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Net Community Production Dynamics in the Herb-Shrub Stratum of a Loblolly Pine-Hardwood Forest: Effects of Clearcutting and Site Preparation

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SUMMARY

Prior to clearcutting, the forest contained few herbaceous species, and net community production (NCP) of the herb-shrub stratum (vegetation below 1.5 m height) was low. Removal of overstory trees by clearcutting increased the number of herb species and NCP of herbs and woody plants. Burn, chop, and KG blade site preparations further increased species numbers, NCP, and relative frequency (RFR) of herbs, while mechanical site treatments temporarily reduced the number, NCP, and RFR of woody plants. As planted pines and residual hardwood trees grew taller and the canopy closed, the number of herb species and their NCP and RFR gradually decreased. The number of woody plant species did not decrease, but their NCP decreased and their RFR increased. Some herbaceous and woody species that were absent or low in frequency in the uncut forest occurred with high frequencies after site preparation but disappeared again in subsequent years.

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INTRODUCTION

Clearcutting of forests and site preparation greatly influence the species composition and net community production (NCP) of herbaceous and woody plants. Such even-aged silvicultural systems play an important role in intensive forest management of southern pines and are widely used. These practices have the potential to drastically change the forest environment.

The clearcutting system that produces even-aged forest stands has both proponents and opponents. According to Meyer and others (1961), the proponents point out that: (1) the silviculture of shade intolerant species requires even-aged management, (2) the planning and execution of timber harvesting operations is more efficient, and (3) the costs are lower for marking, stand improvement, inventory, protection, road construction, aids to regeneration, logging, and general supervision. Therefore, even-aged management produces the greatest timber volume in the shortest time. On the other hand, opponents of the even-aged system claim that uneven-aged forest systems work better for intolerant species because they: (1) provide higher production of larger and presumably more valuable trees, (2) maintain all areas of the forest under continuous active production, (3) can more profitably meet changing market requirements by flexible volume regulation, and (4) can overcome calamities with less economic loss.

Similar comparisons are offered by Troup (1952) and by Köstler (1950), based mostly on European experience. Both authors conclude that clearcutting has great advantages if applied under suitable soil and topographic conditions. In the loblolly pine (*Pinus taeda*)-shortleaf (*P. echinata*) pine-hardwood forests of east Texas, unpublished data from several long-term studies showed that adequate pine regeneration was consistently obtainable only with clearcutting, site preparation, and planting.

Considerable information exists on the effects of clearcutting and site preparation on pine seedling survival and growth. However, fewer references are available about their effects on herbs and woody plants in the herb-shrub stratum of the forest understory. Most plant successional studies have documented plant succession on abandoned agricultural land rather than on disturbed forest land.

Shrubs, trees, and woody vines in the open grew twigs that were seven times longer than twigs on plants beneath a sawtimber stand of pines (Halls and Alcaniz, 1968). Studies by Schuster and Halls (1963), Schuster (1967), Blair (1971), and Blair and Brunett (1976) showed the relationship of overstory density to NCP in the herb stratum. However, these studies did not consider the influence of site preparation.

Site preparation improves survival of planted pine seedlings by reducing competition for available soil moisture (Stransky 1961). This is especially important in east Texas, the western edge of the southern pine belt, because summer droughts frequently occur and result in considerable seedling mortality. Also, site preparation increases seedling growth for many years (Wagenknecht 1941, Stransky 1964, Schultz 1975).

All site preparation methods are designed to eliminate or retard woody plants that compete with the planted pines for growing space. In Alabama, Carter and others (1975) noted that many of the woody plants escaped injury, recovered, or resprouted after chemical site treatment. Intensive mechanical treatments were more effective in eliminating woody plants, and some woody species were absent in the next rotation.

In east Texas, herbaceous plants quickly occupied the cleared area during the first growing season after clearcutting and site preparation by chopping and burning (Stransky and others 1974). Sixty-eight percent of the recorded 105 herbaceous species grew only in cleared areas.

In the west Florida Sandhills, Burns and Hebb

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(1972) noted that mechanically prepared sites were rapidly colonized by herbaceous and woody plants. Chopped sites were first dominated by members of the composite family. Twelve years after chopping, Hebb (1971) distinguished four stages of succession: (1) the denuded site, (2) the profusion of forbs, (3) the dominance of a few species, and, eventually, (4) the shading out of the ground cover by the overstory of planted pines.

Also in Florida, White and others (1976) reported the impact of clearcutting and site preparing on the aboveground mass of herbs and woody plants 9 years after treatment. The site preparation intensities and treatments were: (1) low—burn; (2) medium—burn, KG blade, shear, and harrow; and (3) high—burn, KG blade, harrow, and bed (mounding of the planting row). Herbage mass was inversely related to site treatment intensity. Woody plants, including planted pines, grew best under the medium- and high-intensity treatments.

The effect of fire on vegetation and sites are enumerated by Odum and others (1973) as follows: (1) plant species characteristic of earlier stages return to dominance, (2) net primary production increases, (3) species diversity decreases, and (4) the inorganic mineral pool in living plants increases, at least temporarily, as nutrients are released from the organic detritus pool. The authors also observed that plant succession following fire was rapid.

Early stages of plant succession following logging and burning in Oregon indicated similar trends (Dyrness 1973). Invading herbaceous species dominated from the second through the fourth growing season after burning. By the fifth year residual herbaceous species regained dominance. In east Texas, Lay (1956) recorded that NCP of yaupon (*Ilex vomitoria*) diminished after fire; however, NCP of other woody plants increased. The increase of legumes after fire was reported by Cushwa and others (1970) and by Komarek (1974).

