UNDERSTORY FORAGE PRODUCTION FOLLOWING THINNING IN SOUTHERN APPALACHIAN COVE HARDWOODS

DONALD E. BECK, Southeastern Forest Experiment Station, P.O. Box 2570, Asheville, NC 28802
RICHARD F. HARLOW, Southeastern Forest Experiment Station, Department of Forestry, Clemson Univesity, SC 29631

Abstract: Understory response was studied for 4 years following thinning in 44 cove hardwood stands in the mountains of western North Carolina and northern Georgia. Stands were in the pole and small-sawtimber stages, raning in age from 20 to 56 years. Understory vegetation increased from 334 kg/ha before thinning to 574 kg/ha the 1st year after thinning. Peak production of 777 kg/ha was reached in the 3rd year and began to decline slightly by the 4th year. Implications for deer, grouse and songbird management are discussed.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 35:185-196

Hardwood timber types that occupay the coves and moist slopes of the southern Appalachians are highly productive. Because of the shade intolerance of most species, timber production in these types is most efficient when they are maintained in even-aged stands with regeneration obtained by clearcutting (Trimble 1973).

These types are also highly productive of low vegetation for the 1st few years after a clearcut harvest (Harlow and Downing 1969). Suggestions as to size, shape, and distribution of cuts to maximize their utility for deer have been made by Blymyer and Mosby (1977). However, forage production in a clearcut dwindles rapidly as the stand develops and the crown canopy closes. In the past, most stands have gone relatively undisturbed from 1 regeneration cut to the next. However, increasing scarcity of large, high-quality sawtimber and veneer along with improving markets for small roundwood is making thinnings more attractive to forest managers as a way of improving species composition and concentrating growth on fewer, larger trees.

It is well documented that thinning stimulates development of understory vegetation and generally improves habitat for certain wildlife species in the more zeric upland types dominated by oaks (Crawford 1976). However, with the exception of a paper by Della-Bianca and Johnson (1965) on response to cleaning in 1 11-year-old stand and response of woody browse to thinnings in a 35-year-old stand (Knierim et al. 1971), relatively little is published about the effect of thinning on wildlife habitat over a wide range of mesic upland sites. In this paper we measure production of understory vegetation in undisturbed stands in pole and small-sawtimber stages of cove hardwoods in the southern Appalachians and relate how this production is affected by the 1st thinning.

METHODS

Study Areas

The study included 44 cove hardwood stands in the mountains of western North Carolina and north Georgia that ranged in elevation from 600 to 1,380 m. Stands were in the ple and small-sawtimber stages, ranging in age from 20 to 56 years. Site index (the height attained by oaks in 50 years) ranged rom 19 to 30 m (Olson 1959) with an average of 25 m. Basal area of the unthinned stands averaged 26 m^2/ha with a range of 17 to 43.

The overstory of the stands was composed ob 35 tree species of which 8 contributed nearly 80% of the total basal area. Percent abundances for the 8 major species were : yellow-poplar (*Liriodendron tulipifera*), 14%; northern red oak (*Quercus rubra*), 14%; chestnut oak (*Q. prinus*), 12%; white oak (*Q. alba*), 12%; red maple (*Acer rubrum*), 9%; sweet birch (*Betula lenta*), 8%; black oak (*Q. velutina*), 5%; and black locust (*Robinia pseudo-acacia*), 4%. Less abundant species were black cherry (*Prunus serotina*), scarlet oak (*Q. coccinea*), silver bell (*Halesia carolina*), hickory (*Carya* spp.), beech (*Fagus grandifolia*), sugar maple (*A. saccharum*), ash (*Fraxinus americana*), yellow birch (*B. lutea*), and umbrella tree (*Magnolia fraseri*).

Also present, but not a part of the main overstory, was a large number of midstory stems over 1.37 m tall and 2.5 to 7.6 cm dbh — an average of 1,828 per hectare. Among the 38 separate midstory species encountered, the most abundant were flowering dogwood (*Cornus florida*), red maple, silver bell, blackgum (*Nyssa sylvatica*), sourwood (*Oxydendrum arboreum*), hickory, sugar, maple, sweet birch, and white oak. These species made up 70% of the total number of midstory stems.

