinning pine stands to basal areas of 16–18 m^2/ha as a compromise for producing both deer browse and timber. However, their suggested target basal areas did not include hardwoods which create proportionally more shade than pines Studies that addressed browse production following thinning of pine-hardwood stands to different levels of pine and/or hardwood basal area consistently showed improvements in deer habitat (Schuster and Halls 1963, Halls and Schuster 1965, Blair 1971, Hurst et al. 1979, Blair and Brunett 1980, Conroy et al 1982, Fenwood et al. 1984). However, the responses of browse species to varying densities of both pine and hardwood has not been fully evaluated Wigley et al. (1989) and Blair (1971) examined habitats across controlled levels of pine and/or hardwood basal areas, hut their results were restricted to narrow ranges in treatment levels. Wigley et al (1989) evaluated stands with only 15 m^2/ha of total basal area,

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and Blair (1971) evaluated stands with the merchantable pine component removed and hardwoods thinned to a basal area of 9 m^2/ha or areas harvested by clearcutting.

Our study compared the biomass of dominant white-tailed deer browse species 2 and 4 yr after thinning a loblolly pine-hardwood stand to a range of pine and hardwood basal areas. Since succession is the driving force behind the response of browse production to thinning, we expected that individual species should respond uniquely because of their growth habits.

Methods

Study Area

Our study was established in a natural, even-aged, 35 yr old loblolly pine (*Pinus taeda*)–hardwood stand located in the School Forest of the University of Arkansas at Monticello, Drew County, Arkansas. Soils of the area are the Henry (Typic Fragiaqualfs) and Calloway (Flossaquic Fragiaqualfs) series (Larance et al. 1976). Both soils have silt loam surfaces and were formed on windblown silt. These poorly drained soils occur on broad upland flats and have a site index of 28 m at 50 yr for loblolly pine.

The stand was regenerated from an existing hardwood-pine stand in the early 1950s; the hardwood component was killed, and a new loblolly pine stand established from seeds produced by residual trees. A few remnants of the original stand still existed prior to study installation. This stand was typical of many privately owned and unmanaged pine stands in the southeastern United States. Loblolly pine dominated the overstory canopy with hardwoods forming a dense mid-canopy. However, a few hardwoods reached into the overstory canopy. Before thinning, the loblolly pine basal area averaged 27 m^2 /ha and the hardwood basal area averaged 8 m^2 /ha. The hardwood component was primarily willow and water oak (*Quercus phellos* and Q. *nigra*, respectively), with lesser amounts of southern red oak (*Q. falcata*) and sweetgum (*Liquidambar styraciflua*). Stem quality of the loblolly pine component was sometimes poor because of past damage from ice storms and stem cankers. Some of the hardwood stems were hollow or had other obvious stem defects.

Study Design

Twenty-seven circular, 0.2 1 ha plots with a core sampling plot of 0.08 ha inside a IO m isolation strip were established. Treatments consisted of combinations of three loblolly pine (15, 18, and 2 I m^2 /ha in trees with dbh $\geq$ 9.1 cm) and three hardwood (0, 3.5, and 7 m^2 /ha) basal areas, replicated three times. Treatments were randomly assigned as much as possible in a randomized blockdesign with three blocks. Blocking was based on proximity to an ephemeral drain. Treatments were randomly assigned to plots, although a few were reassigned if the existing basal area was below that which was randomly assigned. This was especially true for plots with the highest level of hardwood retention. The pine component of each plot was harvested as a free thinning. Most of the trees were below the stand's mean dbh, but a few low-quality dominant and codominants were also thinned. Thinning of the hardwood component favored retention of the larger and better quality oaks. Plots and their adjoining isolation strips were thinned to the same basal areas. The area between the 0.2 1 ha plots was thinned to basal areas of about 18 m^2/ha for pines and 3 m^2/ha for hardwoods.

All trees were harvested as pulpwood in 1.5 m bolts to minimize damage to the residual stand. Logging began in fall 1988 but was terminated during early winter because of wet soil conditions. Loblolly pine thinning was completed by late spring 1989, but unusually wet weather during the summer prevented completion of hardwood thinning until late summer of 1989. Thus, logging continued intermittently for about l yr, with the pine component being mostly harvested before the 1989 growing season and the hardwoods being harvested by the end of the 1989 growing season. During late winter and early spring of 1990, all submerchantable hardwoods 2.5 to 9.0 cm dbh were killed with stem-injected herbicides.

