Herbivore Response to Alternative Forest Management Practices

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Abstract: We evaluated wildlife responses on a small-scale study to determine possible forest management alternatives for large-scale application on Wildlife Management Areas (WMAs). Pellet-group counts of white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), and eastern cottontails (*Sylvilaqus floridanus*), and cervid frequency of browse use were used to determine use of oak-pine sites subjected to an array of management prescriptions including timber harvest, prescribed fire, and traditional food plots. We found that sites subjected to timber harvest were used to a greater extent than unharvested sites. Use of food plots was similar to harvested and burned sites for elk and deer but not for cottontails. Use of burned treatments was unrelated to burn frequency. Pellet-group counts and browse utilization frequency measured different aspects of habitat use and thereby treatment use. Ranks of pellet-group counts by treatments were more reflective of preferred bedding areas or screening cover, while ranks of browse utilization frequency indexed cervid foraging on a given treatment. Management for elk, deer, and rabbits in forests of southeastern Oklahoma should incorporate a mixture of commercial timber harvest using natural regeneration and clearcuts to provide cover; harvested, thinned, and burned stands to provide forage; and a mosaic of mature timber to produce mast rather than relying solely on food plots for supplemental forage.

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A basic problem in determining the utility of habitat management is obtaining data about response to habitat change by wildlife populations (Rollins et al. 1988). Large-scale applications of an array of untested habitat management practices are not cost effective. The Oklahoma Department of Wildlife Conservation established the Pushmataha Forest Habitat Research Area (PFHRA) in 1982 to evaluate forage responses to a variety of timber harvest and prescribed fire regimes, and to determine possible forest management alternatives for large-scale application on Wildlife Management Area (WMAs). Forest openings created through commercial pine timber harvest and maintained in early successional conditions with prescribed fire provide additional forage in years of low mast production (Masters et al. 1993*a*). However, quantification of forage production alone will not provide an indication as to treatment preference by targeted wildlife species. Because of small experimental unit size ($\leq$1.6 ha) population response was invalid as a measure of treatment preference. However, pellet-group counts provide an alternate index to discriminate treatment preference.

Pellet-group counts compare favorably with other techniques to determine relative habitat use for white-tailed deer (Rollins et al. 1988), mule deer (Leopold et al. 1984, Loft and Kie 1988), and elk (Edge and Marcum 1989). Percent habitat use determined from pellet-group counts may not be valid because of small unit size, differential pellet deposition rates in response to behavior (e.g., feeding, traveling, and bedding), and changes in deposition due to seasonal change in forage quality (Collins and Urness 1979, 1981; Loft and Kie 1988). Counts of rabbit pellet-groups have been used successfully as an index of habitat use (McKee 1972). Compared to deer and elk, rabbits have limited home ranges (~2 ha), high reproductive rates, and high rates of dispersal (Chapman et al. 1982). Given our experimental design and availability of all treatment types, rabbit pellet counts may give a reasonable approximation of habitat use or preference.

Our objective was to assess use of varied habitat treatments by white-tailed deer, elk, and eastern cottontails on oak (*Quercus* spp.)-pine (*Pinus* spp.) sites. Previously established supplemental forage openings (food plots) located peripheral to the PFHRA offered further comparison as a potential forest wildlife management strategy. Our approach was to create a situation similar to a cafeteria feeding trial, with an array of replicated forest and habitat management treatments randomly applied on a small (<40 ha) area. Each of these treatment units were within the range of deer, elk, and rabbits that frequented the area.

A secondary objective was to fit pellet group counts for these species to theoretical frequency distributions. Pellet-group counts may be random or non-random in distribution, depending on habitat conditions and behavior of the animal (McConnell and Smith 1970). Frequency distribution is important to determine appropriate data transformations and statistical procedures (Bowden et al. 1969, Stormer et al. 1977, Leopold et al. 1984, Loft and Kie 1988, Rowland et al. 1984). White-tailed deer, mule deer (*Odocoileus hemionus*), and elk pellet-group distributions were previously fitted to the negative binomial distribution (Bowden et al. 1969, McConnell and Smith 1970, Stormer et al. 1977). Frequency distributions of cottontail rabbit pellet-groups have not been fitted previously to theoretical distributions.