Stand Treatment

Each 0.06 to 0.08 ha study plot was thinned from below to favor the best formed stems of the most desirable timber species. Suppressed and intermediate crown classes were removed first; codominant crown classes were cut as needed to obtain the desired residual basal area and spacing. Thinning removed 30 to 70% (mean 50%) of overstory basal area — enought to removed trees from the higher crown classes — thus admitting considerable light to the forest floor. Residual basal area ranged from 7.4 to 22.5 m^2/ha in overstory trees (mean 14 m^2/ha). Midstory trees were left intact except for those broken or knocked down in the thinning operation.

Understory Sampling Method

Understory vegetation was sampled in early August before thinning and at the same season for 4 years afterward by the 100% clip method described by Harlow (1977). Ten systematically arranged 0.9-m^2 subplots were clipped on each thinning plot. All green vegetation, fungi, and current annual growth of woody twigs up to a height of 1.37 m were clippled, weighed, and recorded by species. Samples of the major species were weighed then ovendried. The ratio of ovendried weight to green weight was used to convert and express weights in kg/ha ovendried weight.

Conversion factors for the minor species were obtained from previous work by Harlow and Downing (1969).

Analysis

For purposes of analysis, understory vegetation was grouped into 7 categories: 1) trees, 2) shrubs, 3) vines — leaves and annual growth of wood portion, 4) forbs, 5) ferns, 6) grasses and sedges, and 7) fungi — entire aboveground parts of plants.

We used correlation and regression analyses to assess associations of site, stand, and thinning level with change in understory vegetation. Variables tested included site index, stand age, residual basal area, percent of basal area cut, residual number of overstory trees, percent of overstory trees cut, number of midstory stems, and appropriate interactions. The dependent variables used in this analysis were the differences between dry weights of each understory vegetation category prior to thinning and those existing 4 growing seasons after thinning.

RESULTS

Unthinned Stands

Dry weight of understory vegetation in the unthinned stands averaged 334 kg/ha. The total weight was rather evenly spread among several of the categories. Forbs accounted for the greatest amounts, with 92 kg/ha or about 28% of the total. There was a great victory of forbs but relatively few species dominated the distribution and amount. Aster (*Aster* spp.), violet (*Viola* spp.), beggar lice (*Desmodium* spp.), cinquefoil (*Potentilla* spp.), and goldenrod (*Solidago* spp.) comprised more than 50% of all forbs. Other prominent forbs were white lettuce (*Prenanthes* spp.), white snakeroot (*Eupatorium rugosum),* Solomon's Seal (*Prenanthes* spp.) geranium (*Geranium* spp.), false Solomon's Seal (*Smilacina racemosa*), bedstraw (*Galium* spp.). This latter group composed about 17% of total forbs.

Among the ferns, which accounted for 85 kg/ha or about 26% of total dry weight, New York fern (*Thelypteris noveboracensis*) was by far the most widespread and abundant species, contributing 46 kg/ha to understory dry weight. Christmas fern (*Polystichum acrostichoides*) was also widespread and fairly abundant (19 kg/ha). Maiden hair (*Adiantum pedatum*) and grapefern (*Botrychium* spp.) occurred sporadically and were never abundant at any location.

The 3rd most prevalent category — annual growth trees — amounted to 65 kg/ha or 19%. There were 29 species of trees in the samples but only 10 species accounted for 80% of tree weight: red maple, northern red oak, flowering dogwood, hickory, silver bell, sugar maple, witch-hazel (*Hamamelis virginiana*), birch, white pine (*Pinus strobus*), and hemlock (*Tsuga* spp.). The first 8 of these were very widespread; the last 2 were not frequently encountered but were locally abundant.

Vines produced only slightly less than trees — 56 kg/ha (17%). Vines were principally greenbriar (*Similax* spp.) Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Rhus radicans*), and wild yam (*Dioscorea* spp.) were also fairly widespread and abundant.