Biomass was determined for the dominant browse species before thinning (summer 1988) and 2 (summer 1991) and 4 (summer 1993) yr after thinning on 25 l x l m understory plots systematically located within each plot. These browse species were American beautyberry (*Callicarpa americana*), blackberry (*Rubus* spp.), Japanese honeysuckle (*Lonicera japonica*), grape (*Vitis* spp.), blackgum (*Nyssa sylvatica*), poison ivy (*Toxicodendron radicans*), elm (*Ulmus* spp.), greenbrier (*Smilax* spp.), blueberry (*Vaccinium* spp.), Virginia creeper (*Parthenocissus quinquefolia*), red maple (*Acer rubrum*), sweetgum, supple-jack (*Berchemia scandens*), and persimmon (*Diospyros virginiana*). Browse biomass before thinning was determined by clipping current annual increments of growth ($\leq$ 1.0 m in height) for each species occurring in the understory plots. Green weights were determined, and a subsample of each species was oven dried at 40°C to a constant weight to determine the green weight to dry weight ratios. After thinning, browse biomass was determined on 25 0.5 x 0.5 m understory plots within each 0.08 ha plot due to the large amount of browse. Locations of understory plots were offset during each evaluation so that clipping did not influence subsequent measurements. All browse dry weights were converted to kg/ha prior to statistical analysis

Data Analysis

The basal area of individual plots varied within a treatment class because of (I) tree mortality from logging damage and natural causes, (2) growth during study installation, and (3) the inability to precisely control basal areas on small plots. In addition, many trees retained above target basal areas as a cushion against logging damage were not required because mortality was low. Basal areas after study installation ranged by a mean of 1.5 m^2/ha within treatment classes for both pines and hardwoods. Because of this variation, data were analyzed using regression, which allowed use of the actual basal area of each plot rather than its class designation. Several candidate equations were evaluated for use in data analysis. However, based on residual plots and fit indices of each equation, the following form was selected:

$$B_i = \exp\,(b_0 + b_1 T + b_2 P + b_3 H)$$

where B_i is the biomass (kg/ha) of browse species I at the specified year after thinning, T is the time after thinning in years, P and H are the retained pine and hardwood basal areas, respectively, in m^2/ha after thinning and the b_i's are coefficients to be estimated. Coefficients were calculated by nonlinear least squared regression using the SAS procedure MODEL (SAS Institute 1988). Data for fitting the equation were the average biomass of individual species, calculated from the 25 understory plots within each of the 27 0.08 ha plots evaluated at 2 and 4 yr after thinning. This provided a total of 54 observations for each plant species. Variables were eliminated from the full model if their coefficient did not significantly differ from zero at $P \leq 0.10$. The fit indices reported for these equations are equivalent to R^2 (coefficient of determination) in linear regression (SAS Institute 1988).

Results

Thinning reduced the loblolly pine basal area by an average of 26, 32, and 41% and the hardwood component by an average of 27, 44, and 100% for treatments with high, medium, and low basal arearetention, respectively. Positive regression coefficients in developed regression equations (Table 1) demonstrated that all vine species responded positively to time after harvest between the second and fourth growing seasons. Poison ivy, supple-jack, and Virginia creeper responded the greatest to time after harvest. Trees and shrubs did not respond to this same time period after harvest with the exception of elm and American beautyberry.

Retained pine basal area tended to influence vines more than trees and shrubs. However, this was a negative influence, with blackberry and greenbrier being affected the most by retained pine basal area. Red maple and blueberry were the only tree and shrub species that responded negatively to retained pine basal area.

The retention of hardwoods negatively affected all browse species except blackgum, persimmon, blueberry, and Virginia creeper. Virginia creeper was the only species positively influenced by retained hardwood basal area. On average, hardwoods exerted 1.5 times more negative influence on browse species responding to retained basal area as pines.

Browse biomass was dominated by grape in all treatment combinations at both 2 and 4 yr after harvest (Figure I). Blackberry was second in biomass production at 4 yr for treatments with no hardwoods. Greenbrier replaced blackberry in biomass production as retained hardwood and pine basal areas increased. At 2 yr after harvest, Japanese honeysuckle was the second most dominant species in terms of biomass produced by treatments retaining no hardwoods. However, by 4 yr after harvest, Japanese honeysuckle was the third dominant species in terms of biomass produced on all treatment combinations. Elm on average produced the least amount of biomass across all treatment types for browse species showing significant responses. The combined biomass of all browse species ranged from 107 to 637 kg/ha at 2 yr and from 204 to 1214 kg/ha at 4 yr (Figure 2).