The objectives of this study were to explore how clearcutting, site preparation, and planting of pine on a loblolly pine-hardwood forest site affect species numbers, species composition, and NCP in the herb-shrub stratum of the developing new forest stand.

STUDY AREA

The study area near Jasper, Texas, is part of the loblolly-shortleaf pine-hardwood forest type that covers approximately 28 million ha in the southeastern and southern United States, reaching its westernmost limit in east Texas. The area was never cleared for agriculture but may have been grazed by cattle.

The area is part of the Gulf Coastal Plain Quaternary deposits, underlain by sands, sandstones, and clays of the Oligocene period (Dumble 1918). Soils belong to the Bernaldo-Elysian complex and to the Sacul series. The moundy Bernaldo-Elysian soils occur in such patterns that separation is difficult. Bernaldo soils (Glossic Paleudalfs, fine-loamy, siliceous, thermic family), constitute the lower part of the mounds and most of the adjoining low areas. They comprise about 50 percent of the area. Elysian soils (Haplic Glossudalfs, coarse-loamy, siliceous, thermic family) occupy the upper part of the mounds and make up about 40 percent of the area. The major difference between these soils is that the Elysian has a sandy surface layer more than 50 cm thick, while the Bernaldo has a thinner layer. With slopes ranging from 0 to 3 percent, these well-drained, moderately permeable soils have slow surface runoff. Sacul soils (Aquic Hapludalfs, clayey, mixed thermic family) are found at the drainage heads of and normally are associated with concave topography. They occupy slopes from 1 to 6 percent, are moderately well-drained, and have slow permeability (U.S. Department of Agriculture 1975).

The region has hot humid summers, mild winters, and a growing season of about 230 days. Annual rainfall averages 129 cm (U.S. Department of Commerce 1965). However, in 1972, 1973, and 1974, rainfall was 137, 218, and 178 cm. Such high precipitation often interfered with site preparation, burning, and planting schedules.

Prior to clearcutting, the site supported a sawtimber stand of pines and hardwoods. Average age of the forest stand was 45 years.

METHODS

The forest was clearcut and the merchantable timber removed in September 1972. The following site preparation treatments were applied to 0.6 ha plots in a randomized block design with three replications:

Control—no site preparation, but all remaining nonmerchantable woody stems greater than 2.5 cm d.b.h. (diameter at breast height) were cut and left in place in the winter of 1972-73.

Burn—all stems larger than 2.5 cm d.b.h. were cut (as in control) and burned with the logging slash on 6 March 1974. Spread by winds of about 20 km/hr, the headfire consumed the tops of all remaining herbaceous plants, most shrubs, small trees, nearly all leaf litter, and all but the largest branches of the logging slash.

Chop—logging slash and all stems were cut with a 16,000 kg chopper in October 1972, and again in October 1973. The chopper resembles a huge lawn roller equipped with cutting blades parallel

to the long axis of the cylinder. Pulled by a D-8 crawler tractor, the chopper cut nonmerchantable trees and shrubs into 50-cm lengths and crushed much of the debris into the surface soil. The chopped plots were burned on 6 and 7 March 1974, but the fire was spotty and of low intensity.

KG blade—all stems were cut with a KG blade in November 1973 and the logging slash was raked off the plots into windrows that were burned on 6 March 1974. The KG blade has a heavy cutting edge mounted at an angle on the front of a large crawler tractor. The blade sheared off all stems approximately at ground line. The cutting and raking process disturbed the soil surface and pushed some litter and topsoil off the planting site into the windrows.

Due to rainy weather, only the chop treatment was completed in 1972. All site preparation treatments were completed one growing season after clearcutting during the 1973–74 fall-winter period. The chopped plots were rechopped in 1973. All plots were hand-planted with 1-0 (one-year-old nursery-grown) loblolly pine seedlings at 2.4- by 3.0-m spacings in mid-March 1974.

Vegetation inventories were conducted prior to clearcutting (July 1972); one growing season after clearcutting (August 1973); and one (August 1974), three (July 1976), five (July 1978), eight (July 1981), and ten (June 1983) growing seasons after site preparation. Samples from the herb-shrub stratum (all plants, except the planted pines from ground level to 1.5 m height) were collected from twenty 1.01 m^2 quadrats evenly spaced at 11.1 by 11.1 m within the central two-thirds of each plot. Sample quadrats were offset from the permanently marked sample points to avoid areas where prior samples had been collected.

Annual NCP was determined by the harvest method. The current growing season's new growth of herbaceous and woody plants was clipped from ground level to 1.5-m height. Although rooted outside the sample quadrat, plant parts that projected into the sample space were harvested also (Daubenmire 1968). Clippings were separated into 10 plant groups, oven-dried at 70 °C, and weighed (Stransky 1976). The plant groups were: grasses, grasslikes, legumes, composites, other forbs, vines, shrubs, pines, oaks, and other trees. The NCP for species or genus (as in *Panicum*, *Carex*, *Rubus*, or *Crataegus* spp.) was computed by visually estimating the percentage of the total weight that individual species or genus composed within each plant group. This percentage was multiplied times the actual total ovendry weight of that group. Both NCP and frequency were computed for species or genera. Relative frequency (RFR) was computed by plant group only. Plant nomenclature follows the "Manual of the Vascular Plants of Texas" (Correll and Johnston 1970).