Shrubs were a relatively minor component of the cove hardwood stands, only 20 kg/ha or 6% of total. Laurel (*Kalmia latifolia*), rhododendron (*Rhododendron* *maximum*), strawberry bush (*Euonymus* spp.), buffalo nut (*Pyrularia pubera*), hydrangea (*Hydrangea* spp.), azalea (*Azalea* spp.), and huckleberry (*Vaccinium* spp.) were the more commonly encountered shrubs.

Grasses and sedges and fungi grew on most plots, but collectively they added only 16 kg/ha to total dry weight of vegetation.

There was a great deal of variation from stand to stand in dry weight of each vegetative category. To explain some of the variation, we used correlation and regression snalysis to relate dry weight of understory vegetation to some simple overstory and site managements including age, basal area, number of trees, site index, elevation, aspect, slope percentage, and slope position. The only statistically significant correlations ($P < 0.05$) were between total dry weight, age of stand, and site index (Table 1). Within the range of ages studied, there was a definite trend of increasing dry weight with increasing age. Apparently as stands develop through the pole stage and natural mortality of overstory trees occurs, understory vegetation increases. Site quality is also important, as evidenced by the progressively greater weight of understory vegetation with increasing site quality. Overstory basal area, which was expected to influence the quantity of understory vegetation, was confounded with both age and site index and its effect could not be separated.

Table 1. Total dry weight of understory vegetation by age and site class in unthinned stands.[a]

	Age in years									
	20		30		40		50		60	
Site index (m)	Wt[b]	CL[c]	Wt	CL	Wt	CL	Wt	CL	Wt	CL
20	186	125	243	106	301	97	358	101	416	116
22	208	95	265	73	322	65	380	76	437	99
24	229	73	286	49	344	45	401	65	459	95
26	251	69	308	50	365	53	423	75	480	106
28	272	84	329	74	387	81	444	101	502	128

[a] Based on the equation: kg/ha = -143.51 + 10.74 (site index) + 5.74 (age).
[b] kg/ha
[c] CL at 0.05 level.

There was some tendency for the relative proportions of the different vegetative categories to vary with stand and site. For example, there were relatively more forbs and ferns and less woody vegetation on the moister sites of higher site index and in older stands. However, statistical correlations were weak and did not produce reliable predictors of vegetative categories or individual species from stand and site variables.

Response to Thinning

All categories of vegetation increased after thinning but at different rates. Average dry weight increased from 334 kg/ha before thinning to 574 kg/ha the 1st year after thinning. Peak production of 777 kg/ha was reached in the 3rd year and amounted to 2⅛ times prethinning production. By the 4th year, production of understory vegetation had already started to decline slightly from the highest level.

Trees — Annual growth of trees increased more than any other category for the 1st year, from 65 to 223 kg/ha (Fig. 1). From the 3rd-ranked category with 19% of total, trees rose to the 1st-ranked category with 39% of total. During the 2nd and 3rd years after thinning, tree weight increased only slightly. And, in the 4th year, dry weight of new growth of trees declined abruptly as they grew out of the measurement zone.

For the most part the increase in trees was from stump sprouting of those species that were widespread and most abundant before thinning. Red Maple,