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Methods

Study Area

This study was conducted within the 30-ha PFHRA on the 7,690-ha Pushmataha WMA, Pushmataha County, Oklahoma. Pushmataha WMA lies in mountainous terrain along the western edge of the Ouachita Highland Province. The WMA was initially established as a deer refuge in the 1940s. Elk were released on the area in 1969. The Pushmataha WMA supported 15 elk in 1988 and 27 elk in 1994 (Masters 1991*a*; R. E. Masters, unpubl. data). Elk were localized in the vicinity of the PFHRA possibly because of the availability of open areas of various types. The Pushmataha WMA supported an average density of 8.7 deer/km^2 (SE=0.4) from 1986 to 1990 (Masters et al. 1993*a*). An outbreak of epizootic hemorrhagic disease in 1993 lowered the deer population to <5 deer/km^2. Rabbit populations have not been monitored.

Cultural Treatments

During summer 1984, merchantable pine timber was harvested in scheduled treatments, and hardwoods selectively thinned to approximately 9m^2/ha basal area (BA) by single-stem injection using 2,4-D. Prescribed burns using strip-head fires were conducted in winter 1985 and in succeeding years at defined intervals (Masters and Engle 1994).

Nine treatments were applied to 23 1.2- to 1.6-ha units in a completely randomized experimental design, beginning in summer 1984. Cultural treatments and number of replications (*N*) are summarized as follows:

(1) control (*N* = 3);

(2) rough reduction, winter prescribed burn—4-year interval, 1985, 1989, 1993 (*N* = 3);

(3) harvest pine timber only, winter prescribed burn, 1-year interval, beginning in 1985 (*N* = 3);

(4) harvest pine timber, thin hardwoods, no burn (natural regeneration to a mixed stand; *N* = 1);

(5) harvest pine timber, thin hardwoods, winter prescribed burn—4-year interval, 1985, 1989, 1993 (*N* = 3);

(6) harvest pine timber, thin hardwoods, winter prescribed burn—3-year interval, 1985, 1988, 1991, 1994 (*N* = 2);

(7) harvest pine timber, thin hardwoods, winter prescribed burn—2-year interval, 1985, 1987, 1989, 1991 1993 (*N* = 3);

(8) harvest pine timber, thin hardwoods, winter prescribed burn—1-year interval, beginning in 1985 (*N* = 2); and

(9) clearcut, summer burn—1985, planted to loblolly pine (*P. taeda*) ($N = 3$).

Peripheral supplemental forage openings (1.2 to 4 ha) were included to compare use of a traditional wildlife management technique with those under development. Inclusion of this additional treatment is valid in a completely randomized experimental design (Steele and Torrie 1980:126, 139). The food plot treatment is summarized as follows:

(10) cultivated fertilized food plot, planted to fescue, rye, vetch, and Korean lespedeza; plots were mowed each fall and disced periodically ($N = 3$).

Post-treatment harvested and thinned openings were dominated by tallgrasses and woody sprouts of varying density, depending on fire frequency of a given site. Grasses included big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and to a lesser extent, Indiangrass (*Sorghastrum nutans*). Post oak (*Q. stellata*), blackjack oak (*Q. marilandica*), winged sumac (*Rhus copallina*), and dewberry (*Rubus* spp.) were dominant woody species. The overstory was comprised of sparse (2–9 m^2/ha BA stems >5 cm at 1.4-m height) post oak and blackjack oak (Masters 1991*a,b*; Masters et al. 1993*a*). The clearcut treatment was planted with loblolly pine in 1986.