Differences in NCP in kg/ha/yr of herbs, woody plants, and total plants between consecutive years were compared by analysis of variance within each site preparation treatment. All testing was at the 0.05 level of probability.

RESULTS AND DISCUSSION

Before Clearcutting

The uncut forest consisted mainly of loblolly pine interspersed with shortleaf pine, sweetgum (*Liquidambar styraciflua*), blackgum (*Nyssa sylvatica*), red maple (*Acer rubrum*), southern red oak (*Quercus falcata*), water oak (*Q. nigra*), post oak (*Q. stellata*), hickories (*Carya* spp.), hawthorns (*Crataegus* spp.), American holly (*Ilex opaca*), and sassafras (*Sassafras albidum*). Major understory trees and shrubs were American beautyberry (*Callicarpa americana*), flowering dogwood (*Cornus florida*), yaupon, southern waxmyrtle (*Myrica cerifera*), blackberry (*Rubus* spp.), blueberry (*Vaccinium* spp.), and Sebastian bush (*Sebastiania fruticosa*). Prominent vines were yellow jessamine (*Gelsemium sempervirens*), Alabama supplejack (*Berchemia scandens*), poison ivy (*Rhus toxicodendron*), Virginia creeper (*Parthenocissus quinquefolia*), muscadine grape (*Vitis rotundifolia*), and greenbriers (*Smilax* spp.).

Few herbaceous species grew under the dense tree canopy (fig. 1). Panic grasses (*Panicum* spp.), chasmanthium (*Chasmanthium sessiliflorum*), sedges (*Carex* spp.), downy milkpea (*Galactia volubilis*), tobacco-weed (*Elephantopus tomentosus*), goldenrod (*Solidago* spp.), copperleaf (*Acalypha* spp.), twin-eyed berry (*Mitchella repens*), and noseburn (*Tragia urens*) were most prominent.

Annual NCP was low under the dense forest overstory for both herbaceous and woody species (fig. 2). This corroborates the findings by Schuster and Halls (1963), and Schuster (1967), that showed fewer species and less NCP under dense forest canopies than in open forest stands. Chasmanthium, tobacco-weed, and two-eyed berry composed most of the NCP of herbaceous plants. Among woody plants, shrubs contributed most to NCP, and their RFR was highest (figs. 2 and 3). Net community production and RFR of legumes and pines is not shown in figures 2 and 3 because both plant groups occurred at low levels not noticeable on the scale of the graphs. Herbs contributed 14 percent and woody plants 86 percent of the total NCP (359 kg/ha) in the herb-shrub stratum. Total NCP, the relative NCP, and RFR of herbs and woody plants were similar on all areas prior to clearcutting (table 1).

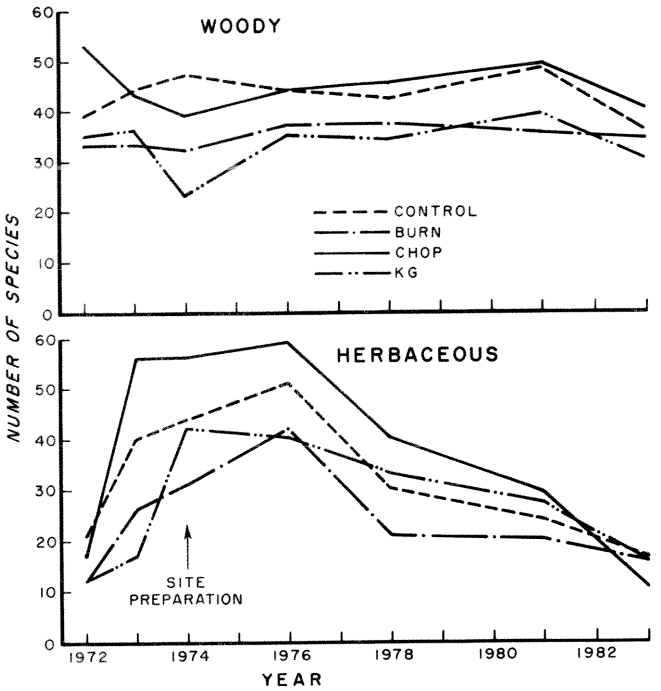

Figure 1.—*Number of plant species in the herb-shrub stratum of a loblolly pine-hardwood forest before (1972) and after (1973) clearcutting, and one (1974), three (1976), five (1978), eight (1981), and ten (1983) growing seasons after four methods of site preparation.*

After Clearcutting

By August 1973, one growing season after clearcutting, the number of herbaceous species had more than doubled (fig. 1) and had increased on most of the plots that had been chopped in October 1972. On the plots destined to be KG bladed, standing cull hardwoods and small pines suppressed herb species the first growing season after clearcutting. Composites and other forbs increased greatly and now averaged 74 percent of all herbaceous species. New species that appeared after the cut were horse-weed (*Conyza canadensis*), boneset (*Eupatorium* spp.), Canada lettuce (*Lactuca canadensis*), and polypremum (*Polypremum procumbens*) (table 2). The frequency of chasmanthium declined, while that of panicum increased.

The number of woody species decreased only on the chopped plots (fig. 1). On the other areas, the number of woody species remained the same or increased slightly. Other trees, shrubs, and vines made up 87 percent of all woody species. Frequency of American beautyberry, blackberry, and St. Peter's-wort (*Ascyrum* spp.) greatly increased (table 2).