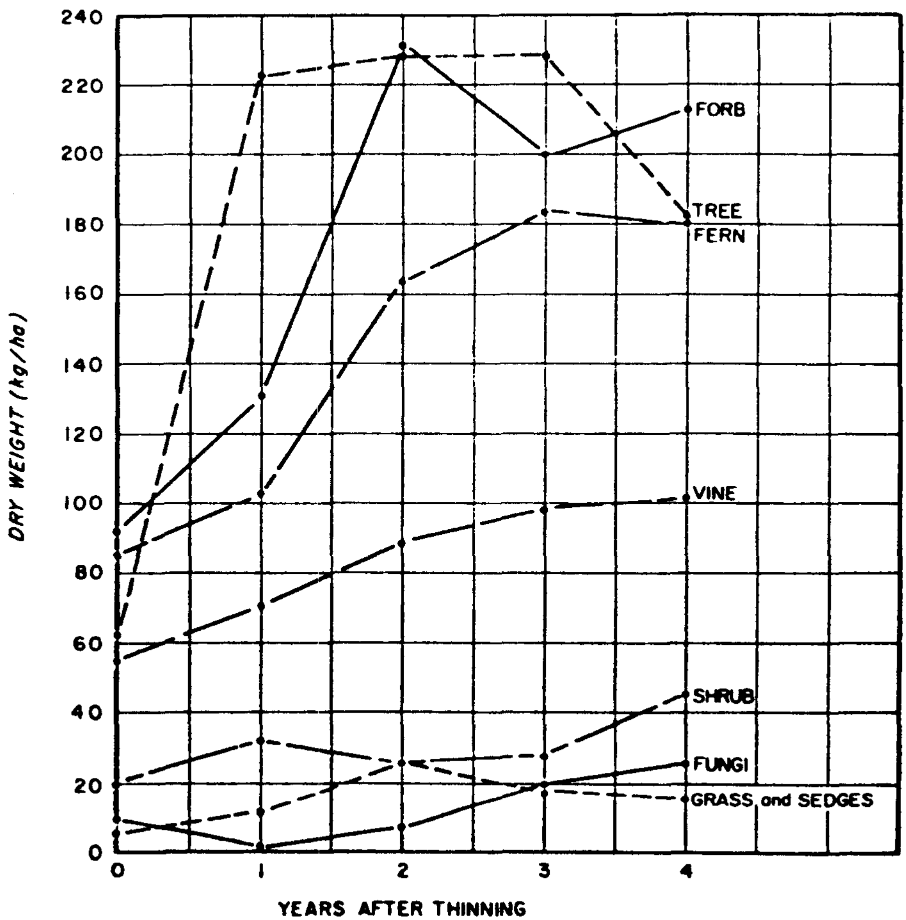

Fig. 1. Average dry weigh to understory vegetative categories by years since thinning.

northern red oak, flowering dogwood, hickory, silver bell, sugar maple, American beech, and sourwood accounted for 41% of prethinning weight and for 57% of the increase after thinning. Two species important before thinning — white pine and hemlock — declined after thinning. Some stems were apparently broken during thinning and were not replced because of their inability to sprout. Three species are notable for their large gains in dry weight and distribution — yellow-poplar, sweet birch, and black locust increased from 1.9 to 17.4 kg/ha. The increase in yellow-poplar and sweet birch resulted in part from new seedlings but mainly sprouts from cut trees. Black locust produced a significant portion of its new stems from root suckers.

We separated trees and shrubs into current-year twigs and green leaves (Fig. 2). Before thinning, twigs amounted to only 12.3 kg/ha. Similar low levels of twigs have been reported for undisturbed cove stands by Harlow and Downing (1969). After thinning, annual growth of twigs increased rapidly in the 1st year and declined almost as rapidly thereafter. In the 1st year there was a 7-fold increase to 84 kg/ha as cut trees sprouted and new seedlings developed. Current-year twigs increased from 4 to 15% of total vegetation. By the 4th year, twig growth had declined to 33 kg/ha and was back to its original proportion of about 5% of the understory production.

In contrast to twigs, green leaves of trees and shrubs maintained a steady increase into the 3rd year after thinning. Production of green leaves was down slightly in the 4th year but was still nearly 3 times that of prethinning levels (Fig. 2).

Forbs and Ferns — Forbs and ferns increased only moderately the 1st year after thinning but made much greater gains in the 2nd year. At their peak, in the 2nd year, forbs produced 231 kg/ha of 2½ times the prethinning level. Ferns showed a very similar trend and at their peak of production in the 3rd year amounted to 184 kg/ha — a little more than twice prethinning levels.

There were moderate increases in many of the forb species, but the increase was dominated by 3 groups. The aster-goldenrod group,which dominated in the unthinned stands, increased by about ⅔ to 43 kg/ha. Blackberry (*Rubus* spp.) increased from less than 1 kg/ha to nearly 20 kg/ha in the 4th year. White snakeroot, rattlesnake plantain (*Goodyeara pubesceus*) and spotted wintergreen (*Chimaphila maculata*) apparently declined. However, because of the small quantities involved and the amount of variability, we cannot attach too much significance to those trends.

In the fern group, *Thelypteris* spp. dominated before thinning and produced nearly 85% of the total increase in fern. The most prominent member of this group was the New York fern.

