Deer Forage and Overstory Dynamics in a Loblolly Pine Plantation

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Highlight: *In a loblolly pine plantation in central Louisiana, forage growth was basically governed by the development of pine crowns and the corresponding reduction of light in the understory. In young stands ready for initial thinning at age 20 years, growth of herbaceous and woody vegetation was virtually precluded by the dense pine canopy. Hardwood trees, shrubs, and woody vines increased as stands were thinned every 5 years. By plantation age 30 years, a multilayered midstory was developing as hardwoods and some shrubs grew beyond the deer feeding zone. Midstory density increased directly with the intensity of pine removal, and by stand age 35 it was the principal deterrent to growth of deer forage. Herbage was not abundant.*

Loblolly pine (*Pinus taeda*) plantations grown on a long-term rotation can provide sustained habitat for deer in the Gulf Coastal Plain, but only if they are intentionally managed for wildlife forage in the understory. Forage growth is largely governed by the forest manager's ability to adjust the overstory so as to provide sufficient light for understory plants.

This paper evaluates composition and growth of deer forage as influenced by pine thinning and development of a hardwood midstory in a loblolly pine plantation. Forage and tree dynamics were evaluated over a 13-year period from stand age 30 to 42.

Study Plantation and Methods

The plantation is on the Alexander State Forest in central Louisiana, an area supervised by the Louisiana Forestry Commission. Pine seedlings were planted in 1928 at a square spacing of 2.44 m.

The soil is a Muskogee silt loam with good surface and internal drainage. Terrain is level. The site is considered average for loblolly pine, and predicted heights at age 50 years are about 25 m.

Beginning in early 1948, when pines were 20 years old, a series of light, medium, and heavy pine thinnings was initiated on a layout of 0.16-ha plots. Pine basal areas after thinning averaged 23.0, 19.5, and 16.1 m^2 per ha. Plots were rethinned every 5 years to these same basal areas. Each thinning level was replicated four times in a completely randomized design. Except for an occasional hardwood tree cut for pulpwood, only pines were removed. Pine crop trees are managed for high-quality sawtimber or veneer bolts.

Fire was excluded until December 1962, when a backfire was prescribed for hazard reduction. A second controlled burn was made in December 1966.

Tree strata and understory flora for the study of deer forage were first sampled in the late summer of 1957. Sampling immediately preceded a pine thinning. Measurements were taken in 1962 and 1967 prior to scheduled thinnings and again in 1969, 2 years after the fifth pine cut. All pines, hardwoods, and shrub stems larger than 3.81 cm in diameter at breast height (dbh) were inventoried by 2.54-cm diameter classes on the central 0.04 ha of each thinning plot.

To appraise forage responses to overstory dynamics, the current season's growth of leaf and stem tissue on understory vegetation was clipped from the ground to a height of 1.52 m on nine 2-m quadrats located in a grid pattern within each of the central 0.04-ha plots. Samples were taken in late summer, after growth was completed. Growth of herbaceous species was sampled separately by grasses, grass-like plants, composites, legumes, and miscellaneous forbs. Browse, consisting of current twig and leaf tissues of shrubs, small hardwoods, and woody vines, was sampled by species or species groups. A new set of sampling quadrats was selected each measurement year. Clipped plant tissue was dried to constant weight in a forced-draft oven at 65°C.

The relations between both herbaceous and browse forage and the overstory were evaluated by correlation and multivariate regression analyses (Grosenbaugh, 1967) when pines were 30, 35, 40, and 42 years old.

Dependent variables for testing herbage relations were dry-matter yields in kg/ha (Y_1) and their logarithmic transforamtions (Y_2). Independent variables were the per-hectare density (X_1) and basal area (X_2) of pines, the density (X_3) and basal area (X_4) of midstory hardwoods and large shrubs, the dry-matter yields of browse in kg/ha (X_5), and the logarithmic transformations of these variables (X_6 to X_{10}). The relationships of browse yields (Y_3) and their logarithmic transformations (Y_4) were tested with four independent variables expressing the density and basal area of pine and midstory stems and their logarithmic values.

The objective was not to develop precise mathematical expressions for predicting forage yields but to clarify the ecological relationships. The relations between overstory density or basal area and forage production were generally curvilinear. Changes in production of forage dry matter as the plantation developed were tested by analyses of variance. In addition, mean forage yields were compared by Duncan's (1955) multiple range test, with Harter's (1960) tables. All statistical tests were at the 0.05 probability level.