Unharvested treatments (control and rough reduction burn), were dominated by post oak, shortleaf pine (*P. echinata*), blackjack oak, and mockernut hickory (*Carya tomentosa*). The BA of unharvested treatments ranged from 24 to 27 m^2/ha. Common woody understory species included tree sparkleberry (*Vaccinium arboreum*), poison ivy (*Toxicodendron radicans*), and greenbriar (*Smilax spp.*). Dominant herbaceous plants were little bluestem, panicums (*Panicum* spp., *Dicanthelium* spp.), and sedges (*Carex* spp., *Scleria* spp.). The study area and application of cultural treatments were further described by Masters (1991*a,b*), Masters et al. (1993*a,b*), and Masters and Engle (1994).

Browse Use

We conducted browse use surveys in September 1988 because this was a critical period of the year for deer (Fenwood et al. 1984). Browse frequency was assessed in 10 4- by 4-m plots on 2 parallel transects for each experimental unit. Methods and relative ranks of treatment use were reported in Masters (1991*b*).

Pellet-group Counts

Pellet-group counts for white-tailed deer, elk, and cottontails were made using randomly located parallel transects in each of the 26 experimental units. Lines were 100×1 m (100 m^2) and located ≥20 m from the edge of any experimental unit. Transect locations were randomized each sampling period and pellet-groups were counted in late April or early May, September and December 1988, and in May and December 1994. We sampled 2 to 4 transects/experimental unit during all periods except May 1988, when only 1 transect was sampled per unit. Sampling dates were chosen to evaluate possible seasonal shifts in treatment use.

All deer, elk, and rabbit fecal pellet groups within a transect were counted and recorded. A pellet group was defined as >5 pellets in a pile or trail. Pellet group that occurred on a transect boundary were counted if >5 pellets were within the transect boundary (Kinningham et al. 1980). Only pellets that exhibited charring from burn treatments were excluded because they indicated deposition prior to the season of interest.

Temporary rather than permanent transects were used because randomization was necessary to meet statistical assumptions (White and Eberhardt 1980). Permanent plots have been used because of pellet group persistence (Robinette et al. 1958), but where pellet groups can be accurately aged, temporary plots can provide similar estimates (Freddy and Bowden 1983). In southeastern U.S., deer fecal groups do not persist for long periods of time (Kinningham et al. 1980). A single rain can erode deer (Jenks et al. 1990*b*), and elk pellet groups (R. E. Masters, unpubl. data) in Oklahoma. Rabbit pellet groups may persist longer, depending upon type of food consumed, temperature, and weather. No reliable method of aging rabbit pellet-groups has been reported (Cochran and Stains 1961). However, in warm climates with high rainfall and high dung beetle activity, pellets may not persist long enough to have a confounding effect.

All transects were counted within a 2–3 week period. The food plot treatment was not sampled in September 1988 because rainfall >3 cm occurred on a single day during the sampling period and affected counts. Wallmo et al. (1962) reported that heavy rain adversely affected pellet counts.

Analysis

We tested mean pellet-group counts among treatments for homogeneity of variance using Levene's test (Snedecor and Cochran 1980). Pellet-count frequency distributions were compared with Poisson and negative binomial distributions by a chi-square test (goodness-of-fit). Data were pooled in the tails of the frequency distribution to assure minimum expected frequency values of at least 3 (White and Eberhardt 1980, Ludwig and Reynolds 1988). Analysis of variance (PROC GLM) on ranked data, equivalent to the Kruskal-Wallis non-parametric procedure, was used to compare pellet group counts among treatments, months, and years for each species. Analysis was treated as a 3-way factorial and all interactions were tested. When differences were significant ($P < 0.05$), means were separated with Turkey's test (Conover and Iman 1981; SAS Inst. 1985, 1987).

Browse utilization frequency for all sample plots was summed by unit, ranked, and analyzed by ANOVA (SAS Inst. 1985). Mean ranks were separated by Turkey's Test (Conover and Iman 1981). Pellet-group data were compared with utilization frequency data for 1988 using the Spearman rank correlation procedure (SAS Inst. 1985, 1987).