While the trends were not as obvious as that for trees, ferns and forbs both appeared to be on the decline by the 4th year after thinning. One could speculate that they will decline less rapidly than trees because much of the decrease in tree weight results from their crowns growing out of the measurement zone. Conversely, the decreased tally of forbs and ferns is a real decrease in production caused by the closure of overstory and midstory tree canopies resulting in less light, moisture, etc., available to the understory.

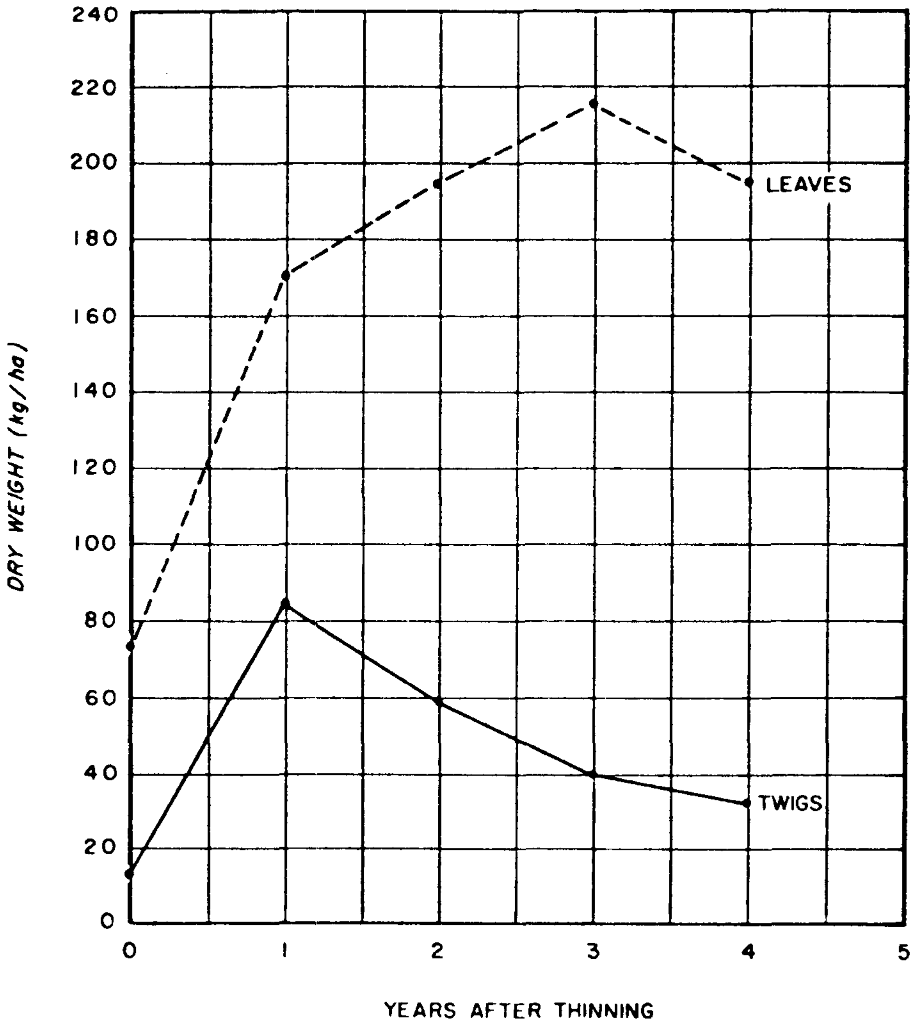

Fig. 2. Dry weight of trees and shrubs in the understory components — leaves and current-year twigs.

Vines — Vines showed a steady increase after thinning, but at a lower rate than the other major categories. Their peak production of 102 kg/ha in the 4th year was about 80% greater than prethinning levels. Greenbriar was the most frequently encountered species and dominated the increase. Four other vines made large percentage increases but their proportion of the total remained relatively low.

Shrubs — The production of shrubs was higher after thinning but no clearcut future trend is discernable because the increase was erratic. The biggest increases were for rhododendron and hydrangea, which accounted for about ¾ of the increase.