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Overstory Dynamics

Pine stocking was reduced appreciably by the initial thinnings in 1948. For example, stocking decreased from 1,137 to 776 stems per ha in lightly thinned stands and from 1,151 to 583 stems per ha with heavy thinning. Thinnings in 1948 and again in 1953 increased the light reaching the understory and thereby stimulated growth of suppressed hardwoods and favored the invasion of additional stems. Compositional and structural trends in the tree strata were consistent with Chapman's (1948) conclusion that thinning will inevitably allow hardwoods to develop under pure stands of loblolly pine.

By 1957 all plots had a multilayered but discontinuous midstory of hardwood trees and large shrubs (hereafter referred to collectively as hardwoods) beneath a dominant pine canopy (Blair, 1967). Hardwood stocking was directly related to pine cutting intensity (Fig. 1). Pines ranged from 593 stems per ha with light thinning to 420 stems under heavy thinning, while hardwoods ranged from 432 to 672 stems per ha. Over the next 5 years hardwoods continued to increase in all stands, and their density continued to be highest with heavy thinning.

Hardwood stocking declined appreciably in all stands after the 1962 and 1966 prescribed burns, which killed many small stems. Before the burns, the 5.08- and 7.62-cm diameter classes comprised more than 71% of the stocking. By 1967 only 49% of the hardwoods were less than 9.02 cm dbh. During the 12 years from 1957 to 1969, average hardwood dbh increased from 7.11 to 11.18 cm. Large trees were more numerous in stands receiving medium and heavy thinnings than in those thinned lightly.

Pine basal area in 1957 ranged from 27.55 m^2 per ha with light thinning to 21.16 m^2 with heavy cutting. Hardwood basal area varied directly with pine thinning intensity from 1.29 to 3.19 m^2 for light and heavy cutting, respectively. While pines were cut back to prescribed levels each 5 years, hardwood basal area continued to increase unabated except for losses caused by prescribed burning and an occasional tree cut for pulpwood.

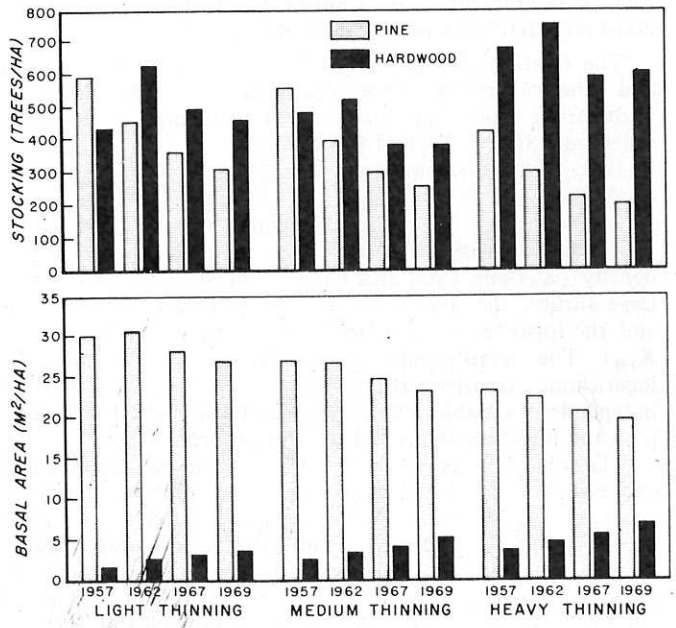


Fig. 1. *Stand characteristics of pine and hardwood trees > 3.81 cm dbh under three levels of pine thinning.*

The successively narrowing basal-area ratio of pine to hardwood at all thinning levels from 1957 to 1969 further illustrates the progressive alteration in the mixed tree strata. With light thinning the ratio narrowed from 21.4:1 in 1957 to 7.7:1 in 1969. In heavily thinned stands where hardwood growth was greater the ratio narrowed from 6.6:1 to 2.9:1. Negative linear relations between pine and hardwood basal areas were significant in 1957 ($r = -0.67$), 1962 ($r = -0.55$), and 1969 ($r = -0.56$). The nonsignificant association in 1967 ($r = -0.39$) probably was attributable to the loss of hardwood stems from the burns in 1962 and 1966.