During the first growing season after clearcutting, grasses increased most quickly in response to overstory removal. Net community production and RFR of all herbs showed the greatest increase on the plots chopped in 1972 (fig. 2, table 1). Herb NCP and RFR increase on the other plots were suppressed by numerous unharvested hardwoods and dense tangles of shrubs and vines.

Woody NCP peaked on the controls the first year after overstory removal (fig. 2). Net community production increased to a lesser degree on the plots to be burned or KG bladed. The NCP increase of oaks and other trees, and also their RFR, was less on chopped than on other plots (figs. 2 and 3). On all treatments, the NCP of shrubs showed the greatest response to complete or partial overstory removal (fig. 2). Halls and Alcaniz (1968) found that NCP of shrubs and vines in the open was greater than under the shade of a forest canopy and increased with partial overstory removal (Blair and Brunett 1976). Relative NCP of herbs increased to 32 percent and of woody plants dropped to 68 percent (table 1).

First Year After Site Preparation

Approximately one growing season after site preparation (August 1974), the number of herbaceous species further increased with all site treatments. The NCP and RFR increased most among grasses, composites, and other forbs. All treatments greatly increased the frequency of Canada lettuce and polypremum. The mechanical disturbance caused by chop or KG blading increased the frequency of horse-weed and boneset (table 2).

Such rapid colonization by herbs of clearcut and site-prepared areas has also been reported by Hebb (1971), Burns and Hebb (1972), Stransky and others (1974), Stransky (1976), and White and others (1975). Burning of the planting site created conditions similar to those described by Odum and others (1974), and Dyrness (1973).

The number of woody species and their RFR declined with chopping and even more with KG blading (figs. 1 and 3). The frequency of some shrubs, vines, and trees decreased after KG blading and decreased to a lesser degree after chopping (table 2).

Herbaceous and woody plant species found on the study site are characteristic of the east Texas Piney Woods, and have been enumerated by Schuster (1967), Stransky and others (1974), and Stransky (1976). During the course of this study, the distribution of the 124 herbaceous and 77 woody plants that were identified to species or genus follows: 14 grasses, 8 grasslikes (sedges and rushes), 15 legumes, 40 composites, 47 other forbs (representing 22 families), 28 shrubs (18 families), 17 vines (7 families), 2 pines, 9 oaks, and 21 other trees (16 families).

Of the total herbaceous NCP, composites and other forbs made up 73 percent, with the remainder being mostly grasses (fig. 2). Some species and genera experienced their greatest NCP and frequency during the first growing season after site treatments; for exam-