Grass and Fungi— Grass and fungi had fairly large percentage increases but remained relatively minor components of total vegetation. Their patterns of development after thinning were also erratic and future trends are obscure. It should be noted that most of the increase in fungi developed on the rotting tops, etc., of trees cut in thinning whereas prethinning fungi were mostly of the fleshy, toadstool type.

Factors Controlling Change

Change in vines, shrubs, grasses and sedges, and fungi was not related to any of the independent variables examined. Therefore, the best estimator of increased production in those categories across all stand, site, and thinning conditions is the mean difference available from Figure 1.

Increase in production of forbs, ferns, and trees was related ($P < 0.01$) to several of the independent variables (Table 2). It should be noted that these equations related to *change* in understory vegetation in the 4 years following thinning and do not predict *total* forage available. Although absolute levels of basal area would seemingly be more important, the thinning effect wwas best expressed by percent of stand basal area removed. The 4-year change in forbs, ferns, and trees increased linearly with percent basal area removed within the range of data available.

Table 2. Regression equations relating 4-year change in dry weight of understory vegetation after thinning cove hardwoods to stand and site variables.

Vegetation type	Equation[a]	R^2
Forbs	$= 315.12 - 2.41\ (X2) + 252.60\ (X4) - 0.19\ (X7) + 0.23\ (X7)^2/100$	0.53
Trees	$= 452.15 - 18.41\ (X1) + 369.19\ (X4) - 0.04\ (X7)$	0.44
Ferns	$= 390.19 + 21.38\ (X1) - 2.95\ (X2) + 131.13\ (X4)$	0.24
Total	$= 408.93 - 5.40\ (X2) + 864.49\ (X4) - 0.12\ (X7)$	0.40

[a] XL = Site index; *X*2 = Percent basal area cut; *X*7 = Number of midstory stems.

Age of stand affected production of herbs, ferns, and total vegetation. With other factors equal, these categories increased more in young stands than in other ones. Site index affected production in trees and ferns but in opposite directions. Trees tended to increase more on the lower quality sites than on higher quality sites. Ferns reacted just the opposite. The strongest effect on change in understory vegetation was exerted by the number of midstory stems increased. This factor had stronger effect on change than all others combined. In some stands midstory stems form a continuous canopy and effectively block solar radiation as well as competing for moisture and nutrients.

Because of relatively low R^2, the equations in Table 2 many not serve as particularly reliable estimators of change for specific stands. They do serve to