Number of species comprising the midstory increased with pine thinning intensity. Sweetgum (*Liquidambar styraciflua*) was the principal midstory component under all pine thinning regimes, varying little in relative ranking from 1957 to 1969. Thus, it averaged 84% or more of the hardwood stocking with light pine thinning, 52% with medium thinning, and 71% with heavy thinning. Blackgum (*Nyssa sylvatica*) ranked second in prominence in association with such species as southern red oak (*Quercus falcata*), water oak (*Quercus nigra*), flowering dogwood (*Cornus florida*), red maple (*Acer rubrum*), and tree sparkleberry (*Vaccinium arboreum*). As midstory density increased from 1957 to 1962 several less abundant species succumbed—among them were white ash (*Fraxinus americana*), rusty blackhaw (*Viburnum rufidulum*), Elliott's blueberry (*Vaccinium elliottii*), and sassafras (*Sassafras albidum*). The controlled burn in the winter of 1962 eliminated American holly (*Ilex opaca*) and southern bayberry (*Myrica cerifera*) from the midstory.

Thinning levels also influenced pine growth. Heavier cuts resulted in the fastest diameter growth but the least cubic-meter or board-foot volume growth by stand age 40 (Enghardt, 1970). From 1957 to 1969 average pine diameter increased from 24.6 to 33.0 cm.

Understory Vegetation

Herbage

Herbaceous vegetation, especially grass-like plants and forbs, was sparse in 1957 (Table 1). Average dry-matter yields tended to vary inversely with pine basal area and directly with hardwood basal area, though differences between thinning regimes were not large. By 1962, when stands were scheduled for the fourth thinning, yields had not increased significantly and varied little by cutting intensity. The change in pine-herbage relations appeared to be the product of invading hardwoods and the subsequent increase in midstory density. Under light thinning where hardwood basal area was least, herbage increased 23% from 1957 to 1962. With moderate thinning it declined 25%, and with heavy thinning and the greatest hardwood basal area it was down 29%.

The prescribed winter burns in 1962 and 1966 favored herbaceous vegetation not only by reducing the density of competitive woody stems but also by destroying litter and thus improving seedbeds. By 1967 herbage had increased 208, 285, and 293% under light, medium, and heavy thinning (Fig. 2). The greater increases under medium and heavy thinning probably resulted from a proportionately greater fire kill of small hardwoods and shrubs. Dry-matter production did not change significantly from 1967 to 1969 in response to the fifth thinning.

Grasses comprised 62% or more of the herbage dry matter over all thinning regimes and years.

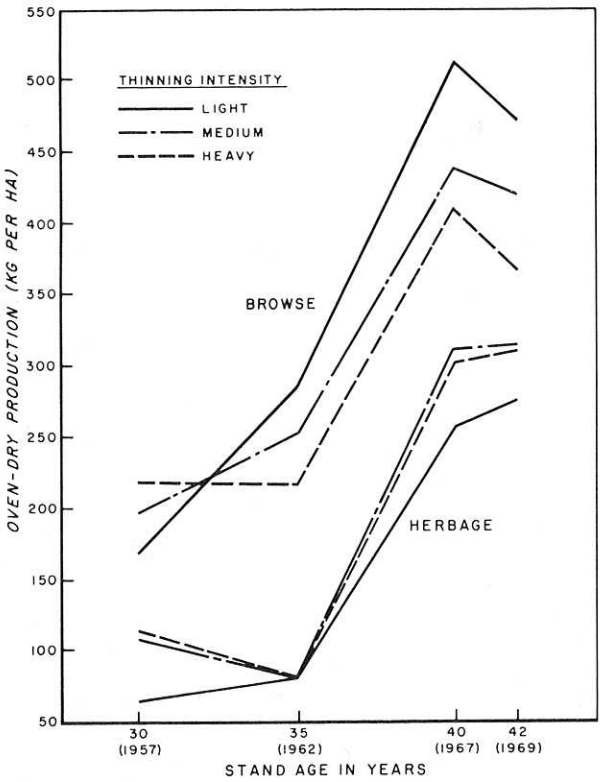


Fig. 2. *Variation in the production of forage dry matter per ha as the stands aged.*