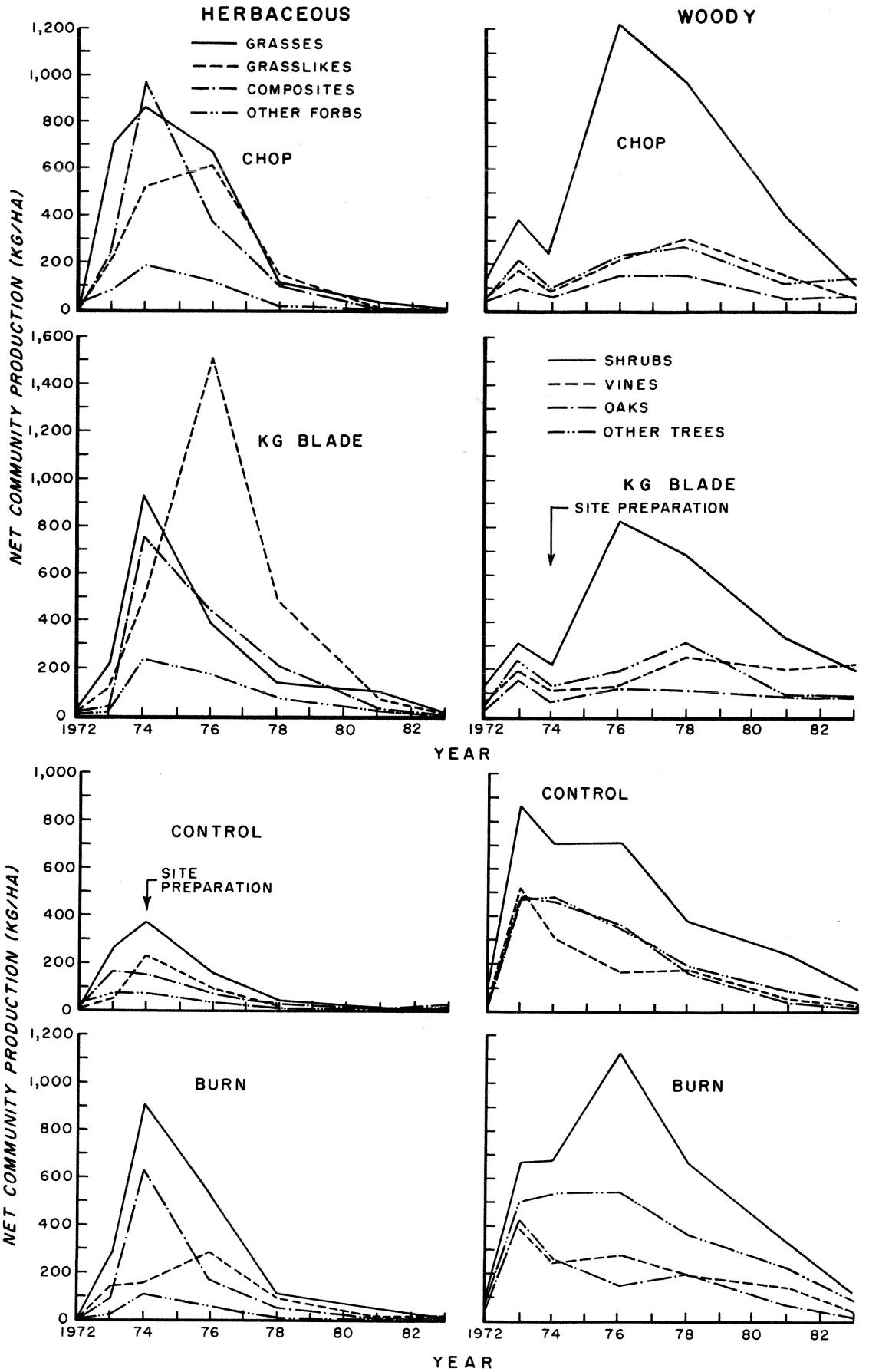

Figure 2.—*Annual net community production (kg/ha) of plant groups in the herb-shrub stratum of a loblolly pine-hardwood forest before (1972) and after (1973) clearcutting, and one (1974), three (1976), five (1978), eight (1981), and ten (1983) growing seasons after four methods of site preparation.*

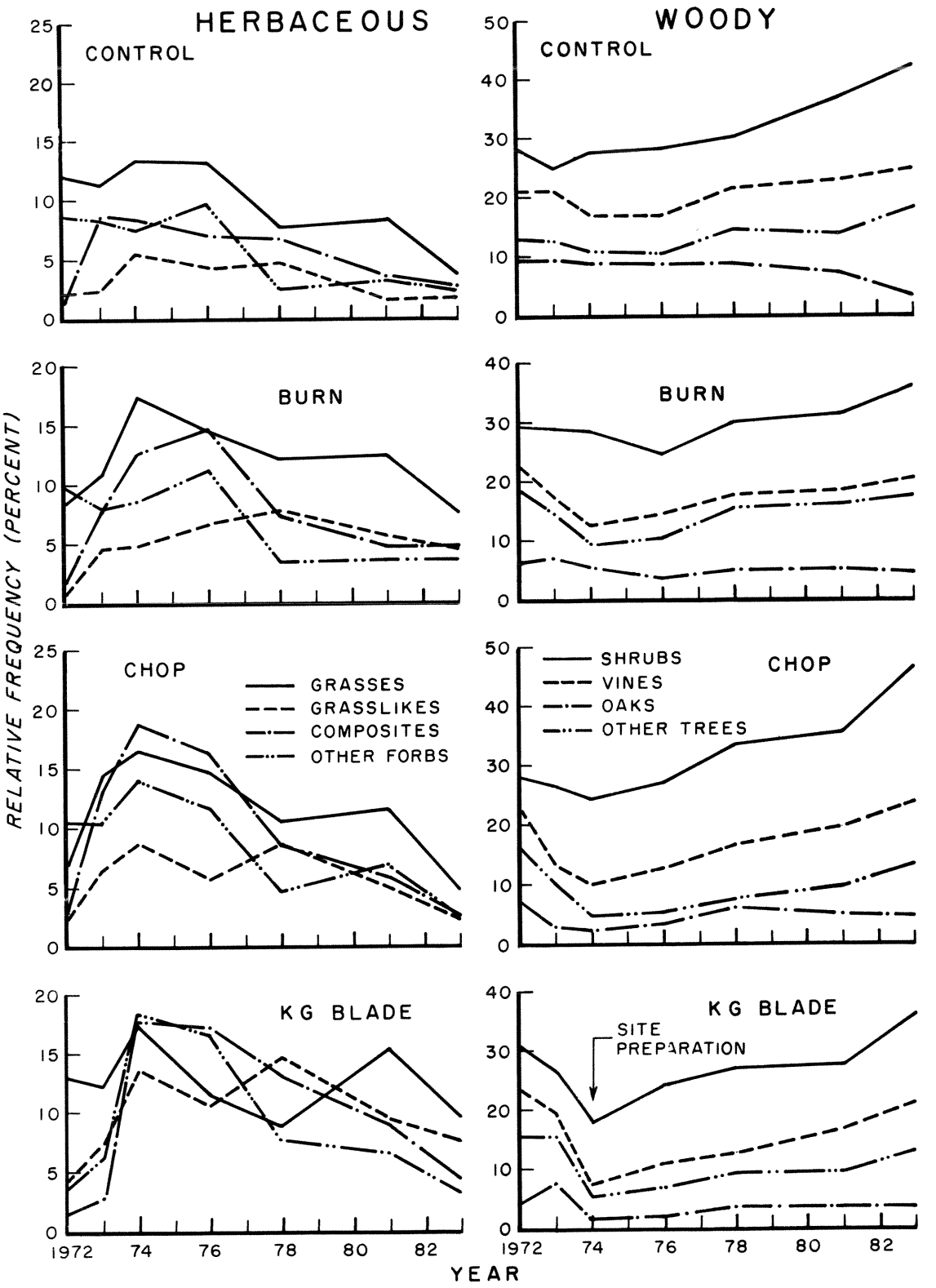

Figure 3.—*Relative frequency (percent) of plant groups in the herb-shrub stratum of a loblolly pine-hardwood forest before (1972) and after (1973) clearcutting, and one (1974), three (1976), five (1978), eight (1981), and ten (1983) growing seasons after four methods of site preparation.*