Table 1. Regression coefficients and associated statistics for determining biomass of plant species important as browse for white-tailed deer from the number of years after stand thinning, retained pine basal area, and retained hardwood basal area in a 35 yr old natural loblolly pine-hardwood stand in southeastern Arkansas. Also shown are regression coefficients for determining total browse biomass.

	Regression coefficients[a]				Mean		Fit
Browse species	b_0	b_1	b_2	b_3	biomass (kg/ha)	RMSE	index
Vines							
Blackberry	6.00	0.624	-0.198	-0.541	31.9	25.1	0.83
Grape	6.52	0.307	-0.121	-0.145	121.3	101.2	0.37
Greenbrier	5.46	0.433	-0.138	-0.120	50.4	33.6	0.50
Japanese honeysuckle	5.69	0.368	-0.133	-0.183	49.6	58.5	0.28
Poison ivy	2.75	0.752	-0.131	-0.110	12.0	14.5	0.36
Supple-jack	ns	0.698	ns	-0.264	5.6	8.0	0.27
Virginia creeper	1.29	0.686	-0.095	0.109	10.2	10.2	0.29
Trees							
Blackgum	1.43	ns	ns	ns	4.2	8.7	
Elm	ns	0.547	ns	-0.100	4.4	5.3	0.18
Persimmon	1.07	ns	ns	ns	2.9	6.2	
Red maple	5.77	ns	-0.102	-0.163	28.9	31.9	0.24
Sweetgum	3.96	ns	ns	-0.211	28.3	46.3	0.13
Shrubs							
American beautyberry	2.41	0.345	ns	-0.209	18.5	24.6	0.22
Blueberry	5.31	ns	-0.128	ns	18.9	25.8	0.08
Total browse biomass	7.43	0.323	-0.108	-0.162	387.1	177.4	0.68

[a] $B_i = \exp(b_0 + b_1T + b_2P + b_3H)$ where B_i is the biomass (kg/ha) of browse species I at the specified year after thinning, T is the time after thinning in years. P and H are the retained pine and hardwood basal areas, respectively, in m^2/ha afterthinning. Shown coefficients were significant at $P \leq 0.10$. Non-significant coefficients are indicated by ns.

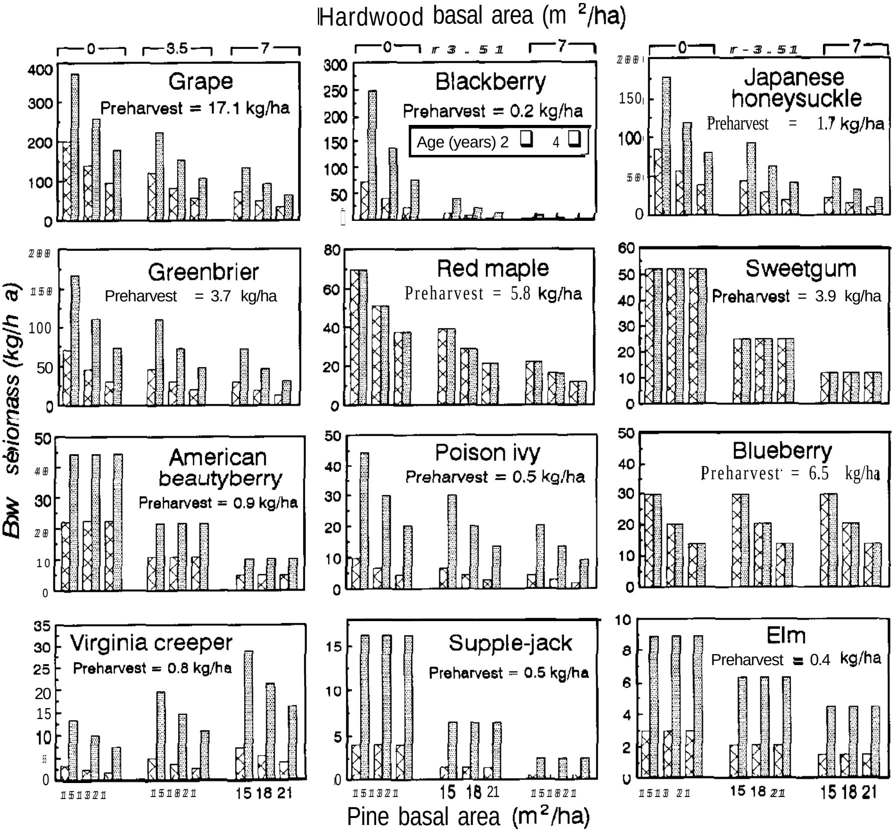

Figure 1. Effects of retained pine and hardwood basal areas on biomass of dominant white-tailed deer browse species 2 and 4 yr after thinning a 35 yr old natural loblolly pine-hardwood stand in southeastern Arkansas. Values were calculated from appropriate equations in Table 1.