Shade-tolerant longleaf uniola (*Uniola sessiliflora*) and spike uniola (*Uniola laxa*) contributed around 60% of the dry-matter yield of grasses in 1957 and 1962. Pinehill bluestem (*Andropogon divergens*), broomsedge bluestem (*Andropogon virginicus*), and several species of panicum (*Panicum* spp.) were common associates of uniola at this stage of plantation development. By 1967, when the hardwood midstory was extensively developed, the two species of uniola yielded over 90% of the grass dry matter. Competition had eliminated the more intolerant bluestems and drastically reduced the panicums. Sedges and rushes in the genera *Carex* and *Rhynchospora* had virtually disappeared, while nutrushes (*Scleria* spp.) increased.

Though forbs are a highly desirable food for deer, most species are intolerant of low light levels. Except for legumes, the comparatively low forb yields tended to increase after the controlled burn. Dry-matter yields of legumes varied little. Prominent composites such as bonesets (*Eupatorium* spp.), grassleaf goldaster (*Chrysopsis graminifolia*), and ironweed (*Vernonia texana*) declined appreciably after 1962, while the occurrence of bushy aster (*Aster dumosus*), elephantfoot (*Elephantopus tomentosus*), and goldenrods (*Solidago* spp.) changed little with increasing midstory density. Tickclovers (*Desmodium* spp.) and partridgepea (*Cassia fasciculata*) were the principal legumes. Of the remaining common forbs, copperleaf (*Acalypha gracilens*) and poor-joe (*Diodia teres*) declined as the plantation aged, while narrowleaf mountainmint (*Pycnanthemum flexuosum*), skullcap (*Scutellaria* spp.), lobelia (*Lobelia puberula*), and the highly tolerant partridgeberry (*Mitchella repens*) increased. Bracken-fern (*Pteridium aquilinum*) was the only fern observed.

Because of the low herbage production, plantations generally afford only limited grazing for livestock. Cattle should be excluded where deer are desirable, since both eat the leaves and tender twigs of browse.

Browse

Current leaves and stems of woody plants dominated understory forage growth (Table 1). In 1957 browse yields varied inversely with the basal area of pine and directly with that of hardwoods. Over the ensuing 5 years this relationship reversed and remained so through 1969 as the hardwood midstory progressively increased with pine removal (Fig. 2). From 1957 to 1962 browse dry matter increased 66% with light pine thinning and 27% with moderate thinning. With a heavy cut there was no significant increase.

Following the prescribed burns in 1962 and 1966, browse yields rose by an average of 81% throughout all stands. The increase was significant under all thinning regimes. By killing above-ground fractions of many single woody stems, fire stimulated multiple-stem sprouting, greatly increasing growth per plant. Production did not change significantly from 1967 to 1969.

The tree-browse relationships for the composite of species regarded as palatable deer food generally followed the same pattern as that for total browse (Table 2). The ratio of palatable to total browse dry matter varied little as the stands aged and as the composition and structure of the overstory changed. It ranged from a high of 0.70 in 1962 to a low of 0.61 in 1969.

Table 1. Forage dry matter (kg/ha) in late summer under pine stands thinned every 5 years (means of 36 2-m sampling quadrats per year and thinning intensity).

	Light thinning				Medium thinning				Heavy thinning			
Vegetation class	1957	1962	1967	1969	1957	1962	1967	1969	1957	1962	1967	1969
Herbage												
Grasses	42.6	65.1	226.6	238.9	78.5	57.2	264.7	280.4	78.5	55.0	242.3	267.0
Grass-like plants	3.4	2.2	5.6	3.4	7.9	4.5	24.7	11.2	5.6	4.5	9.0	6.7
Forbs												
Composites	7.9	3.4	10.1	10.1	11.2	3.4	12.3	13.5	11.2	3.4	16.8	19.1
Legumes	2.2	2.2	2.2	5.6	2.2	4.5	2.2	4.5	3.4	4.5	2.2	6.7
Miscellaneous	5.6	1.1	3.4	6.7	9.0	7.9	11.2	7.9	10.1	4.5	14.6	11.2
Ferns	6.7	10.1	11.2	14.6	T[1]	4.5	T	1.1	3.4	7.9	20.2	4.5
Total herbage	68.4 a[2]	84.1 a	259.1 b	279.3 b	108.8 a	82.0 a	315.1 b	318.6 b	112.2 a	79.8 a	305.1 b	315.2 b
Browse	172.8 a[2]	286.1 b	518.3 c	476.8 c	200.8 a	255.8 b	444.2 c	422.9 c	223.2 a	218.8 a	415.1 b	374.7 b
Total forage	241.2	370.2	777.4	756.1	309.6	337.8	759.3	741.5	335.4	298.6	720.2	689.9

[1] < 0.051 kg per ha.