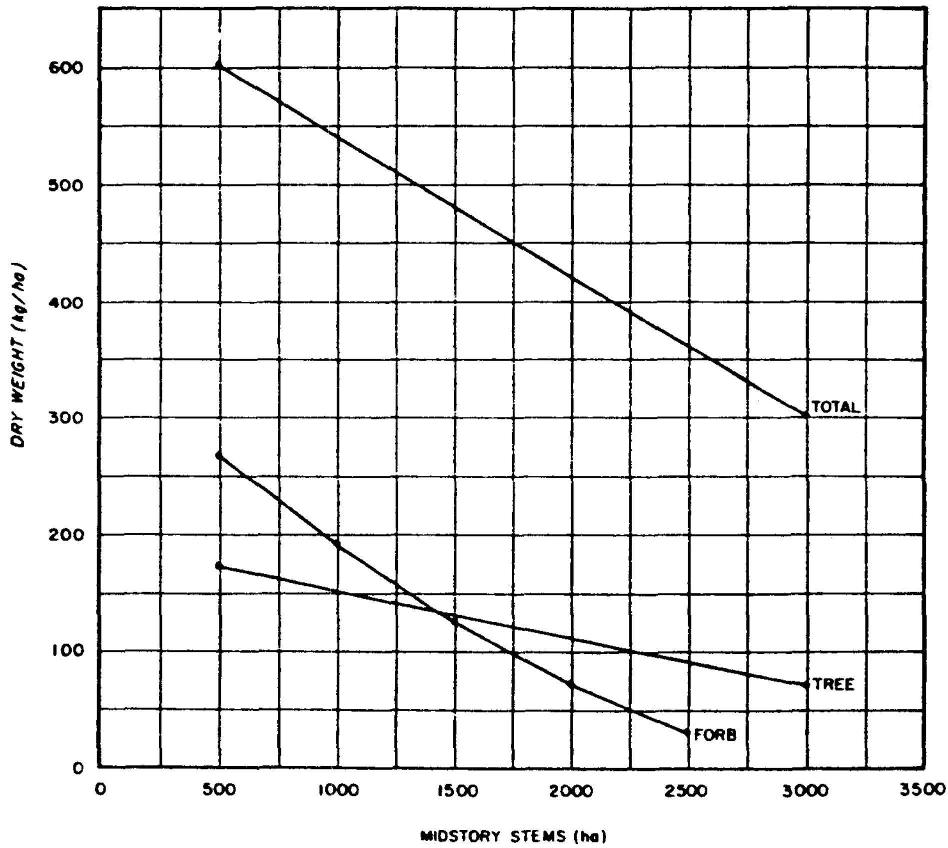

Fig. 3. Effect of midstory woody stem density on change in understory vegetation after thinning.

illustrate the underlying relationships and suggest management directions. Because the sample stands covered a wide geographic range and diverse site and stand conditions, the relationships are more broadly applicable than many previous studies that reported high correlations under very restricted conditions.

DISCUSSION

Thinning hardwood stands on mesic sites appears to be a useful tool for managing wildlife habitat because of the variety and increased quantity of understory vegetation that results. Understory vegetation produced after thinning in the more zeric oak and oak-pine types is comparable in quantity but is dominated by wood sprouts — in some cases, as much as 90% woody material (Crawford 1976). The quantity and variety of herbaceous plants produced on the mesic sites seem particularly important. Forbs are a significant part of the diet of deer in the southern Appalachians when available and are apparently used in preference to other material available (Harlow and Downing 1969, Harlow and Hooper 1971, Harlow et al. 1975). Ferns, which are very abundant in the thinned cove stands, are not known to be heavily used in the southern Appalachians. However, in a Pennsylvania study, ferns were heavily used by tame deer from late autumn through early spring (Healy 1971). New growth of ferns and forbs could be important during the food-short period of early spring before leafing out of woody vegetation.

Thinning also appears to greatly increase the value of cove stnads as grouse hapitat. Stewart (1956) found that grouse broods were concentrated from late May to early July in the mesic forest types in coves and along streams where there were abundant herbaceous plants, woody sprouts, and tree seedlings — conditions typical of the thinned cove stands in this study. Plant species that are indigenous to mesic sites and increased greatly by thinning are important fall and winter foods of ruffed grouse throughout the southern Appalachians (Nelson et al. 1940, Harlow and Guthrie 1972, Stafford and Dimmick 1979). In addition to an increase in the quantity of heavily used species, they are also more available because thinning results in increased growth of woody sprouts, vines, etc., that provide protective cover to feeding grouse — a quality Stafford and Dimmick (1979) considered to be of great importance.

Observations by MacArthur and MacArthur (1961) and MacArthur (1964) indicated that avian species diversity in deciduous forest habitat was positively related to both foliage height diversity and horizontal diversity within a foliage level. A study of the effects of logging in a northern hardwood forest by Webb et al. (1977) was in close agreement with this in that they found that foliage height diversity was increased by logging; bird species diversity increased as a result. Hooper et al. (1973) found a positive linear relationship between the percentage of understory cover and the density of breeding birds in forest recreational areas in the southern Appalachians. Because the thinnings we studied greatly increased diversity of the foliage heights and forms within the stands, it is reasonable to assume that songbird diversity would correspondingly increase.

Cutting midstory stems in conjunction with thinning the overstory would be beneficial to forage production. In fact, cutting may well be necessary to maintain appreciable quantities of herbaceous vegetation in the thinned stands. Our observations of other thinned cove stands show that midstory canopies are effectively closed 10 to 15 years after thinning and that ground vegetation is scarce. Blair and Enghardt (1976) reported that by age 35 the hardwood midstory that developed in pine stands thinned at age 20 was the principal deterrent to growth of deer forage. Periodic cutting of midstory trees and shrubs would allow growth of herbaceous plants and renew woody sprouts in the feeding zone. However, fruit production by midstory trees would be reduced. Reduced fruit production would have to be balanced against the increase in forage production achieved by cutting midstory trees.