Results

Frequency distributions of elk, deer, and rabbit pellet groups fit the negative binomial distribution ($P > 0.05$). Distributions for elk and deer differed from the Poisson distribution ($P < 0.05$). Values of k in the negative binomial ranged from 0.936 to 1.630 for elk, 0.921 to 1.381 for deer, and 0.696 to 1.277 for rabbit.

We found the only significant interaction for elk pellet-group counts was year-treatment ($P = 0.02$; Table 1). The year-treatment interaction may be partially explained by successional changes on the treated units. For example, the natural regeneration treatment was considerably more dense with sapling shortleaf pine in 1994. We found that elk pellet-group counts differed ($P < 0.001$) among treatments (Table 1). Food plots and clearcut units had higher counts than control, rough reduction burn, or harvested and burned treatments. However, they were not different than harvested and thinned sites with or without fire. Seasonal shifts in elk pellet counts on treatments did not occur ($P = 0.27$). A year effect ($P < 0.001$) was evident between

Table 1. Average elk, white-tailed deer, and cottontail rabbit pellet groups/ha on experimental units subjected to pine timber harvest, thinning of hardwoods, and periodic dormant season prescribed fire, May and December 1988 and 1994, Pushmataha Forest Habitat Research Area, Oklahoma.

		Species											
		Elk				White-tailed deer				Rabbit			
		1988		1994		1988		1994		1988		1994	
Treatment[a]	N	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Control	3	17c	17	16	7	25	17	16	11	0f	0	5	5
Rough reduction burn[b]	3	0c	0	16	16	25	17	42	19	25ef	17	31	14
Harvest, annual burn[c]	2	25c	17	5	5	75	31	36	25	167cd	54	78	16
Natural regeneration	1	250a	50	16	16	475	25	31	31	125cd	25	31	31
Harvest, thin, 4-yr burn[b]	3	67bc	25	26	13	192	71	83	43	208abc	42	104	59
Harvest, thin, 3-yr burn[d]	2	350a	124	31	18	200	106	63	26	225bcd	111	281	144
Harvest, thin, 2-yr burn[e]	3	183ab	46	57	45	225	85	73	32	367abc	108	73	33
Harvest, thin, 1-yr burn[c]	2	213ab	66	16	16	238	69	21	13	425a	78	94	50
Clearcut[f]	3	358a	97	117	89	208	42	63	53	425ab	125	47	37
Food plot[g]	3	208ab	62	260	88	275	70	109	18	50de	18	0	0

Effect	df	Elk $P>F$	White-tailed deer $P>F$	Rabbit $P>F$
Treatment	9	<0.001	0.11	<0.001
Month	1	0.27	0.15	0.48
Month*Treatment	9	0.19	0.84	0.73
Year	1	<0.001	0.004	<0.001
Year*Treatment	9	0.02	0.49	0.04
Year*Month	1	0.60	0.21	0.01
Year*Month*Treatment	9	0.60	0.05	0.67

a. Column means followed by the same letter were not significantly different at the 0.05 Level. Means and standard errors were from untransformed data.

b. Winter burn, 4-year interval (1985, 1989, 1993).

c. Winter burn, annually (1985–1994).

d. Winter burn, triennially (1985, 1988, 1991, 1994).

e. Winter burn, biennially (1985, 1987, 1989, 1991, 1993).

f. Summer site prep burn (1985).

g. Planted to fescue, rye, vetch, and Korean lespedeza, and mowed early fall.

1988 and 1994 counts, possibly from dispersal of elk into nearby recently harvested areas (Table 1).

Deer pellet-group counts exhibited a year-month-treatment interaction (P = 0.05; Table 1), which may have been partially related to successional change and lower deer densities. Counts were not different (P= 0.11) among treatments although pellet-group numbers varied considerably. Highest counts were made in the natural regeneration (harvest and thin only), clearcut, and food plot treatments. Seasonal shifts in deer pellet-group counts were not evident (P = 0.15; Table 1). A year effect was evident between counts in 1988 and 1994 (P = 0.004), possibly a result of lower deer density following the outbreak of epizootic hemorrhagic disease in 1993.