Table 1.—*Net community production, relative net community production, and relative frequency of herbaceous and woody plants in the herb-shrub stratum of a loblolly pine-hardwood forest before (1972) and after (1973) clearcutting, and one (1974), three (1976), five (1978), eight (1981), and ten (1983) growing seasons after four methods of site preparation*

Site preparation	Year	Net community production			Relative Net community production		Relative frequency	
		Herb	Woody	Total	Herb	Woody	Herb	Woody
		--------- *kg/ha* ---------			----- *percent* -----		--- *percent* ----	
Control	1972	73	309	382	19	81	25.0	75.0
	1973	560*	2355*	2915*	19	81	31.0	69.0
	1974	830	1957	2787	30	70	35.0	64.9
	1976	370*	1613	1983*	19	81	34.9	65.1
	1978	95*	919	1014*	9	91	22.3	77.7
	1981	26	427	453	6	94	17.9	82.1
	1983	28	175	203	14	86	11.3	88.7
Burn	1972	22	340	362	6	94	22.2	77.8
	1973	524*	2007*	2531*	21	79	31.9	68.1
	1974	1803*	1737	3540	51	49	43.9	56.0
	1976	1029*	2098	3127	33	67	47.2	52.0
	1978	254*	1429*	1683*	15	85	30.5	69.5
	1981	72*	771*	843*	9	91	27.1	72.8
	1983	19	268	287	7	93	21.0	79.0
Chop	1972	59	324	383	15	85	23.5	76.5
	1973	1256*	877*	2133	59	41	45.9	54.1
	1974	2555*	498*	3053*	84	16	58.9	41.1
	1976	1795*	1824*	3619*	49	51	51.3	48.7
	1978	389*	1774	2163*	18	82	33.9	66.2
	1981	83*	732*	815*	10	90	30.0	69.8
	1983	10	372	382	3	97	11.5	88.4
KG Blade	1972	44	265	309	14	86	23.1	76.9
	1973	375	911	1286*	29	71	29.7	70.4
	1974	2411*	522*	2933*	82	18	67.0	33.0
	1976	2507	1267*	3774*	66	34	55.9	44.0
	1978	906	1392	2298	39	61	45.3	54.7
	1981	222*	707*	929*	24	76	40.5	59.5
	1983	43	619	662	7	93	25.0	74.9

*Significantly different from previous year's net community production at 0.05 percent level.

ple panic grasses, polypremum, horse-weed, and Canada lettuce; while the shade-tolerant chasmanthium showed little if any increase (table 2). The mechanical and burn treatments favored grasses and composites. The NCP of all herbaceous plant groups was smaller on the control plots than on the other treatments (fig. 2, table 1).

Woody NCP began to decline on the control plots this first year after site preparation. Burn plots showed a small increase in shrubs and other trees, but production of vines and oaks dropped. Mechanical site treatments noticeably reduced NCP and RFR of all woody plant groups (figs. 2 and 3, and table 1).

Third Year After Site Preparation

By July 1976, the number of herbaceous species peaked on all but the KG blading treatment, on which species richness decreased. The RFR of herbs began to decline on all treatments. Frequency of horse-weed, Canada lettuce, and polypremum declined drastically from previously sampled peaks (table 2). It is possible that one-generation seral species may owe their brief tenure to the accumulation of autotoxic substances (Daubenmire 1968). Strong evidence for autotoxin accumulation has been presented for horse-weed in abandoned-field succession in the North Carolina Piedmont (Keever 1950).

The number of woody species was close to pretreatment levels (fig. 1). The return to the stable original pretreatment number was especially noticeable on the mechanically treated plots that had experienced a substantial drop after the treatments were applied. The RFR of woody species was increasing. This increase was slower on the KG blading than on the other treatments.

Herbaceous total NCP decreased with all site treatments except KG blading. The NCP of grasslike species peaked on all but the control plots. Panic grasses decreased on most treatments, while shade-tolerant

Table 2.—*Frequency (percent) of common plants in the herb-shrub stratum of a loblolly pine-hardwood forest before (1972) and after (1973) clearcutting, and one (1974), three (1976), five (1978), eight (1981), and ten (1983) growing seasons after four-methods of site preparation*