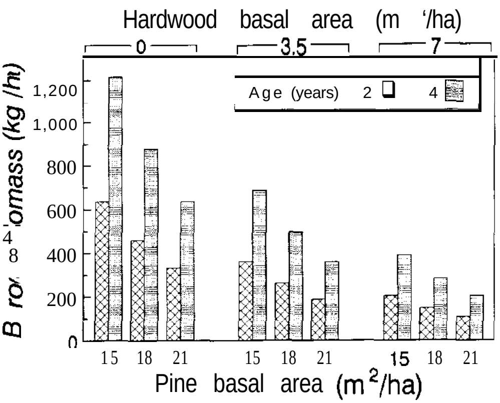

Figure 2. Effects of retained pine and hardwood basal areas on the combined total biomass of dominant white-tailed deer browse species 2 and 4 yr after thinning a 35 yr old natural loblolly pine-hardwood stand in southeastern Arkansas. Values were calculated from the appropriate equation in Table 1.

Discussion

Production of white-tailed deer browse species in thinned stands is controlled by time after harvest and the canopy cover of retained pines and hardwoods. A similar conclusion was made by Blair and Brunett (1980) in their study of deer browse response in a selectively thinned, uneven-aged, pine–hardwood stand. The rapid response and dominance of vines after thinning was also observed by Wigley et al. (1989). The dominance of grape, greenbrier, and honeysuckle in our study is important. These species were found to be an important component of the diet of hunter-harvested deer even in years when oak mast was plentiful (Nelson et al. 1988). In years of low oak mast, these three dominant browse species would likely make up an even greater percentage of the diet of deer. Biomass of blackberry, red maple, and sweetgum was intermediate across all treatment combinations, but these species are important components of deer diets in the Gulf Coastal Plain of southeastern Arkansas (Harlow and Hooper 1971). Therefore, the quantity of deer browse and thus the quality of habitat on this study area was improved by thinning even at the lowest intensity. However, the response of browse biomass increased with the thinning intensity for both pines and hardwoods.

In our study, a greater number of browse species responded more negatively to retained hardwoods than pines. Tappe et al. (1993) reported that hardwoods produced about twice as much shads as pines in this study. Hardwoods produce more shade than pines because they: (1) develop larger crowns than pines of the same dbh, (2) tend to grow less in height than pines, thus their crowns are closer to the understory and produce more direct shade, and (3) have broader leaves capable of intercepting more light than pines. Therefore, retaining hardwoods in a forested stand to improve mast potential, habitat diversity, and aesthetic quality is a trade-off with providing deer with more browse Loblolly pine stands on good sites in the southeastern United States can be thinned every 5 to IO yr. Thus, browse biomass production for deer can be maintained at high levels even if quality hardwoods are retained for mast production. This stand was growing at a mean annual rate of 0.8 m^2/ha in loblolly pine basal area; thus, a thinning interval of about 5 yr would be possible

Nine of the 14 browse species studied showed significant increases from 2 to 4 yr after harvest, suggesting that a short thinning interval will benefit the response of these species. Virginia creeper was the only studied species that could be negatively affected by thinning the hardwood component. In addition to increased browse production for deer, thinning produces other benefits which include (1) generating revenue for the landowner, (2) redistributing growth potential of the stand to trees of higher quality or more desirable species, (3) harvesting potential tree mortality, (4) promoting growth and vigor of residual trees by reducing competition levels, and (5) modifying understory conditions to improve herbaceous forage production and wildlife habitat quality Repeated stand disturbance from subsequent thinnings will maintain improved browse production and habitat quality for some species of wildlife by: (1) scarifying the forest floor, (2) destroying some of the existing understory vegetation which allows for new browse growth. and (3) reducing overstory shading and competition

In conclusion, total browse production in this stand increased by 155–1417% at 2 yr and 386–2790% at 4 yr after thinning Production of browse biomass declined as more pine and hardwood basal area was retained. Amounts of browse production similar to ours were reported by others (Fenwood et al 1984, Master? et al 1993, and Wigley et al 1989) for stands in the southeastern United Slates The retained pine and hardwood basal areas also affected browse species composition. Blackberry, for example, was only dominant on plots with no hardwoodsand a low pine basal area. As the amount of hardwood and pine basal area mcreased, the amount of blackberry biomass decreased. In contrast, increased retention of hardwoods favored Virginia creeper browse production. Differences in responses of individual species reflect their shade tolerance and reproductive ecology

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