We found that rabbit pellet group counts exhibited a year-treatment (P = 0.04) and a year-month interaction (P = 0.01; Table 1). These effects resulted from successional changes (crown closure) on the clearcut and natural regeneration (harvest, thin and no fire) sites. Counts differed among treatments ($P \leq 0.001$) with the clearcut, harvest and burn, and all harvested, thinned and burned treatments having consistently higher pellet counts than control, rough reduction burn, and food plot treatments. Harvested, thinned and burned treatments were similar regardless of fire frequency. We observed no seasonal shift in counts among treatments (P = 0.48), but a strong year effect ($P \leq 0.001$) was noted, possibly the result of successional changes.

Cervid fecal counts (deer and elk combined) were not correlated with browse utilization frequency (P = 0.82). The 2 methods ranked habitat use differently (Table 2). Clearcut sites and naturally regenerated sites (harvest, thin and no fire) were preferred over rough reduction burn treatments seasonally in both methods (Table 2). The average rank of both methods may indicate treatments to apply on a larger scale. Average ranks of natural regeneration, clearcut, and harvest, thin and 3-year burn treatments were higher than other treatments (Table 2). Browse utilization on

Table 2. Ranks of browse utilization frequency and cervid pellet-group estimates of treatment use on Pusmataha Forest Habitat Research Area, Oklahoma, September 1988.[a]

Treatment	Browse utilization frequency	Pellet groups	Average rank of both methods
Harvest, thin, 3-year burn[b]	9a	5abc	7
Natural regeneration	8ab	9a	8.50
Harvest, thin, 2-yr burn[c]	6.5abc	1c	3.75
Clearcut[d]	6.5abc	8ab	7.25
Control	5abc	3c	4
Harvest, thin, 4-yr burn[e]	4abcd	6abc	5
Harvest, thin, 1-yr burn[f]	3bcd	7ab	5
Harvest, 1-yr burn[f]	2cd	4bc	3
Rough reduction burn[e]	1d	2c	1.5

a. Column ranks with the same Letter are not significantly different, Kruskal-Wallis test. Highest numbers (9) represent the greatest utilization or the highest number of pellet group counts.

b. Winter burn 1985, 1988.

c. Winter burn 1985, 1987.

d. Summer burn 1985.

e. Winter burn 1985.

f. Winter burn 1985, 1986, 1987, 1988.

the harvest, thin and 3-year burn treatment may have been highest because it had been burned in an earlier season that year. The 3-year burn treatment had higher browse utilization than 1-year burn treatments (burned at the same time) likely because of more abundant woody sprouts.

Discussion

The parameter *k* measures the degree of clumping (contagion) in the negative binomial distribution and is useful for making inferences about pellet-group data (White and Eberhardt 1980). The low values of *k* reported here indicate distributions clumped according to site treatment by elk, deer, and rabbit, thus providing additional support for differential treatment use.

Unharvested treatments were used less than those with limited or no canopy cover (food plots). Harvested, thinned, and burned treatments had higher pellet counts for all herbivores than control and rough reduction burn treatments. These data were consistent with observations by Raskevitz et al. (1991) that deer and elk use open areas to a greater extent than forested areas in eastern Oklahoma. Rabbit pellet-group counts also were higher on harvested sites than on unharvested sites, corroborating findings by McKee (1972). However, limited use of food plots (≥20 m from the edge) by rabbits suggest that escape cover is an important habitat requirement. Burning regime (1-, 2-, 3-, or 4-year intervals or no burning) had little effect on elk, deer, and rabbit pellet-group counts on harvested and thinned sites (Table 1). Higher cervid pellet-group counts on harvested sites may be related to foraging, bedding and traveling behavior. Our results suggested that young clearcuts and natural regeneration areas without initial burning for site preparation provided bedding and escape cover and, to a lesser extent, forage.