Species or genus	Site preparation method																										
	Control							Burn							Chop							KG						
	1972	73	74	76	78	81	83	72	73	74	76	78	81	83	72	73	74	76	78	81	83	72	73	74	76	78	81	83
Liquidambar styraciflua	30	37	40	38	37	32	35	28	35	35	45	47	55	47	22	23	10	17	25	23	15	25	43	22	20	30	35	35
Nyssa sylvatica	12	30	22	23	17	15	10	25	33	35	47	42	50	27	15	22	10	12	17	20	20	23	27	17	27	30	25	32
Quercus falcata	13	37	30	30	22	10	5	10	15	15	15	7	12	10	12	13	5	15	15	20	5	10	28	5	7	10	10	7
Ilex vomitoria	28	17	18	33	38	48	52	33	35	12	7	15	17	40	42	30	23	42	48	55	48	35	28	7	20	20	27	32
Myrica cerifera	22	30	28	40	40	48	40	15	27	35	52	60	62	55	15	13	12	22	22	23	28	18	17	12	25	40	40	40
Sehastiania fruticosa	23	18	18	20	15	23	13	18	7	27	30	20	25	27	7	0	5	0	8	7	8	18	17	22	7	12	20	20
Callicarpa americana	30	47	48	47	28	45	38	28	50	50	47	35	30	35	20	45	50	63	52	68	57	13	22	10	27	15	22	30
Vaccinium spp.	27	27	40	38	33	37	22	22	25	27	32	15	15	12	38	30	27	32	28	22	17	30	28	17	27	35	22	22
Ascyrum spp.	8	13	18	3	7	5	2	5	20	20	10	2	12	10	8	43	47	27	3	10	3	8	10	52	15	12	30	0
Rubus spp.	23	40	62	83	60	55	30	25	50	60	77	60	77	47	15	48	48	93	75	83	60	27	48	42	87	75	62	35
Rhus copallina	0	2	7	12	7	3	0	2	7	17	12	15	12	7	2	12	28	35	30	17	7	0	5	2	17	10	10	10
Baccharis halimifolia	0	0	7	18	7	3	2	0	2	5	20	17	17	0	0	3	3	27	27	8	5	0	0	3	35	20	15	2
Berchemia scandens	13	18	17	18	20	20	18	5	13	2	5	7	12	10	8	8	2	7	15	18	12	10	5	7	7	12	17	17
Smilax spp.	25	35	30	27	12	20	18	23	22	22	27	20	22	17	30	38	45	48	30	28	18	22	15	25	22	22	27	15
Gelsemium sempervirens	65	55	62	77	75	65	42	65	45	42	70	62	72	67	72	43	32	72	63	77	65	77	72	30	47	50	72	65
Chasmanthium spp.	58	23	52	67	22	35	13	45	27	17	62	40	39	20	43	13	18	37	25	48	17	55	33	5	32	15	55	25
Panicum spp.	17	53	68	62	38	27	5	3	62	100	85	52	57	32	5	100	100	100	43	62	13	15	50	100	85	50	77	37
Andropongon virginicus	3	8	0	12	0	0	0	2	0	2	25	5	0	0	0	2	8	48	22	0	0	0	0	0	20	10	0	0
Eupatorium spp.	0	38	25	15	10	12	5	0	22	22	57	12	12	17	0	48	65	100	42	22	8	0	12	67	100	72	27	20
Lactuca canadensis	0	13	5	3	0	0	0	0	12	60	5	0	0	0	0	18	52	0	0	0	0	0	2	42	2	0	0	0
Polypremum procumbens	0	5	17	3	0	0	0	0	3	42	22	5	0	0	0	5	37	30	7	2	0	0	5	35	17	7	5	0
Conyza canadensis	0	10	7	0	0	0	0	0	0	7	0	0	0	0	0	15	38	8	0	0	0	0	2	37	7	0	0	0

chasmanthium increased. Boneset decreased and Canada lettuce, which had a high NCP 1 year after site preparation, had almost disappeared by the third growing season. Broomsedge (*Andropogon virginicus*) reached its peak frequency on the treated plots.

Woody NCP peaked in 1976 on all but the controls, where it had peaked 1 year after clearcutting. Shrubs recovered most quickly from site treatments and produced the greatest NCP of all woody plant groups on all treatments. The frequency of sea-myrtle (*Baccharis halimifolia*), absent from the uncut forest and low in frequency 1 year after cutting and site preparation, peaked in 1976, as did blackberry, American beautyberry, and shining sumac (table 2). The frequency of St. Peter's-wort began to decrease.

Fifth Year After Site Preparation

By July 1978, the number and RFR of herbaceous species on all treatments other than KG fell steeply from previously recorded highs in the third year (figs. 1 and 3). On KG bladed plots, species numbers declined gradually with the slowly closing canopy of planted pines and residual hardwoods.

Frequency of panicum decreased on all treatments. Broomsedge, which was nearly absent in the uncut forest, remained at high frequency on the mechanically treated plots, as did boneset. Canada lettuce and horse-weed disappeared completely, and polypremum disappeared from the control plots and occurred with much lower frequency on the other treatments.

The number of woody species on all treatments changed little from 1976 levels. Generally, the RFR of woody plants increased. The RFR of shrubs on all treatments approached or exceeded precut levels. On the mechanical treatments, RFR of vines, oaks, and other trees was still below precut levels. Increases in the frequency of most trees, shrubs, and vines that were common before disturbance indicated recovery from site treatments. Species that were either absent from the uncut forest or occurred with low frequencies, for example, blackberry, shining sumac, sea-myrtle, and St. Peter's-wort, decreased in frequency. The decrease was most noticeable on the control plots and to a lesser degree on the mechanical treatments.

The NCP of herbaceous plants dropped drastically from its 1976 level on all treatments. On control plots NCP approached that measured in the uncut forest. Burn and chop treatments were intermediate between KG blade and control. KG bladed plots had the highest NCP because the tree canopy was still open enough to permit herbaceous plant growth.

Woody NCP dropped from its 1976 high, as trees and vines grew above the 1.5-m high measurement zone for the herb-shrub stratum. Shrubs produced most of the woody NCP.

Eighth Year After Site Preparation

The number of herbaceous species on all treatments continued to decrease from July 1978 to July 1981. Except for grasses on KG blade and other forbs on chop plots, RFR of other herbaceous plant groups also decreased (fig. 3). The number of woody species showed some increase, and with the exception of oaks on the control and chop plots, their RFR increased to precutting levels (fig. 3).