[2] Yield values within a thinning regime and vegetation class followed by a common letter are not significantly different.

Table 2. Leaf and stem tissue produced (kg/ha, ovendry) by palatable[a] and nonpalatable browse species.

Palatability class & year	Light thinning		Medium thinning		Heavy thinning	
	Leaves	Stems	Leaves	Stems	Leaves	Stems
Palatable species						
1957	55.3	43.4	73.5	50.1	88.5	61.7
1962	103.4	89.2	88.7	88.5	91.4	68.9
1967	169.0	154.7	143.6	137.3	140.6	124.6
1969	156.1	131.8	138.7	116.1	132.8	105.1
Nonpalatable species						
1957	61.0	13.1	59.6	17.6	58.3	14.7
1962	75.5	18.0	56.6	22.0	45.2	13.3
1967	149.0	45.6	98.8	64.5	100.4	49.5
1969	121.8	67.1	94.4	73.7	102.5	34.3

[a]Species generally ranked as palatable deer forage within the western region of the loblolly-shortleaf pine-hardwood forest association.

Over all years and levels of pine thinning, woody vines contributed more than 55% of the palatable browse. Principal species were Carolina jessamine (*Gelsemium sempervirens*), Alabama supplejack (*Berchemia scandens*), common greenbrier (*Smilax rotundifolia*), and cat greenbrier (*Smilax glauca*). Shrubs and trees included American beautyberry (*Callicarpa americana*), flowering dogwood, blackgum, blackberries and dewberries (*Rubus* spp.), water oak, and Elliott's blueberry. With the exception of blackgum, occurrence and growth of these species generally increased.

Principal nonpalatable species were muscadine grape (*Vitis rotundifolia*), sweetgum, southern bayberry, southern red oak, post oak (*Quercus stellata*), common deerberry (*Vaccinium stamineum*), and rabbiteye blueberry (*Vaccinium virgatum*).

Under all thinning regimes, dry-matter yield of leaf tissue exceeded that of stems each year (Table 2), but the leaf:stem ratio was considerably higher for nonpalatable than for palatable species. The abundance of large-leaved species in the nonpalatable category accounted for the differences. Carolina jessamine, a small-leaved evergreen, consistently yielded a third or more of the total leaf dry matter in the palatable group.

The leaf:stem ratios of the palatable and nonpalatable categories did not vary appreciably with intensity of pine removal, controlled burning, or subsequent invasion of hardwoods.

Timber Stand-Herbage Relationships

In 1957, when pines were 30 years old and ready for the third thinning, analyses indicated that growth of herbaceous plants was governed primarily by the influence of pine stocking and basal area in conjunction with browse growth. When pine overstory and browse growth were combined into a multivariate expression, they accounted for 73% of the variation in herbage production. Pine overstory alone accounted for 66% of the variation.

After the third pine thinning, hardwoods and shrubs continued invading. By 1962 the midstory was so dense that the growth of herbaceous forage now appeared to be governed primarily ($r = -0.50$, significant) by hardwood stocking.

By 1967, midstory had become a progressively greater herbage deterrent, even though prescribed burns in the winter of 1962 and 1966 reduced the number of stems. Collectively, midstory stocking and basal area accounted for 74% of the variation in herbage yield. Pine or browse attributes, individually or in combination, were exerting little influence on herbaceous vegetation.

A number of hardwoods were cut or broken over during pine harvest in the winter of 1967-68. This disturbance appeared to temper the effect of the midstory. Sufficient time had not elapsed by 1969 for hardwoods and shrubs to invade and shade out herbage, primarily grasses, that seeded into openings created by the reduction of both pines and hardwoods. Herbage yields were significantly correlated with hardwood stocking ($r = -0.62$), pine stocking ($r = -0.86$), and pine basal area ($r = -0.53$). In combination, these overstory attributes accounted for 94% of the variation in herbage.