Comparison of cervid pellet-group counts with browse utilization frequency and general observations suggested that higher pellet counts of deer and elk were found on treatment units where deer and elk bedded most often. Habitat use as measured by time spent browsing on a given unit was inadequately measured by pellet-group counts. Inferences of habitat preference from pellet count data assume that pellet-group deposition is a linear function of time spent within a given habitat type and that defecation rates are similar among types. This assumption is likely incorrect (Collins and Urness 1979, 1981).

The high pellet group counts for cervids on natural regeneration and clearcut treatments in 1988 were consistent with previous observations that deer and elk normally defecate soon after leaving beds (Collins and Urness 1981). They also were consistent with our observations that deer and, to a lesser extent, elk, were flushed frequently from beds mid-day in the young natural regeneration (harvest and thin only) and clearcut treatments (R. E. Masters, unpubl. data). These treatments had abundant sapling (1-3 m) pines in 1988 (Masters 1991*b*; Masters et al. 1993*a*). Use of these treatments in 1988 was probably related to the presence of pines as screening and bedding cover. Pines provided a more dense horizontal cover than tallgrasses and scattered woody shrubs on other units, but we did not measure this parameter. Deer were rarely flushed mid-day on other treatments but were observed at night on harvested and burned treatments when spotlight counts were conducted. Elk were observed on all treatment units except rough reduction burns.

Successional changes by 1994 on harvested or burned sites influenced elk, deer, and rabbit use of treatments. By 1994, woody stem density and height was inversely related to the burning regime on experimental units with lower stem density and stature found on more frequently burned sites. However, all harvested, thinned, and burned treatments had a woody component, with 3- and 4-year burn interval treatments having a distinct dense, shrubby appearance. The rough reduction burn treatment also had changed structurally after 3 burning cycles. Fire caused mortality of small-diameter, midstory hardwoods, thus opening up the stands and allowing increased light penetration and increased forage production in the understory.

Elk use generally declined on the study area as succession to an increased woody component proceeded on harvested and thinned treatments. Elk appeared to shift use to an adjacent harvested site (40 ha) to a greater extent, thereby causing the year effect noted earlier. Food plot use remained high because they were maintained as open areas and thus did not change in terms of woody stem density. Use of clearcut sites apparently remained high because of the abundance of pine saplings for dense screening cover. The natural regeneration site had become extremely dense by 1994 and therefore exhibited little use by elk.

Deer pellet-group counts were substantially lower in 1994 than in 1988 as a result of the outbreak of epizootic hemorrhagic disease. Successional changes also influenced counts. As woody stem density and preferred browse increased on the harvested and burned treatments, cover and available forage became less different among small treatment units. As a result, we observed a year-month-treatment interaction between our sampling periods.

Deer use increases on recent clearcuts but may be limited to 100 m from cover on large clearcuts (Tomm et al. 1981). However, Sweeney et al. (1984) found that deer used all portions of recent (<1-year-old) small (<25 ha) clearcuts. As pine stands develop in height on regeneration areas, deer use of the central portion of the stand will increase. All portions of large (128–276 ha) 4- to 5-year-old pine stands were used in southeastern Oklahoma pine plantations (Melchiors et al. 1985).

The successional changes noted on the harvested, thinned, and burned treatments evidently influenced rabbit use of treatments and caused many of the interactions noted. Population levels for rabbits may have been lower in 1994, causing the year effect. This decrease may have resulted from either population decline following an initial peak after application of treatments at the beginning of the study, or successional changes, or a combination of both. With an increased woody component on harvested units by 1994, herbaceous plants became less prevalent on some treatments. The natural regeneration and clearcut treatments had achieved crown closure and accumulated a considerable amount of litter, effectively shading and mulching out herbaceous understory plants. Rabbit use was dramatically lower on these treatments in 1994.