Herbaceous NCP on control plots decreased below the level measured in the uncut forest, and NCP on burn and chop plots was about equal to uncut conditions. It remained higher on the KG bladed plots. Panic grasses, chasmanthium, and boneset still occurred on KG bladed plots with greater frequency than on burn or control, but broomsedge had disappeared from all treatments (table 2).

Cushwa and others (1970) and Komarek (1974) reported that fire increased the number of legumes. In our study, legumes occurred with low RFR on all treatments and in all sampling years. They exceeded 1.0 percent RFR for more than 1 year only on the mechanical treatments. The NCP of legumes in the uncut forest ranged from 0.6 to 1.0 kg/ha. NCP peaked with 3 kg/ha on control, 7 kg/ha on burn, 16 kg/ha on chop, and 10 kg/ha on KG bladed plots; but only on the KG bladed plots did it reach 1.0 percent of the total herbaceous NCP. By 1981, NCP of legumes decreased on all treatments and ranged from 0.03 to 1.0 kg/ha, or somewhat less than in the uncut forest.

Woody NCP decreased too, but had not yet fallen to the low levels of the uncut forest. Shrubs comprised most of the NCP. The frequency of most of the common shrubs and vines increased, except for sea-myrtle, which decreased on the treated areas and occurred with low frequency on control plots (table 2).

Tenth Year After Site Preparation

By late June 1983, the number of herbaceous species fell to precutting levels. Herbaceous RFR decreased to or below precutting levels. The number of woody species were at precutting levels, but their RFR increased for most plant groups, except oaks, which showed a slight decrease (fig. 3). Oak RFR declined because most oaks had grown beyond the 1.5-m height zone and their branches no longer extended into the measured quadrat.

Polypremum had disappeared completely. Panicum grasses occurred in the uncut forest with much lower frequencies than chasmanthium. Whereas panicums had far exceeded the latter after site treatments were applied, now, 10 years later, panicums had decreased on all treatments to about the level of chasmanthium. Panicums decreased more on the dense control than on the treated plots. Chasmanthium's frequency,

which decreased after timber harvesting and reached peak levels 3 to 8 years after site preparations, decreased again in 1983. Fluctuations in chasmanthium's frequencies may be explained by climatic variations (table 2).

The NCP of herbs decreased to or below precutting levels, probably because less sunlight reached the herb-shrub stratum in the dense young pine hardwood forest than in the uncut forest. The NCP of woody plants decreased to or below precutting levels, except on KG bladed plots where the stand was more open. Thus, NCP of both herbs and woody plants was greater on KG bladed plots.

CONCLUSION

The uncut forest had a dense timber overstory, and consequently few (32) herbaceous plant species were present. There were 64 woody species. Total NCP of the herb-shrub stratum averaged 359 kg/ha, 86 percent of which was from woody plants.

One growing season after the merchantable timber was cut and removed, the number of herbaceous species doubled. Most of this increase was in grasses, composites, and other forbs. The number of woody species decreased only on the plots that were chopped in the fall of 1972. Both herbaceous and woody NCP increased.

One growing season after site preparation treatments in the fall of 1973, the number and NCP of herbaceous species further increased. Burning and, in particular, the mechanical site treatments, reduced the number, RFR, and NCP of woody species. Frequency of some herbs and woody plants, absent from the uncut forest, peaked one growing season after site preparation.

Three growing seasons after site preparation (1976), the number of herb species peaked, though the RFR of some herbaceous plant groups began to decline. The number of woody plants nearly recovered to precutting levels, and their RFR increased. Frequency of sea-myrtle and broomsedge peaked on all plots. Boneset peaked on the mechanical treatments. Canada lettuce and horse-weed all but disappeared. Total woody NCP peaked on the prepared areas, while herbaceous NCP began to decline.

From the fifth through the tenth growing season after site preparation, the number, RFR, and NCP of herbaceous species continued to decrease as the canopy of planted pines and residual hardwoods gradually closed. By July of the tenth year, the number, RFR, and NCP of herbaceous species approached or fell below the low levels recorded in the uncut forest. At the same time the woody plants regained precut species numbers, and their NCP dropped below that found in the uncut forest on all but the KG bladed plots. Except for KG bladed plots, most woody plant groups exceeded their RFR in the uncut forest.

During the 12-year regeneration cycle—from sawtimber stand through clearcutting, site preparation, pine planting, and to the established pine plantations—average NCP in the herb-shrub stratum increased tenfold, from 359 kg/ha to 3,462 kg/ha at the peak NCP of each site treatment, and then dropped to nearly its initial low level (383 kg/ha) in 1983. The number of herbaceous species more than doubled at the peak, but fell to the low precutting levels as the crown canopy closed. The number of woody species dropped temporarily after site preparation, but regained precutting levels after 10 growing seasons. Some herbaceous and woody species that were absent from the uncut forest peaked with high frequency after site preparation, then disappeared, or nearly so, two to five growing seasons later.

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During the 12-year regeneration cycle—from sawtimber stand through clearcutting, site preparation, pine planting, and to the established pine plantations—average net community production in the herb-shrub stratum increased tenfold, from 369 to 3,462 kg/ha at the peak of each site treatment, and nearly dropped to its initial low level after 10 years.

Keywords: Herb/shrub relative frequency, undergrowth, forest management, plant succession.