The greatest benefit from thinning can be achieved in early pole-stage stands 20 to 30 years old, where initial levels of understory vegetation are lowest. To be most effective for wildlife, thinnings should be fairly heavy and will need to be repeated. The greatest quantities of understory vegetation were obtained at thinning intensities which removed 70% of stand basal area. Developing trends in the data suggest the effective duration of 1 thinning will probably not exceed 10 years. Thinnings of an intensity and frequency that would maximize understory vegetation will probably not be prescribed for maximym timber production. More realistic prescriptions for commercial timber production might be to cut 30 to 40% of stand basal area at 15- to 20-year intervals. Even this level of thinning can greatly increase understory vegetation in stands in pole and small-sawtimber stages that make up more than half of even-aged timber rotations on the cove and moist-slope sites of the southern Appalachians.

LITERATURE CITED

Blair, R. M., and H. G. Enghardt. 1976. Deer forage and overstory dynamics in a loblolly pine plantation. J. Range Manage. 29(2):104-108.

Blymyer, M. J. and H. S. Mosby. 1977. Deer utilization of clearcuts in southwestern Virginia. South. J. Appl. For. 1(3):10-13.

Crawford, H. S. 1976. Relationships between forest cutting and understory vegetation: An overview of eastern hardwood stands. USDA For. Serv. Res. Pap. NE-349. 9pp.

Della-Bianca, L., and F. M. Johnson. 1965. Effect of an intensive cleaning on deer-browse production in southern Appalachians. J. Wildl. Manage. 29:729-733.

Harlow, R. F. 1977. A technique for surveying deer forage in the southeast. Wildl. Soc. Bull. 5:181-185.

__________, and R. L. Downing. 1969. The effects of size and intensity of cut on production and utilization of some deer foods in the southern Appalachians. Trans. Northeast. Fish and Wildl. Conf. 26:45-55.

__________, and W. A. Guthrie. 1972. Grouse crops — a habitat barometer. Va. Wildl. 33(10):10-11.

__________, and R. G. Hooper. 1971. Forages eaten by deer in the southeast. Proc. Ann. Conf. S.E. Assoc. Game and Fish Comm. 25:18-46.

__________, J. B. Whelan, H. S. Crawford, and J. E. Skeen. 1975. Deer foods during years of oak mast abundance and scarcity. J. Wildl. Manage. 39:330-336.

Healy, W. M. 1971. Forage preferences of tame deer in a northwest Pennsylvania clear-cutting. J. Wildl. Manage. 35:717-723.

Hooper, R. G., H. S. Crawford, and R. F. Harlow. 1973. Bird density and diversity as related to vegetation in forest recreational areas. J. For. 71:766-769.

Knierim, P. G., K. L. Carvell, and J. D. Gill. 1971. Browse in thinned oak and cove hardwood stands. J. Wildl. Manage. 35:163-168.

MacArthur, R. H. 1964. Enviromental factors affecting bird species diversity. Am. Nat. 98:387-397.

__________, and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

Nelson, A. L., T. E. Clark, and W. W. Bailey. 1940. Early winter food of ruffed grouse on the George Washington National Forest. Va. J. Sci. 1:78-84.

Olson, D. F., Jr. 1959. Site index curves for upland oak in the southeast. USDA For. Serv. and Res. Note 125, Southeast. For. Exp. Stn., Ashevelle, NC 2pp.

Stafford, S. K., and R. W. Dimmick. 1979. Autumn and winter foods or ruffed grouse in the southern Appalachians. J. Wildl. Manage. 43:121-127.

Stewart, R. E. 1956. Ecological study of ruffed grouse broods in Virginia. Auk. 73:33-41.

Trimble, G. R. 1973. Appalachian mixed hardwoods. Pages 80-82 *in* Silvicultural systems for major forest types of the United States. USDA Agric. Handb. 445. 114pp.

Webb, W. L., D. F. Behrend, and B. Saisorn. 1977. The effect of logging on songbird populations in a northern hardwood forest. Wildl. Monogr. No. 55. 35pp.