Timber Stand-Browse Relationships

In 1957 the combined influence of hardwood stocking and basal area and pine basal area inversely governed browse yields and accounted for 73% of the variation in production. Individually, these stand attributes were not significantly correlated with browse yields.

From 1962 to 1969 the low, dense hardwood canopy appeared to be the principal deterrent to browse growth. Both midstory stocking and basal area were significantly related to browse dry matter, the correlations ranging from a low of $r = -0.58$ for hardwood stocking in 1962 to a high of $r = -0.85$ for hardwood basal area in 1969. Collectively, the midstory attributes accounted for 67% of the browse variability in 1962, and for 76% in 1967 and 1969.

The canopy of dominant pines was sufficiently high and thin by 1962 to permit the transmission of considerable light. Hence pine offered little competition to browse in the understory by plantation age 35.

Discussion and Conclusions

Even though some timber growth may be sacrificed (Grano, 1970a), quality deer habitat in a loblolly pine plantation requires an interspersion of the herb and shrub stages of plant succession beneath the dominant pine canopy.

A loblolly plantation on a pulpwood rotation of 20 to 25 years generally provides forage, especially herbage, for deer only from the time of planting to crown closure. This is a period of 8 to 10 years, depending on pine spacing and site quality. Thereafter, herbaceous and woody forage is sparse in the understory until trees are harvested. In stands managed for sawtimber and veneer stock, the understory begins increasing again after the initial pine thinning at about pine age 20 (Blair, 1969). Suppressed woody plants respond to the increased light, and additional browse and herbage plants become established. When left uncontrolled, many plants soon grow beyond the deer feeding zone (Blair, 1967; Schuster and Halls, 1963).

The development of a hardwood midstory should be prevented. When the preponderance of leaf material on shrubs and hardwoods grows beyond about 1.5 m aboveground, individual stems can be felled when the pines are thinned. Species that will produce fruit or mast in the reduced light should be retained.

In the absence of a broadleaved midstory, forage growth is generally inversely proportional to pine basal area. For deer habitat, therefore, stands should be managed at a minimum level of pine basal area. A loblolly plantation thinned to about 16 m^2 per ha every 5 years after age 20 can provide adequate forage for deer when the midstory is limited to desirable fruiting trees and shrubs.

Though woody vines are generally a major source of

palatable browse in loblolly plantations, they often form dense entaglements that impede tree marking and harvest, and may kill or deform young pines. Vines that interfere with pine culture have generally grown beyond the deer feeding zone and should be cut back.

Green leaves of browse plants are an important part of the deer forage. Foliage of broad-leaved evergreens is particularly important in late fall and winter, when nutritious foods are scarce. Nutrient quality and dry-matter digestibility of current woody stems are generally at an acceptable level only during a brief period in spring (Blair and Epps, 1969; Short et al., 1973). Thereafter the ingestion of fibrous stems declines appreciably. Harlow and Hooper (1972) concluded from investigations in the southeastern Coastal Plain that deer eat more green leaves than twigs at all seasons.

Judicious prescribed burning can also control the density of midstory hardwoods (Grano, 1970b) and subsequently improve the forage (Lay, 1957). Winter backfires at about 5-year intervals will kill the aboveground portions of many smaller stems of hardwoods, shrubs, and woody vines—including many that have grown beyond the deer feeding zone. Multiple-stem sprouting the following spring increases the productivity and nutrient quality of forage. But frequent burning, as at 2- to 3-year intervals, eradicates the understory browse community (Grano, 1970b) and eliminates food and cover for deer and other wildlife.

The size, shape, and distribution of plantations greatly influence desirability for deer habitation. Where a large block of forest land is scheduled for regeneration, only a portion should be clearcut and planted yearly. Then if the planting sites are small and well distributed they will provide deer with a diversity of food and cover. Long, narrow plantations of 10 to 20 ha are usually the most desirable (McGinnes, 1969), since they have more edge than units that tend toward a square or circular form.

Guidelines for sustaining deer habitat in plantations are generally applicable also to the vast acreage of natural loblolly-shortleaf pine (*Pinus echinata* Mill) stands. The thinning cycle in natural stands can be extended to 7 or 8 years. These stands should be maintained as a pine-hardwood association, but overstory and midstory hardwoods with no commercial potential or of no value to wildlife should be deadened.

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