Other values associated with controlled burning and overstory removal are increased availability of preferred food items for elk, deer, and rabbit. Harvested sites had more abundant and diverse forage production than control and rough reduction burn treatments (Masters et al. 1993*a*). Winter prescribed fire on harvested units at 1- or 2-year intervals favored legumes and other preferred forbs (Masters 1991*b*). Less frequent burning or no burning allows woody browse species preferred by deer to increase on harvested sites (Landers 1987). A prescribed burning rotation at 2- to 4-year intervals on harvested sites will allow growth of preferred deer, elk, and rabbit foods (Masters 1991*a, b*). However, successional change on 3- and 4-year burn interval treatments will make these areas less suitable for elk over time.

Browse use by cervids on treated areas was probably related to percent cover of preferred browse and shrub species richness (Masters 1991*b*). Woody browse is the major component of deer diets in all months except May in southeastern Oklahoma (Jenks et al. 1990*a*). However, when hard mast is available in fall and winter, it composes the major portion of deer diets (Fenwood et al. 1985). Relative abundance of preferred forbs, panicums, and sedges on a treatment unit probably affected use because of the selective foraging nature of deer (Vangilder et al. 1982). Food habits of elk are generally unknown in eastern Oklahoma.

Management Implications

Browse quality and quantity are limited in the Ouachita Highlands (Segelquist and Pennington 1968), Fenwood et al. 1984, Masters 1991*a*, Masters et al. 1993*a*). On low productivity sites, forest opening created by timber harvest and maintained with prescribed fire will increase use by deer, elk, and rabbits. Cover is often overlooked as an important component of deer habitat in the Southeastern U.S. This study demonstrated that deer and elk will use unburned, naturally regenerated areas or areas clearcut, burned, and planted to pine as screening and bedding cover when located adjacent to forested or harvested and burned sites. Although pellet counts do not accurately portray total habitat use, they may be useful for determining relative habitat use when interpreted with caution (Rowland et al. 1984).

Forest openings maintained in early succession with fire are a viable alternative to traditional food plots for deer. Harvested sites were used as frequently as food plots and are more cost-effective (Masters et al. 1993*a*). Commercial timber harvest produces income and preferred forage. Food plots require capital expenditures for equipment and annual costs associated with seed and fertilizer.

Forest openings may be essential for successful elk management strategies in areas enzootic for the meningeal worm (*Parelaphostrongylus tenuis*). Raskevitz et al. (1991) found that elk increased on Cookson Hills WMA (5,456 ha), where 25% of the area was maintained in grassy openings or meadows. This is significant because Masters (1991*a*) found that elk began increasing on Pushmataha WMA (7,690 ha) after 21% of the area was in openings. With this percentage of open areas, elk avoided forested areas where the intermediate gastropod host of the meningeal worm was found in high numbers, thus lowering the probability of infection (Raskevitz et al. 1991). It seems reasonable that managers contemplating elk reintroductions in eastern areas enzootic for the meningeal worm and with high deer density should insure that 20%–25% of the potential range occur in grassy forest openings. However, presence of open, low basal area stands may substantially reduce these minimum guidelines.

Preference for clearcuts and naturally regenerated sites has important implications for the use of commercial logging to manage deer and elk in forested areas of the southeast. Rough reduction burns and clearcutting are often justified based on purported benefits to deer and other wildlife. Minimal deer, elk, and rabbit use of the rough reduction burn treatment does not support this justification. Later hazard reduction burns may provide beneficial cumulative effects but should be evaluated through long-term studies. Thinning and burning of stands will significantly increase forage production in a much shorter time frame (Masters et al. 1996).

Clearcuts planted to pine and naturally regenerated stands offer short-term advantages to wildlife by increasing cover and forage production. However, the long-term loss of mast production and mid-rotation loss of forage production must be addressed as stand conditions change by providing additional foraging areas through well-spaced regeneration areas or by thinning and burning the stands (Masters et al. 1996). Naturally regenerated stands of mixed oak and pine can provide forage and cover, and produce mast as the stand matures. We recommend testing, on a larger scale, a management strategy that periodically creates clearcuts and unburned natural regeneration areas in contoured blocks for cover, within a mosaic of mature timber and harvested, thinned, and periodically burned sites. Further, cervid response should be evaluated using radio telemetry to assess relative habitat use within this larger context.

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